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FACULTY OF BUSINESS AND LAW

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Modelling future demand for long-term care

By

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ABSTRACT

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This research was jointly funded by the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC). As such, its underpinning and innovative aim was to explore the use of Operational Research (OR) techniques, a research area traditionally associated with the EPSRC, to address key societal problems traditionally associated with the ESRC.

The ageing population presents many significant challenges for social care services at both a national and local level, one of which is to meet the demand for long-term care. The population of people aged over 65 will continue to grow for some time as the "baby boom" generation ages. The concern for policy planners is whether there will be enough resources in place to handle the expected strain on the system in the future. The research presented in this thesis addresses this key issue, and was carried out in collaboration with the Adult Services Department of Hampshire County Council (HCC). The overarching aim of this thesis was to develop computer models (using data local to Hampshire) which would be of practical use in estimating the future demand and planning the supply of long-term care in Hampshire.

A cell-based model was built to forecast the demand for long-term care in Hampshire from people aged 65 and over for the period 2009 to 2026. An important part of this research was to understand the main drivers of future demand for long-term care and to predict the future number of people with a disability. Hampshire County Council has already tried to address these issues of demographic change through a modernisation programme. Part of this has been the establishment of a contact centre called Hantsdirect. A discrete-event simulation model of the contact centre was developed. The two models were combined to explore the short- and long-term performance of the contact centre in the light of demographic change. This hybrid model has enabled HCC to explore the short- and long-term performance of the contact centre.

This study combines OR with Gerontology, Demography and Social Policy. This research is novel as it iteratively combines a compartmental population model with a discrete-event simulation model. From an OR perspective, the aim was not only to explore the use of modelling in social care (where, unlike healthcare, there has not hitherto been a lot of research), but also to investigate the potential for combining different modelling approaches in order to obtain additional value from the modelling. This novel approach in a social care setting is one of the main contributions of this thesis.

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Declaration of Authorship

I, Mitul Shivam Desai, declare that the thesis entitled "Modelling future demand for long-term care" and the work presented in it are my own. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University
- where any part of this thesis has been previously submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated
- where I have consulted the published work of others, this is always clearly attributed
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work
- I have acknowledged all main sources of help
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself
- Part of this work has been presented at:
    - Young Operational Research 15 conference, University of Bath, Bath, UK, 28th-30th March 2007
    - The Institute of Mathematics and its Applications, Fifth International Conference on Quantitative Modelling in the Management of Health Care London, 2nd-4th April 2007
    - The Operational Research Applied to Health Services PhD Workshop, Toronto, Canada, 24th-25th July 2008
    - The 34th International Conference on Operational Research Applied to Health Services, Toronto, Canada, 28th July-1st August 2008
    - Young Operational Research 16 conference, University of Warwick, 24th-26th March 2009
    - Student Conference on Operational Research (SCOR), Lancaster University Management School, 27th-29th March 2009
    - Invited speaker, Simon Fraser University, Vancouver, Canada, Modelling of Complex Social Systems, 13th May 2009

- The 35th International Conference on Operational Research Applied to Health Services, University of Leuven, Belgium, 12th-17th July 2009
- Invited speaker, Cardiff School of Mathematics, Operational Research Group, 3rd September 2009
- Invited speaker, System Dynamics+, Simulation Special Interest Group joint meeting, Warwick Business School, 25th February 2010
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Mitul Desai was invited to spend a month working with Professor Warren Hare at the Simon Fraser University, Vancouver, Canada in May 2009. He worked with the Modelling of Complex Social Systems (MoCSSy) Research Group.

Signed: …………………………………………..

Date: …………………………………………….

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Abbreviations

A&E	Accident and Emergency
CLGD	Communities and Local Government Department
CD	Compact Disc
DES	Discrete-event simulation
EPSRC	Engineering and Physical Sciences Research Council
ESDS	Economic and Social Data Service
ESRC	Economic and Social Research Council
GHS	General Household Survey
HCC	Hampshire County Council
KPIs	Key Performance Indicators
NHS	National Health Service
ONS	Office for National Statistics
OR	Operational Research
PAT	Professional Advisory Team
PSSRU	Personal Social Services Research Unit
QoS	Quality of service
SD	System Dynamics
SMS	Short message service
UK	United Kingdom

1. Introduction

1.1 Background – the ageing population

Population ageing is a global phenomenon. It is defined as an increase in the proportion of the population who are older (i.e. 65 years and over). This changing age structure of the population is due to: (i) falling fertility, which leads to fewer younger people in the population and hence a rise in the proportion who are elderly; and (ii) mortality decline at older ages, which impacts upon the ageing of the elderly population itself, that is, the increases in the proportion of the ‘oldest old’ (e.g. 85 years and older). This poses many challenges to developed governments, but it is important to note that an ageing population is something that should be welcomed and celebrated. The challenges include fiscal pressures in the financing, planning and delivery of state health and social care services in the community; long-term care support, such as residential services; state pensions and appropriate life course sensitive housing. However, a longer life expectancy offers people the opportunity to have more time to spend with family and friends, more time volunteering in the community, more time for leisure pursuits and keeping fit and active.

There are many significant challenges associated with the provision of long-term care for older people. The number of people aged over 65 in the United Kingdom will continue to grow for some time as the “baby boom” generation ages. Using data provided by the Office for National Statistics (2007a), the number of people aged 65 and over is predicted to increase by 45.43% from 2008 through to 2026. The Government Actuary’s Department (2008b) shows that there has been an increased life expectancy year-on-year for people aged 65 and over. There has also been a reduction in the number of people who make up the working population, which has led to less money being raised by taxation, an important source of funding for long-term care. Using data from the Office for National Statistics (2006) it is shown that nationally limiting long-term illness increases with age. As the proportion of older people increases, some will require care from the state, private care providers and from friends and family. The concern for policy planners is whether there will be enough resources in place to handle the expected strain on the system in the long term.

1.2 The Hampshire context

The county of Hampshire is the focus of this thesis, chosen partly because of its convenient location and partly because of pre-existing links between the University of Southampton and Hampshire County Council (HCC), developed over the course of many previous collaborative research projects. Hampshire is located in the South of England and as such, is a popular choice for retirement because of its mild climate. Hampshire County Council (2010a) has provided some the key facts about the county. Hampshire has a population of 1.28 million people and is the third largest shire in England. There are 525,000 households in Hampshire, and HCC Adult Services provides support and advice to about 95,000 residents each year. People aged over 65 are a major client group for the Council. People aged over 65 are categorised as being elderly by the Council and it is this client group that is the concern of this research. Analysis of data (Hampshire County Council Environment Department and Vision of Britain, 2008) for Hampshire shows that similar trends to the UK in general are being experienced at a local level. In particular, the number of people aged 85 and over is predicted to increase significantly.

1.3 Long-term care

Long-term care in this context refers to social care, as distinct from healthcare, which is provided by the National Health Service. Social care consists of help with the activities of daily living provided to anyone with a chronic condition, i.e. an ongoing condition or disease that limits a person’s ability to carry everyday tasks. Such care can be potentially provided by the local authority, known as *formal care*, or unpaid care can be provided by friends or family, known as *informal care*, or in the form of *private care*. For the purposes of this research, private care includes privately paid care and a smaller category called other. Other includes care from voluntary organisations and churches for example. The majority of private care is privately paid for which is care services paid for privately by the older person or their family.

Not everyone with a chronic condition actually receives a care service. This could be either because they are managing to live without it, or because they cannot access it. Care can be provided either in the home and community, or an institutional setting. The latter includes care provided in either a residential or nursing home. Residential care is long-term care that is provided in a care home, not the home of the person in need. Nursing homes are for people with medical needs which require the help of nurses in a care home. As a result of demographic change there are likely to be significant increases in the demand for long-term care services.

HCC has already tried to address these issues through a modernisation programme. Part of this has been the establishment of a contact centre called Hantsdirect which will help improve efficiency so that HCC can take advantage of economies of scale. The design, staffing and planning of the contact centre is an important concern of the Council. Whilst the original, aim of the study was to model the system for long-term care, it quickly became apparent that the contact centre is an important issue for the Council and was incorporated into the modelling.

1.4 Aims of this research

This research was jointly funded by the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC). As such, its underpinning and innovative aim was to explore the use of Operational Research (OR) techniques, traditionally associated with the EPSRC, to address key societal problems traditionally associated with the ESRC.

The thesis addresses many of the challenges being experienced by Hampshire County Council Adult Services Department. The overarching aim of this thesis was to work with HCC and develop computer models (using data which was local to Hampshire) which would be of practical use in planning the future demand and supply of long-term care in Hampshire. The advantage of this approach is that HCC will be able to the evaluate the likely impact of proposed policy changes to their system in an artificial, risk-free environment before actual changes are made to the real-world system and the lives of older people affected.

From an OR research perspective, the aim was not only to explore the use of modelling in social care (a relatively new application area where there has not hitherto been a great deal of research), but also to investigate the potential for combining different modelling approaches in order to obtain additional value from the modelling. A hybrid model was created by combining a long-term (cell-based) care model and a contract centre (simulation) model. This would enable HCC to explore the short- and long-term performance of the contact centre in the light of demographic change. This is a novel approach to such a problem in a social care setting.

1.5 Research questions

In order to achieve its overarching aim, the research addressed the following specific research questions:

1. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people with a disability?

2. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people requiring long-term care?

3. How could a detailed tactical model for the Contact Centre benefit from the additional use of a long-term dynamic demographic model for population change?

4. What benefits and insights would result from a combined approach based on these two different models?

1.6 Modelling approach

A cell-based model was created to model the elderly population of Hampshire. As the modelling evolved, the system for long-term care was modelled for the home and community system only. This is an important part of the system for long-term care. The system was modelled from 2009 until 2026. It is important that HCC has a useful set of data to help plan services over the next eighteen years. This will potentially allow appropriate funding and resources to be allocated to meet the increases in demand. This has become an important challenge in the light of the current economic crisis, where budget cuts at both the national and local level are impacting on services. The results of this model can potentially aid the decision making process. The model has been designed at a local level and populated with actual data from a wide range of sources. These include population data from the Communities and Local Government Department and the National Statistics Subnational Population Projections Unit. Both datasets were provided by personal communication to the author. An important part of the model was the creation of a disability index using data from the 2001 General Household Survey (Economic and Social Data Service, 2001). Service receipt data was created from the same survey. This was supplemented with data from the Local Authority.

An important part of this research was to understand the future demand for long-term care and to predict the future number of people with a disability. This was done in the cell-based model, using data from the 2001 General Household Survey. This was created using analysis of data related to people's ability to carry out specific activities that are required as part of their everyday routine. Anyone with a disability is a likely candidate for long-term care. One of the key responsibilities of the Council is to ensure they have the resources in place to meet future demand. This also addresses research question two. This thesis investigated the number of people who receive a care service, especially in the form of statutory care services from the local authority. Using data from the 2001 General Household Survey, participants were asked to identify what they consider to be their main care provider. Using this information, projections were made that identified a person's main care provider. Future levels of formal care services were projected using data provided by the local authority. This was for anyone potentially requiring day or domiciliary care services. The numbers of people with a disability who receive no care or support have also been identified.

Discrete-event simulation was used to model the contact centre. The model was designed with data from the local authority as well as data collected by the researcher. This was finally combined with the cell-based model. The benefits and insights of combining the two models, of which there were many, were explored in this study.

1.7 Research Philosophy

The research philosophy of this study is scientific positivistic. The researcher is independent of the study and the work is unbiased. The research is based on quantitative data based on large samples of data from a range of data sources. The sample sizes of data from the 2001 General Household Survey are considered large enough to enable generalisations to be made.

The positivistic approach can be broken down into the following steps. After defining the research questions (see section 1.5, p.4), the data is collected, analysed and interpreted. The results of the analysis are reported in Chapter 7. Saunders et al. (2009) note that an important principle is that with this approach the researcher will be working with an observable social reality which leads to credible data being used. Saunders et al. argue that the emphasis of the approach is quantifiable observations that can be analysed with statistics. This research uses a deductive approach in line with the key features identified by Saunders et al. (2009): it is a highly structured approach that uses scientific principles, quantitative data is used, controls are put in place to ensure that the validly of the data is correct and large samples of data are collected before any generalisations are made.

1.8 Research Contribution

This study makes four main contributions to knowledge and research.

1. This study combines Operational Research techniques with an understanding of Gerontology, in particular demography and social policy. It is important to have a combined approach to gain a better understanding of the future implications of an ageing population in Hampshire.
2. The OR literature contains many papers relating to health care, but there are far fewer dedicated to social care issues. This study aims to fill this gap as it addresses the provision of social care in the home and community for a specific region of England, Hampshire.
3. This research is novel as it combines a population model with a discrete-event simulation model. There are no papers related that uses the hybrid approach in the area of social care or involving a contact centre.
4. The findings of the cell-based model are being used by the Adult Services Department in HCC to help plan the provision of long-term care in Hampshire. The findings of the hybrid model are being used to assist with future planning of the contact centre; the results should help inform this process.

The hybrid framework has made both an academic contribution and has had a practical impact for Hampshire County Council. There are no existing papers of the hybrid approach in the area of social care or modelling of contact centres. There has been a lot of research dedicated to the modelling of contact centres but they take a short-term view of the contact centre. The hybrid framework allows a long-term view to be taken. All the papers dedicated to research in the application of social care look at the impact of cost or future changes in the number of disabled people. None of existing research looked at the impact of demographic change upon an operational part of the system for long-term care.

This research looks not only at the changing demographics of Hampshire but models the impact it has on the contact centre. It allows for a more sophisticated demand profile to be created instead of simply inflating call arrival rates. The research allowed for the inclusion of feedback created from abandoned calls from the previous month. As well as this, the demand profile excluded people with no incapacity when creating the change in the number of callers on a month by month basis. Cell-based models and discrete-event simulation models alone have been proven to work successfully across many application areas but this research shows that by having a combined framework a more robust modelling technique can be formed. The new framework has all the strengths of the original methodologies but also allows the researchers to address new questions that could not have been answered with one model alone. In this research, a discrete-event simulation model study of the contact centre would have only looked at the performance of the contact centre today and would not have studied the impact of changing population demographics and increased numbers of disabled people in the Hampshire population.

The hybrid framework can be potentially extended beyond social care to other problem areas. For example, hospitals in England face increasing pressure to meet many targets, one of which is that a patient who is admitted to an accident and emergency (A&E) department must be served within four hours. A discrete-event simulation model could be used to model the A&E department and a compartmental model could model the local population. This allows the modeller to consider factors outside the control of the hospital that would impact upon the number of patients needing support from the A&E department. In this research, contact centre demand was impacted by changes in the number of disabled people. An example of a factor impacting the A&E department could be changes in the incidence of influenza. The wider application of the hybrid framework will lead to the creation of more robust models that can answer many more questions than could be by previous models.

The two standalone models can potentially be useful for Hampshire County Council. The Adult Services Department have taken ownership of the cell-based modes and are using it as an additional piece of evidence in the planning of future services. The data provided the Council with a set of information they did not have before and the results of the model has the potential to improve decisions both in the short and long term. The discrete-event simulation was useful as a standalone model. The model was run for a number of scenarios where the number of call handlers was altered. For example, one scenario showed the impact of Swine Flu which meant that a number of staff could not work. The combined framework of both models is being used to help plan the future of the contact centre. The data allows the decision makers to make long-term decisions supported by evidence. The results of the hybrid framework are being used by the

Programme Manager within the Adult Services Department to access the number of resources required to run the service in the future.

1.9 Structure of this thesis

The thesis is structured as follows.

Chapter 1. Introduction. This chapter includes a general introduction to the background, aims and context of the study as well as the research questions addressed in the study.

Chapter 2. Demography and Social Policy in the UK and Hampshire. This chapter explores the key concepts of demography in relation to the county of Hampshire, and makes comparisons between the regional and local level. Key policy documents at both the regional and local level are explored.

Chapter 3. Literature Review of Relevant Models. This chapter reviews the OR literature in relation to the long-term care models, call centre modelling and hybrid modelling. It identifies gaps in this literature addressed by the research in this thesis.

Chapter 4. The long-term care model. The cell-based model is presented in this chapter. The model structure, data and data collection methods are described, together with the processes for validation and verification of the model.

Chapter 5. Contact Centre Model Methodology. The discrete-event simulation model for the contact centre is presented in this chapter. The model structure, data and data collection methods are described, together with the processes for validation and verification of the model.

Chapter 6. Hybrid Model Methodology. This chapter describes the hybrid model produced by combining the cell-based model and the discrete-event simulation model.

Chapter 7. Results. This chapter presents and analyses the results from the various models presented in Chapters 4, 5 and 6.

Chapter 8. Conclusions. This final chapter reviews and answers the research questions and includes a summary of the key findings. The research contribution is discussed. The implementation of the model is described, together with the limitations of the study and ideas for potential future work.

2. Demography and Social Policy in the UK and Hampshire

2.1 Demography

This chapter contains a discussion of the demographic issues related to the United Kingdom (UK) and Hampshire.

2.1.1 Demographic change

Population change and population ageing are global issues. Figure 2.1 shows the extent to which populations are expected to change in most developed countries between 2005 and 2030. For example, for all the European Union countries, the total number of people in the population is projected to increase by 9.9 million people.

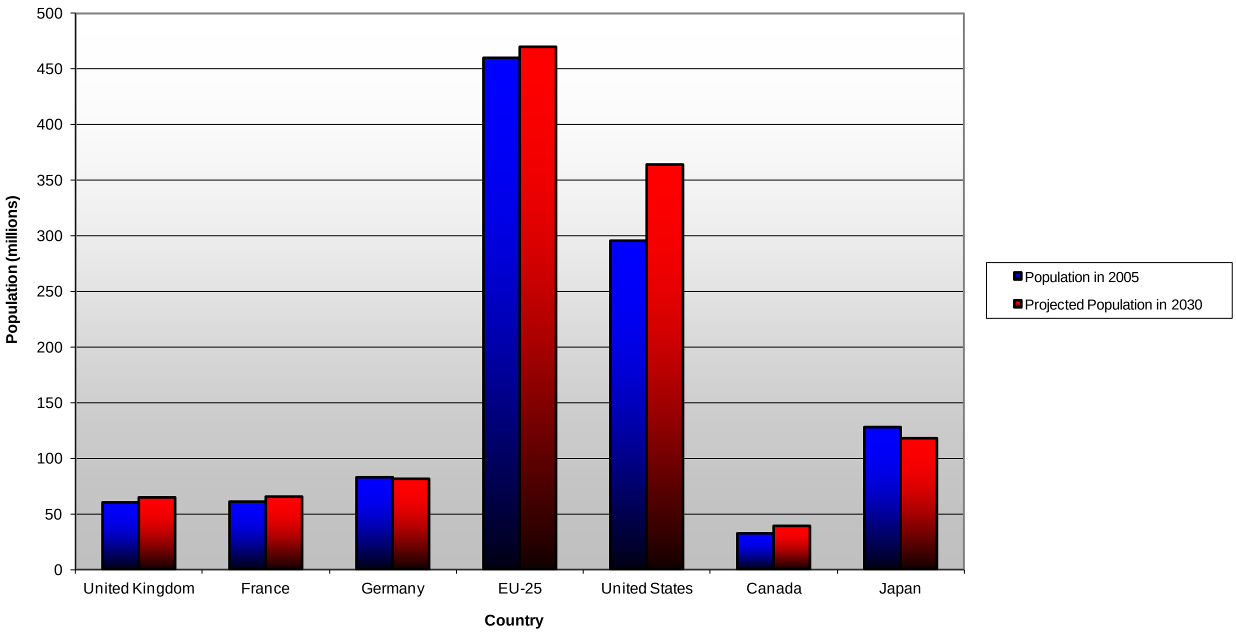

Figure 2.1: International Population Increases

(Source: Vienna Institute of Demography, 2006)

Tomassini et al. (2004) noted that ageing has occurred at different speeds between various developed nations. It is important to note that the number of people aged 65 and over is increasing over time in most developed countries. Figure 2.2 represents the percentage of the population aged 65 and over, and clearly shows the ageing of the population in England and Wales, Japan and the United States of America between the beginning of the 20th century and projected to the year 2020. For example, in England and Wales, the percentage of people aged 65 and over in the total population was about 5% at the beginning of the 20th century, and this is projected to increase to about 20% by 2020.

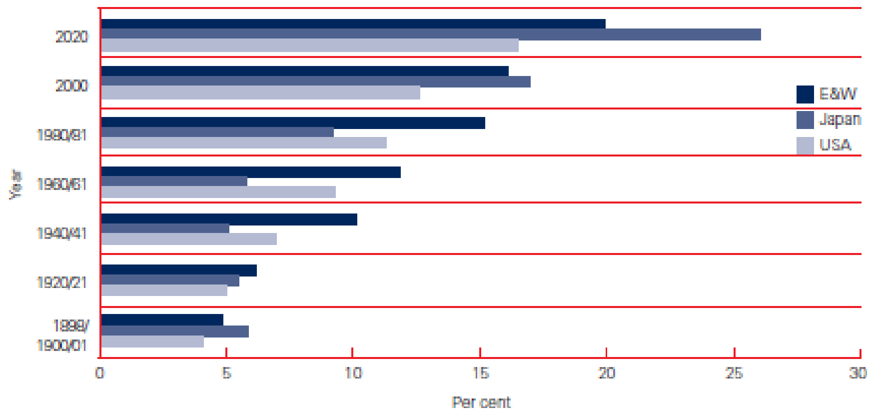

Figure 2.2: Percentage of the population aged 65 or over

(Source: Falkingham and Grundy, 2006, p5)

Such trends are particularly important for those who are involved in planning care services for older people, because as individuals age, the probability they will require care services increases (see for example Figure 2.20 in section 2.1.8, p.34). As expected, limiting long-term illness (LLTI) increases with age and those with such ill health are likely to need some sort of care and support. The highest rates of LLTI were found amongst those aged 65 and over, where the rates were much greater than in the younger age groups. For example, amongst those aged 65-69, 41% of males and 38% of females reported as having a limiting long-term illness. The concern then is that as we are likely to have an increased demand for long-term care services, policy planners need to prepare for increases in future demand.

This chapter will begin by discussing the impact of demographic change on the age structure of the United Kingdom (UK) and the county of Hampshire. Demographic change is an important driver for changes in demand for care from all the main sources of provision, such as informal and formal care provision. However, although the changing population structure poses significant policy challenges it can nevertheless be viewed also as an opportunity.

The focus of this thesis is to study how the demand for long-term care is going to change in Hampshire, and to consider how the local authority in Hampshire can better prepare for the impact of demographic change in the future demand for social care. The Hampshire population is projected to undergo significant demographic change in the next two to three decades, according to a report by Hampshire County Council (2007) on the demographic profile of the county. The county faces the following:

- *continued below replacement birth rates*
- *declining death rates in all ages, leading to higher life expectancies*
- *a shift in the age structure of Hampshire's population, leading to higher proportions of older people relative to young people*
- *changes exacerbated over the next 20-30 years as the high numbers born immediately post-war and during the baby boom move into and through retirement age*
- *more people spending more time in retirement supported by a decreasing working age population*
- *increased burden on care agencies for health and long term care needs as high levels of divorce, family breakdown, smaller family sizes and migration reduce the support provided by family members*

Hampshire County Council, 2007, p8

With such changes in mind, it is important to examine the overall population size, age structure, fertility and mortality patterns in the UK, in order to understand how such patterns might change in the future. In addition, one can also infer the size of the working population and the number of older people, which can provide an estimate of the numbers of people who are likely to need some sort of long-term care in the future.

2.1.2 United Kingdom Population Projections

The Government Actuary's Department (2007) estimated the population of the United Kingdom (UK) in mid-2006 to be 60.6 million. The population has been rising considerably and is set to continue. The central concern of this thesis is how the long-term care needs of older people are likely to change in the future. It is of importance to examine the current population structure and how it is expected to change in the future. The next section is dedicated to this.

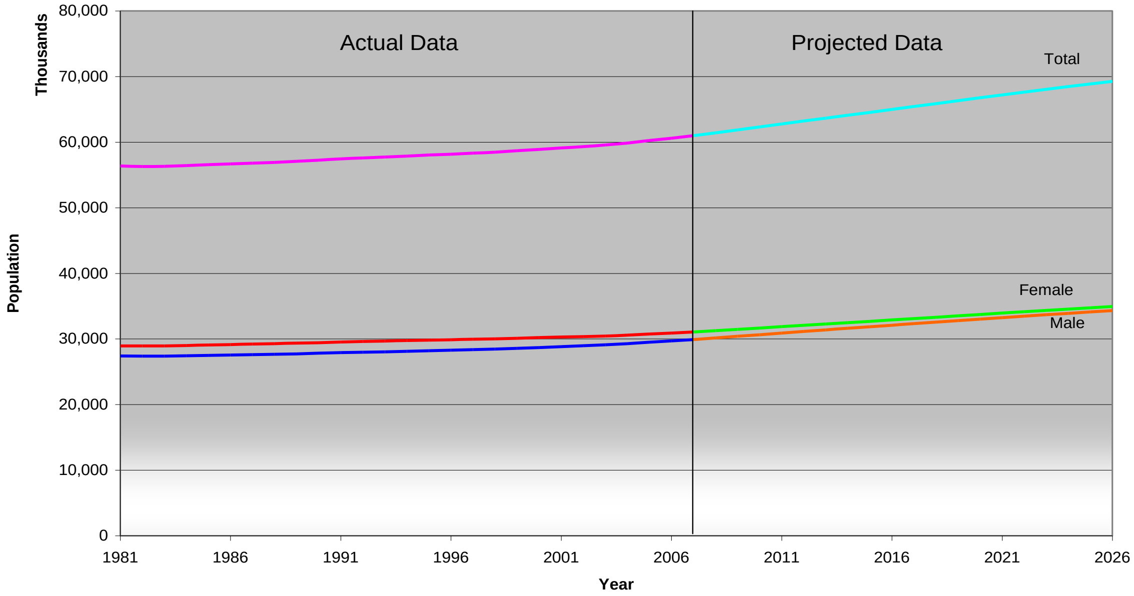

Figure 2.3: UK population 1981-2026: Actual and Projected

(Source: Office for National Statistics, 2007a)

Figure 2.3 illustrates how the population of the UK has increased since 1981 and shows the population projections to 2026 by the Office for National Statistics (2007a). The year 2026 has been chosen as it sufficiently captures the ageing of the "baby boom" generation, and the further the projection moves in the future, the greater the uncertainty around the projections (the "funnel of doubt") becomes. Comparisons with the county of Hampshire are carried out over this period as well, illustrating a steady rise in both the male and female population. For example, from 1978 until 2007, the total population was estimated to have increased by 8.91%. For males the increase was slightly more than the national level, with an estimated increase of 9.10%, and for females it was slightly less at 7.33%. The projected increases from 2008 to 2030 are much larger. The total population is projected to increase during this time by 12.78%. The total number of males in the UK is projected to increase by 13.81%, while the number of females is expected to increase by 11.79%.

Using the same data from the Office for National Statistics (2007a) the population of older people is analysed. Figure 2.4 shows that the number of people surviving into older age has been increasing with time, and the increases in the number of older people have been considerably higher than the increases experienced in the total population.

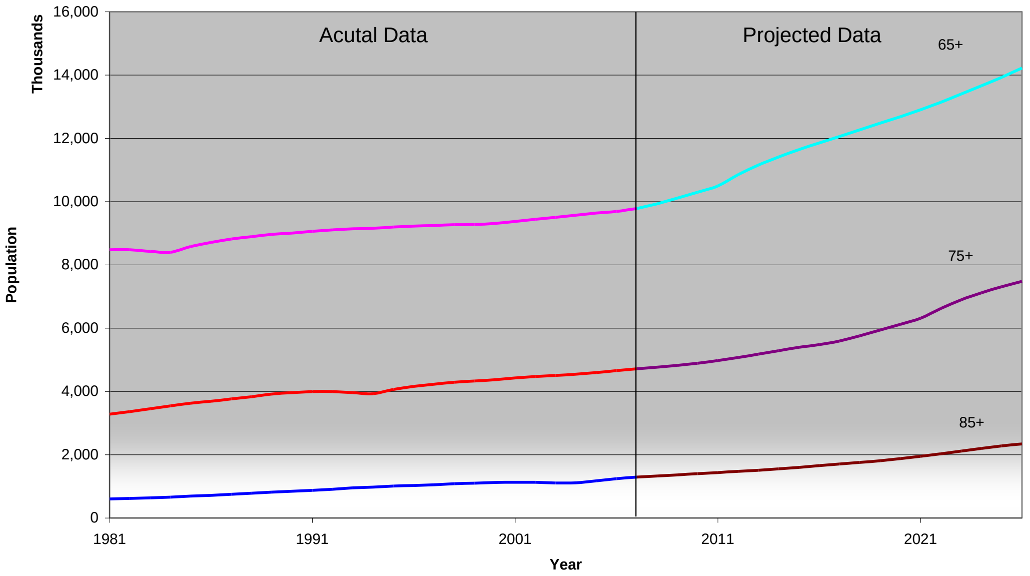

Figure 2.4: UK population aged 65 and over, 1981-2026

(Source: Office for National Statistics, 2007a)

For example, there was an estimated 15.36% increase in the number of people aged 65 and over between 1981 and 2007. This number will rise considerably: Figure 2.4 illustrates a projected increase by 45.43% by the year 2026. It should be noted that not all older people will require some sort of care service from the local authority, but the proportion of people requiring social care will rise. As people age, the chance of an individual person receiving some form of care service increases, and it is for this reason that two further age groups will be considered, namely those aged 75 and over, and those aged 85 and over. The increases within these two groups are a great deal higher than for everyone aged 65 and over. For example, the number of people aged 75 and over was estimated to have increased between 1981 and 2007 by 43.73%, and this is projected to increase by another 58.57% by 2026. In addition, the number of people aged 85 and over was estimated to have increased between 1978 and 2007 by 114.05%, and this is projected to rise by another 81.37% by 2026. The increase in the proportion of the latter group creates a greater policy challenge, as those aged 85 and over are more likely to receive the most intensive care packages which have significant cost implications. Understanding patterns of demographic change which are likely to affect the demand for social care policies is a crucial step for policy planners.

In addition, it is important to consider the gender differences permeating demographic changes. Evidence has shown that women on average tend to outlive men, while the age difference between many spouses may also result in a greater likelihood for women to experience widowhood in later life. Consequently, the needs of older women may be quite different than those of older men. For example, older men who have lost a partner tend to have the highest needs of all older people. Differences in the needs of older men and women need to be accounted for by service planners, both now and in the future.

Arber (2004) provides some additional evidence as to why gender differences are important and why policy planners should be aware of them. Women in Britain are 4.7 times more likely to have a personal income of less than £100 per week. Arber's analysis of the General Household Survey between 1994 and 1998 shows that women are less likely than men to own their own home or own/have access to a car. This illustrates the availability of resources which can affect a person's ability to cope in later life.

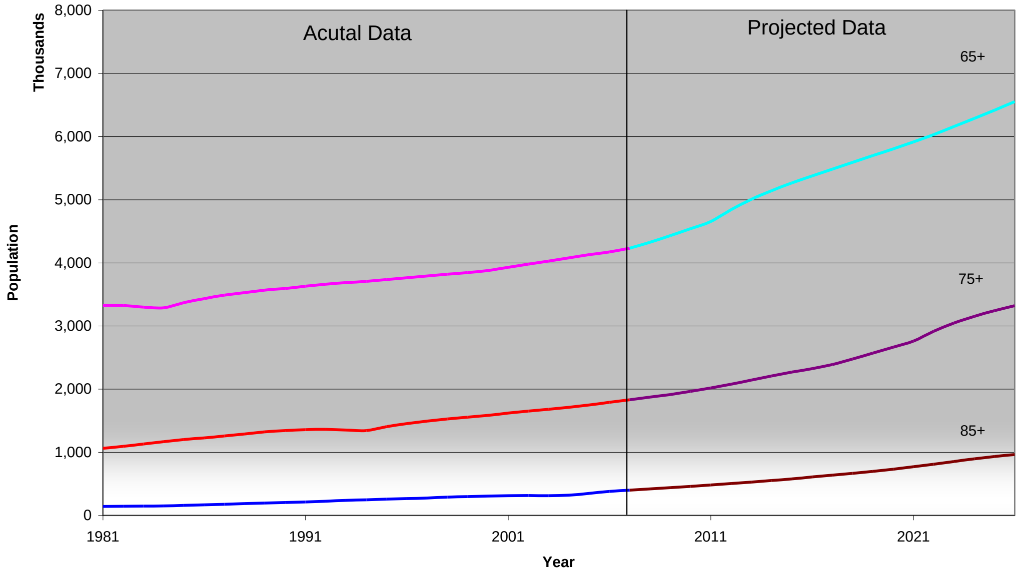

Figure 2.5: UK male population aged 65 and over, 1981-2026

(Source: Office for National Statistics, 2007a)

Figure 2.5 shows that increases in the number of older men have been significantly higher than increases in the general population in the UK. There has been an estimated 27.18% increase in the number of men aged 65 and over during the period 1978-2007, and it has been projected that this number will increase by 54.87% by 2030. Over the period 1978 to 2007, the number of men aged 75 and over is estimated to have increased by 72.32%, and this is projected to increase by another 81.42% by 2026. Finally, over the same period, the number of men aged 85 and over is estimated to have increased by 184.29%, and this is projected to rise by another 140.82% by 2026.

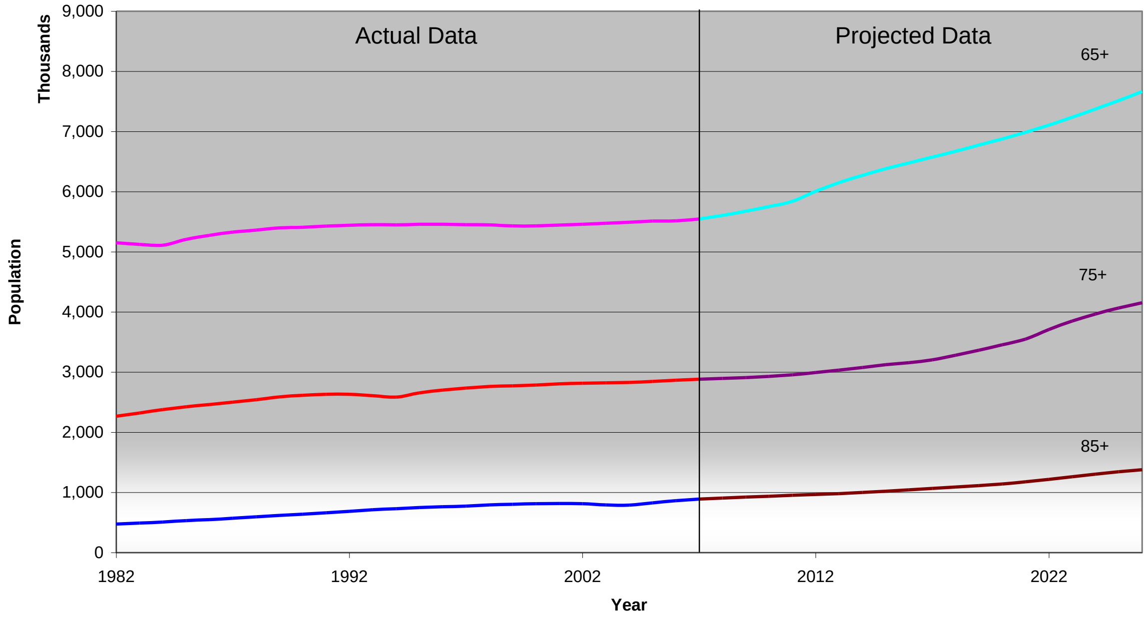

Figure 2.6: UK female population aged 65 and over, 1981-2026

(Source: Office for National Statistics, 2007a)

Similarly, as shown in Figure 2.6, increases in the number of older women have been notably higher than those of the general population in the UK. There was an estimated 7.73% increase in the number of women aged 65 and over during the period 1978-2007, and it has been projected that this number will increase by 38.22% by 2026. Over the period 1978 to 2007, the number of women aged 75 and over is estimated to have increased by 30.03%, and this is projected to rise by 44.07% by 2026. Finally, over the same period, the number of women aged 85 and over is estimated to have increased by approximately 92.64%, and this is projected to increase by another 54.63% by 2030.

The projected increases in the number of older people will have important implications on social care provision.

2.1.3 Hampshire Population

The focus of this thesis is concerned with older people in the county of Hampshire and the focus will now turn to changes illustrated in the Hampshire area. Data from Hampshire County Council's Environment Department was provided to the author by personal communication. Population data for Southampton and Portsmouth have been excluded as these areas are not in the remit of care provision by Hampshire County Council.

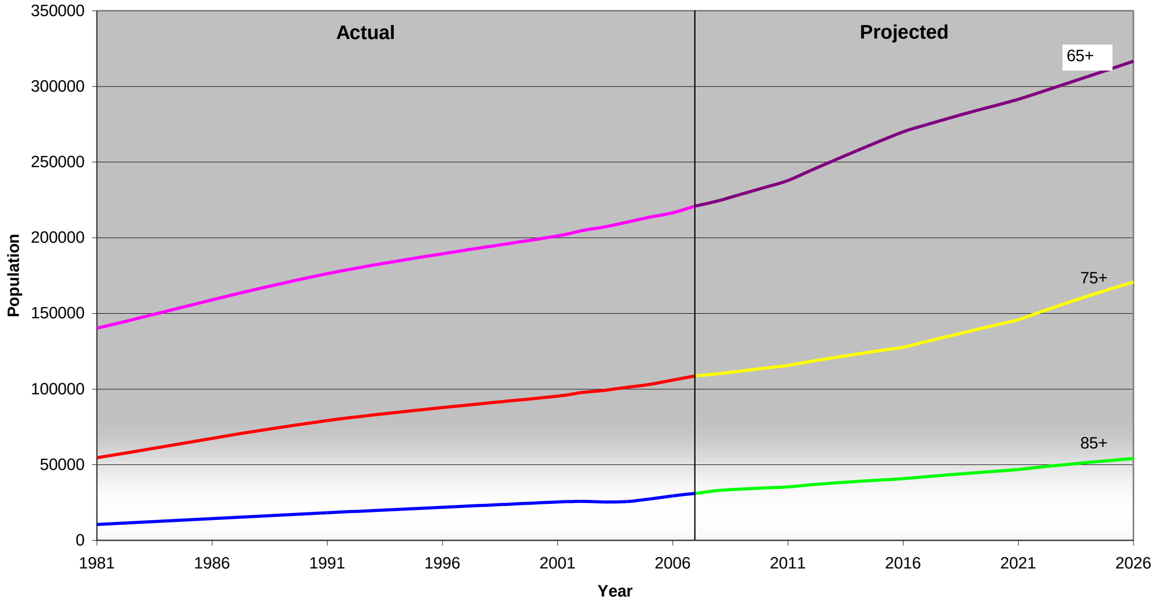

Figure 2.7: Hampshire population aged 65 and over, 1981-2026

(Source: Hampshire County Council Environment Department and Vision of Britain, 2008)

According to Figure 2.7, Hampshire will experience significant growth in the total older population. Over the period 1981 to 2007, the growth in all older people has been estimated to be 57.68% and it is projected to increase by 41.07% by 2026. Over the same period, the increases for those aged 75 and over, and those aged 85 and over are considerably higher. For example, for those aged 75 and over, the population increase from 1981 to 2007 was estimated to be 99.18%, while for 2007 to 2026 it is projected to be 55.06%. For those aged 85 and over, the growth in the population from 1981 to 2007 was estimated to be 195.01%, while for 2007 to 2026 it is projected to be 64.32%. These projections are summarised in Table 2.1. As already mentioned, the chances of receiving some sort of support increase with age and with the considerable growth in the older age groups over the projected period, there are likely to be important implications on the demand for support from Hampshire County Council and other sources of care provision.

1981-2007	United Kingdom	Hampshire
Those aged 65 and over	15.36%	57.68%
Those aged 75 and over	43.73%	99.18%
Those aged 85 and over	114.05%	195.01%

2008-2026	United Kingdom	Hampshire
Those aged 65 and over	45.43%	41.07%
Those aged 75 and over	58.57%	55.06%
Those aged 85 and over	81.37%	64.32%

Table 2.1: Population increases for the UK and Hampshire 1981- 2007 and 2008-2026
(Source: Office for National Statistics, 2007a, Hampshire County Council Environment Department, and Vision of Britain, 2008)

Hampshire experienced higher rates of growth in the older age groups over the period 1981 to 2007 in comparison to the UK as a whole. However, over the period 2008 to 2026, the UK is projected to experience higher rates of increase especially for those aged 85 and over. For Figures 2.8 and 2.9, the actual data are for the period 1981 to 2005 and the projected data are for the period 2006-2026.

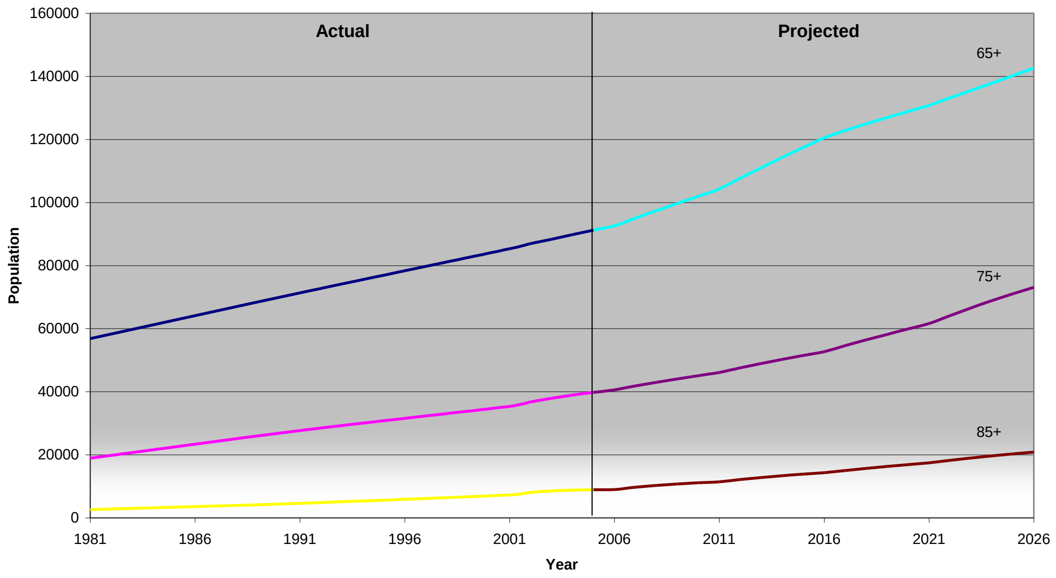

Figure 2.8: Hampshire male population aged 65 and over from 1981-2026: Actual and Projected
(Source: Hampshire County Council Environment Department and Vision of Britain, 2008)

As shown in Figure 2.8, over the period of 1981 to 2005, the growth in all older men was estimated to be 60.49% and the number is projected to increase by 59.26% from 2006 until 2026. This is much higher than the projected increases for all older people. For men aged 75 and over, the population growth was estimated from 1981 to 2005 to be 110.65%, while for 2006 to 2026, this group is projected to increase by 83.61%. For those aged 85 and over, the growth in the male population from 1981 to 2005 was estimated to be 239.61%, and for 2006 to 2026 this group is projected to increase by 133.33%.

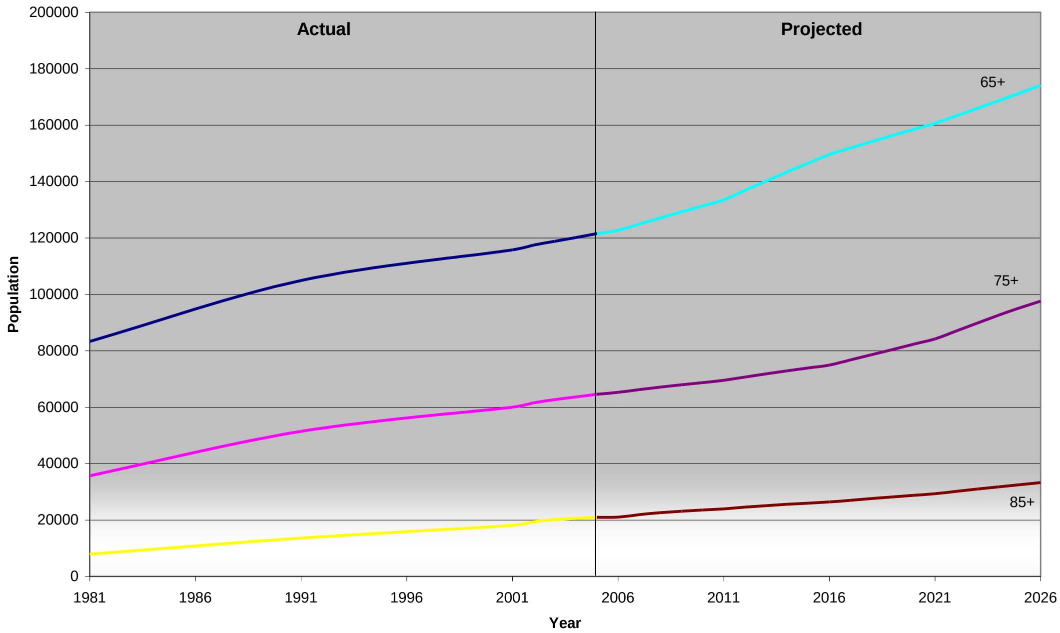

Figure 2.9: Hampshire female population aged 65 and over from 1981-2026

(Source: Hampshire County Council Environment Department, and Vision of Britain, 2008)

Figure 2.9 shows that over the period of 1981 to 2005, the growth in all older women was estimated at 45.84% and this is projected to increase by 43.24% from 2005 until 2026. This is lower than increases projected for all males. For women aged 75 and over, the growth in the population from 1981 to 2005 was estimated to be 80.91%, while for 2006 to 2026, this group was expected to increase by 51.25%. For those aged 85 and over, the growth in the female population from 1981 to 2005 was estimated to be 165.83%, while for 2006 to 2026 the increase was projected to be 58.78%.

Evidence has been provided to show that Hampshire is changing demographically and is likely to continue to do so in the future. This is resulting in an increase in the number of older people. However, in order to have a better understanding of the social care needs of older people, both today and in the future, we need to examine the prevalence of disability among older people.

2.1.4 United Kingdom Population Pyramids

An analysis of the population structure is important in understanding the impact of an ageing population. Population pyramids are a graphical illustration of the population size of each age group. In the past, the age structures of populations around the world have taken the form of a pyramid, where the base represents the youngest and largest group of the population, while the size of the population at each older age group decreases, as a result of age-related mortality, forming a pyramid-like shape. Figure 2.10 illustrates the population pyramid of the UK in 1978.

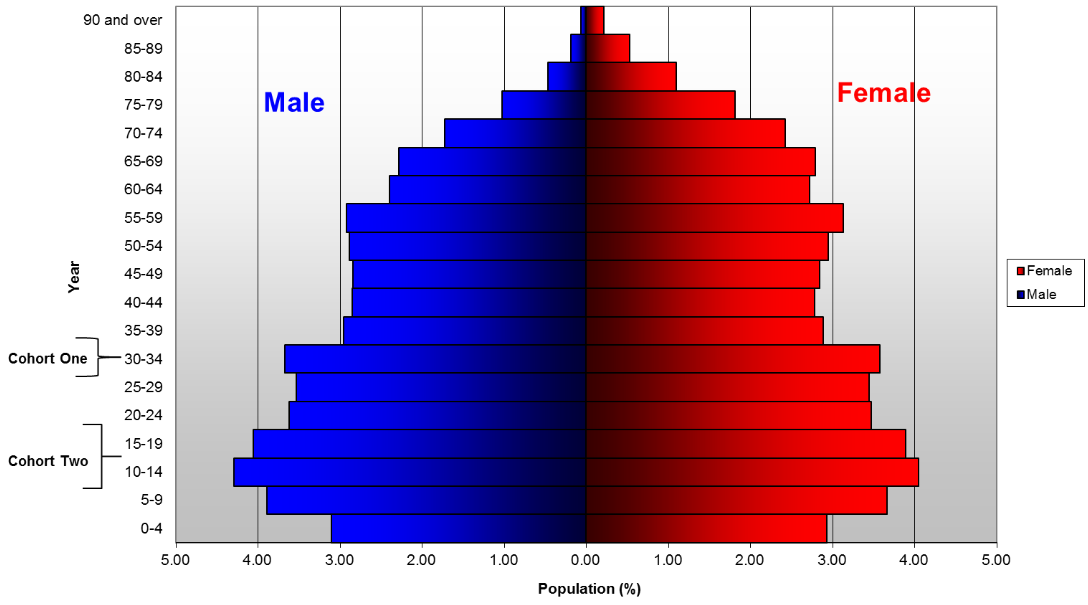

Figure 2.10: Population Pyramid for the UK 1978

(Source: Office for National Statistics, 2007a)

Figures 2.10, 2.11 and 2.12 are population pyramids for the United Kingdom for the years 1978, 2006 and 2026 respectively. It is very noticeable how each shape is not very representative of a pyramid, and the deviation from a pyramid shape increases with time. A contributing factor to this is the ageing population. An examination tracing the “baby boom” cohort exemplifies the changing age structure. The baby boom generations are those born in the UK after the Second World War in the late 1940s and the 1960s. They are called the baby boom generation as the number of births was significantly higher than in previous periods. For example, in 1978, people born between 1946 and 1950 would have been aged between 28 and 32, and this age group is represented as cohort one in Figure 2.10. Cohort one corresponds to a distinct peak which stands out as a large group in comparison to the rest of the population. The second baby boom generation are those born in the 1960s, who in 1978 would have been aged between 8 and 18 years. This age group is represented as cohort two in Figure 2.10. Like cohort one, they correspond to another peak in the population pyramid for 1978. Cohort one and two make up the current and future older generation in this country respectively. In 1978 just under 15% of the population were aged 65 and over. A more thorough look at the older age groups reveals that just over 5% of the UK population are aged over 75 and just under 1% are aged over 85.

Figure 2.11 is a population pyramid for the UK in 2006. It shows that members of cohort one are approaching the state pension age in 2006, as they are aged between 56 and 60. Once again this cohort is represented by a distinct peak in the population pyramid, while cohort two is also represented by a peak.

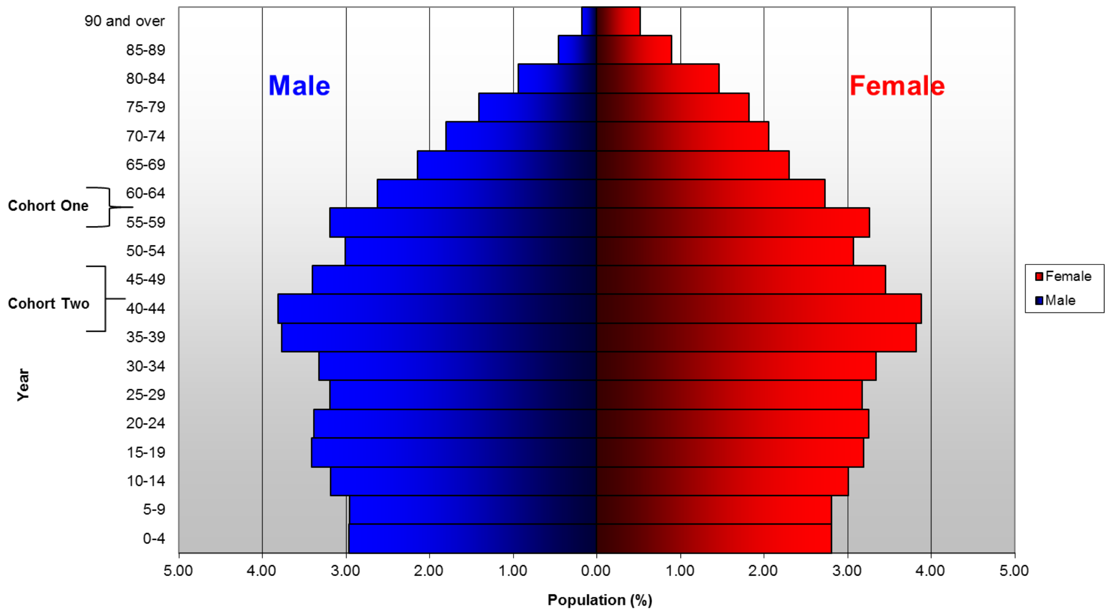

Figure 2.11: Population Pyramid for the UK 2006

(Source: Office for National Statistics, 2007a)

In addition, in 2006, 15.99% of the population in the UK were estimated to be aged 65 and over which is higher than in 1978, and the more significant age increases can be seen in the higher age groups. For example, 7.69% of the population were estimated to be aged over 75 and just over 2% of the population were estimated to be aged 85 and over.

Finally, Figure 2.12 is a projected population breakdown for the UK in the year 2030.

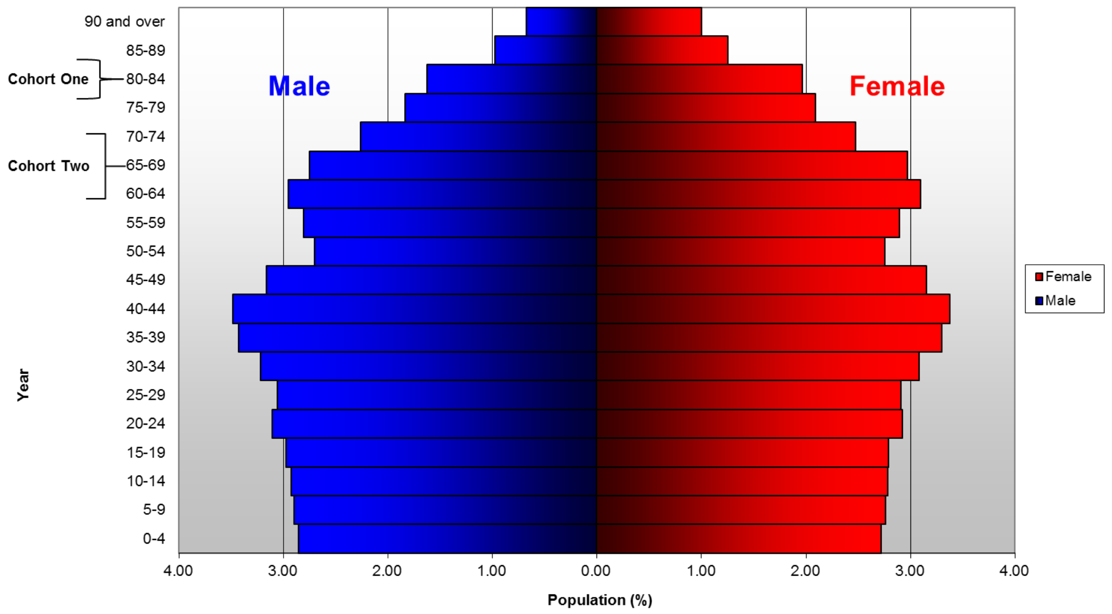

Figure 2.12: Population Pyramid for the UK 2030

(Source: Office for National Statistics, 2007a)

In Figure 2.12, cohort one is no longer an identifiable peak in the population pyramid, however cohort two is represented by a distinctive peak. By the year 2030, a considerable rise in the number of people aged over 65 has been projected. For example, it is projected that 20.53% of the population will be aged 65 years or over, while approximately 10.79% of the population will be aged 75 or over and 3.38% of the population will be aged 85 or over. What is shown by these projections is that the population structure will continue to change for a considerable period of time, and policy makers need to plan both in the short- and long-term in order to be prepared to address the implications of an ageing population. However, at the same time such demographic patterns are also occurring at a local level.

2.1.5 Hampshire Population Pyramids

Figures 2.13 and 2.14 represent the population pyramids for Hampshire for the years 2006 and 2026.

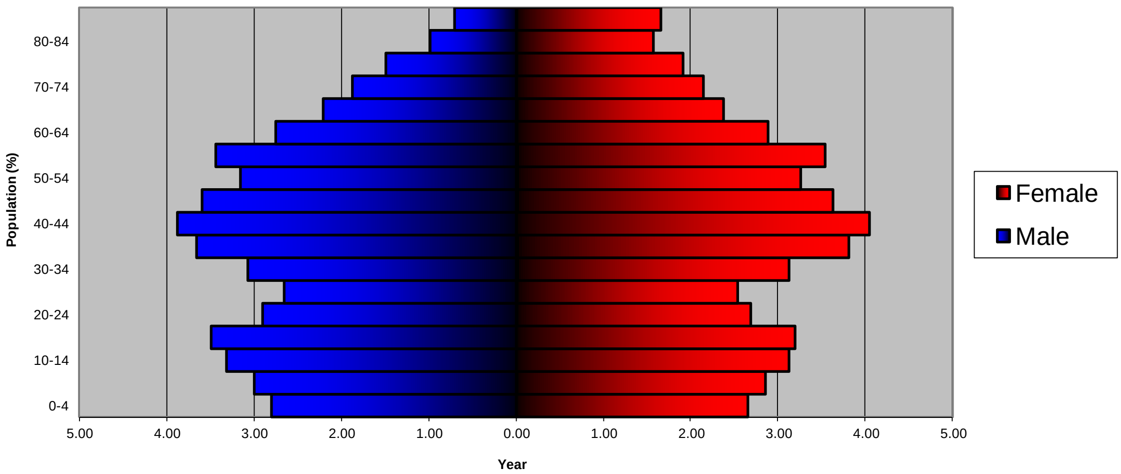

Figure 2.13: Population Pyramid for Hampshire 2006

(Source: Hampshire County Council Environment Department)

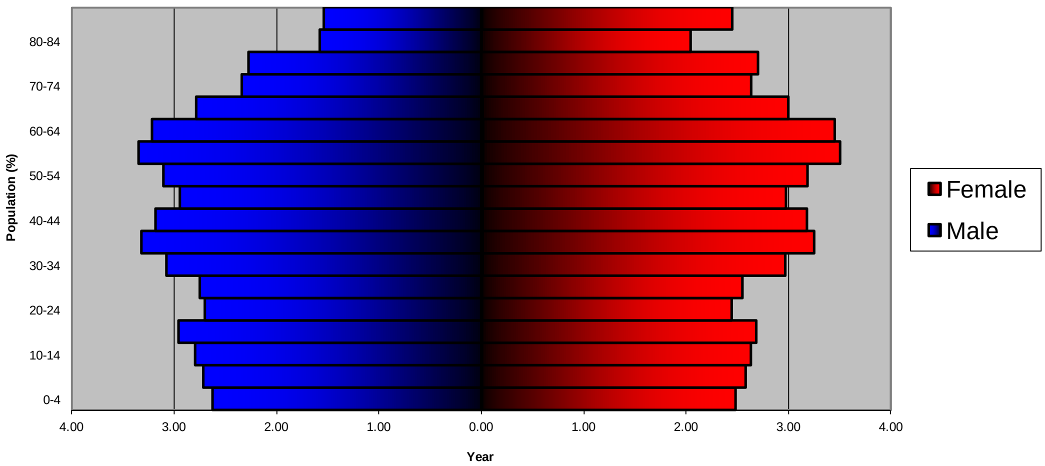

Figure 2.14: Population Pyramid for Hampshire 2026

(Source: Hampshire County Council Environment Department)

Age	**Year**	
	2006	2026
65+	16.93%	23.35%
75+	8.32%	12.59%
85+	2.36%	3.99%

Table 2.2: Percentage of Hampshire population by age group

(Source: Hampshire County Council Environment Department)

Age	Year	
	2006	2026
65+	15.99%	20.53%
75+	7.69%	10.80%
85+	2.05%	3.38%

Table 2.3: Percentage of the UK population by age group

(Source: Office for National Statistics, 2007a)

In addition, Table 2.2 is based on data used for the Hampshire population pyramids (Figures 2.13 and 2.14). It shows that in 2006, approximately 17% of the population was estimated to be aged over 65, and by 2026 this was projected to increase to nearly 24%. In 2006, 8.32% of the population were estimated to be aged 75 and over and 2.35% of the population were estimated to be 85 and over. By 2026, this was projected to increase to 12.59% for those aged 75 and over and approximately 4% for those aged 85 and over. Such projections highlight the critical importance of population ageing in Hampshire, with nearly a quarter of the Hampshire population aged 65 and over by 2026.

At the same time, the working-age population in Hampshire is projected to decrease in size, while the population aged 65 and over is projected to increase as a proportion of the total population. For example, in 2006, 61.24% of the population were estimated to be aged between 18 and 64 and 16.93% to be aged 65 and over. By 2026, the percentage of people aged between 18 and 64 in Hampshire is projected to be 57.45%, while the number of older people is projected to be 23.35%.

In order to understand the current population structure it is important to understand the process of demographic transition which the UK has undergone. Demeny (1972) notes that “in traditional societies, fertility and mortality are high. In modern societies, fertility and mortality are low. In between there is a demographic transition” (Demeny, 1972, p153). Different countries experience demographic change in different ways, however the overall effect is that as mortality and fertility fall, the population size increases to a point where it remains fairly stable. The UK is currently at a point when both low fertility and low mortality rates are being observed. According to the Office for National Statistics (2010a) the total fertility rate in 2009 was 1.94 children per woman in the United Kingdom. The Office for National Statistics (2010b) reported that in 2009 the age-standardised mortality rates for the England and Wales were the lowest ever reported.

Total fertility rates provide a good insight into the replacement level. This is the level that is required to replace each person due to deaths, and it is taken to be 2.1 children per women.

"*The Total Fertility Rate (TFR) is the average number of children a group of women would have if they experienced the age-specific fertility rates of the calendar year in question throughout their childbearing lifespan*." (Office for National Statistics, 2010a)

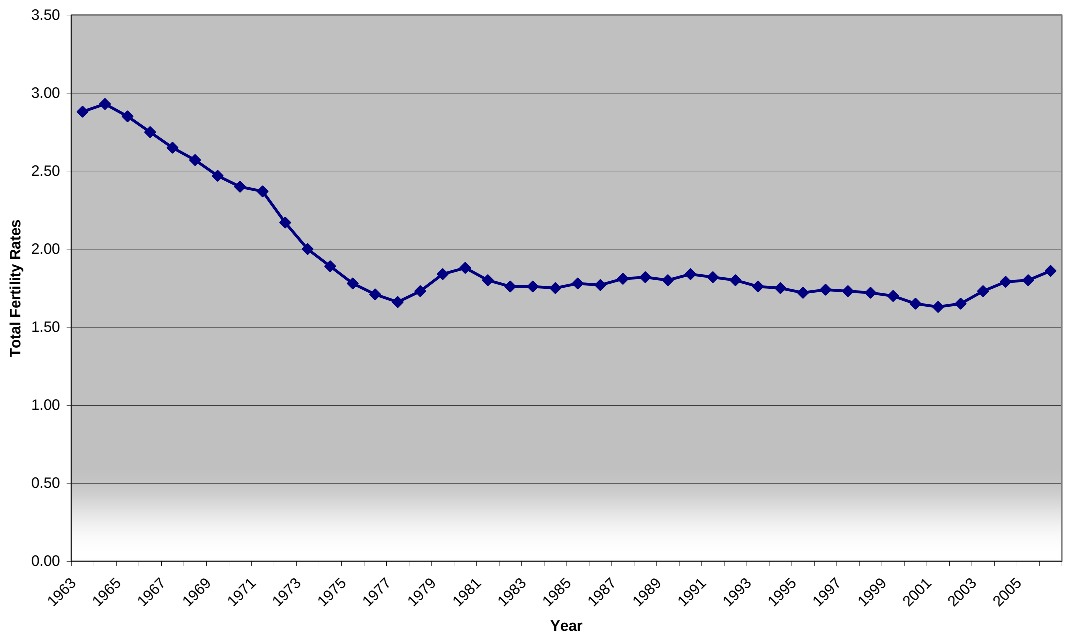

Figure 2.15: Total fertility rates for the UK 1963-2007

(Source: Office for National Statistics, 2007a)

What is evident in the UK is that population growth is currently below the replacement rate. There are a number of reasons why this is happening, for example fertility postponement and higher rates of divorce can partly explain this pattern (Tomassini et al, 2004).

2.1.6 Ageing Population

The result of population ageing can be witnessed at both the individual and collective levels. At the individual level, people are living longer than ever before and fertility rates, combined with mortality rates, cannot guarantee the replacement of people in the working-age population at the same rate as people are retiring from the labour force. At the collective level, the economic and financial implications of an ageing population mean that greater numbers of older people who are living for longer might require additional health and social care resources, while at the same time there is a reduction in the overall working-age population. Such patterns have the potential to impact on the extent to which taxpayers can contribute to public resources in order to fund public services, in particular health and social care, and also pensions.

There are many reasons why mortality rates are falling, particularly relating to the considerable fall in infant mortality. Szreter (2002) notes three important factors leading to the improved health of developed nations: economic growth, rising standards of living and improved nutrition. Szreter (2005) commented on the importance of improving public-health information as a key source of improvements in public health. These are all contributing factors to the reduction in mortality rates over time. Other important influences include improved sanitation and personal hygiene, and one of the most important contributing factors is the considerable growth in medical discoveries. A consequence of falling infant mortality rates, which is particularly illustrated in less economically developed countries, is that adults do not need to have many children in order to offset the impact of infant mortality, which in turn leads to falls in fertility rates.

In addition, one of the significant reasons behind the fall in fertility rates was the introduction of the contraceptive pill in the 1950s in most of the developed world. Over time, people have been having fewer children, or postponing having children, as women’s labour force participation increased, both in full-time and part-time work. The economic benefit of having children has been significantly reduced over time.

Historical data produced by the Office for National Statistics (2007a) is utilized in Figure 2.16 in order to illustrate the crude birth and death rates for every thousand people, explaining the natural increases in the population size in the UK. The two peaks in the birth rate reflect the two post-war baby booms.

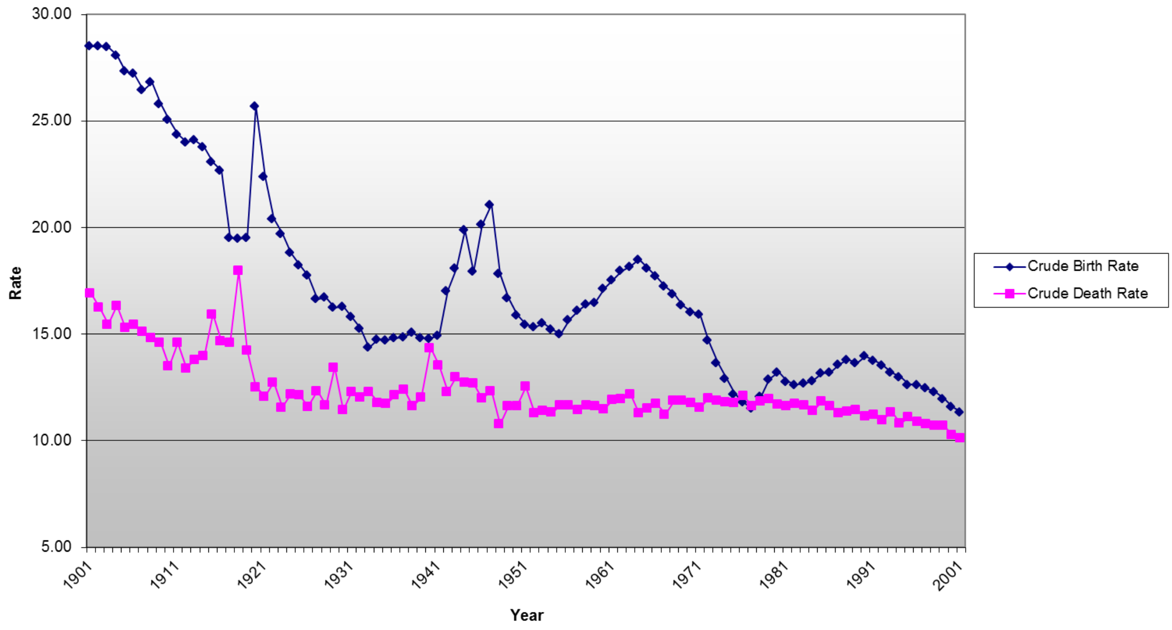

Figure 2.16: Crude UK birth and death rates per 1000 population, 1901-2001

(Source: Office for National Statistics, 2007a)

With both the crude birth and death rates falling over time, more people are surviving to later life and fewer people are entering the working population, which has a significant impact upon the total *dependency ratio*, i.e. the ratio of those not in the labour force over those who are. The vital effect is that the age structure is changing to one which includes a greater proportion of older people and this is being experienced at the local level in Hampshire.

"*Changes in the number of deaths over time are the result of improvements in age-specific mortality rates and changes in the age distribution of the population*." (Hampshire County Council, 2007, p18).

Grundy (2003) notes that mortality improvements in the 1970s were largely down to improvements in decreases in circulatory diseases. At the local level, Hampshire County

Council (2007) explains the dip in the birth rate in the 1970s as due to widespread uptake of the contraceptive pill.

An important point made in the report by Hampshire County Council (2007) is that people are becoming more mobile, which will have an important impact upon the community. The population size will also depend on net migration which has been positive in the UK for many years. Hampshire County Council note that there are two types of migration that should be considered: internal and international. An internal migrant is someone who migrates within the UK. Hampshire County Council defines an international migrant as someone who leaves or enters the UK for a year or more.

2.1.7 Life Expectancies

At the same time as the number of older people is increasing, older people in the UK are also living longer. This can be shown by examining life expectations produced by the Government Actuary's Department (2008b). The analysis has been carried out for both males and females. The Government Actuary's Department (2008a) produce two types of life expectancy: period and cohort. Period life expectancy is the number of years a person would live if the individual experienced age-specific mortality rates and this did not change. Cohort life expectancies allow for changes in mortality which has been projected. Cohort life expectancies are considered by the Government Actuary's Department (2008b) as the more appropriate measure. This has been used in Figures 2.17 and 2.18, which illustrate the life expectancy for all people in the United Kingdom aged between 65 and 95. For each calendar year the life expectancy for each age category is plotted. Figure 2.17 is for all males and Figure 2.18 is for all females.

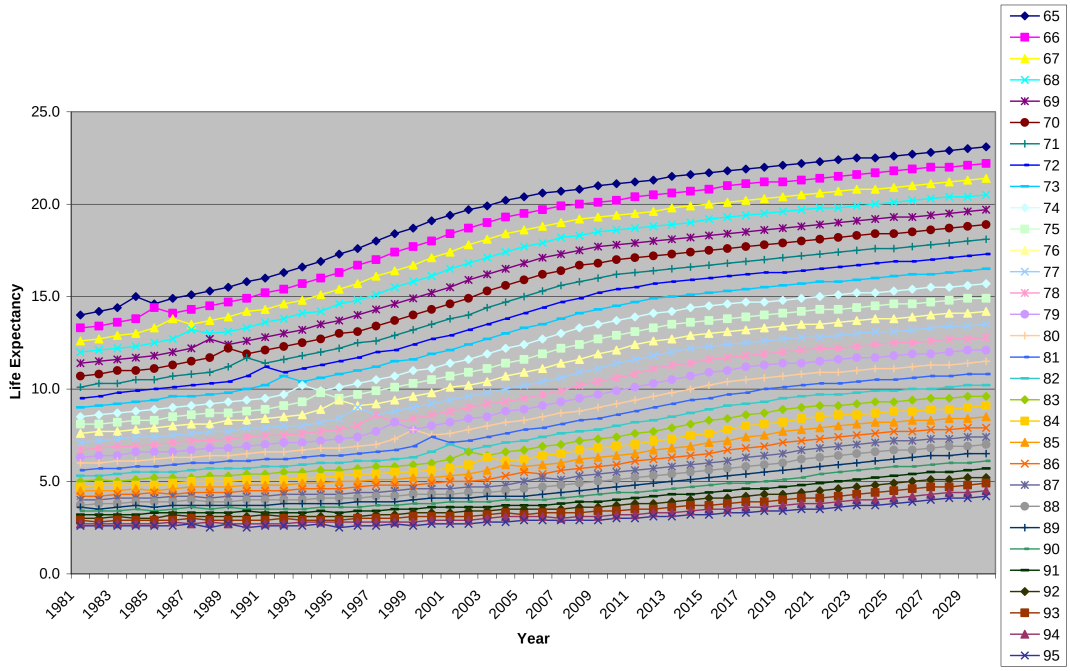

Figure 2.17: Life expectancy for UK males aged 65 and over, 1981-2030

(Source: Government Actuary's Department, 2008b)

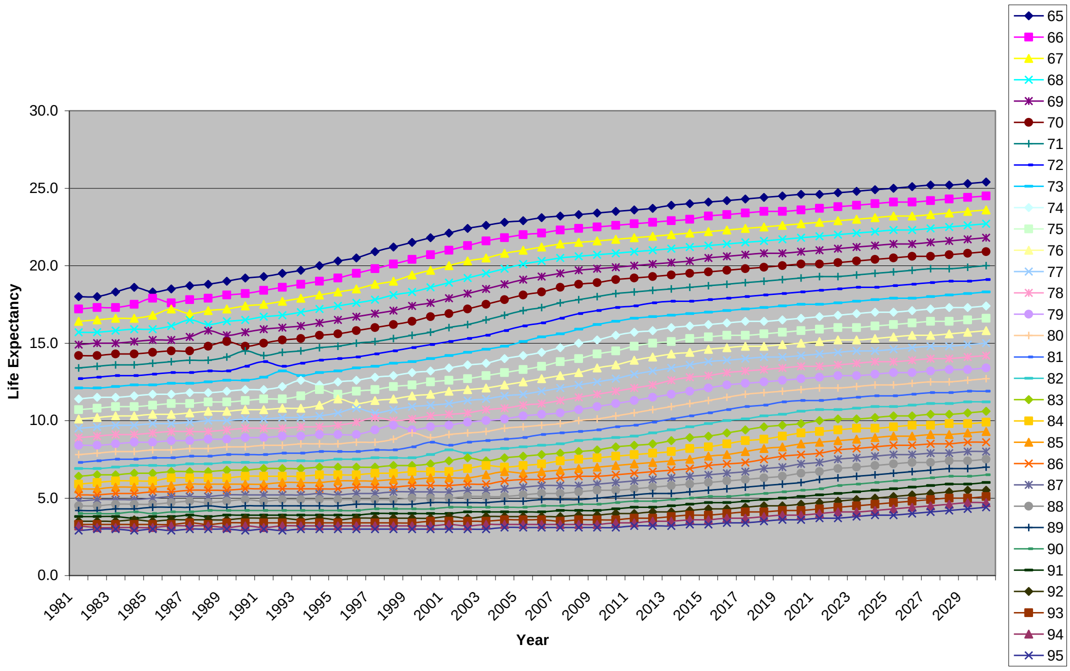

Figure 2.18: Life expectancy for UK females aged 65 and over, 1981-2030

(Source: Government Actuary's Department, 2008b)

For each age group there have been year-on-year increases in life expectancy since 1981, and this trend is expected to continue. These increases are important as they have been an important contribution to the number of older people. For example, in 1981, a man aged 65 had a life expectancy of 14 years, in 2008 it was 20.8 years and in 2030 it is expected to be 23.1 years. The same effects are occurring for older women, however women are expected to live longer than men on average. For example, in 1981 a woman aged 65 had a life expectancy of 18 years, in 2008 it was 23.3 years and in 2030 it is expected to be 25.4 years.

2.1.8 Limiting Long-standing Illness

When discussing the potential need for care among older people, it is important to examine not only the number of years older people can expect to live but also the number of years they can expect to live *in good health*. This concept is described as the 'healthy life expectancy' of people. It is often the additional years in poor health gained from life expectancy which policy planners are focussed on as it is in these years that a proportion of older people will require help. The level of help required will vary according to the person and so will the source of help. For example, many older people might require help from their local authority, while other people might draw support from informal or voluntary sources. These different types of care are summarised in Figure 2.19.

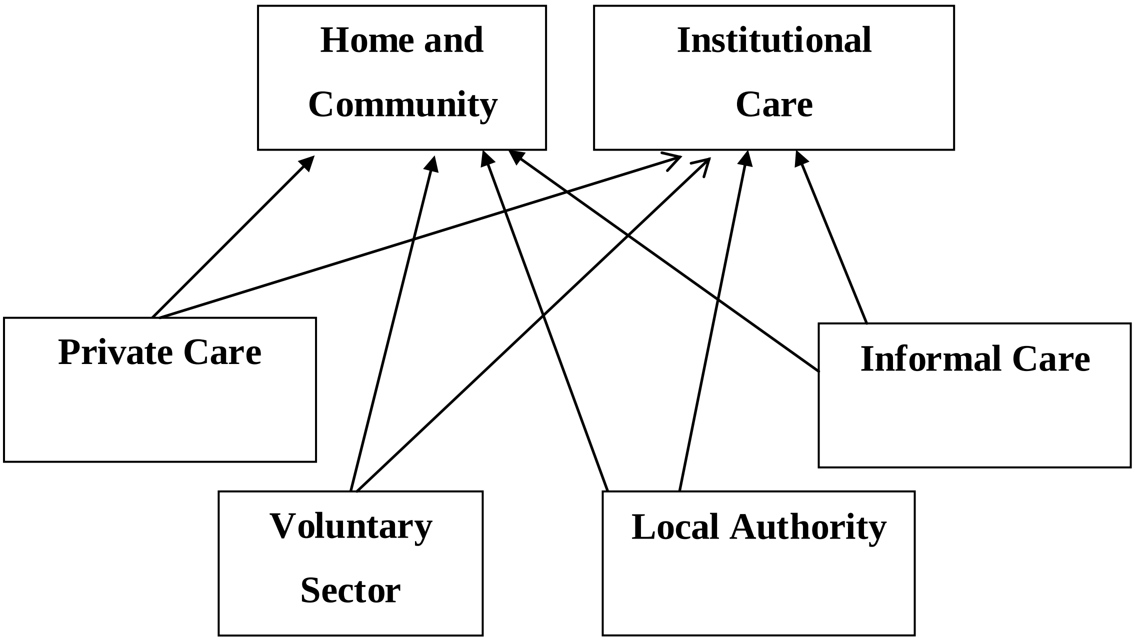

Figure 2.19: Sources of care

The focus of this thesis is on care provided in the home and community, rather than institutional care. Care provided by the voluntary sector is not considered as a separate category, rather it is grouped with private care due to the available information in the General Household Survey. In order to understand how many people might require some sort of help in later life, it is important to analyse data related to the report and prevalence of limiting long-standing illness, and to the performance of activities of daily living.

The prevalence of limiting long-term illness was reported by the Office for National Statistics (2006) in the Focus on Health in 2006 using data from the 2001 Census. Figure 2.20, which excludes residents of communal establishments, shows that there is a clear trend between increasing age and the report of a limiting long-term illness. For example, individuals with a limiting long-term illness are more likely to require care. There are differences between the genders. For those aged 65-74, more males were reported as having a limiting long-term illness in comparison to females. More females aged above 75 are reported as having a limiting long-term illness, in comparison to males. Such patterns are important in understanding the extent to which older people who report a limiting long-term illness are more prone to receive some sort of support.

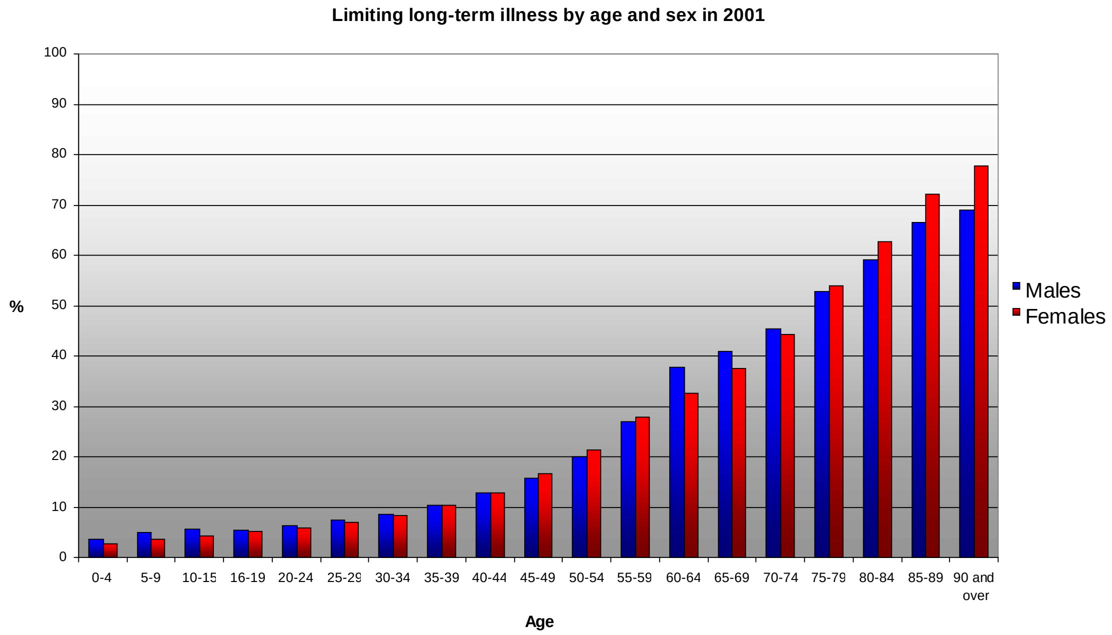

Figure 2.20: Limiting long-term illness by age and sex in 2001

(Source: Office for National Statistics, 2006, p25)

2.1.9 Disability

The extent to which older people can perform activities of daily living is an important measure of disability. Questions on activities of daily living relate to a person's ability to carry out an activity that would normally be carried out on a daily basis, such as managing to go up the stairs or going outdoors. The following is a discussion of the work presented in the Focus on Older People published by the Office for National Statistics (2005), which uses data from the General Household Survey. Out of the activities listed, most individuals aged 65 and over can carry out the basic activities without any help at all. This indicates that many older people are able to live in the community with little or no support. The first activity under consideration is the ability to use stairs, which is a particularly important activity especially for those who live in homes with more than one floor. The next activity considered is the ability to go outside and walk down the road, which is useful in understanding the extent to which an older person can live an active social life and access commodities. The ability to use the toilet is also taken into account, as is the ability to get around the house in order to carry out household routines. The final activity taken into account is the ability of the person to get in and out of bed.

The first question presented by the Office for National Statistics (2005) relates to an older person's ability to use their stairs. Analysis by the Office for National Statistics (2005) showed that 78% of men and 72% of women were able to carry out this activity on their own with no difficulty. In addition, 7% of men and 11% of women were only able to use stairs with help or not at all.

The second question relates to an older person's ability to go out of the house and walk down the road. Analysis by the Office for National Statistics (2005) showed results which are similar to the first activity discussed, with 79% of men and 75% of women being able to go outside and walk down the street with no problem at all. The concern for policy makers are that 9% of men and 16% of women were only able to do the activity with help and that some of them were unable to carry out the activity at all.

Another important activity is the ability to use the toilet. Analysis by the Office for National Statistics (2005) showed that there is no difference at all between males and females. About 75% of the sample had no problem carrying out this activity on their own, while 5% of the older people in the survey could not carry out this activity without any help or not at all. This is significantly smaller than that of the first two activities considered

Very similar results are found by the Office for National Statistics (2005) when considering the activities of getting around the house and getting in and out of bed. The majority of older people can carry out these activities without any problems. Analysis by the Office for National Statistics showed 70% of men had no problem in performing both activities, whilst 65% of women had no problem getting around the house and 68% of women had no problem getting in and out of bed. Once again the important figure to note is the percentage of people who cannot perform the activity at all, or who can perform it only with some sort of aid. Analysis by the Office for National Statistics showed that 5% of men and 3% of women are in this category when getting around the house, and 9% of men and 6% of women are in this category when getting in and out of bed.

Older people who have difficulties performing activities of daily living are likely to need some sort of support in their everyday lives.

2.1.10 Living Arrangements

Living arrangements are important to consider as many older people receive informal support from the people they live with. A key demographic trend in Hampshire is that the numbers and proportion of older people living alone are increasing. This is due to a range of factors, including increasing longevity, one spouse being outlived by the other, which is often wives outliving their husbands due to age differences between husbands and wives; and older people continuing to reside in their own homes in the community rather than move into institutional care due to personal preference and also community care policies over the last 20 years to reduce public expenditure and numbers in residential care (Hampshire County Council, 2007; Iacovou, 2000; Falkingham and Grundy, 2006).

Figure 2.21 illustrates the proportions of elderly people who live in households with two or more generations. A comparison between 1971 and 2001 for England and Wales shows there has been a considerable reduction in the number of people living in households with two or more generations. Older people with a need for support living alone are more likely to require external sources of care, as they do not have anyone in the household to support them. However, Tomassini el al. (2004) argue that "the trend toward greater residential independence among older people reflects, to a large extent, positive developments." (Tomassini el al., 2004, p26)

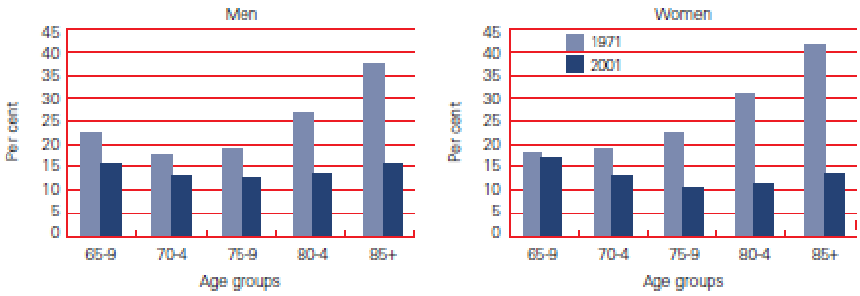

Figure 2.21: Percentage of men and women living in households with two or more generations, England and Wales, 1971 and 2001 (private household population)

(Source: Falkingham and Grundy, 2006, p12)

Older people living alone tend to be viewed as a priority group, particularly by policy planners. The majority of older people living alone are women and this is due the fact that they tend to outlive their spouse (Iacovou, 2000). Tomassini el al. (2004) argue that "while older people may enjoy greater autonomy and independence when living alone, they may be placing themselves at greater risk for adverse health outcomes, including premature death." (Tomassini et al., 2004, p32).

If older people do not receive the social care support they need to perform activities of daily living, often in their own homes in the community, then they face the risk of their health and mobility deteriorating and experiencing social exclusion from their local community (Iacovou, 2000). Social exclusion is a difficult concept to define as it is multi-dimensional and multi-faceted. Some authors view social exclusion as a process where individuals are excluded from usual activities of daily life as a result of, for example low income, physical disability, lack of access to local services, reduced access to social networks and lack of access to education (Iacovou, 2000).

2.1.11 Demography key findings

An ageing population does not mean that every older person is going to require some sort of support, as many older people live active lives, and many will be carers to others and have an important role to play as grandparents. The concern of health and social care policy planners is that a small number require some sort of support whether it is in the community or in an institution. This costs a considerable amount of money to fund and as the number of older people increases, it is likely that health and social care services will face increasing demand (Wanless, 20006).

Demographic change such as an ageing population has implications for the welfare state and public expenditure and taxes are used to pay for the current health care and social care services. As the population structure changes and there are more older people and fewer school leavers to enter the labour market, there are fewer tax payers to contribute to the health and social care bill.

We have seen that Hampshire is experiencing growth in the number of older people and has proportionally more older people living in the county than in the UK as a whole. This means that more people than ever before are likely to be making demands on long-term care services. It is important that Hampshire County Council has high quality data so that it can plan key services, currently and in the future. Thus HCC will be better prepared to meet the expected increases or changes in demand. It is the aim of the thesis to provide the local authority with data to support future planning.

2.2 Social Policy

The following is a discussion of a selection of the key social policy documents that have led to the need to better understand how the system for long-term care is likely to evolve in both the short- and long-term future.

The Welfare State was established following the Second World War to promote health and well-being in the country. The Welfare State was a result of the Beveridge Report in which the ‘five evils’ that existed and the solutions to remedy them were outlined.

“*[T]he Five Giant Social Evils which had undermined British society before the war: ignorance, disease, idleness, squalor and want.*” (Alcock, 2008, p6)

The solutions to these evils were free education up to age 15, to combat ignorance; a free national health service (NHS) free at the point of use, to combat disease; state commitment to securing full employment, to combat idleness; public housing for all citizens to rent, to combat squalor; national insurance benefits for all in need, to combat want (Alcock, 2008, p7).

Two important acts have shaped the history of long-term care provision, the 1946 NHS Act and the 1948 National Assistance Act. The former Act established the NHS, and the latter established the system of social care. These Acts created a split between the two systems, which exists until today, and they mean that the state took over the existing provisions of care, the long-stay hospitals and workhouses. The NHS is free at the point of use, while social care has always been, and still is, means-tested. The provision of social care has been an ongoing challenge which persists (Alcock et al., 2008).

2.2.1 Government Spending

Government spending for 2010-11 is estimated to be £32 billion for personal social services as reported by HM Treasury (2010a). The Health and Social Care Information Centre (2010) reported that £16.1 billion was spent on Adult Social Care in 2008-09, and of this, £9.1 billion was spent on older people. Hampshire County Council (2010b) reported a total net expenditure of over £314 million in their budget for Adult Services for 2009-10, of which over £155 million was expenditure for older people's services. Funding personal social care is a considerable challenge which has become greater as a result of the Comprehensive Spending Review brought about by the Coalition government in 2010. Following this review, the HM Treasury (2010b) fixed spending for government departments until 2014-15. In addition, the government has put in place measures to reduce the deficit it faces, in order to ensure future economic stability and economic growth. The HM Treasury (2010c) reported that local government spending will be reduced year-on-year from 2010-11 until 2014-15. This will impact upon the provision of key local services. It is important that the Hampshire County Council has a set of data at its disposal to help it plan its resources appropriately over the next five years; a long-term projection model will be potentially of use. One of the main aims of this thesis is to produce the data to aid in policy planning.

2.2.2 Wanless Report

The provision of long-term care is a critical ongoing issue, thus policy and the future direction of care provision at both the local and national level is very important in the context of an ageing population. In 1999, the government appointed a Royal Commission (The Royal Commission on Long Term Care, 1999) to investigate the issues regarding the provision of long-term care. The Commission looked at bringing about short-term improvements and ways of paying for care in the long-term, however eleven years later the debate still exists. Currently the issue of funding of care and support is being investigated by a commission chaired by Andrew Dilnot with results expected in July 2011 (Department of Health, 2011). In addition, it is of importance that the ongoing issues are examined at the regional level as well. One of the key points of the Wanless Commission was the need for better data to help aid in planning future care services. This thesis aims to use the best available data to create a long-term care population model.

One of the key documents of the ongoing debate has been the work of Sir Derek Wanless in 2006. Wanless led a year-long independent review which culminated in the report *Securing Good Care for Older People* (Wanless, 2006). The aim of the study was to consider the costs for providing care for older people over the next twenty years and ensuring that appropriate financial arrangements are in place to meet these costs. In turn, sources of funding mechanisms were reviewed. The key factors examined were demographic, economic, social and health trends driving demand.

The Wanless report argued that there was a lack of evidence regarding whether the government's main objectives of choice, independence and prevention are being met, and it argued that budgets are not allocated with a long-term perspective.

The Wanless review projected a significant increase in the numbers of people requiring help by 2030: a 53% increase for those with some need and 54% with those with a high level of need. The Commission expected the number of people with some level of impairment and dependency to increase notably by 2030, in turn increasing the demand for social care and resulting in greater pressure on the government's finances and resources.

The Wanless review highlights the shortcomings of the system, which are associated with the result of poorly delivered services, but crucially to do with limited funding. The Wanless report argues that the baby-boomers are likely to be more demanding than any other previous generation, as they will expect more choice and higher quality. One improvement suggested is to move towards more care close by or in the home. As budgets are limited, a significant part of the resources are used for those with the highest levels of need.

Wanless (2006) cites other criticisms of the current care system, including the complexity of the system for means-testing and the "post code lottery" for domiciliary care charges. A critical issue is that those individuals who are most likely to require long-term care are also most likely to be the ones who cannot afford it.

The Wanless review makes a number of recommendations and highlights some of the strengths of the current system. These include a number of best performances which could be achieved with better management; Councils which kept a better record system tended to do better than those who did not; gains have been realised from health and social systems working close together. There is much potential to move care from hospitals into the community, but planning should be done in advance.

The Wanless review tried to identify an appropriate level of expenditure needed for the future. The model created drew upon two previous models: the Personal Social Services Research Unit (PSSRU) long-term care model and the CARESIM model[1], although the model created was the PSSRU Wanless review model. This is an adapted version. The aim of the model was to explore the costs for both private and public sources under different financial models. In the projections to 2026, three different scenarios were explored. The first scenario is the current service model, the second changes the core business of social services (achieving the highest level of personal care taking into account cost), and the third includes well-being.

Level of disability	Older population (thousands)						% change 2002–26
	2002	2007	2012	2017	2022	2026	
No disability	5,550	5,720	6,370	7,040	7,520	8,020	44
1 IADL	600	620	680	760	830	910	51
Bathing difficulty	280	290	320	360	390	420	49
ADL difficulty (other than bathing)	530	550	600	670	740	810	51
1 ADL without help	370	390	430	480	530	580	56
2+ ADLs without help	550	580	630	690	770	850	54
All	**2,340**	**2,450**	**2,670**	**2,950**	**3,270**	**3,560**	**53**

Source: PSSRU Wanless model and PSSRU long-term care finance model estimates

Table 2.4: Projected disabled population by disability level, England, 2002-2026.
(Source: Malley et al, 2006, p16)

Considering the results from the Wanless review model, an important issue is that over the period 2002-2026 the number of people who cannot carry out at least one activity of daily living is projected to increase by over 50% as shown in Table 2.4. Disability is a key determinant need for care. An estimated increase of over 50% in the number of people with some level of disability will lead to a significant increase in the number of people who will require some level of support. Table 2.5 summarises the three scenarios.

[1] Further details of the PSSRU and CARESIM models can be found in the modelling section (see Chapter 3).

Type of services/care	Older people (thousands)						% change 2002–26
	2002	2007	2012	2017	2022	2026	
Scenario 1							
Informal help	1,720	1,800	1,960	2,180	2,400	2,600	51
Institutional care[1]	320	340	360	400	450	500	56
Local authority-funded home help	340	360	380	420	470	520	53
Private home help	390	420	450	510	570	630	62
Day centre services[2]	120	120	130	150	160	180	51
Meals	260	270	290	320	360	400	50
Scenario 2							
Informal help	1,780	1,860	2,030	2,250	2,480	2,700	51
Institutional care	250	270	290	320	360	390	55
Community-based services	910	950	1,030	1,140	1,270	1,390	53
Other community-based services							
for personal care	270	280	310	340	380	410	52
for supervision	60	60	70	70	80	90	53
for well-being	–	–	–	–	–	–	–
Scenario 3							
Informal help	1,780	1,860	2,030	2,250	2,480	2,700	51
Institutional care	250	270	290	320	360	390	55
Community-based services	910	950	1,030	1,140	1,270	1,390	53
Other community-based services							
for personal care	270	280	310	340	380	410	52
for supervision	60	60	70	70	80	90	53
for well-being	490	500	550	600	660	720	47

Source: PSSRU long-term care finance model (scenario 1) and PSSRU Wanless model (scenarios 2 and 3) estimates
[1] Excludes all those in nursing homes or hospitals whose care is paid for by the NHS.
[2] Does not include day care services funded through the NHS.

Table 2.5: Projected numbers of older people receiving formal social services and informal care, under the base assumptions, England, 2002 to 2026

(Source: Malley et al, 2006, p17)

There are noteworthy increases in the numbers of older people receiving care in all three scenarios. There is estimated to be a 53% increase in those requiring community-based services under scenarios two and three. It is important to remember these are projections, yet these large increases will have a considerable impact upon resources and finances.

On the basis of the Wanless review's assumptions for their PSSRU Wanless Review model, the improved outcomes are not being fully realised under current conditions. A recommendation made is to make the system more universal and make the classification for eligibility criteria broader.

Many organisations have made responses to Derek Wanless's report. It has been welcomed by all political parties and it is felt that it will help generate a long overdue debate on the topic. The Alzheimer's Society (2006) described it as "a shocking indictment of the current care system, which is failing to meet the needs of older people." Skills for Care (2006) agree that there are serious shortcomings in the system for social care provision. There is a general acceptance of the main recommendations of the Wanless report; there is overwhelming support for reforming the current system of means testing.

The British Medical Association (2006) remarks that this should end the problem of a postcode lottery system for care services. The Association of Directors of Social Services (2006) back the idea of the partnership model, and that the cost should be shared by the client and the state. There is a call for an urgent and long-overdue debate about the issue of funding social care for older people. The government needs to act now, and major investment is needed. The Alzheimer's Society (2006) comments that extra investment is not the only answer, but the Wanless report is a good start. If the government fails to do anything, CCC (2006) state that this will lead to extra costs in both human and financial terms. Help the Aged (2006) point out that doing nothing is not an option. The Commission for Social Care Inspection (2006) believe it is essential that informal carers should be properly supported as they provide much more care than paid workers. This Commission calculated that to provide funding for them would be like funding a second NHS. An important point made by Help the Aged (2006) is that while it is important to prepare for the future, the needs of the current generation of older people must be met. There are persistent calls for a long overdue debate on the issue of care for older people. Derek Wanless's review should prove an important step towards this. The projections have been updated after 2006.

The modelling of the Wanless report was performed at the national level. Whilst this is of importance, a regional model is critical. It has been shown from the Wanless report that planning in both the short- and long-term is needed. The aim of this study is to help the local authority in Hampshire better understand how the number of people with a disability is going to evolve over the same time span as the Wanless report. Understanding how many have a disability will potentially support future decision making in Hampshire. Costs are not considered as part of this thesis after discussion with Hampshire County Council Adult Services Department.

2.2.3 The National Perspective

The government has produced many policy documents over the last few years in regards to the provision of Adult social care and in response to the issues raised from the Royal Commissions Report in 1999 and the Wanless report, and of critical importance is the Green Paper, *Shaping the Future of Care Together* (HM Government, 2009). The key ideas of the previous policy documents and public discussions have been brought together in this single document.

It is of importance that the Government responds directly to the challenges faced by the social care system. As shown in the population projections, people are living longer than ever before. "*Greater advances in healthcare mean we are all likely to live much longer*." (Department of Health, 2005, preface)

In 2006, the Department of Health released a paper a called *A new ambition for old age: Next steps in implementing the National Service Framework for Older People*, a report by Professor Ian Philip, the National Director for Older People. Liam Byrne who was the Minister for Care Services at the time noted in the paper that demographic change is "*a once-in-a-lifetime opportunity if we grasp it*." (Department of Health, 2006, p1)

It is noted in the Green Paper, *Shaping the Future of Care Together* (2009) that the future direction of social care involves the provision of personalised care. This can be provided through increased use of direct payments and personalised budgets. Whilst the provision of personalised care is not considered in this work, understanding the number of people likely to need long-term care is what will be potentially important in planning a system of increased personalised care.

The Government in the Green Paper recognise the need to help people live more independent active needs; social care services need to help encourage this. The HM Government (2009) identify that the current system needs to be reformed to meet the challenges it faces. Whilst an older person can receive care from a number of sources, it is noted that a large number of people receive no help towards the costs of social care. This means many people might go without care or support and when their situation worsens, they could end up being candidates for formal care services. The modelling aims to help Hampshire County Council identify this potential group by identifying the number of people who currently receive no care or support.

An important point made in the Green Paper is that resources have not been used efficiently previously and local authorities target those with the highest level of need. They identify that money should be invested in programmes to keep people active such as prevention and rehabilitation. This study will aim not only to identify the number with a high level of disability but anyone with some sort of incapacity. This could potentially help Hampshire County Council plan for preventative services to help enable people remain in their home and live active lives. It is noted in the Green Paper, *Independence, Well-being and Choice* (Department of Health, 2005) that technology has a key role to play in the future of helping people remain independent. Like the Wanless report, the Green Paper addresses the point that expectations over service provision will increase over time. The quality of services is not addressed as part of this study.

There are many aims for the system noted in the Green Paper (HM Government, 2009). The modelling could potentially aid the local authority achieving some of these goals at the regional level. People will be given the right support to remain independent. It is vital that the Adult Services Department have disability projections in order to plan services now and in the future. It is noted that people need to be supported in better understanding the system and Hampshire County Council have gone about achieving this through the establishment of the contact centre. The contact centre will advise older people on all kinds of issues regarding the provision of social care. The modelling in this study will explore the performance of the contact centre in light of an ageing population. This could potentially help the local authority have resources in place to help them achieve this aim of providing advocacy.

The Green Paper states that the Local Authority is best placed to make sure the correct level of services are in place. Local circumstances need to be addressed at the local level. The model of this thesis will be an essential tool to aid in this process.

Informal care provision is a key part of the provision of long-term care. One of the aims of the Green Paper is to support carers in their very important roles. The modelling of this study explores the role of the informal care.

Many funding schemes are discussed in the Green Paper, however these are not discussed in this study as they are not relevant but two of the key roles of local authorities identified in these finding schemes are to provide information and advocacy to individuals and to manage the market of social care provision as well as provide support to care providers. As already mentioned, the modelling could potentially support future planning of the contact centre and the long-term care model aims to identify the number of people with some level of incapacity. It is this group who might potentially need care from all the different care providers. This could potentially help the Adult Services Department better manage the market for social care provision.

2.2.4 The Hampshire Perspective

It has been shown in national policy that the Local Authority needs to be central in the provision of long-term care at the local level. The modelling of this thesis is carried out at the regional level.

The Adult Services Department has set out its goals in its annual service plan. This was provided to the researcher by personal communication. Hampshire County Council has three corporate priorities: making Hampshire safer and more secure for all; maximising well-being; and enhancing quality of place. To meet these priorities they acknowledge that it is important to work with other agencies and the voluntary sector. They will also support the families of those who need support as well as carers. Monitoring services is of importance. They note that it is important to work with partners to ensure that the best outcomes are achieved. The projections of this study could potentially aid this process.

The key outcomes are also listed. These include treating people in ways that maximise well-being and independence. Another key outcome is to make sure that the right care is provided in the right place and at the right time. Once again, the outputs of this study could be a useful aid in ensuring that this goal is achieved.

As discussed in national policy, it is important that the local government are able to meet local challenges. "*Decisions about the best models to suit local circumstances should be made locally*." (Department of Health, 2005, Executive Summary)

In 2008, Hampshire County Council produced the report *Getting Personal: a fair deal for better carer and support* (Hampshire County Council, 2008) which sets out a series of national recommendations. A local Hampshire model is also discussed; at the heart of the local model are not only the issues discussed in this section but a system of personalised care. As already mentioned, personalised care is not considered in this research. They also note the importance of working across the health and social care boundary. These issues are not discussed in this study.

It is noted that whilst the future of Adult Social Care is great opportunity for all it is also a great challenge. Some of the key challenges discussed for Hampshire – demographic pressures as already discussed, changes in the health care system and higher expectations in terms of service provision – have created many resource issues that need to be addressed. Another finding is that many people want to stay in their own homes and community. The resources need to be in place to achieve this. The study aims to help the Adult Services Department plan resources to meet these future challenges.

The report recognised that a large number of people are not able to receive publicly funded services and that this could contribute to inequalities, which in turn can lead to social exclusion (Hampshire County Council, 2008). The localised Hampshire model discussed in the report aims to help this group by identifying what services they require and the costs of this. Advocacy will be provided to ensure people get the best service possible. Many of these people fund their own care; the report notes that many of them are given little information on getting the best care. The Council, through the contact centre, have the potential to address this problem. This study aims to help ensure that this solution is sustainable in the long-term as a result of demographic pressure.

The report also found that people with a low or moderate level of need should be provided with appropriate support (Hampshire County Council, 2008). The modelling will estimate the number of people who fall into lower levels of disability categories. By implementing preventive services to this group, their progression into higher levels of disability can be potentially slowed down, possibly resulting in less people needing expensive services. An investment in the short-term in terms of preventative services could potentially lead to long-term savings. The report suggests that a new system should not only focus on care for those in most need of it but that something should be provided to everyone in need of care.

The report also recognised the need to support carers, especially in terms of benefits, as they provide a valuable service. By providing services such as respite care, carers can potentially be prevented from reaching crisis point (Hampshire County Council, 2008). The report notes the importance in the localised model of using existing services in a better way. The modelling will allow for projections at the district level which could aid in the better planning of services. It is known that services in each district differ, and disability projections can potentially help the Council ensure the right services are in place in each district to meet the changes in demand for long-term care services.

The report also recognises the role the local authority plays in monitoring the market for social care (Hampshire County Council, 2008). The modelling in this thesis could help to help the Adult Services Department to match supply and demand by having projection data for the number of people with some level of incapacity. The modelling could also help the local authority to shape the market.

2.2.5 Social Policy Key Findings

It has been shown that the provision of social care is an important national issue. A local solution is important to meet the challenges faced by the system of long-term care. The modelling of this thesis could potentially help Hampshire County Council better plan a limited number of resources to meet the challenges that lie ahead to ensure that the system is sustainable. It could help them to take a more holistic view of the challenges at hand. The Hampshire reports suggest a Universal Offer, where services are not just targeted at those with the highest level of need but there is something available for everyone. The projections of this study could help the Council gain a better understanding of how many people are likely to be in need of support. Additionally, this could potentially help in planning for more personalised care.

Preventative services are also going to be critical, both now and in future. This study could be a useful tool in identifying the number of people that will require some sort of preventative service. The model could also be useful in helping the local authority to better manage the market for long-term care. To meet the future demands for long-term care, all the providers of long-term care will have an important role to play in the future.

There are going to be many cost implications with the changes of social care and the increasing demands. The modelling could potentially aid in better use of resources in both the short and long term, especially as a result of the budget cuts over the next five years. It is critical that the local authority meets the future challenges and is able to provide a high quality service to individuals in need of care.

3. Literature Review of Relevant Models

This chapter reviews the relevant literature in the following areas:

1. Long-term care models
2. Call Centre models
3. Hybrid models

The literature review will aid in the decision of choosing the final modelling techniques to address the research questions of this thesis. Discrete-event simulation, system dynamics and compartmental models are discussed throughout the literature review. Before reviewing their application within the specific area of long term care and call centres, a general discussion of these the techniques is provided below. Section 3.1 then goes on to review models relating to long-term care, section 3.2 call centre models and section 3.3 reviews hybrid models.

Discrete-event simulation (DES) is a stochastic modelling process that is ideal for modelling queuing networks such as surgical and out-patient waiting lists, airport check-in, and many manufacturing processes. See, for example Pidd (2004) and Robinson (2004), and studies in the health area such as Vasilakis et al. (2007). Changes occur at discrete points in time as individuals move through the system of queues and services. The time spent in each service is sampled from probability distributions. As stochastic processes are involved, a number of experiments need to be run in order to obtain statistically significant results. The number of experiments needed depends on the inherent variability in the system.

System dynamics (SD) is a deterministic approach that is used to model a system and understand its behaviour over time. The method was originated by Forrester (1961). A holistic view of a system is taken. Royston et al. (1999) list a range of application areas where system dynamics has been applied in health care:

- *assessing public health risks;*
- *screening for disease;*
- *managing waiting for hospital treatment;*
- *planning the health care workforce;*
- *developing emergency health and social care.*

Source: Royston et al., 1999, p294

By modelling the relationships between the different components of a system, its behaviour can be better understood. The methodology includes both quantitative and qualitative aspects. The qualitative side involves the creation of *causal loop diagrams*: through discussion with stakeholders various factors of a problem are identified. These factors are graphically depicted illustrating their relationships and their influences upon each other, which may be positive (as A increases, so does B) or negative (as A increases, B decreases). The process leads to the identification of feedback loops, of which there are two types; balancing loops (leading to a steady state) and vicious cycles (uncontrolled growth). These feedback loops can then be incorporated into a quantitative model through the use of stock- flow diagrams.

> "*System Dynamics models a system as a series of stocks and flows, in which the state changes are continuous. A system dynamics model views "entities" as a continuous quantity, rather like a fluid flowing through a system of reservoirs or tanks connected by pipes. The rates of flow are controlled by valves, and so the time spent in each reservoir is modelled by fixing the rates of inflow and outflow.*" (Brailsford and Hilton, 2001, p1)

A quantitative SD model is a representation of the system in question, and by the use of computer simulation the system behaviour (and the impact of the feedback loops identified in the qualitative stage) can be observed. Furthermore, "what if" analysis can then be performed, to investigate the effect of making changes to the system.

Compartmental models are used to model large populations where it is not necessary to model at the individual level. The total population is subdivided into different compartments or states depending on chosen characteristics, such as age group, disease status or gender. A model can include several different characteristics, although the number of compartments grows exponentially with the number of characteristics, a limitation of such models. A further (and potentially more serious) limitation is that such models are typically Markovian, i.e. the probability of transition from one compartment to another depends only on the current state and not on the length of time spent in that state or the previous history before entering that state. The number of people in each compartment changes over time, for example by birth/death, ageing or change in disease state. These changes can be modelled continuously (using mathematical differential equations) or discretely, where the changes take place only at given time-steps, for example each week or each year, depending on the context. Discrete models are implemented either using system dynamics or as spreadsheet models. Compartmental models are used frequently in epidemiology and demography, where individual variability is less important and the numbers of people in each compartment are relatively large.

3.1 Long-term care models

The following is a review of modelling related to long-term care. Firstly, a review of the Operational Research literature was carried out. Secondly, a review of models from other fields was carried out: these were mainly carried out at a national level, and only one paper was found that modelled at the regional level. There are no known studies for the county of Hampshire in the academic literature.

3.1.1 Long-term care models – OR literature

A study of future long-term care provision was carried out by Hare et al (2009). British Columbia in Canada is experiencing an ageing population in the same manner as the rest of the developed world. Hare et al. notes the importance of preparing for the future in terms of home and community care and proposes the use of a deterministic multi-state Markov model to prepare for the future strain that will be imposed upon the system. The compartmental model in this case has proved to be a useful technique in modelling the system for long-term care, especially as it can be used to include all the key aspects of the system. The model is used to predict future client numbers and allowed for the inclusion of various types of care as well as private care.

Hare et al. comments that most past literature is devoted to modelling residential care and little attention is given to home and community care. This is an important point because policy planners need a complete picture before decisions can be made. The authors also note some of the factors that need to be taken into account when modelling home and community care, including: gender, marital status, geographical location, ethnicity and chronic disease. None of these are currently taken into account in their model. Depending on data availability, these will be considered for inclusion in the model that is to be built as part of their ongoing research. These considerations were taken into account in the modelling of this research in sections 4.3 (pp.116-124), 4.4 (pp.124-131) and 4.5 (pp.131-137).

The multi-state Markov model allows for the entry of new clients as well as transitions between states. The model is then used to project the number of clients for each state every year and allows for entry into the various states. Hare et al. discusses some of the limitations of the model. Firstly, it is limited due to data constraints. Secondly, the client groups need to be re-defined to better represent the data. Another limitation is that regional health and wealth differences are not taken into account.

Lagergren (2005) in another study used simulation to examine the future demand of long-term care in Sweden. The author makes the point that when projecting forward the demand for long-term care it would be a mistake to simply scale up the numbers in a fixed proportion. Lagergren discusses a new model called ASIM III. There are two parts to the model, retrospective and prospective. The former is based on two different types of data source: a longitudinal study and local surveys of recipients of care. The latter is based on future trends. The model contains the following age groups: 65-74, 75-84 and 85+. The older population are further subdivided by three categories: gender, their civil status and their degree of ill-health. Degree of ill-health is subdivided by the number of hours of community care they receive and whether the person is in a residential or nursing home. These categories can be considered as some of the main indicators when predicting the demand for long-term care.

Lagergren discusses how the forecasts are made. Future service levels are based on present ones. The forecasts are made every five years from the year 2000. It involves the following multiplication.

> "*…simply by multiplying the estimated number of persons in the population per sub-group (gender, age group, marital status, class of disability) each year with the respective proportion of persons receiving services on the respective levels in the year 2000 as calculated in the retrospective part of the model*." (Lagergren, 2005, p327)

This is an effective method for making projections and the results can be very useful for policy makers. This approach is adopted for the research presented in this thesis and is discussed further in section 4.6 (pp.137-139). Lagergren ran the model in Excel to test the impacts of a continued ill-health trend and explore various scenarios. "*Meeting the future care needs of the baby-boom generation is definitely a challenge, but in no way insurmountable, if action is taken today*." (Lagergren, 2005, p334). Lagergren has shown the need for, and use of, building a predictive model for long-term care.

In another paper, Batljan and Lagergren (2005) discuss how demographic changes will affect the demand for formal long-term care (LTC) in Sweden. This is another successful application of a cell-based model. The demand for human resources is investigated as well as various scenarios. In the modelling, the authors use the current service level usage by age and gender as well as demographic projections to make projections.

> "*It is well known that the utilisation of LTC for the older people rises with age. This fact has been used as a starting point for the assessment of future demand for LTC for older people in Sweden.*" (Batljan and Lagergren, 2005, p216)

Batljan and Lagergren note that it is vital to understand that service use varies greatly between different ages and gender and because of this detailed demographic information should be used. An important data source used by Batljan and Lagergren is the Swedish National Survey of Living Conditions (Statistics Sweden, 2011) which asks individuals questions related to health status and an index is formed from this. The limitation of this data source is that it has an upper age limit of eighty-five. This was not too much of a problem as it was assumed that the rate of health improvements decline in the later stages of life. As a result, Batljan and Lagergren note that policy planners and researchers need good information on health trends when planning long-term care. Modelling disability rates are important when projecting demand for long-term care in Hampshire. The best available disability data will be used in the modelling of long-term care in Hampshire. This is discussed in detail in sections 4.3 (pp.116-124) and 4.4 (pp.124-131).

3.1.2 Institutional care – OR literature

The following review of papers from the Operational Research literature is for a specific part of the long-term care system, institutional care using Markov models.

Xie et al. (2005) develop a continuous time Markov model to study length of stay of elderly people in an institutional care setting. The authors modelled only publicly funded clients and excluded clients who use institutional care as a means of providing respite for their carers. Xie et al. have three states in the model: one for those in residential homes, one for those in nursing homes and an absorbing state called discharge. Residents that are in residential care can move to either of the other two states, and those in nursing care can only move to the death state. These flows are captured using the Markov model. There are two phases for residents: short and long stay. This provided a better length of stay in nursing homes. Data used in the model were provided from the London Borough of Merton over a four-year period using cohort data, reflecting 889 publicly-funded residents in the model. The model concerns current clients in the system. Xie et al. modelled only publicly-funded clients in institutional care, who represent only a small part of the system for long-term care. Markov models once again have proved to be a useful way of modelling client flow, even though this is only for a small but important part of the system for long-term care. This paper has shown the usefulness of working with a local authority in gathering data.

This is one of the reasons for working closely with Hampshire County Council (see section 4.7, p.139).

The model created by Xie et al. is used by Pelletier et al. (2005a). The aim of the study is to project forward costs of institutional care and then to test the outcomes of various cost scenarios. The authors needed a model that could calculate survival in both residential and nursing homes to meet the study objective. The authors used the model developed by Xie et al. (2005) to predict cost implications occurring from elderly people in institutional long-term care. Costs are a feature of Pelletier et al.'s model but are not considered in the research in this thesis. A weakness of the model is that projections are made only for seven years. The impact of the "baby boom" generation will be seen long after this. Pelletier et al. limited their research to current clients of the local authority with whom they were working. A major limitation of the study is that account is not taken of arrivals in the long-term care system (this is indicated as an area for future research).

A further extension of the model created by Xie et al. (2005) is carried out by Pelletier et al. (2005b) where multi-census data is used instead of cohort data. The authors note the value of having a good estimate of length of stay in an institutional environment for elderly people. This is important for both providers and purchasers in terms of future resource allocation. Pelletier et al. consider using both system dynamics and discrete-event simulation. The authors found both techniques useful as one could run various scenarios but tend to rely on too many assumptions and data that could not be collected for their research. Xie et al. (2005) use cohort data which can be advantageous as it contains a full variety of data. There are problems with cohort data in that it needs to be collected for a number of years. Pelletier et al.(2005b) discuss an alternative method to overcome this problem. Data were provided from the London Borough of Merton relating to clients already placed in the system of institutional long-term care. Seven censuses were created over the period 1999 to 2002. Xie et al. note cohort data is good but it is difficult to acquire: multi-census data is a good substitute. The model parameters are compared to the cohort data and were found to be very close.

Markov models have proven to be a good technique of modelling transitions between the different types of institutional care. A limitation of studies is that they are limited to current clients of the local authority. The research presented is not limited to local authority clients (see section 4.5, pp.131-137). However, what is shown is that it is important to work with a local authority to obtain the best local data. This study used data provided by Hampshire County Council (see section 4.7, pp.139-142).

3.1.3 System Dynamics models for long-term care

Kim and Goggi (2005) used system dynamics to model the system for long-term care for a state agency. The authors modelled both institutional care as well as home and community care, to show the impact of a major policy change in accessing care. Access to care is very fragmented: system dynamics was used to show what is likely to happen if a new single point of access were to be created. This single point would act as an information provider as well as a place to have an individual's needs accessed. This new system should reduce the number of people given institutional care unnecessarily, thus reducing costs. System dynamics proved to be a good way of modelling the whole system as well as assessing the implications of a policy change. The model was able to project costs until 2030 as well as the numbers requiring institutional and home and community care. The modelling period of the research presented in this thesis is until 2026 (see section 4.3.2, p.119). The model required population dynamics and thus included the ageing process through the use of an ageing chain model. A strength of the methodology is that the ageing process can be explored. A highly detailed stock and flow diagram was built to represent flows of the people through the system for long-term care.

There are some limitations noted by the authors. The modelling is incomplete due the lack of data. This in turn limited the validation process. The researchers were unable to include all the feedback identified due to the model structure which limits the usefulness of the application of the technique.

The consultancy group, the Whole System Partnership (Whole System Partnership, 2010) have shown that system dynamics can potentially be a useful way of modelling the long-term care at the regional level in the United Kingdom. The consultancy group modelled services for elderly people in the city of Leeds (Lacey, 2003) and region of Leicestershire (Lacey, 2007). One of the strengths of the modelling is the way key stakeholders were brought together in the modelling process. For example in Leeds, Lacey (2003) built two models, one for all older people and one for elderly people with mental health needs. The model looked at both the demand and supply until 2021. The model was potentially useful for the local authority to identify both short- and long-term pressures on the system in terms of commissioning services for elderly people. System dynamics is a useful technique for modelling a complex system over a long period of time. As the modellers worked closely with the clients throughout the modelling process, acceptance of the model was much more likely. The models presented in this thesis involved members of Hampshire County Council throughout the process (see Chapters 4 and 5).

Desai et al. (2008) constructed a system dynamics model for Hampshire County Council to project the demand for older people's service over the period 2006 through to 2011. The study was a result of concern relating to demographic change. Part of the study was to model the assessment process to calculate the number of people who make contact with the local authority and their outcomes.

Various modelling techniques were considered by the authors: system dynamics was finally chosen, for a number of reasons. The qualitative modelling was important; the concepts of feedback and causal loops proved to be useful. Even though system dynamics does not model at the level of the individual, characteristics of the population could be included. A similar approach was taken with the research presented in this research (see section 4.1, p.115). The characteristics modelled were age, the source of referral and the initial level of need. The authors were able to provide the local authority with a set of potentially useful results through running various scenarios.

Wolstenholme (1993) also used system dynamics, although only the qualitative aspects, to investigate the impact of a policy change. The responsibility of community care for the elderly was passed onto the local authority during the time that the paper was written. The study was brought about by health service managers who wanted to test the impact of the new policy on the interface between the two sources of public care provision, the National Health Service and the local authority. Influence diagrams were able to aid in understanding the situation. Wolstenholme's objective was to try and represent the new system as simply as possible and to represent the movement of people across organisational boundaries. The diagrams grew in complexity as the project progressed and helped give a clear understanding on the possible consequences of the policy change. The concept of feedback illustrates the possible implications of a policy change in one sector upon other sectors. The study was useful at creating a thorough understanding of the impact of a policy change.

Gray et al. (2006) used two models in a study to investigate the interactions between the acute and aged care systems. The authors used both system dynamics and agent-based simulation. Carried out in Australia, the study built models at both the national and regional level. One of the reasons for the study is that 20% of beds utilised in hospitals were in fact for non-acute patients. It is noted that there are many stakeholders involved in both systems so system dynamics is a good way of representing all their views. Gray et al. note that simulation is advantageous where real life experiments cannot be carried out or when it would take too long to get any results or it could be too costly. The authors discuss strengths of simulation techniques when dealing with messy real-world systems.

Gray notes that system dynamics is good at understanding how a system behaves over time and agent-based simulation is good at understanding the interactions between individuals and their environment. This methodology could be used to answer many questions, such as, "what is the average time spent waiting in acute care?" and "how many people are waiting for a residential care place at any given time?" Whilst this paper attempts to answer a different set of questions compared to this thesis (see section 1.5, p.4), the advantages of the methods are well presented for their use in a social care setting.

Chen (2003) uses system dynamics to investigate non-acute services for elderly people in Norway. The author notes that existing studies do not separate acute and non-acute services. Non-acute services are treated as an addition to acute services. The study investigates patient flow through the non-acute system, with a ten-year time horizon. The author was able to identify various types of feedback. Using the systems thinking methodology, different systems are no longer treated in isolation. Chen notes that system dynamics allows for the inclusion of lots of information and it can be tested with various stakeholders. It should be noted that no results were published in this paper but the use of system dynamics is well presented in the area of non-acute care.

The various applications of system dynamics have shown that this is a potentially a good way of modelling the system for long-term care. The technique was considered for selection for this thesis but as there was no data to support the inclusion of feedback it was not chosen (see section 4.1, p.115). Many benefits have been described such as: it can be used to model the impact of a policy; a whole system can be modelled; it can be used to project over a long period of time; it allows the inclusion of various stakeholders, feedback is captured and it allows for what-if analysis. However, quantitative system dynamics modelling is dependent on the data available: the model by Kim and Goggi (2005) was incomplete because of the lack of data.

3.1.4 Long-Term Care models – Other Literature

The following papers are not from the field of Operational Research. The first three papers reviewed include models that were used in the Wanless Report in 2006, described in the Social Policy section 2.2.2 (p.40). The models in this section have proved to be useful but it should be noted that they are all used at the national level apart from one which models long-term care in Hong Kong.

Wittenberg et al. (2006) constructed a model to project demand for long-term care for older people in England over the period 2002 through to 2041. The authors pose some key questions:-

> "*How many older people are likely to require long-term care services in the coming decades? How much are these services likely to cost? Will the cost to public funds prove affordable? Who should pay? How should costs be*

divided between public expenditure and private sources of finance?"
(Wittenberg et al., 2006, p2)

To address these questions, good projections are needed on the potential demand for long-term care as well as the related expenditure. The Personal Social Services Research Unit (PSSRU) model (Wittenberg et al., 2006) attempts to address this need for good projections in the United Kingdom. There are several versions of the model. The original model was published in 1998 and was used by the Royal Commission in their report into long-term care in 1999. The model attempts to make projections of the following:

> "*…the future numbers of disabled older people, the likely level of demand for long-term care services and disability benefits for older people, the costs associated with meeting this demand and the social care workforce required.*" (Wittenberg et al., 2006, p3)

The PSSRU model utilizes data from a variety of sources including the General Household Survey, population forecasts as well as data related to care services. Future home ownership rates are taken from a *microsimulation* model, i.e. it is individual-based and stochastic, but not a DES in which the human "entities" interact. Referrals, Assessments and Packages of Care were also used and provided by the Department of Health. The data is related to the number of people receiving various types of local authority services.

Wittenberg et al. use a cell-based model which is a *macro-simulation*; it was formulated in a spreadsheet. The model subdivides the older population by disability into cells by age group, gender and by both household type and tenure. Each of these cells is assigned a probability of receiving long-term care, from which expenditure is then calculated. The model is projected forward using population projections. A similar approach was adopted for the research presented in this thesis (see section 4.6, pp.137-139). Wittenberg et al. ran various different scenarios, and make a number of assumptions in the base case run. However, the authors do not allow for changes in the disability rates taken from the General Household Survey. Under this scenario there potentially would end up being a 100% increase in the number of older disabled people. Wittenberg et al. make two points: the assumptions of the model are not the only ones possible and projections are made, not forecasts. Policy planners clearly need to prepare now for the uncertainty that lies ahead. The model has shown to be a useful way of modelling the demand for long-term care.

Hancock et al. (2003) link a macro- and micro-simulation model to analyse who will pay for long-term care in the United Kingdom. The authors also investigate the potential outcomes of a free personal care system. The work has come about through the ongoing debate about who should pay for long-term care in the United Kingdom especially as the National Health Service is free at the point of use while social care services are subject to means testing. Hancock et al. utilize the work of two simulation models, the PSSRU model and the Nuffield Community Care Studies Unit (NCCSU) model. The former is a macro-simulation model and the latter is a micro-simulation model. The NCCSU model uses data from the British Family Resources Survey. The model is used to calculate how much money each older person in the survey would spend on care if they needed to go into a care-home. Simulating the future involves the process of ageing those people in the survey. Hancock et al. discuss how the NCCSU model is linked to the PSSRU model. Two pieces of information are sent from the NCCSU model to the PSSRU model: the likely number of residents who would require care from the local authority and the contribution they would be required to make. The PSSRU model has once again shown to be potentially a useful way of addressing issues related to long-term care.

Hancock et al. (2006) discuss CARESIM, another microsimulation model. It was previously known as the NSSCU model. The main outputs of the CARESIM model are:

- *the proportion of care home residents and home care clients eligible for local authority support under the current or an alternative charging regime;*
- *for care home residents, the proportion of gross costs of care met by disability benefits in the case of those not eligible for local authority support;*
- *the proportion of gross costs met by users, in the case of those eligible for local authority support; and*

- *the proportion of gross costs of home care met by disability benefits, for those eligible for local authority supported home care.*

Hancock et al., 2006, p10-11

These outputs are used as inputs for the PSSRU model. Hancock et al. (2006) run three scenarios as summarised in Figure 3.1.

Scenario	Life expectancy assumptions	Disability assumptions	Real unit costs assumptions
Low expenditure scenario (Low base case)	Official principal population projections*	Disability rates fall in the line with a 'Brookings' scenario+	Unit costs of care rise by 2 per cent per year, in line with average earnings (except that non-staff revenue costs remain constant).
Central scenario (Central base case)	Official principal population projections	Current age- and gender-specific disability rates #	Unit costs of care rise by 2 per cent per year, in line with average earnings (except that non-staff revenue costs remain constant).
High expenditure scenario (High base case)	High life expectancy variant to the official projections*	Current age- and gender-specific disability rates #	Unit costs of care rise by 2.5 per cent per year, faster than average earnings (except that non-staff revenue costs remain constant).

Figure 3.1: Assumptions for three possible future scenarios

(Source: Hancock et al., 2006, p19)

The model is projected forward from 2002 through to 2051 and the authors were able to present a variety of useful results from the scenarios. Of course, this is a trade-off since the further one projects forward, the results become increasingly unreliable. This was an important consideration when deciding upon the study period for the long-term care model used in this thesis (see section 4.3.2, p.119).

Chung et al. (2009) study the implications of demographic change on expenditure of long-term care in Hong Kong. The authors chose the approach of the PSSRU model to model expenditure until 2036. Various services are modelled, including day and home care, nursing homes and hospices. The model outputs included the number of people requiring long-term care and the associated costs. The authors were able to run various scenarios to test the sensitivity of the results. These included, for example, reducing the number of informal carers available and adjusting unit costs. The authors were able to present a wide range of results, including total expenditure for different services and expenditure by funding source. This study shows the benefits of the PSSRU model but there is a limitation: the authors note that when presenting the total expenditure as a proportion of gross domestic product it relies on a good estimate of economic growth. Nuttall et al. (1994) are concerned with the financing of long-term care in Great Britain. This paper was published around the time when local authorities took over the assessment process and the public funding of long-term care. The authors found that previous research into future demand for long-term care was reliant on simple calculations. Nuttall et al. built a three state model: the three states were healthy, disabled and dead. The authors used separate models to cover the different levels of disability. The authors took prevalence rates from the OPCS survey which was carried out in 1985 (Martin et al., 1988). There results show that potentially the greatest increases in the number of disabled people occurred in the elderly population over a forty year period. Growth starts to occur significantly after ten years. The authors took the results and tried to find a value for long-term care. Nuttall at el. had difficulty in valuing informal care: the same rate as formal care was used. Nuttall et al. noted that this would potentially lead to an overestimate.

Nuttall et al. discuss the implications of their findings: informal care might not be able to carry its share of the workload as demand increases; the private sector will have to expand their activities; there is a real need for forward planning; various experts need to collaborate to study various possible future scenarios and the need for better data is suggested. These issues are still under discussion fifteen years later. It is shown that by modelling over a long period of time, both the short- and long-term impact of demographic change can be captured.

Rickayzen and Walsh (2002) develop a multi-state model in which the authors attempt to project the number of people with disabilities over a thirty-five year period in the United Kingdom. The authors recognise the uncertainties in projecting forward the provision of long-term care. People aged twenty and over are modelled and projected forward to the year 2036. The model is similar to the Nuttall et al. (1994) multi-state model; however, Rickayzen and Walsh (2002) have increased the complexity of the model and taken into account new trends in healthy life expectancy.

Rickayzen and Walsh needed data for three parts of the model: disability prevalence rates, transition rates and trends data. Like Nuttall et al. (1994), Rickayzen and Walsh (2002) use the 1985 OPCS survey. The information is used to form the prevalence rates. It was chosen for a variety of reasons, including: the sample was large, the survey includes all adults and it covered a large variety of disabilities. The survey results show rapid increases in the disability rates as age increases. Rickayzen and Walsh note that the survey was carried out in the mid-1980s but overcome this by starting the projections in 1986 and projecting forward using healthy life expectancies from 1986. The model is run up to 1996 and then data from the Government Actuary's Department is used. The authors note other limitations as the assignment of disability is complex and there could be potential errors in the data.

Rickayzen and Walsh use the General Household survey to study changes over time. The authors note another limitation in that the General Household Survey is only for households while the 1985 OPCS survey also includes communal establishments. The authors infer transition rates from the prevalence data. The authors choose rates that can generate the prevalence rates from the OPCS survey. Rickayzen and Walsh note that transition data is likely to change over time. The authors look at both healthy life expectancy and disabled life expectancy. This is done for people aged-sixty five and over as they are the group that receives the highest amount of care. This reiterates the need to study older people as an exclusive group.

Rickayzen and Walsh populate the model initially using data from the OPCS survey and then project forward using transition rates. Population projections are taken from the Government Actuary's Department. Rickayzen and Walsh allow for trends by allowing changes in transition rates. Seventeen scenarios are run to account for different possible trends. The authors criticise Nuttall et al. (1994) as transitions between disability states are not included. This is an important advancement on the work by Nuttall et al. (1994). While the model can be criticised for using a survey from a long time before the model was created, it does show that it is important to use the best available data. Much time was spent searching for the best data for the long-term model created in this thesis (see Chapter 4).

Karlsson et al. (2006) examine the impact of demographic change and changing health status on the future of long-term care in the United Kingdom. It is noted that there is a general belief that an ageing population will be a public financial burden. This paper attempts to examine this and analyse how sustainable the system is. Karlsson et al. have two main outputs from the study. Firstly, the public cost of long-term care and secondly whether there will be enough informal carers to satisfy demand. The Rickayzen and Walsh (2002) model was used as an input into the projections. Karlsson et al. (2006) justify the use of the OPCS survey as the authors claim it to be the richest source of data for modelling long-term care. This model is used to provide projections for the United Kingdom population by the degree of disability. Additional sources of data are used: the Health Survey for England is used to analyse the disability for those in institutional care, and the data from the Department of Health are used to examine the disability of those who receive formal home care. Karlsson et al. do not include day care, community nursing, and long-stay hospitals. The authors are also interested in whether there will be enough carers to meet the demand for informal care. The model used in the study has shown that is useful to model the long-term care system. It has also been shown in both the Rickayzen and Walsh (2002) and Karlsson et al. (2006) papers that data to model transitions between disability states is not readily available and is difficult to access. The authors used fairly old data (from the 1980s) which could be considered as a limitation of this model.

Johnson et al. (2007) investigate the issue of an ageing population and implications it will have upon long-term care in the USA. The authors project the number of people aged 65 and over who have a disability, and their use of long-term care services until 2040. Results are presented for 2000, 2010, 2020, 2030 and 2040. Population projections of long-term care use were made in a microsimulation model. Long-term care arrangements were based on a national survey of older people. As there is much uncertainty with regards to disability projections, three different scenarios are run by the authors: a low, intermediate and high disability scenario. The authors define somebody as being disabled if they have difficulties with any of the specified activities of daily living or instrumental activities of daily living. The authors note that there is much disagreement over the future of disability rates and whether rates will continue to fall in the future. It is for this reason that various scenarios are run.

A important point made by the authors is that not only is disability a key determinant if somebody requires a long-term care service, but so is the availability of informal carers. Much care is provided in the form of informal care, and changes such as increased divorce rates, more women entering the workforce and declining family sizes will potentially impact upon the availability of informal care. There could be an increased demand for formal nursing care. The authors account for education and income levels in the projection of disability rates. In the intermediate scenario, for example, it is shown that increases in income and education would in fact reduce disability rates. The authors allow the rates to rise for the very old population. Johnson et al. used projections of family characteristics to determine future levels of paid and unpaid services. The authors note that previous projections do not account for changes in the availability of informal care workers. The authors were able to show the changes in the proportions of people receiving unpaid and paid help. This is a useful study and provides a great deal of information with regards to the provision of long-term care. The authors account for many different factors. However, one of the issues in dealing with a large population such as the USA is that the range of results between the scenarios is very large. Another problem is that regional differences are not accounted for.

3.1.5 Synthesis of long-term care papers

Many different studies have been reviewed and Table 3.1 provides a synthesis of the various studies allowing easy comparisons to be made between them. Various fields are reported; the author(s), the country and date of the study, the problem setting, the modelling approach used, the characteristics of the population studied and the key points of the study.

Author(s)	**Country and date of study**	**Problem Setting**	**Modelling approach used**	**Characteristics of population studied**	**Key points of study**
Batljan and Lagergren	Sweden, 2005	The authors investigate how demographic changes will impact formal care for those aged over 65 over the period 2000 to 2030.	Cell-based model	The following age groups are considered: 65-69, 70-74, 75-79 and 80-84. Based on the individual's self-assessment of their own health, the following health categories were used: full health, slight ill-health, moderate ill-health and severe ill-health.	The study provided valuable insight on how demographic change will impact upon human resources and was a useful application of a spreadsheet model. The authors were able to run various scenarios including unchanged health status and improved health status.
Chen	Norway (2003)	The study is used to investigate patient flows in Norway for non-acute services and to deliver a tool for budget planning.	System dynamics	None presented.	System dynamics allowed of the inclusion of feedback, different parts of the system are no longer treated in isolation and various stakeholders are included in the process. It is shown that system dynamics can be a good technique to use in a non-acute care setting for long-term planning.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Chung et al.	Hong Kong (2009)	The authors model the expenditure of long-term care in Hong Kong until 2036.	A PSSRU model methodology was used. Macrosimulation model.	Age groups included: 60-64, 65-69, 70-74, 75-79, 80+. Both genders are included.	The PSSRU model in a different county is shown and worked well in a specific region as opposed to a country. Forecasts were made until 2036 which allowed for observations in both the short-and long-term to be made. Various scenarios were run to test the robustness of the model.
Desai et al.	United Kingdom, 2008	Modelled the demand for formal care services over a five-year period.	System dynamics	Three age groups were modelled: 65-74, 75-84 and 85+. The age groups were broken down further by classifying them as either having a substantial or critical eligibility status (classified by the local authority).	A useful study but only looked at formal care over a five-year period. The study showed the importance of working closely with the local authority, the benefits of the system dynamics approach using both qualitative and quantitative modelling and ability to run “what if” scenarios.

Author(s)	**Country and date of study**	**Problem Setting**	**Modelling approach used**	**Characteristics of population studied**	**Key points of study**
Gray et al.	Australia, 2006	The study investigates the interactions between the acute and aged care systems.	System dynamics, agent-based simulation.	None mentioned.	System dynamics is good at bringing many different stakeholders together and understanding how a complicated system behaves over time and agent-based simulation is good at including interactions of individuals into a model. The authors extend the boundary of the problem to include both acute care systems and residential care. Both a national and regional models are constructed.
Hancock et al.	United Kingdom, 2003	The authors investigate who will pay for long-term care in the United Kingdom until 2051. Expenditure for older people was investigated.	Micro- and macro-simulation model.	Expenditure projections were presented as a total of the whole population. Income groups were considered.	The projections were carried out over a very long period of time, there could be a lot of doubt regarding the meaningfulness of results in 2051. The modelling allowed for various scenarios to be run accounting for different assumptions regarding life expectancy, dependency and real unit costs.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Hancock et al.	United Kingdom, 2006	The authors investigated the issues of paying for long-term care until 2051. Costs were modelled.	The paper draws on a macrosimulation and microsimulation model.	The following groups were presented in the results for all the scenarios considered: number of older people aged 65 and over, number of older people aged 85 and over, number of disabled older people and the number of severely disabled people.	The paper illustrated the benefits of macro- and micro-simulation in order to look at issues in regards to expenditure of long-term care and the authors were able to present the projected numbers of people requiring different types of care. The authors were able to run various scenarios.
Hare et al.	Canada, 2009	British Columbia is experiencing an ageing and authors investigate the impact upon home and community care.	Deterministic multi-state Markov model	The authors note that it is important to properly define client groups. Hare et al. also note that the following factors are important to take into account: gender, marital status, geographical location, ethnicity and chronic disease.	The deterministic model was a useful way of modelling long-term care and various types of care providers were included. The model is being used by the Ministry of Health for British Columbia to develop a strategic direction for the home and community sector.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Johnson et al.	United States of America, 2007	The study investigates the issue of an ageing population and the implications it will have upon long-term care in the United States of America until 2040.	Microsimulation model	Factors included in the model: age (65-74,75-84, 85 and over), gender, financial status, marital status and availability of an informal carer. Education attainment is also accounted for. Race is also accounted for.	The authors are able to present useful results from the model, however, results are only reported in ten-year increments so this could mask some of the important changes in the number of people requiring long-term care. The sensitivity analysis shows a large range of results between the scenarios, this is a problem of dealing with a large population. Regional differences are not accounted for as it is a national model.
Karlsson et al.	United Kingdom, 2006	The study examines the future costs for long-term care for elderly people in the United Kingdom.	The disability model used is by Rickayzen and Walsh (2002).	The disability model has ten disability states. Three disability groups are presented in the results: no disability, moderate disability and severe disability. Recipients of informal care are reported by gender.	The authors used a multi-state model to investigate costs of long-term care until 2050 and disability transitions were included. The authors use the OPCS survey from the 1980s which is a limitation of the study. It illustrates the issues of data availability when modelling disability transition rates.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Kim and Goggi	United Kingdom, 2005	The study used system dynamics to examine the impact of a policy where the system for long-term care will have a single point of entry instead of multiple points.	System dynamics	Age groups considered were 0-17, 18-49, 50-59, 60-85, 85+. The authors note that a possible advancement of the model could include insurance coverage, income and family size.	Using system dynamics, the authors were able to model both institutional care and home and community care and project forward numbers until 2030. Whilst the authors were able to identify lots of feedback, they were not incorporated due to a lack of data. The technique is good at modelling flows of people.
Lacy	United Kingdom, 2003	The study was used to inform the process of commissioning of long-term care for elderly people in Leeds.	System dynamics	Age groups considered were 65-74, 75-84 and over 85. Both genders were considered.	The methodology allowed for the key stakeholders to be included and this allowed for the acceptance of the modelling. The modelling allowed for both short- and long-term pressures to be identified. System dynamics allowed for a greater understanding of supply and demand.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Lacy	United Kingdom, 2007	The author helped Leicestershire County Council "develop a more robust 'evidence base' for commissioning services for older people." (Lacy, 2007, p1)	System dynamics	The model when built will include the following age bands: 65-74, 75-84 and 85+.	This report is an initial step towards the creation of a model. The first step was to have a workshop; this shows the strength of the system dynamics methodology in that it brings together different stakeholders. It is suggested that the model captures aspects at the district level.
Lagergren	Sweden, 2005	Lagergren investigated the demand for long-term care in Sweden from 1985 and 2030. As the demand increases for long-term care, there are concerns over the resources needed to meet this demand.	Cell-based model	Three age groups were: 65-74, 75-84 and 85+. These groups were split by gender, civil status and degree of ill-health. The results were broken down by people with full health, slight ill-health, moderate ill-health and severe ill-health.	The model provided useful results. The author was able to present the number of people living in the community with public help and without. Various scenarios were able to be run in the model.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Nuttall et al.	United Kingdom, 1994	The authors investigate who will pay for long-term care in the United Kingdom.	Three state model	The three states were healthy, disabled and dead. The authors looked at disability projections for the whole population.	Nuttall et al. included formal, informal and private care in the model. By projecting over a forty-year period both the short- and long-term effects of changes in the number of disabled people were captured.
Pelletier et al.	2005a	The authors use the model created by Zie et al. to investigate the costs of institutional care.	Continuous time Markov model	There is no mention of population characteristics.	A useful study but limited only to institutional care and only projects forward seven years into the future. These models are often hard to understand for stakeholders.
Pelletier et al.	United Kingdom, 2005b	The authors provide an estimate of the length of stay in institutional care.	Markov model	There is no mention of population characteristics.	A good study for looking at transitions of clients in institutional care but is limited to this type of care. The authors note that the model by Xie et al. (2005) is very attractive but it relies on cohort data which is not easy to access.

Author(s)	**Country and date of study**	**Problem Setting**	**Modelling approach used**	**Characteristics of population studied**	**Key points of study**
Rickayzen and Walsh	United Kingdom, 2002	The authors projected forward the number of people with a disability in the United Kingdom and studied the future implications for long-term care for elderly people.	Multi-state model.	People are defined as being either healthy or disabled. For those who are disabled, the authors further categorised them from relatively mild to very severe. There are ten possible disabled states. Gender is incorporated.	Projected over a thirty-five year period, the results show a large funnel of doubt as projections are made over a long period of time. Three types of data were used: prevalence data, transitional data and trends data. Transition data between disability states data is hard to access so Rickayzen and Walsh used the OPCS survey from 1980s which is a limitation of the study.
Wittenberg et al.	United Kingdom, 2006	Projected the demand for long-term care for older people in England over the period 2002 through to 2041. The study looked at the associated costs of the changes in the demand for long-term care.	A cell-based model which is known as a micro-simulation model. It was built in a spreadsheet.	Six disability groups were used in the model based on a person's ability to carry out activities of daily living and instrumental activities of daily living. Eight household types were used in the model which included whether there was any informal care.	A useful study that modelled long-term care at the national level. The authors were able to run various scenarios where the authors change future disability rates. Wittenberg et al. were able to report costs for both public and private expenditure. The model potentially provided policy makers with a useful set of results regarding the future of long-term care.

Author(s)	Country and date of study	Problem Setting	Modelling approach used	Characteristics of population studied	Key points of study
Wolstenholme	1993	System dynamics was used to investigate the impact of policy change where the responsibility of community care was passed to the local authority.	System dynamics	None mentioned.	Showed the benefits of system dynamics. Did not look at the whole system and was not used to make projections.
Xie et al.	England, 2005	The authors investigate the length of stay of elderly people moving between residential and nursing home care.	Continuous time Markov model	Does not account for age and gender.	A good technique for allowing flows between the different states but the problem is that it is limited only to institutional care. The paper shows the benefits of working with the local authority to access local client data.

Table 3.1: Synthesis of papers related to long-term care modelling

3.1.6 Long-Term Care models – Conclusions

Many different papers have been reviewed and different techniques that inform the choice of methodology used in this research. This is discussed in detail in Chapter 4. The cell-based model by Lagergren (2005) is an effective method of modelling future demand for long-term care. Lagergren was able divide the population into sub-groups such as gender and age and then multiply a service receipt rate. This technique was used in section 4.6 (pp.137-139). The sub-groups were divided by level of ill health. Future long-term care projections were made using population projections. Another example of a compartment model is Wittenberg et al. (2006) which sub-divided the older population by disability into cells by age group, gender and both household type and tenure. Each of these cells is assigned a probability of receiving long-term care in the cell-based model. Once again, future projections were made using population projections. Chung et al. (2009) showed the usefulness of the PSSRU model in a different country and that the methodology works well in a regional setting. The PSSRU model methodology was used as part of the Wanless Review (Wanless, 2006) into social care.

Compartmental models have also been shown to be useful in studies by Xie et al. (2005) and Pelletier et al. (2005a). The continuous time Markov models used in the studies have proven to be a good technique of modelling transitions between the different types of institutional care as shown in these studies. However, the limitation of these studies is that they were only limited to current publically funded clients in institutional care. It is also noted that continuous time Markov models are often hard for stakeholders to understand.

Other applications of compartmental models have been presented by Rickayzen and Walsh (2002) and Karlsson et al. (2006). The authors have shown that multi-states models can be a valuable way of modelling the system for long-term care. The authors were able to model transitions between disability states. However, this type of data is often difficult to access: in both papers appropriate data was not readily available. Transitions between disability states were not included in this research due to a lack of data to support this. The disability rates used in this research are presented in section 4.4 (pp.124-131).

Compartmental models have also been shown to be a good way of modelling long-term care when implemented as a system dynamics model. Many benefits of the system dynamics methodology have been presented. Chen (2003) notes that a key point of the system dynamics method is that it allows for the inclusion of feedback. Desai et al. (2008) showed the benefits of system dynamics as it allowed what-if scenarios to be run. Kim and Goggi (2005) have shown that system dynamics allows for the inclusion of various types of care provision. However, the model by Kim and Goggi is incomplete due to a lack of data.

All of the main published long-term models in the UK were at the national level: there is a need to model at the regional level. The region of Hampshire is modelled in this research (see Chapter 4). The regional level models identified in the academic literature in the UK only model a small part of the formal care system. There is a gap in the OR literature to model long-term care at this level. Modelling at the regional level is shown to be of importance in studies such as Gray et al. (2006), Lacy (2003) and Lacy (2007). The application of compartmental modelling could be of valuable use at the regional level in the UK.

Other important findings from the review are that it is important to make projections over a long period of time to capture both the short- and long-term effects of demographic change. The modelling of this thesis is carried out until 2026 (see section 4.3.2., p.119). It is important that the modelling technique allows for various scenarios to be run. The modelling should not just be limited to formal care, as in studies by Desai et al. (2008) or institutional care in studies such as Pelletier et al. (2005a). The modelling technique chosen as part of this thesis needs to be able to include detailed demographic information; it is important to account for differences between ages and gender (see section 4.3, p.116). By not accounting for age and gender, studies can be considered limited, such as that by Xie et al. (2005). It is shown in the study by Lagergren (2005) that it is important to model the number of people who do not receive any support. Compartmental cell-based models allow for all of these considerations to be accounted for. The methodology used in this thesis is discussed further in Chapter 4.

3.2 Call Centre Modelling

A literature search revealed that the two main modelling approaches which have been applied to call centres are queuing theory and simulation. Queuing theory is an analytical, exact, stochastic mathematical approach which makes a number of fairly restrictive assumptions about the system being modelled. Simulation, on the other hand, is an experimental approach but has the benefit of being highly flexible. These two contrasting techniques were considered for modelling the Hantsdirect contact centre.

3.2.1 Call Centres - General

Call centres are a common (and to many people, infuriating) feature of modern life. Most large organisations, both public and private, operate call centres as a way of communicating with their customers, users or clients. Avramidis and L'Ecuyer (2005) provide an excellent definition of a call centre:

"*A call center is a set of resources (communication equipment, employees, computers, etc.) which enable the delivery of services via the telephone*." (Avramidis and L'Ecuyer, 2005, p144)

"*…call centres can be thought of as stochastic systems with multiple queues and multiple customer types*." (Mehrotra and Fama, 2003, p135)

Avramidis and L'Ecuyer (2005) provide a list of the important performance measures of a call centre. The most well-known ones are the service level, the abandonment ratio, the expected waiting time and additionally the number of outbound calls for call centres where outbound calls are made. The authors define service level as percentage of calls that wait less than a predefined time. The abandonment ratio is the percentage of calls abandoned. It is important that the modelling technique chosen is able to produce these measures. Two further definitions are provided by Cezik et al (2008): quality of service (QoS) and abandonment.

> "*The QoS constraints are that the fraction of calls answered within a certain time limit, in the long run, exceeds a certain threshold. This fraction is called the service level.*" (Cezik et al., 2008, p310)

> "*An abandonment occurs whenever the waiting time of a call exceeds its (random) patience tim*e." (Cezik et al, 2008, p310)

Mehrotra and Fama (2003) point out that most call centres can more accurately be described as *contact centres*, as they deal not only with calls but with a variety of other forms of contact such as emails and faxes.

Mandelbaum (2004) supplies a bibliography of publications related to call centres. His list is by no means exhaustive but has well over two hundred references. It is clearly not the purpose of this thesis to provide a full review of all the research into call centre modelling but a good overview will be presented to justify the eventual use of simulation (see Chapter 5).

A similar call centre to Hantsdirect is that of NHS Direct. The National Health Service (NHS) created NHS Direct. Operational Research played a role in its development. Royston et al. (2003) discuss the role that OR is able to aid in public innovation. OR analysts in the Department of Health played a pivotal role in helping to develop NHS Direct. They were involved in three areas:

- *strategic design: creating and appraising scenarios where health services were delivered in new 'direct' ways that made best use of modern communication technologies;*
- *operational planning: to help determine the size, distribution and staffing of the call centres required to meet the likely demand and satisfy service performance targets;*

- *monitoring and evaluation: establishing performance criteria and developing a performance-monitoring system*.

Royston et al., 2003, p1023

The authors found that there was a lack of similar environments with which NHS Direct could be compared. Silvestro and Silvestro (2003) carried out an evaluation of NHS Direct, noting that designers of NHS Direct could have learnt important lessons from the call centre literature.

3.2.2 Queuing Theory

Understandably, mathematical queuing theory has been widely applied to call/contact centre modelling. Indeed the Erlang C distribution, widely used in such models, originated from observation of telephone exchange data. "*Erlang C calculates the probability that an agent is free to answer a call*." (Royston et al., 2003, p1025) However, the complexities of real-world systems (for example, time-dependent arrival rates) mean that the assumptions underpinning queuing theory are often violated in practice. Nevertheless, the exact nature of the solutions obtained give queuing theory models many advantages, and queuing models are the dominant form in call centre modelling. Brown et al. (2005) point out that call centres use queuing theory so they can get the balance right between efficiency and service quality. Royston et al. (2003) studied the behaviour of healthcare queues mathematically. Exact formulae can be solved analytically to determine evaluate steady-state performance measures. The following section provides various examples of the use of queuing theory to model call centres.

Anderson et al. (2009) provide a useful introduction to Kendall's notation of queuing models, used in this review. The models take the form of A/B/k where A is the probability distribution of arrivals, B is the probability distribution of service times and k is the number of servers. A and B may take the following forms: M where the arrival process has a Poisson probability distribution or the service times has an exponential probability distribution, D where arrival or service times are deterministic or G where the arrival or service distribution has a general (i.e., can be any) probability distribution.

Additional symbols include the number of units allowed in the system, the size of the population and the queuing discipline.

Koole and Mandelbaum (2002) carried out a survey of queuing models of call centres. By far the most common model used is the Erlang-C model which takes the form of M/M/s. Although it is appealing because it is mathematically tractable, Koole and Mandelbaum note that the Erlang-C is often an oversimplification of the problem because modern call centres are far more complex than the Erlang-C representation. The authors list some of the complexities: there are now interactive voice response units, cross-trained staff, call centres can now be at more than one geographical location, there are time-varying arrivals and there are different types of customers.

Borst et al. (2004) addressed the following question using the Erlang-C model:

"*…how many agents are to be staffed in order to provide acceptable service quality and operational efficiency*?" (Borst et al., 2004, p18)

The authors use the model to determine optimal staffing levels, but a limitation of the methodology is discussed:

> "*…the call center environment enjoys many features that are not captured by the M/M/N (Erlang-C) model. Important examples are customer abandonment, time-varying arrival rates, nonexponential service times, and multiple skill classes*." (Borst et al., 2004, p32)

Betts et al. note two additional problems with the work of Erlang: demand must remain constant and the system cannot become too heavily congested. This is not the case with most call centres. Brown et al. (2005) state that research is currently is under way to develop methods to overcome the drawbacks of the Erlang-C. However, as Koole and Mandelbaum (2002) comment, when service times are no longer exponential (M/G/s queue) this type of queue becomes analytically intractable.

Other queuing models have additional benefits. Koole and Mandelbaum note the importance of blocking (when the system reaches some given capacity limit) and there are studies which use the Erlang-B (M/M/s/s). Other work took into account the number of queues (B) to form a new model, M/M/s/B. Koole and Mandelbaum note that this is known as Erlang-A: in the authors' opinion this is a better model than the commonly used Erlang-C model.
Markov models have been built to include some interesting aspects of call centres. Stolletz and Helber (2004) use a Markov queuing system to model two classes of customers and to have three groups of agents. There were benefits of pooling and specialisation.

Aguir et al. (2004) show that Markovian queues can be used to model balking, impatience and retrials. Balking occurs where callers do not join a queue if it is too long; impatience is the situation where the caller does not tolerate waiting to be served after a certain period of time and terminates the call, and retrials happen when the caller did not get served or get the outcome they wanted on a previous call so they attempt to call again. The authors note a common problem that there is no data on retrials. Aguir et al. make the point that a stochastic model is problematic in that it is computationally burdensome. The authors were able to show the importance of retrials on system performance.

Garnett et al. (2002) analyse the simplistic Erlang-A formula so that impatience of customers can be modelled. The use of the M/M/N+M model significantly changes the M/M/N model, which has an unlimited waiting capacity. A comparison showed that two different pictures could be conveyed depending on model choice. The authors note that by ignoring abandonment, wrong information could potentially be provided to managers.

Mandelbaum and Zeltyn (2008) model a call centre using the M/M/n+G where G is the generally distributed patience time of customers and n is the number of servers. In the Erlang-A formula, M/M/n+M, the patience times are exponentially distributed. The authors note that a problem of the Erlang-C model in that customers are assumed to have an infinite patience and will wait indefinitely until they are served.

Chassioti and Worthington (2004) present a model that includes a lot of the main features of a call centre. The authors discuss the use of discrete time modelling. The authors note that time-varying arrivals are not an obstacle to the model being used to find an optimal solution. Service time distribution is exact in this model. The model can deal with overloaded queues and a finite number of lines are incorporated into the model. Chassioti and Worthington's model proved to be a useful approach when compared to other approximations. Work is ongoing to include abandonment, balking and reneging.

Clearly, there are many examples of the use of queuing models in the call centre literature and they have proven to be useful in many of the studies. The next section considers the application of simulation in call centre modelling.

3.2.3 Simulation

The following is a review of some of the key papers of simulation applications. The advantages and disadvantages of simulation are also considered. Queuing models have proved to be useful and are exact for the systems they represent, but simulation can be used to take into account the new complexities associated with call centres. These complexities exist with the contact centre modelled as part of this research (see Chapter 5).

van Dijk (2000) recognises that queuing theory has become too restrictive and that many publications are now about technical issues rather than containing any general insights. It is noted that simulation is a useful tool to evaluate real-life situations. van Dijk discusses the possible use of a hybrid approach using both techniques. Queuing theory can be used to provide queuing insights and rules and simulation can be used to evaluate them. Avramidis and L'Ecuyer (2005) also suggest that because of the role of complexity and uncertainty, simulation modelling can play an important part in the decision making process. Simulation has a role to play in making better staffing decisions. Avramidis and L'Ecuyer criticise existing methods because of the following:

> "*Typically, call center planners solve a single-skill staffing, scheduling, and rostering problem as follows: they ignore (or model very crudely) the uncertainties and invert classical formulas such as Erlang-C (M/M/c, i.e., without blocking or abandonment) or Erlang-A (M/M/c+M, i.e., with abandonment).*" (Avramidis and L'Ecuyer, 2005, p145)

Avramidis and L'Ecuyer argue for the importance of simulation in call centre modelling.

> "*Simulation of call centers may involve large, complex models that incorporate some or all of the elements discussed above, notably: (1) uncertainty in many essential primitives, e.g., attrition, absenteeism, arrival rates, service times; (2) time-varying arrival patterns; (3) daily control; and (4) realtime control (routing and outbound dialing policies).*" (Avramidis and L'Ecuyer, 2005, p148)

Avramidis and L'Ecuyer note the importance of abandonment from other studies. It is of importance to model abandonment. The authors discuss that a key cause of the abandoned calls is staff, who are a bottleneck resource in the system. Avramidis and L'Ecuyer also discuss the importance of retrials, i.e. when a customer tries calling the service again. Like abandoned calls, retrials should not be ignored in the modelling process as they can have an impact upon the system. Simulation can incorporate both these features which was important for the modelling presented in this research (see sections 5.5, pp.155-163 and 6.5, pp.198-201).

Avramidis and L'Ecuyer conclude their paper with a significant argument that existing methods of call centre modelling are not adequate to model the growing complexities and uncertainties as well as sophisticated routing. Existing methods mentioned include queuing theory, optimal queuing control and stochastic programming.

"*Simulation appears to be the most viable option for accurate performance measurement and subsequent decision support*." (Avramidis and L'Ecuyer, 2005, p150)

Mehrotra and Fama (2003) discuss the challenges and opportunities for simulation analysis in call centres. The authors note the need for simulation modelling in the planning of contact centres. Three reasons are given for this: firstly, increased complexity, secondly, the rapid change in operations and finally the fact that computers are now more powerful with more software available. Mehrotra and Fama note that simulation can be used to run various different scenarios, which is another advantage of using simulation analysis. The authors see a continuing trend in complexity of call centres leading to the need for more detailed models. These considerations were taken into account in the modelling of this research in Chapter 5.

Klungle (1999) discusses the role of simulation in a claims call centre.

> "*The days of the "one size fits all" call center is fast eroding. With mass customization becoming more common place, calls can now be easily prioritized and routed to specific agents with multiple skill sets*." (Klungle, 1999, p1648)

Klungle discusses the use of workforce management systems by many call centre managers. They are used for forecasting and producing staff requirements. He criticises these systems because they are static. It is noted that discrete-event simulation is more dynamic in nature; it can be used to developed strategies and study alternatives. He comments that simulation has an important role to play in both process re-engineering and aiding continuous improvement. Klungle criticises the use of Erlang-C. Service level is a key input when deciding staffing levels using the Erlang-C formula, but during slow periods the goal is more or less always achieved, while during busy periods the service level is low. As a result of weighting the day equally, a distorted picture of performance is produced. Klungle, like other critics of the Erlang-C model, notes the problem of the use of the exponential assumption.

> "*…in today's technology driven environment, many of these assumptions are invalid and continued use of the Erlang model results in varying degrees of over staffing. Additionally, this model cannot be used for all of the "what if"*

scenarios that address call handling strategies, call center designs, and call routing options." (Klungle, 1999, p1650)

Klungle discusses other drawbacks of using the Erlang-C method. Agents are assumed to have only one skill and there are no call priorities. For the majority of modern call centres these assumptions are no longer valid. He presents a list of reasons for when it is a good idea to carry out a simulation project:

- *Analytical models not available*
- *Existing analytical models are too complex*
- *Static results of analytical models are insufficient*
- *Analytical models only provide averages, not variability and extremes*
- *Analytical models cannot identify process bottlenecks or recommend design changes*
- *Analytical models often cannot provide sufficient detail nor identify interactions*
- *Animation is a better method of demonstrating results to management*

Klungle, 1999, p1650

Klungle notes that simulation is a good technique to use for testing various scenarios including constructing alternative designs of the call centre in question.

Tanir and Booth (1999) discuss a call centre simulation in Canada. Tanir and Booth, like many others, note that Erlang-C is now an out-of-date technique in call centre modelling. The authors note the need for more advanced techniques such as a discrete-event simulation. Tanir and Booth chose simulation because of its ability to be used for experimentation.

"*The process of simulating something leads to a better awareness of the system*." (Tanir and Booth, 1999, p1645)

Like most simulation studies Tanir and Booth found the visual aspects of the model very helpful in verification. There is also another benefit of visual model building: it leads to rapid construction and lessens the need to get tied down in the simulation language.

Günal et al. (2008) study a police command and control centre. The authors use a problem structuring approach to gain sufficient appreciation of the problem. Discrete-event simulation was used to analyse alternative designs and various staffing levels. Günal et al. comment that discrete-event simulation is a common technique used in modelling call centres. Günal et al. also criticise Erlang C models:

> "*However, such models do not allow for callers who renege or balk after calling and are known not to cope well with systems that are occasionally highly congested*." (Günal et al., 2008, p174)

Günal et al. carried out a series of what-if studies with the use of expert opinion. Once the logic was correct, the authors were able to replicate the actions of the call centre. This allowed various different staffing scenarios to be run to test future performance. This is an important part of the call centre methodology. Simulation was a useful technique and a similar approach is presented in this research (see Chapter 5).

Saltzman and Mehrotra (2001) discuss how simulation can be used to drive strategic change. The study was brought about because managers at a software company had guaranteed that paying customers would have their call answered within one minute. There were concerns as to whether they would be able to meet this requirement under conditions of uncertainty. Simulation was chosen as the method to aid the authors in solving the goal. This was used as a way of testing different options. The authors discuss a whole host of reasons why simulation was chosen. The model will allow the inclusion of two types of customers. Simulation allows the inclusion of abandonment which is an important feature to include when modelling call centres and allow the performance measures to be outputted.

"*The managers saw our simulation analysis as a vehicle for mitigating risk*." (Saltzman and Mehrotra, 2001, p98)

Simulation has shown in the studies presented to be a useful technique for modelling call centres. This is discussed further in section 3.2.5 (p.98).

3.2.4 Synthesis of call centre modelling papers

Several studies have been reviewed in this section, and Table 3.2 provides a synthesis of these studies allowing easy comparisons to be made. The following fields are reported; author(s), country and date of the study, problem setting, the modelling approach used, and the key points of the study.

Author(s)	Country and date of study	Problem setting	Modelling approach used	Key points of the study
Aguir et al.	Europe, 2004	The authors investigate the impact of retrials on call centre performance.	Markov model	The authors were able to model balking, impatience and retrials. Aguir et al. do note an important problem: the stochastic model is computationally burdensome.
Avramidis and L'Ecuyer	Canada, 2005	The authors discuss the role of simulation modelling in call centres.	Simulation	Avramidis and L'Ecuyer discuss that simulation is a good technique for modelling call centres due to the complexity and uncertainty associated with call centres and note that existing studies using Erlang models ignore uncertainties in the modelling. The authors note some of the key advantages of simulation in that you can include features such as abandonment, retrials, attrition, absenteeism and time-varying arrival patterns.
Borst et al.	United States of America, 2004	The authors investigate the number of staff required to provide an acceptable level of service in a large call centre.	Erlang-C	The model is able to report the optimal level of staff required. However, the queuing model was not able to capture many of the key features of the call centre such as abandonment, time-varying arrival rates and multi-skill classes.

Author(s)	Country and date of study	Problem setting	Modelling approach used	Key points of the study
Chassioti and Worthington	United Kingdom, 2004	The authors propose a new model for call centre modelling.	Queuing model, discrete time modelling.	The authors were able to use a queuing model to include the many of the key features of a call centre and showed it to be a useful technique. Work is ongoing to include features such as abandonment, balking and reneging.
Garnett et al.	Israel and United States of America, 2002	The authors use queuing models to include the phenomenon of customers who are impatient and decide to abandon their call.	Erlang-A	The authors were able to model impatience using the Erlang-A model, abandonment is an important feature to include in any modelling of call centres. The authors were able to model a large call centre.
Günal et al.	United Kingdom, 2008	The authors improve the performance of a police call centre.	Simulation	Simulation was a useful technique to analyse alternative call centre designs and various staffing levels. Working closely with the client proved to be useful. Simulation allowed the authors to run various scenarios.

Author(s)	**Country and date of study**	**Problem setting**	**Modelling approach used**	**Key points of the study**
Klungle	United States of America, 1999	Klungle uses simulation to model an insurance claims call centre.	Simulation	Klungle notes one of advantages of simulation is that it can be used to model various customised call centres with the inclusion of all the complexities of modern call centres. Simulation is a good technique as animation is often a good way to present a model to problem owners. Klungle also discusses that simulation is a better choice of technique when analytical methods become too complex.
Koole and Mandelbaum	Netherland and Israel, 2002	The authors carried out a survey of queuing models of call centres.	Queuing models.	The authors note that the most common model is the Erlang-C model in call centre modelling. The authors note that is model is not able to account for the complexities that exist with modern call centres. The authors do note that Erlang-A and Erlang-B are better models than Erlang-C as the first accounts for the number of lines and the latter accounts for blocking.

Author(s)	Country and date of study	Problem setting	Modelling approach used	Key points of the study
Mandelbaum	Israel, 2004	Mandelbaum supplies a bibliography of publications related to call centres.	Not applicable.	The author presented many different studies of calls centres and it is shown that different types of modelling such as queuing models and simulation have a key role to play in the call centre modelling for both development and performance improvement.
Mandelbaum and Zeltyn	Israel, 2008	The authors investigate optimal staffing where there are many server queues with abandonment.	Queuing model	The authors note a problem of the Erlang-C model in that customers are assumed to have an infinite patience and will wait until they are served. By including a distributed patience time, a generalised Erlang-A model is used and is noted by the authors as a better choice of model.
Mehrotra and Fama	United States of America, 2003	The authors provide a tutorial into modelling of call centres using	Simulation	The authors note that there is an opportunity for simulation to be used to model contact centres as a result of the growing complexity of contact centres and rapid change in operations. Mehrotra and Fama were able to use the model to run various scenarios.

Author(s)	Country and date of study	Problem setting	Modelling approach used	Key points of the study
Royston et al.	United Kingdom, 2003	The authors use the case study of NHS Direct to show how Operational Research helps in achieving public service innovation.	Queuing model	Operational Research played a pivotal role in the development of NHS Direct. The modelling helped determine the size and staffing required to meet both demand and performance targets. Queuing models played a key role in this process and allowed for the various key performance measures to be reported.
Saltzman and Mehrotra	United States of America, 2001	The authors used simulation to investigate a change to a call centre. Paying customers were guaranteed their call would be answered within a minute. Call centre managers wanted to better understand the impact this would have upon the call centre performance.	Simulation	Simulation was a useful technique investigating call centre performance under a different policy. Simulation allowed for various scenarios to be run. The model allowed for the inclusion of more than one type of customer and abandonment. The authors believe the use of simulation will grow as the call centre industry grows as it has great potential to help call centre managers with their planning.

Author(s)	Country and date of study	Problem setting	Modelling approach used	Key points of the study
Stolletz and Helber	Germany, 2004	The authors were able to model an inbound call centre with two groups of customers and three different types of agents to carry out a performance analysis.	Markov model	The key benefit of the model is that the authors were able to incorporate different types of customers and agents. The authors allowed for customers to be impatient. The balance equations of the Markov process model were solved to report different performance measures.
Tanir and Booth	Canada, 1999	The paper is a discussion of the design of a simulation for a call centre in Canada.	Simulation	The authors chose to use simulation as they considered Erlang-C to be an out-of-date technique. It is noted that simulation is useful at gaining insight into problems. Simulation allowed the authors to carry out various experiments.
van Dijk	Netherlands, 2000	The authors illustrate that queuing models and simulation models should be combined.	Queuing models and simulation.	van Dijk notes that simulation is a powerful technique that can be used for evaluating real-life situations. It is a good technique for obtaining performance measures. One of the problems noted about queuing theory is that it is too detailed, mathematically complex and has become too restrictive.

Table 3.2: Synthesis of papers related to long-term care modelling

3.2.5 Contact Centre Modelling Conclusions

Traditionally, queuing models are the dominant method in call centre modelling. However, discrete-event simulation now presents itself as the most viable method in call centre modelling and will be used to model the Hantsdirect contact centre (see Chapter 5). Avramidis and L'Ecuyer (2005) note that simulation is a good technique for modelling call centres due to the complexity and uncertainty associated with them.

Many problems with using the Erlang-C distribution have been presented. Most importantly, it excludes many of the key features of modern call centres as noted by Koole and Mandelbaum (2002). Simulation can deal with all these aspects and can incorporate all the key features such time-varying arrivals, different types of callers, different types of call handlers, complex call routing, abandonment and retrials. Simulation is a useful tool and can improve the decision making process in call centres.

Günal et al. (2008) used discrete-event simulation to analyse staffing levels which will be useful for this study. Simulation allows for experimentation, as shown in the study by Tanir and Booth (1999). Another relevant point for this study is that simulation can output all the key performance measures as shown in many studies such as van Dijk (2000). Simulation is a good technique for gaining insights into call centre systems. Klungle (1999) notes another advantage of simulation is that it includes animation, which is a good way of presenting models to problem owners.

Saltzman and Mehrotra (2001) believe the use of simulation will grow as the call centre industry grows, as it has great potential to help call centre managers with their planning.

From the review of the literature, no examples were found of call centre models being used to study long-term performance changes. Any falls in performance are likely to lead to short- to medium-term corrections by call centre management, making long-term projections of call centres unnecessary. This does not mean it cannot be explored, and corrections might not always be able to be made as a result of resource and budget constraints. This is explored further in the hybrid model (see Chapter 6). Much insight can be gained from making long-term projections and this can potentially help call centre management to prepare in advance for potential performance issues.

3.3 Hybrid Modelling

3.3.1 Introduction

Two models were built as part of this research: one to model the system for long-term care and one to evaluate performance of the contact centre. The aim of this study is to build a hybrid model so that interaction can take place between the two models. The aim of this section is to gain an appreciation of previous research into combining modelling approaches and the circumstances in which it is advantageous to do so.

We decided to explore the impact of combining system dynamics and discrete-event simulation. All the papers in this review discuss the benefits of hybrid models, but none represent a true hybrid system of system dynamics and discrete-event simulation. Chahal and Eldabi (2008) describe a "true hybrid" as a model where there is no clear distinction between the two parts. The papers presented here all use two distinct methods, and all describe two distinct models which share information between them.

There are hundreds, if not thousands, of examples of papers which use either discrete-event simulation or system dynamics. Other papers compare the two methods, for example Tako and Robinson (2009). Part of this review will investigate the potential benefits of a combined approach. This review also discusses a selection of papers that combine discrete and continuous simulations from fields such as engineering and computer science. Whilst these models do not reflect exactly an OR understanding of system dynamics and discrete-event simulation, insight can be gained from them, although they are not a genuine hybrid of system dynamics and discrete-event simulation from an OR perspective.

Chahal and Eldabi (2008) explore the applicability of hybrid modelling in a UK health setting. The authors argue that a hybrid approach has the potential to help make better decisions in the health systems as well as improved insights into problem situations.

Three types of hybrid models are identified. The first is the hierarchical format, where the two models are treated separately but exchange information. The second format is the process environment format where the models are still separate and the discrete-event simulation approach sits within a larger system that is modelled using system dynamics. The third format is the integrated format. The authors note that there is no clear distinction between the two techniques in this format. The three formats will be considered as a choice of framework for this research.

Chahal and Eldabi argue that "*that hybrid simulation can aid decision makers in making effective and sustainable decisions*." (Chahal and Eldabi, 2008, p1475).

Fahrland (1970) comments that simulation languages had always either been continuous or discrete, and

"*…never the twain shall meet*." (Fahrland, 1970, p61)

Fahrland poses the question of why modelling should be thus limited, especially when (even back in 1970) problems were requiring interdisciplinary approaches. The author notes that the capabilities of both techniques could be combined to form a better representation of a problem situation. Fewer approximations would be needed since a better tool was being used. The new combination could lead to a better technique that can be used to solve more problems, many of which were avoided before. It should be noted that this was written in 1970 and was a discussion of continuous and discrete approaches, rather than specifically DES and SD. Fahrland comments that there must be strong feedback between the two models as well as interaction. This was case for the research presented in this research (see section 6.5, pp.198-201). If this were not the case, the models could be studied separately. Fahrland suggests a hierarchical approach to modelling. The models represent problem areas at different hierarchies and to varying degrees of detail.

Barton and Tobias (2000) also note that there is a traditional divide between discrete-event and continuous-time simulations. In another study, Barton (2000) describes hybrid systems as:

"*systems that exhibit both discrete state and continuous state dynamics. In addition, these two aspects of system behavior interact to such a significant extent that they cannot be decoupled and must be analyzed simultaneously.*" (Barton, 2000, p117)

Coyle (1985) discusses that there has been a traditional split in simulation modelling between discrete-event and continuous modelling. Coyle discusses how many problems need to be viewed from different standpoints. Many problems can be described either as an open-loop problem or a closed-loop problem. The problem Coyle discusses is when both types are needed. He then goes on to suggest a few remedies. Firstly, he suggests ignoring one of them! Secondly, he discusses how one could include feedback in a discrete-event model, although he then comments that discrete-event languages were never intended to do this. Thirdly, he suggests writing a new software package that incorporates both types of simulation, but comments that this is not only costly but also time-consuming to learn. Finally, he suggests representing stochastic processes in a continuous simulation language. After considering Coyle's remedies, it was decided that there is no additional benefit for combining the two models in a single environment for this research so this will not be explored. Two separate models will be created (see Chapters 4 and 5).

3.3.2 Hybrid Modelling Examples

Greasley (2005) used system dynamics for decision making while discrete-event simulation was used to understand the system's performance at a deeper level. Greasley's main objective was to run various scenarios in the production planning process. The initial DES model was able to explore various operational problems, but it was found that issues affecting the production process lay outside the remit of the original model. System dynamics was then used to look at these issues in order to understand the behaviour of the system as a whole. Greasley found discrete-event simulation to be a good complement to system dynamics. The models were not actually combined, but were used together to analyse the issues at hand. A similar approach is implemented in this research (see Chapter 6).

Donzelli and Iazeolla (2001) criticise existing process simulations in that they only look at certain aspects of the system. The authors comment that it is rare to find combinations of discrete and continuous types of simulation. The authors simulated a software process which has characteristics of both discrete and continuous systems. Donzelli and Iazeolla found the modelling process of great use and the modelling showed how the software process could be altered to meet specified targets.

Fowler (2003) comments that a hybrid model combining both continuous and discrete simulation provides an excellent medium for strategic analysis. Fowler discusses that traditionally in production management the most popular technique has been DES. It is argued that the level of detail needed for DES is unnecessary when exploring the decision making process in the operations strategy. Here is where there is a role for continuous simulation. Fowler argues that continuous types of simulation are close neighbours of discrete-event simulations, and have a role in strategic high-level processes because the level of detail required is not so great.

Rabelo et al. (2005a) observe that hybrid simulation modelling offers an improved approach and that potentially more confidence can be placed in its outcomes. The hybrid model is used to model two distinct parts of an organisation. This is the case for this research (see Chapter 6). A system dynamics model is used at a strategic level while a discrete-event simulation model is used at the operational level to model the actual manufacturing functions. The authors found the advantage of using system dynamics at a strategic level is that the technique is not "data hungry" in comparison with the detailed stochastic approach. At this high level, data are often not readily available and there are issues of accuracy. The authors also make the point that they are not attempting to carry out a thorough analysis at this level but want to explore the implications of various policy changes. Rabelo et al. also list two additional advantages of using system dynamics: it is not as complex to develop in contrast to DES, and it allows the researcher to incorporate qualitative factors.

The model has two-way interactions. The system dynamics model is used to project demand and this information is fed into the discrete-event model. The costs and units produced from the manufacturing process are fed back into the system dynamics model as a means to evaluate performance. Rabelo et al. comment that hybrid modelling is easy to validate. The reason for this is that system dynamics models are easy to validate in the authors' opinion (although this is not a view widely shared by system dynamicists). While discrete-event simulation can be problematic to validate, Rabelo et al state that in a hybrid methodology they are usually small models which can be validated without too much difficulty. Again, this is a somewhat contentious statement! The authors also point out that a hybrid methodology is a good mix of emphasis of long-term and short-term planning through the use of system dynamics and discrete-event simulation respectively, where the models are separate but information is shared between them. This is an important consideration for the hybrid framework presented in this research (see section 6.5, pp.198-201).

Rabelo et al. (2005b) found in another study that discrete-event simulation alone could not capture all the required effects. The authors present the potential need for an integrated system and propose a hybrid simulation approach to the problem. The authors criticise Operations Research techniques because generally they claim they are too reliant on simplifying assumptions which limit their use in real life situations. Production decisions are made in tactical stochastic models while the high level business decisions are made using the system dynamics approach. Information is fed to and from the models, including business decisions and performance of the production process. Rabelo et al. suggest a list of reasons for the use of system dynamics; it gives a holistic view of a system, it looks at policy decisions, feedback loops are very useful, and minimal data are required to build a model. The authors also make an interesting point that the models are often more intuitive than stochastic models. They argue that hybrid modelling can potentially be simple yet very effective; the goal of hybrid modelling is to build a tool that is useful for both decision making and performance analysis. Communication in the model is through a database which is used to exchange data between the two modelling types. The authors note that an important part of the modelling is aggregation and disaggregation of data so it can be used appropriately by either of the individual models. A system of automatic data transfer was not built. Each model was run separately and data were exchanged manually. This was done for a ten-year period over which the authors observed performance. The same approach was used in this research (see section 6.5, pp.198-201)

Mušič and Matko (1999) discuss continuous and discrete-event simulations and comment how each one has a specific role and takes on a certain view of a system. Using only one of the techniques could, the authors say, lead to several interactions being ignored which could have an impact upon the solution. The authors suggested two differing ways of implementing a joint approach. Firstly, they suggested simulating the continuous part of the model as part of the discrete-event simulation. Secondly, the idea of a hybrid methodology was put forward. Some parts of the system are modelled in the continuous part of the model while others are simulated in the discrete part. Some of these parts are dependent on outcomes of the other model. It is suggested that the hybrid approach is simpler. Information is exchanged via an interface. An Excel interface was used in this research (see section 6.5, pp.198-201).

Rabelo et al. (2003) propose a hybrid framework because of the limitations of a discrete-event simulation framework. They argue that discrete-event simulations do not capture decisions that affect the entire organisation. The authors present an example to show the merits of the joint framework but use two distinct models. The authors note how system dynamics is used to capture interactions between various parts of the system and to show the effect of delays within a system. This is why the authors propose the combined framework; system dynamics is used to handle the limitations of the stochastic modelling and discrete-event simulation is used to represent smaller parts of the overall system. System dynamics was used to model strategic decisions related to high level allocation of financial resources, whereas DES was used to model the functions of the manufacturing plant. Feedback from the stochastic model is fed into the system dynamics model which in turn updates the provision of resources. The authors found the system dynamics model useful at capturing long-term effects of the various decisions that were made. The combined methodology has shown to be potentially beneficial.

Venkateswaran et al. (2004) present a hierarchical model of the hybrid methodology. System dynamics is used for higher-level decision making and discrete-event simulation is used for lower-level decision making. Venkateswaran et al. use SD to evaluate decision making, and scheduling decisions are made using DES. The SD model is used to capture the dynamics of production and inventory which are both influenced by decisions on the shop floor. The shop floor needed to be modelled in great detail to capture the operations correctly. This fits in with the remit of the discrete-event simulation framework. The ability of system dynamics to model dynamic complexity was ideal to analyse the impact of decisions made for the whole organisation. DES is generally used for performance measurement. Venkateswaran et al. comment that it is a technique that has been widely used for the design and operation of manufacturing systems. Two explanations are provided for this: firstly, it can model complex operations and include randomness; secondly, individual entities and resources can be tracked in the model.

The two models share information. For example, the sales quantities to be produced in the DES model are received from the SD model. This exchange takes place at every time step in the SD model. The SD model in turn obtains information from the DES model. The authors propose an interface between the two models using a High Level Architecture and RunTime Infrastructure with the use of a distributed Manufacturing Simulation Adaptor. The two models are separate but experimental results present the need for the hybrid framework.

Venkateswaran and Son (2005) comment that Hierarchical Production Planning is generally a two-tier process, one tier for higher level decision making and the other for detailed scheduling. The authors discuss some of the main limitations of existing models. The main problem is that there is no interaction between the two levels. There is a need to analyse the impact of decisions made at each level upon the other ones. They therefore use a hybrid framework. They also review other papers such as work by Rabelo et al. (2003) and criticise these existing models in that the integration of the hybrid model is not thoroughly addressed. It is noted that the Higher Level Architecture is one of the main ways of interfacing distributed simulations. The authors began the validation and verification of the models by testing them individually. Secondly, the system dynamics model's integration with the planned optimiser was tested. Thirdly, what was being exchanged between the system dynamics model and the discrete-event simulation model was inspected. At the end of this process, the framework was successful in achieving its aim of using both the methods to address a problem situation.

3.3.3 Synthesis of Hybrid Modelling Papers

Several different studies have been reviewed and Table 3.3 provides a synthesis of the various studies allowing firm conclusions to be made. Various fields are reported: author(s), country and date of the study, problem setting, the modelling approach used, and the key points of the study.

Author(s)	Country and date of study	Problem Setting	Key points of the study
Barton	United States of America, 2000	The paper discusses the modelling of hybrid systems.	Barton provides a detailed discussion on hybrid simulation. The technical aspects of the framework are well discussed.
Barton and Tobias	United Kingdom, 2000	The authors present a method for combining continuous models into a discrete model.	The authors note there is traditional divide between continuous simulation into a discrete-event simulation models.
Chahal and Eldabi	United Kingdom, 2008	The authors explore the applicability of hybrid modelling in a UK health setting.	The hybrid framework is shown to be a useful approach to UK health areas. Better decisions can potentially be made and valuable insights can be gained into problem areas. Different hybrid frameworks are presented.
Coyle	United Kingdom, 1985	Coyle discusses representing discrete-events in the system dynamics model. The application is demonstrated for the coal mining industry.	Coyle notes the importance of viewing a problem from different standpoints. The hybrid framework is good when you have both open and closed loop problems. Different integration methods are discussed.

Author(s)	Country and date of study	Problem Setting	Key points of the study
Donzelli and Iazeolla	Italy, 2001	The authors discuss the hybrid simulation in the application of modelling the software process.	The process has both characteristics of discrete and continuous systems. The framework is able to capture all the dynamics of the system in question. The authors find the modelling to be flexible and highly adaptable.
Fahrland	United States of America, 1970	Fahrland provides a detailed discussion into combining discrete-event and continuous systems.	Hybrid simulations can provide a better representation of a problem and more problems can be solved. A limitation of the paper is that it was written in 1970.
Fowler	United Kingdom, 2003	Fowler presents a discussion of the use of systems thinking and simulation managing dynamic processes.	Fowler notes that the hybrid framework is a good way of exploring dynamic behaviour. The framework allows for strategic analysis. Fowler notes that the two techniques are closely linked.
Greasley	United Kingdom, 2005	The study uses system dynamics and discrete-event simulation in a manufacturing plant.	System dynamics is used for decision making whilst discrete-event simulation can be used to model system performance. The two models complimented each other well. System dynamics captured issues that affected the production process. This is something that cannot be captured by using a discrete-event simulation model alone.

Author(s)	Country and date of study	Problem Setting	Key points of the study
Mušič and Matko	Slovenia, 1999	The authors present a combined simulation tool for the production process.	A key point made in the paper is that by using both methods, important interactions in the system are not ignored. The authors were able to test various strategies.
Rabelo et al.	United States of America, 2003	The authors analyse the production decisions and application of the hybrid framework.	The authors argue that discrete-event simulation alone does not capture decisions that affect an entire organisation. This is overcome by using system dynamics and discrete-event simulation is used to represent a smaller part of the system.
Rabelo et al.	United States of America, 2005a	The authors use the hybrid framework to analyse global supply chain decisions.	The authors note that one can potentially take more confidence from the outcomes and the framework allows for distinct parts of an organisation to be modelled. Both strategic and operational levels can be modelled. The authors discuss that the validation process is easy for the hybrid framework. The framework allows for both short- and long-term planning.

Author(s)	Country and date of study	Problem Setting	Key points of the study
Rabelo et al.	United States of America, 2005b	The authors analyse the production decisions and application of the hybrid framework.	One of the key findings of the study is that by using discrete-event simulation alone, one cannot capture all the effects. Rabelo et al. suggest using system dynamics as one can take a holistic view of the system in question. The authors are able to form a manual way of exchanging data between the models and this proved to be useful.
Venkateswaran et al.	United States of America, 2004	The authors apply the hybrid framework to production planning.	The authors are able to use system dynamics for higher-level decision making and discrete-event simulation for lower-level decision making. System dynamics is ideal for capturing decisions that affect the whole organisation.
Venkateswaran and Son	United States of America, 2005	The authors apply the hybrid framework to production planning.	The authors consider hierarchical production planning as a two-tier model and criticise existing models for not having interactions between the two. Decisions at each level affect each other. A hybrid framework overcomes this.

Table 3.3: Synthesis of papers related to hybrid modelling

3.3.4 Hybrid Modelling Conclusions

There has been a traditional divide between the two types of modelling but, as shown in the studies reviewed, there are many benefits of an integrated system and there is a need for it in certain situations. There is a clear benefit for a combined system and this was explored in this thesis (see Chapter 6). Chahal and Eldabi (2008) argue that the hybrid approach could potentially help make better decisions in health care systems. Many authors describe the modelling framework as robust.

None of the studies were a true combined system of system dynamics and discrete-event simulation but it has been shown that the use of the two approaches separately to address various problems is beneficial. This is the approach that will be undertaken in this study (see Chapter 6). There are benefits to having two separate models and they can exchange information via an interface as part of a hybrid framework. In addition to this, the review of papers that combine discrete and continuous simulations helps provide a rationale for proceeding with a hybrid framework in this study.

Of course, people prefer to use the tools with which they are most familiar. OR modellers tend to be more comfortable with either SD or DES, but not both. A system dynamicist would not naturally select discrete-event simulation to solve a given problem, but would start by trying SD until it became obvious that this approach was inappropriate. In the Hampshire study, cell-based models are ideal for modelling a system for long-term care provision. However, cell-based models would not be a good approach to modelling a contact centre. Discrete-event simulation is ideal for contact centre modelling. Thus, the approach taken in this study in Chapter 6 is to use a cell-based model to model the system for long-term care, but to model a specific part of it (the contact centre) using DES. Chahal and Eldabi (2008) describe this as a *process environment* format. Having two separate models has been useful in answering many different questions posed by the various researchers in the studies that have been reviewed.

The following is a summary of some of the key benefits of a hybrid framework, all of which are relevant to this research. Donzelli and Iazeolla (2001) argue that the framework is able to capture all the dynamics of the system in question and this will be important for this thesis; Fahrland (1971) notes that it forms a better representation of a problem situation. The study by Greasley (2005) found the two techniques complement each other well. It is argued by Rabelo et al. (2005a) that one can potentially take more confidence from a hybrid framework and that the framework is good for both short- and long-term planning. The hybrid framework allows different scenarios to be run. The combination of two separate models is beneficial where information is shared between them. Rabelo et al. (2005b) have shown that the framework can be useful even when there is no automated link. This approach is taken in this study and is illustrated in section 6.5 (pp.198-201).

There are no published examples in the Operational Research literature of a successful application of the use of the combined models in the area of social care and the aim of this study is fill this gap.

3.4 Literature Review Conclusions

Three distinct areas have been explored in this literature review: long-term care models, call centre models and hybrid models. It has been shown that there is no model in the OR academic literature of the system for long-term care at the local level in the United Kingdom. Cell-based models can be used to model the system for long-term care in Hampshire in both the short- and long-term (see Chapter 4).

Discrete-event simulation is a proven technique for modelling a contact centre such as Hantsdirect. No examples were found where the model was used to model the long-term performance of a contact centre. This is something that is be explored in this thesis (see Chapter 6).

In the review of hybrid literature, it has been shown that there are very clear benefits to having a combined approach. There are no examples of a hybrid approach in the health care modelling Operational Research literature and this study will aim to fill this gap in a social care context (Chapter 6).

3.4.1 A Comparison of Operational Research and Social Science Literature

The literature for long-term care models was split between the disciplines of Operational Research (OR) and Social Sciences. However, the research in both areas has attempted to address very similar issues. For example, the work by Hare et al. (2009) and Lagergren (2005) from the field of OR are comparable to the work by Wittenberg et al. (2006). The difference between the two methodologies is terminology. Lagergren (2005) and Wittenberg et al. (2006) both implemented the models as spreadsheet models. From the field of Social Sciences, the technique is known as a cell-based (macro-simulation model) and from OR, the technique can be known by a variety of names such as spreadsheet models, deterministic simulation models or more commonly as compartmental models. Despite this name difference the techniques are identical and are based on the same theories. Other similarities can be shown by the work by Hare et al. from the field of OR and Rickayzen and Walsh (2002) from the field of Social Sciences. Hare et al. (2009) call their model a Deterministic multi-state Markov model. Rickayzen and Walsh (2002) call their model, which is similar, a Multi-state model. The work by Rickayzen and Walsh (2002) is a Markov model implemented with discrete time steps just like the work by Hare et al. (2009).

It is important that these two disciplines work closely together to address a very important issue. Lessons can be learnt from each, as well as comparisons between results. This will help policymakers across the world to potentially make better decisions and therefore best practices can be learnt. This is already being done, for example Wittenberg et al. (2006) reference work by Marten Lagergren. Hare et al. (2009) reference work by the PSSRU unit. It is important that this continues and develops so that researchers from both fields work together so improved predictive models can be potentially created.

4. The long-term care model

This chapter presents the long-term care model. We discuss the choice of modelling methodology, the model structure and the assumptions made. This chapter also includes a detailed discussion of the data used for the model, and the methodology used to analyse these data, as well as the overall validation and verification process.

4.1 Choice of modelling approach

It became evident from the literature review (see section 3.1, pp.53-81) that either a cell-based model or a system dynamics model would be appropriate to address the modelling needs of this investigation. The model was eventually constructed as a cell-based spreadsheet model.

Many key lessons have been learnt from the literature review and these have helped inform the choice of technique. Some of the key points are that the modelling should allow for a significant period of time to be modelled, such as the work by Wittenberg et al. (2006), a variety of scenarios to be run such as the work by Lagergren (2005). There is a clear need to model at the regional level in the UK and to model the population by disability as well as the various forms of care provision. Existing papers which do model at the regional level, such as Xie et al., only model one part of the system. Cell-based modelling allows for these important considerations to be accounted for.

The cell-based model uses the same logic as a system dynamics model in terms of moving a population through different compartments. Each compartment represents an age group which is further broken down by level of disability and main service receipt. Due to the lack of relevant data, it was decided not to include feedback effects but to treat the model as a population projection model. This is not a weakness of the model, as the fundamental objective of projecting the demand for long-term care is still achieved. The inclusion of feedback would have relied on assumptions based solely on expert judgement. This would have been a weakness of the model and would have added no additional value.

The model was constructed as a spreadsheet model as the features that were needed could be constructed within Microsoft Excel (Microsoft 2010) and hence the model could be easily shared with Hampshire County Council. This will increase the chances that the results will have an impact upon future planning of social care in light of an ageing population. The model will henceforward be referred to as a *Cell-Based Model*.

As with system dynamics, individuals cannot be traced in the model. It is not of importance to track individuals within the model: we only need track the population totals with in each compartment and the predicted changes over time.

Thus all transitions in the model depend only on the current state and are not dependent on the past history. This is not a problem in our case as modelling is not required at the individual level, where personal history clearly is relevant.

4.2 Choice of Software

The model has been built using the spreadsheet software, Microsoft Excel. The model can be found on the compact disc attached to this thesis under the file name *Population Model.xls*. A user guide for the model can be found in Appendix A1.

4.3 Population Data

The following data were required:

1) Hampshire population forecasts, for each individual year of age, for people aged sixty-five and over from 2009 through to 2026. The model required forecasts for the "household" population only, i.e. just people individuals who are not in residential care, since these people were excluded from the model (See section 4.3.2 (pp.119-120) presents the rationale for this decision).
2) The associated mortality rates for this population.
3) The associated "in" and "out" migration numbers for this population.

Much time was spent trying to get hold of the best population forecasts. The Hampshire County Council Environment and Planning Department (Hampshire County Council, 2011) were only able to provide data by five-year age band and only for the entire elderly population (i.e. not just the household population). HCC do not collect the necessary mortality or migration data so this data was sought elsewhere.
Discussion with two departments within the Office for National Statistics (ONS) (Office for National Statistics, 2011a) proved to be useful but again data in the correct format were not available. The only data made available were for the whole population of Hampshire, i.e. not just the household population, although these were available by individual age. The associated mortality and migration data were available from the ONS. Eventually, household data was made available from the Communities and Local Government Department (CLGD) via personal communication to the author. One disadvantage of these data was that they were only available by 5-year age group. There was neither mortality nor migration data. A resolution to both these issues was found and is discussed in section 4.3.4 (pp.121-124).

In summary, population data used came from the following two sources:

- Communities and Local Government Department
- National Statistics Subnational Population Projections Unit

The data provided by the CLGD were considered the best source of population data.

We were not given permission to report exact population figures. For the purposes of this thesis only percentages and data rounded to the nearest one hundredth will be discussed. Given the degree of uncertainty in the base estimates, there is considerable scope for error when discussing exact figures when examining population data. Trends and percentage changes can command much more confidence.

4.3.1 Methodology and data sources for creating the population dataset

The data used from the National Statistics Subnational Population Projections Unit are based on 2006 estimates, and thus any results from 2007 onwards are based on projections. This data was provided by personal communication to the author. The following is a brief review of the methodology used by the Office for National Statistics (2008) for making these projections. Recent demographic data are used to form future population projections. 2006 mid-year population estimates are used as a starting point. Projections were made by ageing the previous year's population by one year. Births and deaths are accounted for using local fertility and mortality rates. After this the population is adjusted to account for both internal and international migration. A control is carried out at the end to ensure the projections match national projections. The whole process was repeated for each year of the projection period. It is important to note that the home and foreign armed forces are treated as two separate static populations in the projection model.

The data required for this are captured from a variety of sources. Local level births and deaths are taken from registered births and deaths over the period 2002-2006. A key source for capturing internal migration (movement with England) is the General Practitioner patient records. A few different sources of data were used to capture international migration. Movement between England and the rest of the UK was captured by using five years of General Practitioner patient data. A key source of data for international migration between England and the rest of the world is the International Passenger Survey (Office for National Statistics, 2011b), and secondly asylum seekers are captured using data from the Home Office and the National Asylum Support Service (Home Office, 2011). Movement between the United Kingdom and the Republic of Ireland is captured using the Irish Quarterly National Household Survey (Central Statistics Office Ireland, 2011).

The Office for National Statistics (2007b) notes some points of caution. The projections only hold true if the assumptions of fertility, mortality and migration are valid. The ONS notes that any small changes in these assumptions can cause large deviations in the predictions, and this uncertainty increases the further out projections are made into the future. Finally, internal migration might not capture all internal movements within the country.

Like the data provided by the ONS, the data provided by the CLGD are based on 2006 projections. Unlike the previous dataset, however, data were provided only in five year age bands. Projections are from 2007 onwards. Population projections from CLGD are based on subnational populations projections provided by the ONS. Subnational population projections are for the different regions of England such as Hampshire. Projected household membership rates are applied to this data. When creating data at the household projection level, marital and cohabiting status is of importance (CLGD, 2009). Data on these factors were obtained from the Government Actuary's Department (Government Actuary's Department, 2011), using the 2003 base data. As this dataset is for England, the Local Authority projections were created using data from the 2001 Census as well (Office for National Statistics, 2011c).

These projections are for the household population and thus do not include the institutional population. The CLGD (2009) defines this as anyone not living in a private household. The number of households is calculated by the CLGD using a household representative rate. This rate is calculated from census data as well the Labour Force Survey (Office for National Statistics, 2011d). Once all the data have been collected, the CLGD (2009) summarise the process as:

"*…the household projections are compiled by applying projected household membership rates to a projection of the private household population disaggregated by age, sex and marital/cohabitational status and summing the resulting projections of household representatives*." (CLGD, 2009, p3).

4.3.2 Study time period and study population

A seventeen-year time period was chosen for investigation, from 2009 until 2026. 2026 was chosen as the cut-off point in the Wanless Report (Wanless, 2006) as well. Given the size and complexity of the model, a longer time period would have exceeded the capabilities of Excel 2003. Moreover, the accuracy of the projections decrease year on year, so a seventeen-year time period was considered sufficiently long for the results to be meaningful and confidently reported.

The research described in this thesis relates to the household population only. People who are in an institution of some sort are excluded from this study. The household population was chosen in preference to the total population because the disability rates and service receipt rates for the county of Hampshire are based on the 2001 General Household Survey (Economic and Social Data Service, 2001). This is a national survey (Great Britain) whose participants are taken from the household population. The following assumptions were made:

Assumption one: The proportions of disability within the elderly household population in the 2001 General Household Survey is assumed to be the same in the elderly household population in the county of Hampshire in 2009.

Assumption two: The proportions of main service receipt (i.e. the main source from which people obtain care) within the elderly household population in the 2001 General Household Survey will be assumed to be the same in the elderly household population in the county of Hampshire in 2009.

These assumptions will not be applied to the non-household population, as disability rates will not necessarily follow the same pattern. It is likely that proportions of disability are much higher than the household population because the majority of people in the institutional population live in residential or nursing homes. The service receipts studied in the General Household Survey are different to people offered in the non-household population. This thesis is therefore concerned solely with the elderly household population.

4.3.3 National Statistics Subnational Population Projections Unit Data Format

As described above, household population projection data were provided by the CLGD for the 17-year study period. The following variables were available in the dataset.

- Calendar year
- Gender (Male, Female)
- Age group: 65-69, 70-74, 75-79, 80-84 and 85 and over

- District
  - Basingstoke and Dean
  - East Hampshire
  - Eastleigh
  - Fareham
  - Gosport
  - Hart
  - Havant
  - New Forest
  - Rushmoor
  - Test Valley
  - Winchester

4.3.4 Combination with ONS Data

The model required data to be broken down by individual year of age allowing for changes to be made to the migration and mortality numbers associated with each age. This level of detail was not provided for the household population dataset. The data provided by the CLGD were manipulated in the following way after discussion with Professor Jane Falkingham, a highly experienced demographer at the University of Southampton. Initially, an attempt was made to try to create a dataset of the associated mortality and migration data. This was only available for the total population dataset and not for the household population. Data from the ONS were reanalysed for the purposes of this research. The validity of the mortality and migration data was checked, as an error was found during the data cleansing process. The projections were recreated using 2009 as the base year and the population was projected forward using the mortality and migration data. There were discrepancies between the projected data and the original dataset. The errors were slight for each year, but the overall difference was significant for the latter years of the projections. This was doubled checked by the ONS, but they regarded the issue as minor. Data that are made publicly available are rounded to the nearest thousand population, so small discrepancies are inevitable. The error was due to a bespoke piece of ONS software. It was assumed that the error was with the migration rate, which is derived from several different datasets. Net migration is made up of both internal as well as international migration. Using the population projections and the mortality numbers, a new set of net migration data was created. This was created by calculating the net population change and subtracting the number of people of projected to die. This was done for each individual age by gender.

The Hampshire household data from the CLGD were reconfigured by scaling in proportion to the individual age data from the ONS, for each district and each gender, in order to allow a range of scenarios to be run under different assumptions about migration rates. There is uncertainty around future migration trends, and migration is a key driver of long-term care. For each five-year age band, the proportions of people at each individual year of age were calculated using the ONS data. Then the 5-year age group totals in the CLGD data were scaled by the individual age proportions previously calculated from the ONS population data. The final result was a set of household data broken down by individual age.

The next step was to try to derive a set of plausible mortality and migration figures. To achieve this, it was assumed that migration only occurs in the household population. This is a credible assumption as one would expect movement within the institutional population to be minimal. An alternative was tested for people aged 85 and over. It was assumed that half the migration would be migration into the institutional community. The probability of requiring an institutional care service is quite high for people aged over 85. The new household population dataset and existing migration data was used to create a new set of mortality data using equation. This was calculated by finding the net population change in the household population and then adjusting this for net migration. This was done for each individual age by gender.

Unfortunately, the mortality figures for the first year in each age group (65, 70, 75 and 80) were higher than the total mortality for the equivalent age for the whole Hampshire population. This was because the method used to obtain individual ages gave rise to a significant gap between the last age of one age group and the first age of the next age group. Hence, the approach was modified. The scaling was altered by adjusting and smoothing the slope. The basic principle for each age group was to increase the number of people in the first two ages of the age group and decrease by the same amount the proportions of people in the last two ages of the age group. This was tested under various proportion changes and it was found that the results were highly sensitive to small changes in these proportions. Although adjusting the proportions would remove the original errors, new (and greater) errors were caused in the other ages. Thus this approach was rejected for most age groups, although it was applied to the 80-84 age band. It is likely that within this age group many people, as they age, will move into the non-household population. The proportion of people aged 80 was increased by 0.009%; people aged 81 were increased by 0.0045%, people aged 82 were left unchanged, people aged 83 were decreased by 0.0045% and, finally, the proportion of people aged 84 was decreased by 0.009%. No alterations were needed for people aged 85 and over as these were treated as a single figure.

In summary, the following two assumptions were made:

Assumption three: The household population distribution for each age is the same as the whole Hampshire population for people aged 65 to 79.

Assumption four: Assumption three does not hold for people aged 80-84, for whom the modified proportions described above were used.

Since credible mortality and migration data could not be obtained, a single number approach was chosen. This single number represents the net combination of the mortality and migration numbers. This number will be henceforward known as the *net population change*. This number is the decision variable which can be altered under various scenarios within the model. Net population change was calculated using equation (1).

$$n_{agt} = h_{agt+1} - h_{agt} \quad (1)$$

where

n_{agt} - is the net population change for those aged *a* (ages from 65-85+), gender *g* (male, female) at calendar year *t*

h_{agt} - is the household population aged *a*, gender *g* at calendar year *t*

This calculation was carried out for each calendar year of the modelling period. The re-proportioned household data and net population change data was used in the model (see section 4.6, pp.137-139). Now that the household population of each age group in Hampshire has been calculated, the next step, to work out the number of people in the various disability categories within each age group. Firstly, the data is discussed in section 4.4 (pp.124-131) and then the equation applied in the model structure is found in section 4.6 (pp.137-139).

4.4 Disability Rates

Disability rates were required to calculate the proportion of the household population of Hampshire with some sort of incapacity. From this, demand for long-term care can be deduced. Disability data were obtained from the 2001 General Household Survey data via the Economic and Social Data Service (ESDS). The data were downloaded and analysed using the statistical package SPSS (SPSS, 2011). The disability data was based on the 2001 GHS dataset, the latest dataset which includes relevant data on disability.

There are some difficulties with using survey data from studies (such as the GHS) which are based on self-assessment. Respondents may not have understood the questions asked, and some people may not wish to admit they have a problem or need help. There are issues around using self-assessment of need. It can be argued that if a professional were to carry out the assessment, a more accurate assessment of disability would be attained. Nevertheless, the GHS was still the best available source of information to address the research questions in this study. The categories selected from the GHS were the following;

- Five age groups (as above)
- Four disability categories (none, slight, moderate, severe)
- Gender

It was decided not to break down the categories even further as the total numbers in each category would be reduced significantly and the meaningfulness of the results would be questionable.
The disability index was created using an updated version of the Townsend Index (Townsend, 1962). Shanas et al. (1968) note the original Townsend Index was designed to test daily activities that would allow a person to maintain an independent lifestyle. The original index has been updated in the current study with new activities from the 2001 GHS. The methodology was used by authors such Arber et al (1988) based on the 1980 GHS. Arber et al note that the GHS has a high response rate and large sample size. They observe that it is not representative of all older people in that it focuses on older people living in the community, however they did not consider it to be a problem. Bebbington and Davies (1983) also employed the 1980 GHS data to create an index of disability.

The updated methodology was applied to create a disability index in this thesis. The range of responses on how difficult an individual finds the activity has been changed to take into account the new responses in the 2001 General Household Survey. The updated Townsend index score is based on the following six activities.

1. Walking up/down stairs
2. Walking indoors (getting around the house)
3. Getting in/out of bed
4. Having a bath
5. Cutting one's toenails
6. Walking outdoors

Assumption five: An equal weighting was applied across all six activities, i.e. no particular activity was considered more or less important than any other.

These questions have an inherent hierarchy built in. For example, those who to use the stairs on their own and find it very or fairly easy are not asked questions around getting around the house or getting in and out of bed.

The updated Townsend Index was constructed in the following way. For each activity a person can score 0, 1 or 2. Each activity has two questions related to it. A score is calculated for each activity in the following way. Each respondent starts with a score of zero. The first question for each activity is used to determine if the respondent can carry out the activity by themselves, or with the help of someone else, or not at all. If the respondent can carry out the activity on their own they score either 0 or 1 depending on how easily they can carry out the activity. This is determined by the response to the second question of the activity. If they also respond that they can carry out the activity very easily they score zero. If they respond that they find the activity fairly easy, fairly difficult or very difficult to do on their own they score 1. If they cannot carry out the activity on their own or not at all they score 2. The following questions were selected from the 2001 General Household Survey. The questions can be found in more detail in Appendix A2.

7. Stairs. *Do you usually manage to get up and down stairs or steps on your own, only with help from someone else, or not at all?*
8. StrsEasy*. Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

11. House*. Do you usually manage to get around the house (except for any stairs) on your own, only with help from someone else, or not at all?*
12. HouseEasy*. Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

19. Bed*. Do you usually manage to get in and out of bed on your own, only with help from someone else, or not at all?*
20. BedEasy*. Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

33. Toenails. *Do you usually manage to cut your toenails yourself, or does someone else do it for you?*
34. TnailsEas. *Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

38. Bath. *Do you usually manage to bath, shower or wash all over on your own, only with help from someone else, or not at all?*
39. BathEasy. *Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

57. Walk. *Do you usually manage to go outdoors and walk down the road on your own, only with help from someone else, or not at all?*
58. WalkEasy*. Do you find it very easy, fairly easy, fairly difficult or very difficult to do this on your own?*

Adapted from the 2001 General Household Survey, p40-51

The questions relating to toenails are different from the other activities in that there are only two possible outcomes for the first question. For this activity the person would score two if they need someone else to help cut their toenails. A cumulative score is calculated – clearly, given six activities the total score can range between zero and twelve. Depending on this score the person is then put into one of the following four disability classes:

- No incapacity
- Slight disability
- Moderate disability
- Severe disability

A similar scoring system to that used by Arber et al (1988) was applied. Arber's disability categories "severe" and "very severe" are treated as one category, Severe. The scores were recoded in SPSS so that if a person scores zero they are classed as having no incapacity; if they score 1 or 2 then they are classed as having a slight disability; a score between 3 and 6 denotes a moderate disability; and a score of 7 or more denotes severe incapacity.

People were classified in SPSS as belonging in one of the following five groups: 65-69, 70-74, 75-79, 80-84 and 85 and over. The data were also classified by gender.

Table 4.1 summarises the number of respondents and Table 4.2 summarises the final disability rates that were used in the model. The data are presented graphically in Figures 4.1 and 4.2.

Gender	Age Group	Disability Classification				
		No Incapacity	Slight Disability	Moderate Disability	Severe Disability	Total
Male	65-69	213	129	101	36	479
	70-74	134	114	139	39	426
	75-79	54	76	120	40	290
	80-84	27	45	86	29	187
	85+	6	15	41	30	92
Female	65-69	190	130	136	41	497
	70-74	119	116	170	75	480
	75-79	82	82	173	90	427
	80-84	31	46	130	78	285
	85+	26	9	72	86	193

Table 4.1: Disability Classification Counts

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

There were 1,474 male respondents and 1,882 female respondents. The sample size was considered large enough for the purposes of this thesis. An important point to note is that the number of respondents decreases as the age increases. This is to be expected, a) because the overall number of people in each group in the national (Great Britain) household population naturally decreases with age, and b) the potential sample is also reduced by the fact that increasing numbers of people will have moved into an institutional facility as they age. These two effects reduce the sample size.

The data in Table 4.1 were used to calculate the proportions in Table 4.2. The percentages represent the proportion of each disability classification within each age group.

Sex	Age Group	Disability Classification			
		No Incapacity	Slight Disability	Moderate Disability	Severe Disability
Male	65-69	44.47%	26.93%	21.09%	7.52%
	70-74	31.46%	26.76%	32.63%	9.15%
	75-79	18.62%	26.21%	41.38%	13.79%
	80-84	14.44%	24.06%	45.99%	15.51%
	85+	6.52%	16.30%	44.57%	32.61%
Female	65-69	38.23%	26.16%	27.36%	8.25%
	70-74	24.79%	24.17%	35.42%	15.63%
	75-79	19.20%	19.20%	40.52%	21.08%
	80-84	10.88%	16.14%	45.61%	27.37%
	85+	13.47%	4.66%	37.31%	44.56%

Table 4.2: Disability Classification Proportions

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

The proportions of people with disability increase with age, as expected. There are some fundamental gender differences in the sample. For people aged 65-69, 71% of males have no incapacity or a slight disability, whereas for females the figure is 64%. For people aged 85 and over, these numbers fall to 23% for males and 18% for females. Furthermore, 29% of males aged 65-69 have a moderate or severe disability, increasing to 77% for males aged 85 and over. However, 36% of females aged 65-69 have a moderate or severe disability. The proportion of females with a moderate or severe disability increases to 82% for people aged 85 or over, significantly higher than the equivalent male percentage. For males aged over 85, the largest disability group is people with a moderate disability, whereas for females in the same age group the largest group is people with a severe disability. All these results have important implications on future projections of disability.

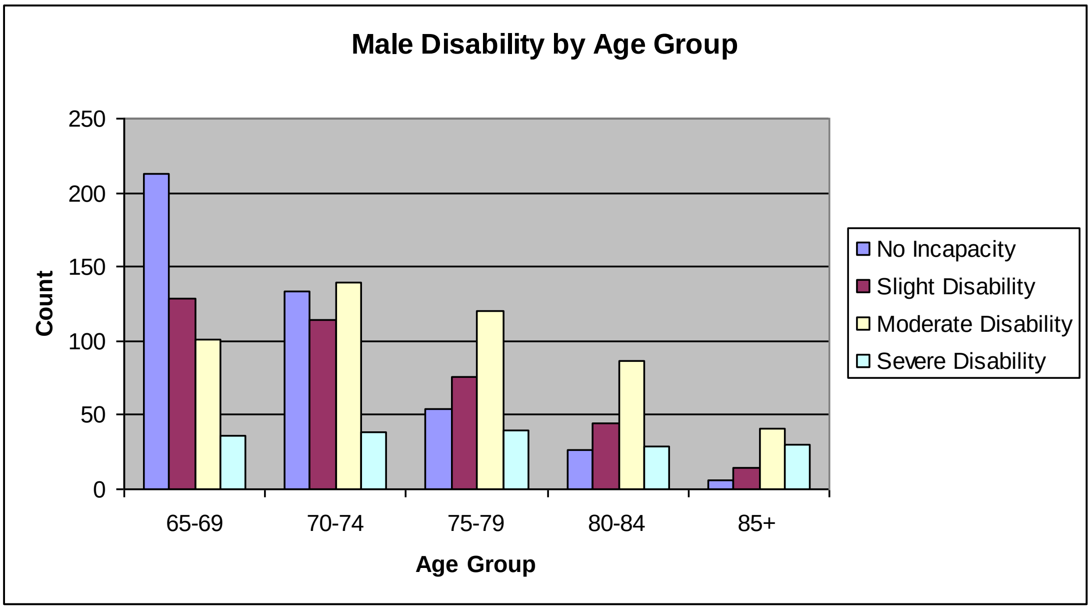

Figure 4.1: Male Disability by Age Group

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

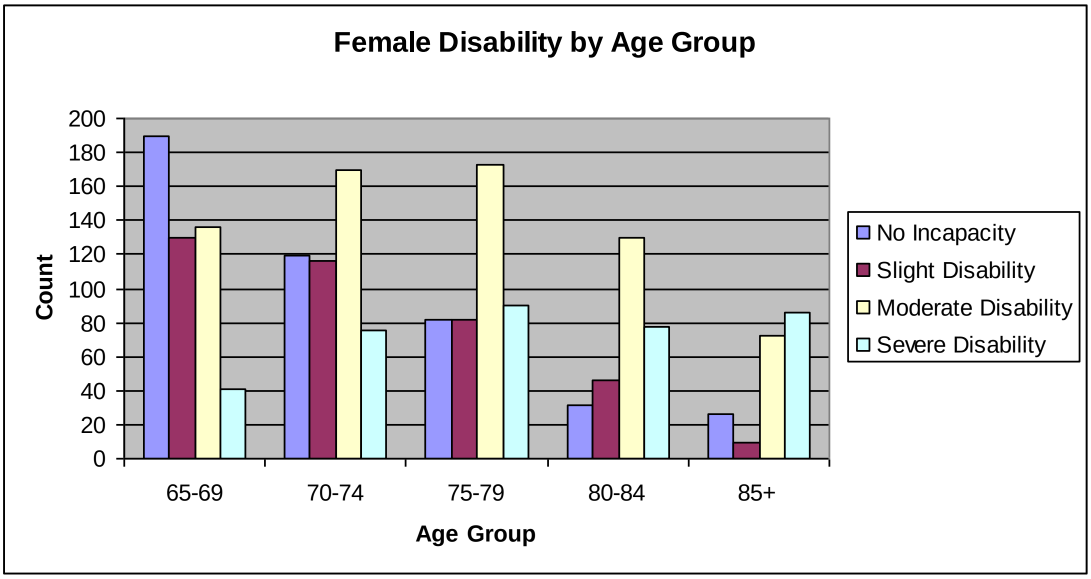

Figure 4.2: Female Disability by Age Group

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

The disability proportions obtained from the General Household Survey will be used as a proxy for demand for social care in Hampshire. The rates applied in the model structure, section 4.6 (pp.137-139).

Assumption six: The disability proportions obtained from the General Household Survey will be used as a proxy for demand for social care in Hampshire.

The next step is to assign a service delivery category to each disability category by age group and gender. The data required is discussed in section 4.5 (pp.131-137) and the equation applied in the cell-based model structure is discussed in section 4.6 (pp.137-139).

4.5 Service Receipt

The 2001 General Household Survey was also used to investigate the main source of care, i.e. to identify the principal person or organisation who helps the respondent with daily living activities for which they need help with. The activities in the disability index were grouped into the following three areas in which people required help:

i) Up/down stairs/around the house/walking to the toilet
ii) Getting in/out of bed/dressing
iii) Wash all over/shower/bath

In the 2001 General Household Survey, if the respondents answered they usually carry out the activity on their own but find it fairly difficult or very difficult, they were asked further questions to investigate if they do get any help. If they did, the source of help was identified.

If the respondent said they did require help with any of these activities, they were asked who provides the help; this was recorded for help provided by someone within the household and by someone outside it.

For the activities related to using the stairs, getting to the toilet and getting around the house, the following questions were asked in the 2001 General Household Survey. The questions can be found in more detail in Appendix A2.

16. WhoHlp. *Who usually helps you to get around the house/to the toilet/up and down stairs? Is it someone in the household, or someone from outside the household?*

18. WhoHlpB. *Who is the person from outside the household?*

Sources: Adapted from the 2001 General Household Survey questionnaire user guide, p41-42

The respondents are asked who usually helps with various daily living tasks. For those who can perform the daily living tasks on their own without help from others, they are classified as not in receipt of care for those daily living tasks. For respondents who reported that they do usually receive help from a member from within their household, they are classified as receiving informal care. A range of options are available for question 18: these include Spouse, Son, Daughter, Brother, Sister, Other Relation, Friend/Neighbour, Social Services, District Nurse/Health Visitor, Paid Help, and Other. It is worth noting that Question 16 refers to “usually”: in many instances people may receive care from several sources, but the GHS recorded only the *main* source of care, designated “primary service receipt”.

The same questions were asked to respondents who need help getting in and out of bed and dressing and undressing, and for the third category, people who had difficulty washing all over, showering and bathing. Each of these activities requires a different set of skills. If help is needed with any of these activities a different response would be expected in terms of who provided the services. Responses for primary care receipt distinguished between *informal* care (i.e. care provided by family inside or outside the household, or by friends and/or neighbours), *formal* care (i.e. local authority or NHS services such as social services, district nurse, health visitor), private care (i.e. care services paid for privately by the older person or their family and a smaller category called other. Other includes care from voluntary organisations and churches for example. The majority of private care is privately paid for.), or no care (i.e. the older person received no care or support for that task; they may or may not have needed care, but they did not receive it). Tables 4.3 and 4.4 below summarise the survey data in relation to primary service receipt for people who need help in carrying out the following activities: bathing, showering or washing themselves. Data for the other activities can be found in Appendix A3. Table 4.3 shows the absolute numbers in each category and Table 4.4 shows the proportions of people in each category.

It is important to note that even if a respondent reported that they can manage the activity by themselves, this could be incorrect. The person might be getting care from another source but for some reason, such as embarrassment, decides not to report it. The respondent may simply have misunderstood the question. Moreover, even if a person might just about manage the activity on their own, they may actually need help but be unable to access it. For example, they may not have any family or friends to help them, or they may not qualify for formal social services support by not meeting the eligibility criteria or not meeting the means testing requirements. It is also important to note that while somebody might see one service as their primary care service, it does not mean they are not receiving another care service. For example, a person might see informal care as their main source of care provision but they still might be receiving some sort of support from social services.

4.5.1 Service Receipt Data

			Disability Classification				
			No Incapacity	Slight Disability	Moderate Disability	Severe Disability	Total
Male	65-69	Formal Care	0	0	0	0	0
		Informal Care	0	0	1	15	16
		No Care	213	129	100	21	463
		Private Care	0	0	0	0	0
	70-74	Formal Care	0	0	0	1	1
		Informal Care	0	0	2	7	9
		No Care	134	114	137	29	414
		Private Care	0	0	0	2	2
	75-79	Formal Care	0	0	0	3	3
		Informal Care	0	1	3	10	14
		No Care	54	75	117	27	273
		Private Care	0	0	0	0	0
	80-84	Formal Care	0	0	0	1	1
		Informal Care	0	0	2	12	14
		No Care	27	45	84	15	171
		Private Care	0	0	0	1	1
	85+	Formal Care	0	0	0	3	3
		Informal Care	0	0	4	7	11
		-No Care	6	15	37	17	75
		Private Care	0	0	0	3	3
Female	65-69	Formal Care	0	0	0	1	1
		Informal Care	0	0	7	12	19
		No Care	190	130	129	27	476
		Private Care	0	0	0	1	1
	70-74	Formal Care	0	0	0	3	3
		Informal Care	0	0	2	30	32
		No Care	119	116	168	41	444
		Private Care	0	0	0	1	1
	75-79	Formal Care	0	0	0	4	4
		Informal Care	0	0	4	21	25
		No Care	82	82	169	64	397
		Private Care	0	0	0	1	1
	80-84	Formal Care	0	0	0	5	5
		Informal Care	0	0	9	19	28
		No Care	31	46	121	51	249
		Private Care	0	0	0	3	3
	85+	Formal Care	0	0	1	15	16
		Informal Care	0	0	0	13	13
		No Care	26	9	71	50	156
		Private Care	0	0	0	8	8

Table 4.3: Service Receipts Counts

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

			Disability Classification			
			No Incapacity	Slight	Moderate	Severe
Male	65-69	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	42%
		No Care	100%	100%	99%	58%
		Private Care	0%	0%	0%	0%
	70-74	Formal Care	0%	0%	0%	3%
		Informal Care	0%	0%	1%	18%
		No Care	100%	100%	99%	74%
		Private Care	0%	0%	0%	5%
	75-79	Formal Care	0%	0%	0%	8%
		Informal Care	0%	1%	3%	25%
		No Care	100%	99%	98%	68%
		Private Care	0%	0%	0%	0%
	80-84	Formal Care	0%	0%	0%	3%
		Informal Care	0%	0%	2%	41%
		No Care	100%	100%	98%	52%
		Private Care	0%	0%	0%	3%
	85+	Formal Care	0%	0%	0%	10%
		Informal Care	0%	0%	10%	23%
		No Care	100%	100%	90%	57%
		Private Care	0%	0%	0%	10%
Female	65-69	Formal Care	0%	0%	0%	2%
		Informal Care	0%	0%	5%	29%
		No Care	100%	100%	95%	66%
		Private Care	0%	0%	0%	2%
	70-74	Formal Care	0%	0%	0%	4%
		Informal Care	0%	0%	1%	40%
		No Care	100%	100%	99%	55%
		Private Care	0%	0%	0%	1%
	75-79	Formal Care	0%	0%	0%	4%
		Informal Care	0%	0%	2%	23%
		No Care	100%	100%	98%	71%
		Private Care	0%	0%	0%	1%
	80-84	Formal Care	0%	0%	0%	6%
		Informal Care	0%	0%	7%	24%
		No Care	100%	100%	93%	65%
		Private Care	0%	0%	0%	4%
	85+	Formal Care	0%	0%	1%	17%
		Informal Care	0%	0%	0%	15%
		No Care	100%	100%	99%	58%
		Private Care	0%	0%	0%	9%

Table 4.4: Service Receipts Proportions

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

There are many interesting points to be observed from the data. For both genders, nobody classified as having no incapacity reported that they required care or support.

However, it can be seen that many people with a moderate disability nevertheless require no help. There are many reasons why this might be the case. Many elderly people with a moderate disability learn to cope with it. This has been made easier by special equipment and aids that enable older people to retain their independence, which can be anything from simply adding extra grab-handles in the bathroom to replacing a traditional bath with a walk-in shower. Much of this equipment is provided by Social Services with the support of occupational therapists. For both males and females with a severe disability, the majority of people required no help washing all over, showering and bathing. The responses were low across all age groups for people whose primary source was formal care and private care.

Many people who are classified as having a severe disability report they require no care or support, however, a great deal of them do report one of the other services as being their many provider of long-term care. This mostly takes the form of informal care. For both genders, the number of people reporting either private care or formal care increases with age but the proportion who require these services is not as much as the other two. There is one example where is not the case, for females aged 85 and over, the number of females who report formal care as their main service is provider is slightly greater than people who report informal care.

For both genders, the proportions are the same for people with are classified as having no incapacity or a slight disability. For males who aged 75-79 with a slight disability, a small number of them report informal care as the main source of care provision. For males and females with a moderate disability, the majority of them report no care or support. The others report informal care as their main care provision. One of the main differences between the genders is for people aged 85 and over. For males, nearly 10% reported informal care as their care provider, whilst no females reported help in the form of informal care. However, 1.39% did report formal care. Many males are likely to have reported informal care as their main source of care as they are likely to have wife who looks after them. It has been shown in Chapter 2 that many women in England survive longer than males.

The key differences between the genders can be seen with people who are categorised as having a severe disability. For males aged 65-69, nearly 41% of them reported that they receive their main care in the form of informal care. Whilst for women, just about 30% reported the same type of care. Interesting, a small number of women reported either formal care or private care as their main care provider. No men reported either of these forms of care in this age group. For males aged, 70-74, the number of men reporting informal care is now nearly 18% which is a lot less than people aged 65-69. However, the number of women of receiving informal care increases to 40%. A number of males report receiving care from the other two sources of care provision. For males in the next age group, people receiving informal care increases by about 7%, whilst the proportion of females to about 23%. For people aged, 80-84, there are once again stark differences between the genders. Nearly, 42% of males receive informal care, and for females it is about 24%. This is very likely due to the fact that many males will have wife to look after them. Many females are likely to have lost their partner by the time they enter this age group and explains why they number of females reporting informal care is significantly less than the number of males. Around 10% of females receive care from either the formal or private sector. For males aged 85 and over, roughly 23% of them receive care in the form of informal care. For females it is about 15%. 10% of males receive formal care and 17% of females receive formal care as their main source of care provision. For both genders, around 10% receive private care. So whilst the majority of people in the sample receive no care or support, it has been shown that there are key differences between genders for people who are classified as having a severe disability.

The service rates that have been derived are applied in the model structure, see section 4.6 (pp.137-139).

4.6 Cell-Based Model Structure

The household data and net population change data were used in the model. The population in the model for the end of each calendar year was calculated using equation (2).

Definitions

h_{kgt} – the household population of age group *k (65-69,70-74,75-79,80-84,85+)*, gender *g (male, female)* at calendar year *t*.

u_{kgt} – the numbers of age group *k*, gender *g*, who have reached the highest year of the age group at year *t*.

n^1_{kgt} – the net population change for age group *k*, gender *g*, through migration and death, for year *t*. This was derived from n_{agt} (*Equation 1*).

d_{kge} – disability rate for disability category *e (low, moderate, substantial, critical)*, age group *k*, gender *g*.

s_{kgef} – service rate for service category *f* (*formal care, informal care, no care, private care*), disability category *e*, age group *k*, gender *g*.

Then the population of age group *k*, gender *g* at calendar year *t* is given by the equation

$$h_{kgt} = h_{kgt-1} + u_{k-1g\ t-1} - u_{k\ g\ t-1} + n^1_{kgt} \qquad (2)$$

The household population (h_{kgt}) at the end of the calender year for any age group is calculated by taking the household population for the same age group from the previous year (h_{kgt-1}) and accounting for population changes. The first population change is the number ageing from the younger age group ($u_{k-1g\ t-1}$). For example, for the age group 70-74 in 2010, the $u_{k-1g\ t-1}$ is the number of people aged 69 in 2009. The second population change is to account for the number of people ageing to the next age group ($u_{k\ g\ t-1}$). For example, for the age group 70-74 in 2010, the number of people aged 74 from 2009 are removed from their current age age group and are now added to the age group 75-79 in 2010. The final population change to account for is the net population change for the age group (n^1_{kgt}). n^1_{kgt} is derived from n_{agt} (equation 1) for all the ages that are represented in that age group. For example, net the population change for the age group 65-69 accounts for migration and mortality changes for the ages 65, 66, 67, 68 and 69.

Using the results of equation (2), the following expansions are applied in the cell-based model. Firstly, the disability rates for each age group and gender are multiplied by the household population in the equivalent age group and gender. The population in disability category e, age group k, gender g at time t is given by $d_{kge}\ h_{kgt.}$ Secondly, the proportions of service receipt for each disability category are multiplied by the number of disabled people in each age group by gender. Thus, the population in service category f, disability category e, age group k, gender g at time t, p_{kgeft}, is given by

$$p_{kgeft} = s_{kgef}\, d_{kge}\, h_{kgt} \quad (3)$$

The results are discussed in Chapter 7.

4.7 Hampshire County Council Data

Hampshire County Council provided service provision data for their current clients. These data were substituted for General Household Data in various scenarios. The proportions requiring formal care services were adjusted using these local data. A year's data were provided by the performance manager from Hampshire County Council. The data were provided as four snapshots for April 2008, August 2008, December 2008 and March 2009. On further inspection of the datasets, a decision was made only to use the most recent dataset, March 2009. This was the most complete dataset and included the eleven districts separately. The other datasets were incomplete, and in some cases some areas had been combined. An attempt was made, by using the same proportions in each area as in the March 2009 data, to disaggregate the combined data in the three earlier datasets and to replace the missing data. However, the final proportions for each age, gender and service category in comparison to the populations for each district were very similar. There were no observable seasonal differences that would be lost by not using the other three datasets. Thus, the March 2009 dataset was used as the baseline from which the various scenarios were run. The dataset contained 10,179 records.

4.7.1.1 Data fields

The following data were available for people aged 65 and over, who are in receipt of a care service from Adult Services, in each of the eleven districts of Hampshire.

1. Unique Identifier Number
2. Age

3. Gender
4. Ethnicity
5. Client Group
6. Eligibility
7. Provider Sector
8. Service
9. Standard Weekly Cost

A brief description of each category, where this is not obvious, follows. Not all of the categories were used in the model.

Unique Identifier Number: a unique identification number was given to each client in the dataset. This was to ensure client confidentiality.

Ethnicity: This category was not used.

Client Group: The client could belong to one of the following categories: older persons, learning disabilities, physical or sensory disability, or mental health. This category was not used.

Eligibility: Anyone requiring a care service from Social Services needs to be assessed both financially and in terms of their need. This category refers to the outcome of the needs assessment. There are four possible values: low, moderate, substantial or critical. The majority of clients who receive a service are either substantial or critical.

Provider Sector: This category refers to the sector which provides the care to the client. The possible values are Social Services Department, independent, or user purchased. This category was not used.

Service: The category refers to the care service which the client receives. The client could be receiving one or more of the following services: day care, direct payment domiciliary care, nursing care or residential care. This research is only concerned with care provided to people in a private household. Therefore, nursing and residential care have both been disregarded. Direct payments can be used by the client to purchase any kind of care they wish. This could include residential or nursing care, so direct payments were disregarded as well. Only clients receiving day care or domiciliary care as at least one of their services were included the analysis.

Standard Weekly Cost: This is just the weekly cost of the service. There are no additional costs.

4.7.1.2 New Service Receipt Rates

A considerable amount of time was spent manipulating the dataset so that the data could be used for modelling purposes. This involved the generation of a new set of service receipt rates in order to model various scenarios. Under the Hampshire County Council eligibility criteria, the needs of potential clients are rated as being low, moderate, substantial or critical. For more information on this criteria, refer to Appendix A4. Clients rated as substantial or critical are potentially entitled to formal care, subject to means testing. Scenarios can be run in the model investigating clients who have either substantial or critical status, or just critical status.

In discussions with members of Adult Services, intensity scenarios (i.e. scenarios in which different levels of care provision are investigated) were mentioned as being of interest. Two levels of intensity were created, people who receive at least five hours of domiciliary care a week and people who receive ten hours a week. As the data did not include this level of detail, it was calculated from the service cost. Since (at the time of the study) each hour of domiciliary care cost on average £12 per hour, the intensity of the care service was calculated by working out the number of people whose weekly domiciliary care package cost at least £60 and £120 respectively.

Assumption seven: Domiciliary care costs on average £12 per hour.

New service receipt rates were calculated and the local authority proportion was changed. As the disability index created as part of this thesis is different from the one used by the Local Authority, the following assumption was made after discussions with members of HCC Adult Services Department.

Assumption eight: Only people with a severe disability are candidates for Local Authority care.

As a result, alterations to formal service care receipts were only made for people with a severe disability. The proportions were calculated by working out the number of local authority clients for each of the six scenarios (see below) as a percentage of the number of people with a severe disability. The other service receipt proportions were rescaled, weighted so as not to change the other proportions. Different rates were calculated for each of the eleven Hampshire districts. New service receipts were calculated for the following:

1) Clients who receive domiciliary or day care whose eligibility status is substantial or critical;
2) Clients who receive domiciliary or day care whose eligibility status is critical;
3) Clients who receive at least five hours of domiciliary care a week and whose eligibility status is substantial or critical;
4) Clients who receive at least ten hours of domiciliary care a week and whose eligibility status is substantial or critical;
5) Clients who receive at least five hours of domiciliary care a week and whose eligibility status is critical;
6) Clients who receive at least ten hours of domiciliary care a week and whose eligibility status is critical.

All these scenarios can be generated in the model. Scenarios 1 and 3 are discussed in Chapter 7. The new service receipts, broken down by district, age group and gender can be found in Appendix A5 for scenarios 1 and 3. The remaining scenarios can be found on the compact disc *Population Model.xls*

4.8 Verification and Validation

The following section describes the validation and verification process for the cell-based model. The following two definitions are for simulation models but are applicable for the cell-based model. Verification is defined as

"… the process of determining that the computer procedure that performs the simulation calculations is logically correct. Verification is largely a debugging task to make sure that no errors are in the computer procedure that implements the simulation." (Anderson, 2003, p610)

Validation is defined as

"… the process of ensuring that the simulation model provides an accurate representation of a real system. Validation requires an agreement among analysts and managers that the logic and the assumptions used in the design of the simulation model accurately reflect how the real system operates." (Anderson, 2003, p619)

4.8.1 Verification

Verification was an important stage of the modelling. It was vital to insure that the numbers generated by the model are correct. For each calculation within the model the logic was checked and tested. Manual calculations were also carried out using simple numbers to check if the same result was found. Small errors were found in various places and solutions implemented. The population data, broken down by disability and service receipt, were checked against the total district population numbers to ensure they were the same for each year in the modelling period. Tests were carried out on the logic and all calculations used to analyse and manipulate the population data to make sure there were no errors in the process.

Similar tests were carried out on the manipulation of the local authority data. The data were also tested to see if the number of people receiving local authority care was equivalent to the real number for March 2009. This was done for all the new service receipt rates. Sensitivity analyses were carried out on the input data to check that calculations produced the correct results.

4.8.2 Validation

Law and McComas (2001) provide ten useful steps in aiding in the construction of a valid model.

1. *Formulating the problem precisely*
2. *Interviewing subject-matter experts*
3. *Interacting with the decision-maker on a regular basis*
4. *Using quantitative techniques to validate components of the model*
5. *Documenting the conceptual model*
6. *Performing a structured walk-through of the conceptual model*
7. *Performing sensitivity analysis to determine important model factors*
8. *Validating the output from the overall simulation model*
9. *Using graphical plots and animations of the simulation output data*
10. *Statistical techniques for comparing model and system output data.*

Law and McComas, 2001, p24-28

The problem was formulated precisely through close discussions with members of the Adult Services Department of Hampshire County Council. The second point was addressed throughout the study: various members of the Council were interviewed to ensure that the model captured what was expected by the Council, and the model used the best available data that they could provide. There was regular contact with the decision maker to make sure there was "buy in" for the final product and to make sure that the Council were fully aware of any changes in the modelling process. Point 4 was addressed in the verification process. The conceptual model was shown to the Council at the beginning of the process and as the model developed over the modelling period, changes were shown and accepted by members of the Adult Services Department. This also involved a structured walk-through of the model.

Sensitivity analysis was carried out in the verification stage but not to determine the important model factors. The output data were tested in the verification section.

Graphical outputs were created and manually checked to make sure that expected trends and patterns were produced. No statistical tests were carried out between the model and system output data. Tests were carried out to make sure the right output data was created in the model in the verification section as the projections by disabilities and service should add up to the total population projection totals. This was carried out in the verification section.

The model can be considered to be fully validated and verified for the purposes of this thesis. The results of various scenarios generated by the cell-based model are discussed in Chapter 7.

5. Contact Centre Model Methodology

The contract centre was modelled using discrete-event simulation (DES). As shown in section 3.2 (pp.81-99), DES is a proven and successful approach to modelling call centres in order to test various changes and observe the impact upon performance. It allows for all the key features of Hantsdirect to be modelled (see section 3.2, pp.81-99). The software used was Simul8 (Simul8, 2011), an off-the-shelf user-friendly software package widely used in many different sectors, including models of call and contact centres. In this chapter we describe the DES model, the process of developing and validating it, and the data used to populate it.

5.1 Discrete-event simulation

The Hantsdirect contact centre (Hantsdirect, 2010) has many complex features which suggest that discrete-event simulation would be an appropriate approach. These features include different types of staff (advisors and agents), time-dependent arrival times, different types of call which require different call handling times, complex routing rules, various forms of contact (telephone, email, fax), outbound and abandoned calls. As shown in the literature review in section 3.2 (pp.81-99), discrete-event simulation has been successfully used to model contact centres. The purpose of modelling Hampshire County Council's call centre is able to produce performance outputs under various demand levels. Many different performance measures can be produced from a simulation model. However, people of particular interest in this study are:

- Distribution of time in the system (total processing time)
- Staff utilisation rates
- Numbers of abandoned calls
- Percentage of calls answered
- Percentage of calls answered within 20 seconds

5.2 Modelling history

We were involved in the modelling of the contact centre right from its inception. The advantage of this was that we had time to fully understand the process and build up relationships with members of Hantsdirect, thus allowing useful data to be collected and used in the simulation model. The downside was that the planned operating processes of the contact centre evolved during the lifetime of the project, and therefore the simulation modelling had to adapt in line with these changes. This is often the reality of working within a fast-changing real-world environment, especially with a new system in the process of development.

Initially the entire contact centre was going to be modelled, including all the other local services provided by HCC such as rubbish collection, road sweeping, library services, schools, and so on. The reason for this was that HCC's original plan was that anybody could take any call. Thus if there were no social service call handlers available to take a social service call, any other call handler could take a message and pass it to a social service call handler. However, HCC decided that social service calls should only be taken by people with social service skills. Anyone calling about a social service matter would either have to wait for their call to be answered by an appropriately skilled person, or terminate their call if they were not willing to wait. This limited the scope of the DES model, which otherwise would have been even more challenging. The final model therefore only dealt with social services calls, which were grouped into two categories, Adult Services and Children's Services.

Another change to the process was the issue of other forms of contact, such as faxes, emails and texts. Initially, the contact centre received a large number of contacts of this nature. After a few months of operation, Children's Services decided to handle these kinds of contact in the back office, away from the contact centre. This reduced the number of messages received by other forms of contact significantly, but nevertheless it was decided that as this is still a service of the contact centre, it would be included in the simulation model.

It is important to note that the simulation model described in this thesis represents the real life system as it was set up in August 2009. Any new changes to the contact centre process are not incorporated.

5.3 Call types

Social services calls are enormously varied, as they relate to individual clients' needs. No two calls are really the same. There are thus potentially hundreds of different call types, and it would have been impossible to create service type distributions for each of these. Following discussion with various members of Hantsdirect, three broad call categories were chosen, shown in Table 5.1 below. This categorization, which is based solely on the complexity of the nature of the call rather than its content, was created after discussion with various members of the contact centre management team.

	Adult Service Calls	Children's Service Calls
Call Type 1	Information calls, signposting calls or calls requiring no further action	Information calls, signposting calls or calls requiring no further action
Call Type 2	Calls passed to a key worker	Calls passed to a key worker
Call Type 3	Calls passed to the Professional Advisory Team	Complex case call

Table 5.1: Call Types

Assumption nine: There are only three types of calls for each service.

Call type 1 is the same for both Adults and Children's services. These are calls considered to be basic in nature. The agent or advisor may provide the client with the information they require, or may give them information about another agency that can help them (signposting), or the call might require no action at all.

Call type 2 is once again the same for both services. Calls passed to a key worker are for calls where the caller is an existing client who is already registered with a key worker (social care worker).

Call type 3 represents complex calls where the client potentially requires a service. Adult Service calls are passed to the Professional Advisory Team (PAT), a team of social care workers who will make the decision whether or not the caller needs an assessment. Some of these calls are from a client (or a client's representative) who is calling back to find out if there has been any progress relating to a pre-existing query. For children's calls, only advisors (the more skilled call-handlers) can deal with Type 3 calls. If an agent answers this type of call they have to transfer the call to an available advisor or wait on the line with the caller until an advisor becomes available. The advisor decides upon which course of action to take. They have the ability to pass this case onto a key team (a team of social workers).

5.4 Workflow diagrams and flow chart

Figures 5.1 to 5.4 illustrate the potential flows of social service calls received by the contact centre. A call may go through many different routes. When a call arrives, there is no way of knowing the nature of the call or even whether it is an Adult or Children's Service call. When a call arrives it waits in a queue for the next available agent or advisor. There is no priority system and the caller waits until a member of staff with a social service skill is free to answer it.

Figure 5.1 illustrates the flows of Type 1 calls. The process is the same for both Adult and Children's calls. When callers phone Hantsdirect they wait in a queue until an agent or advisor is free to take the call. After the call is completed it requires no further action.

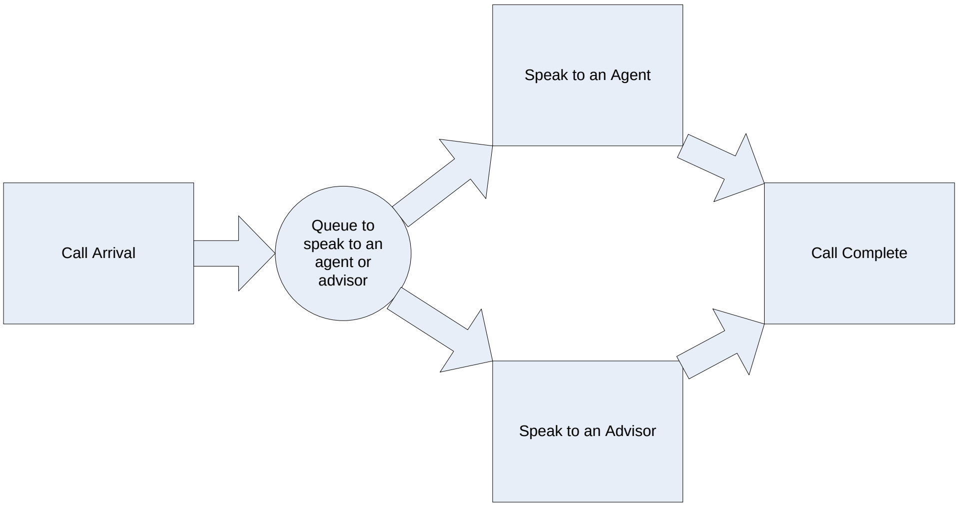

Figure 5.1: Call Type 1

Figure 5.2 illustrates the flows of type 2 calls. The process is the same for both Adult and Children's calls. When callers phone Hantsdirect they wait in a queue until an agent or advisor is free to take the call. Callers will either be transferred directly to their key worker or, if their key worker is not available, a message will be left with a member of the key team to which the key worker belongs. Occasionally, if the key worker is not available, the client will be given the phone details of the key worker so they are able to phone the key worker at a later time. Once this has occurred the call is complete.

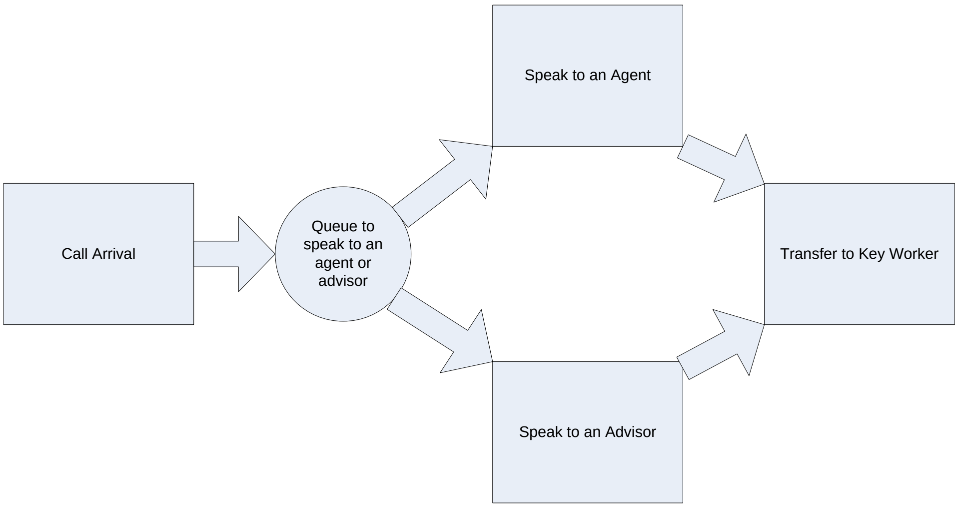

Figure 5.2: Call Type 2

Call type 3, the most complex type, has different processes for Adults and Children's services. Figure 5.3 illustrates the process flow for a call that requires an assessment for a care package from Adult Services. When callers phone Hantsdirect they wait in a queue until an agent or advisor is free to take the call. The call handler fills in a form and this is passed on to a member of the PAT who will take the case further. The agent or advisor sends a copy of the form electronically to the member of the PAT and gives them a quick call to warn them to expect the case – this is called a *warm hand off*. Some calls require the agent or advisor to transfer the caller directly to the PAT. Once the call has been passed onto the PAT, the call is completed.

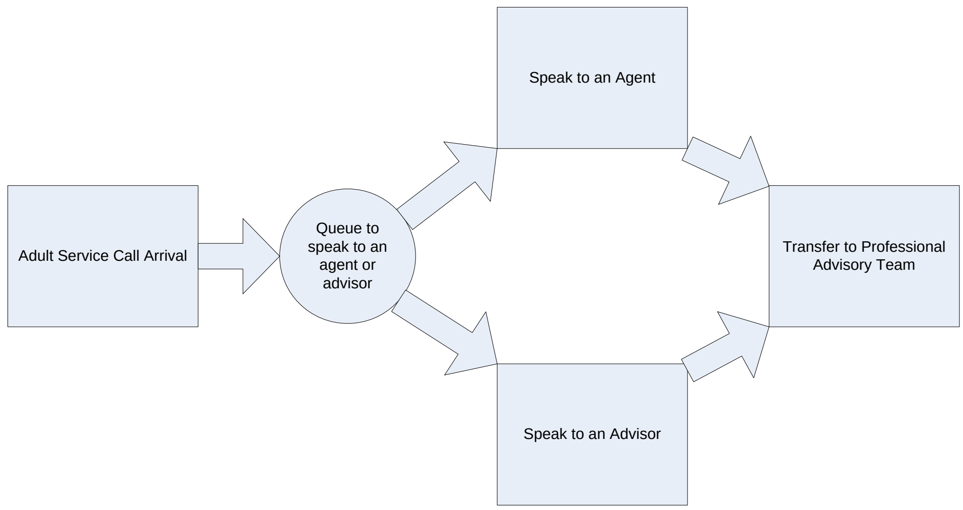

Figure 5.3: Adult Service Call Type 3

The process for type 3 Children's Service calls is significantly different from Adults Service calls. This is illustrated in Figure 5.4. Agents have not been trained to take these types of calls. In fact, this is the key difference between an agent and advisor: an advisor has the skills to handle this type of call and can make the judgement about whether the call needs to be passed on to a children's social worker or not. Thus, when callers phone Hantsdirect, the calls wait in a queue until an agent or advisor is free to answer the call. If an agent answers the call s/he passes it on to an advisor as soon s/he ascertains the nature of the call. When s/he transfers the call s/he will wait on the line with the caller until an advisor is free. The call handling system prioritises this type of transfer so that the next available advisor will take the call. When an advisor becomes available the agent spends a short time explaining the situation and electronically passes his/her notes over before transferring the call. The advisor would then take the case further and either complete the case, or pass it onto a Children's social worker if necessary. Of course, if an advisor were to take the call directly s/he would be able to deal with the case straight away and would be able to complete the case or pass it onto a Children's social worker.

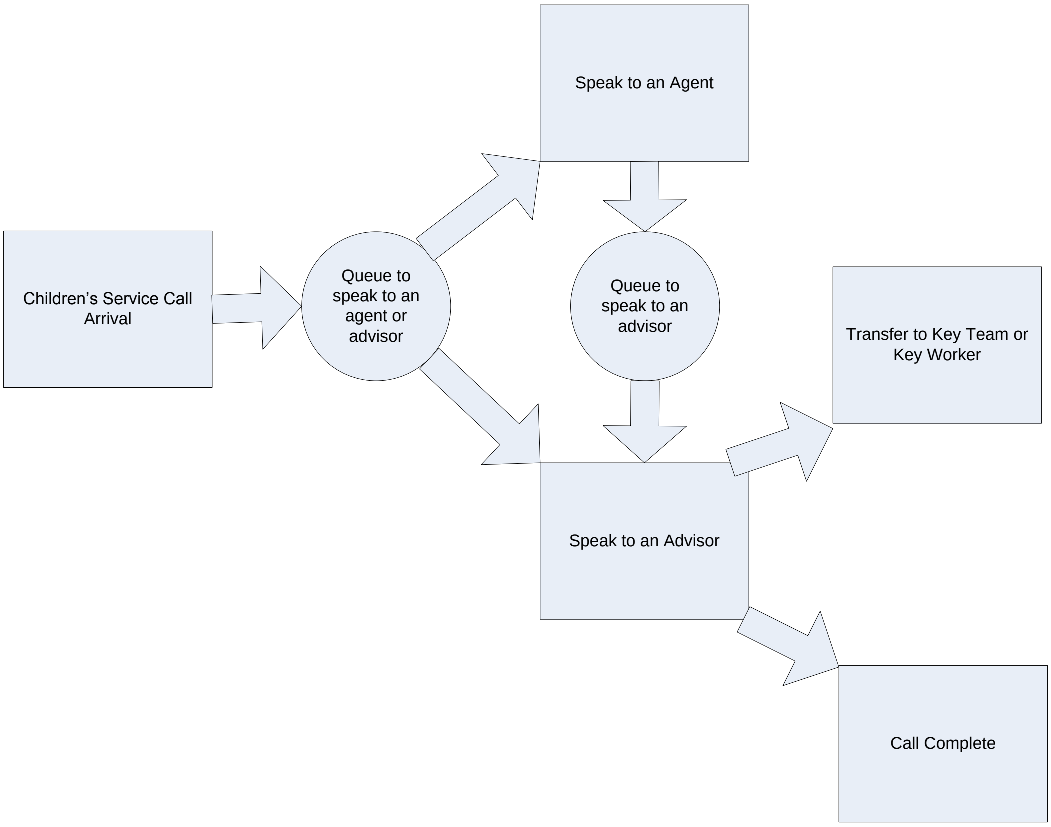

Figure 5.4: Children's Service Call Type 3

Figure 5.5 illustrates the workflow of the contact centre. The process is described in various sections of this chapter.

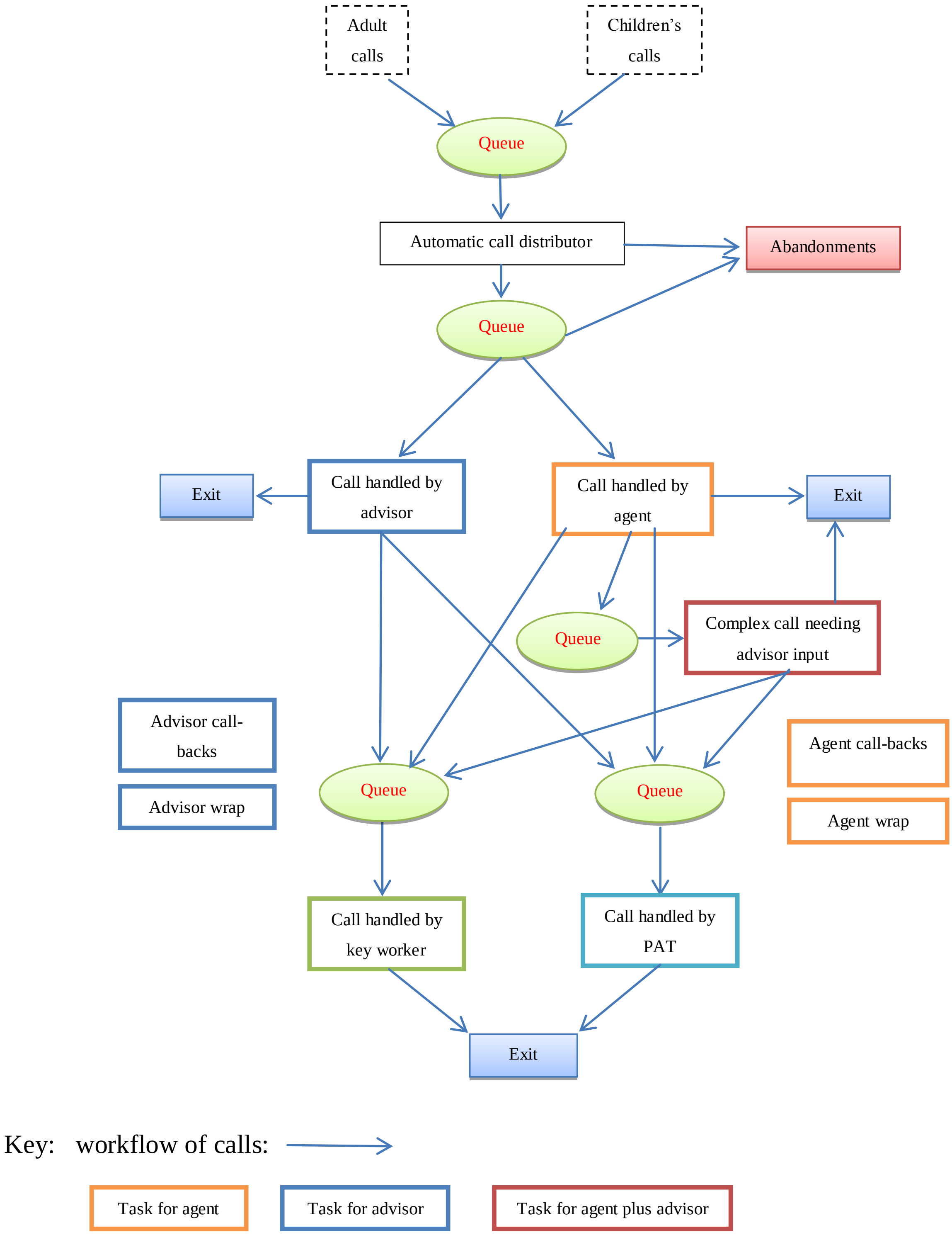

Figure 5.5. Simplified flow chart of the contact centre

5.5 The Simul8 model

The following section contains a description of some of the key elements of the DES model. Figures 5.6 and 5.7 present screenshots of the Simul8 model. The model was coded so that the main decision processes were as close as possible to what happens in real life.

As mentioned above, Hantsdirect deals with many calls related to all kinds of issues, from queries about library opening hours to complaints about refuse collections. This model is only concerned with calls related to social services. Social services is a 24/7 service as cases can potentially occur at any hour of the day. However, the contact centre operates in normal working hours from Monday to Friday. The contact centre opens at 08.30 and stops taking calls at 17.00, although call handlers work until 17.30 to complete any calls that are still in progress at 17.00. The services offered out of hours are not considered in this thesis. On a Friday the contact centre finishes half an hour earlier. The simulation is therefore a terminating simulation and the daily call centre simulation ends when the final call is finished.

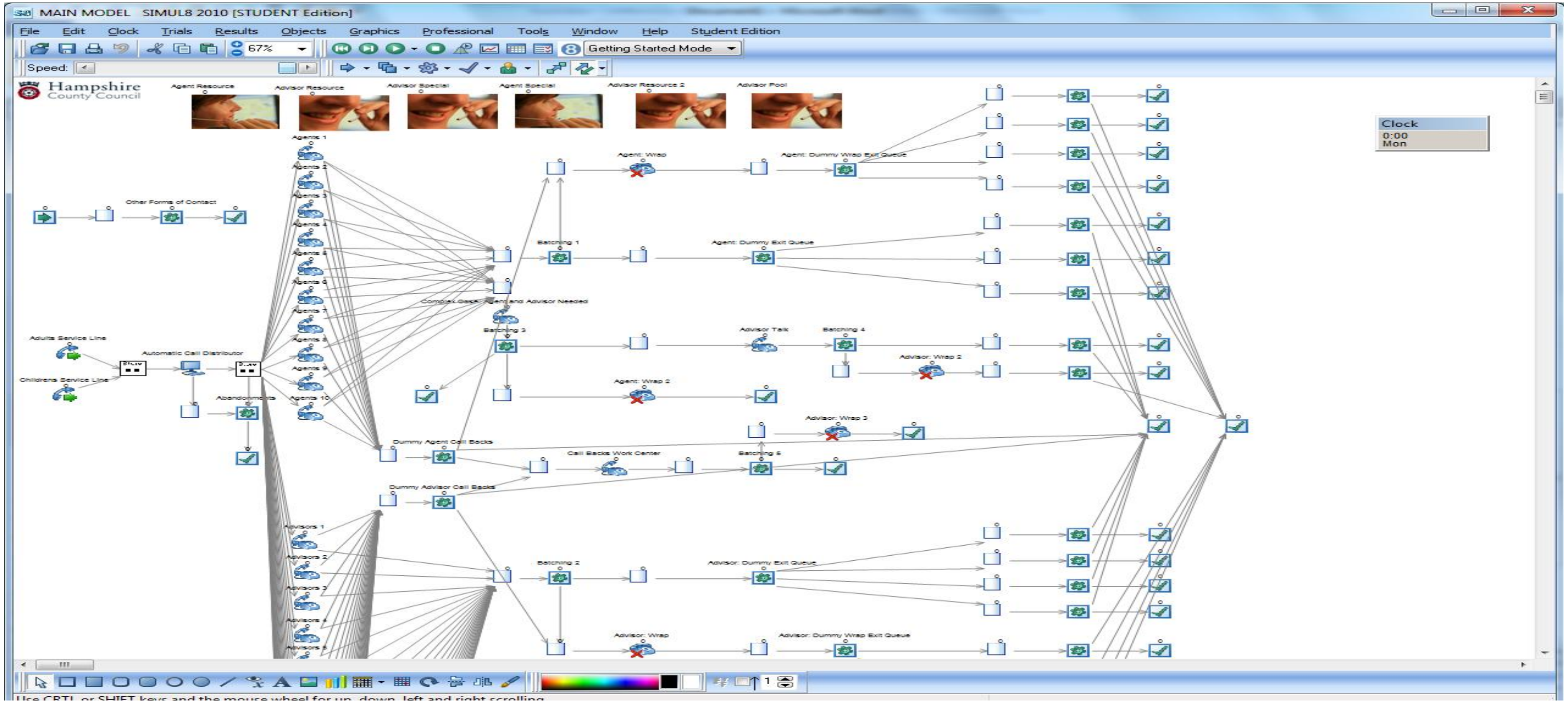

Figure 5.6: Simul8 Snapshot One (Top half of the model)

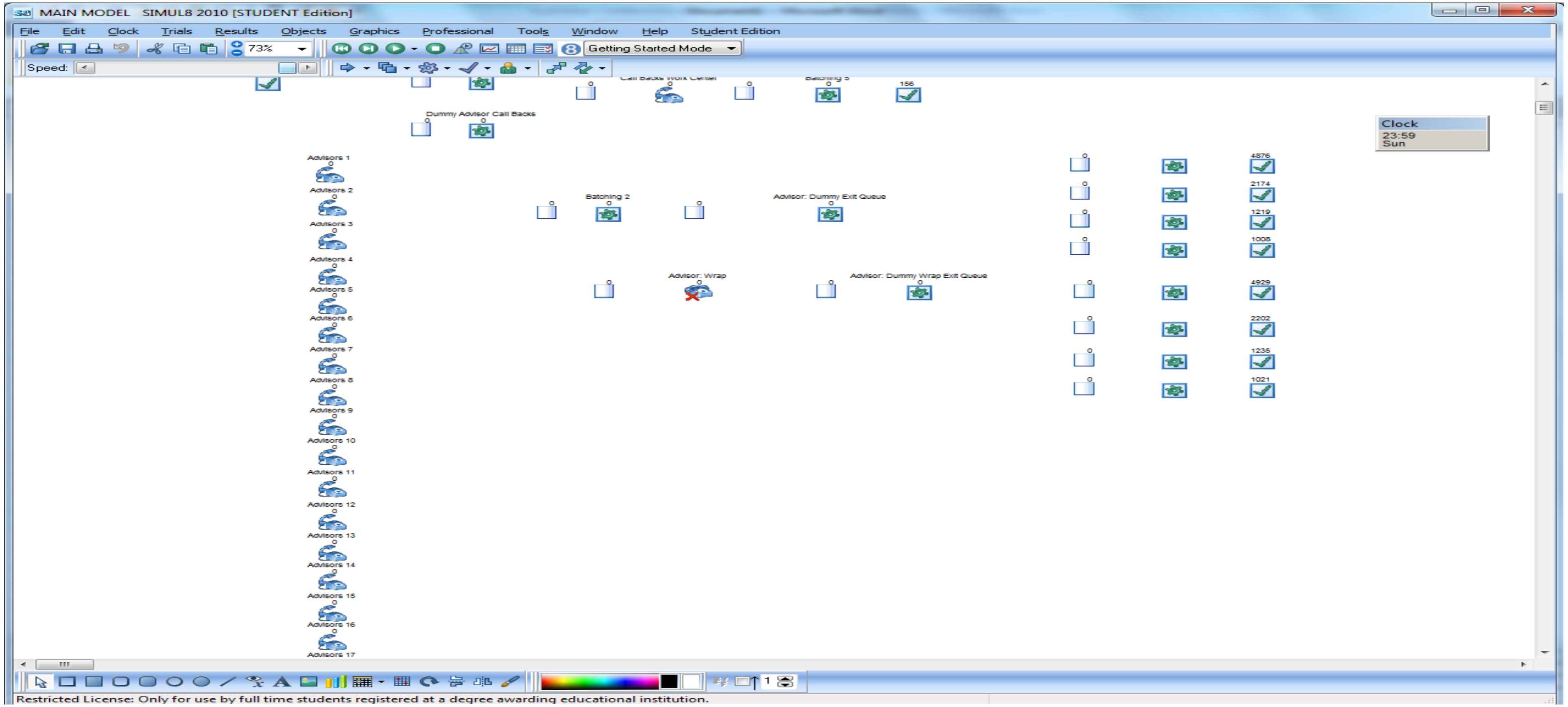

Figure 5.7: Simul8 Snapshot Two (Bottom half of the model

5.5.1 Simul8 Model Detailed Discussion

The simulation model has been coded to replicate the activities in the workflows in Figures 5.1 to 5.4 and the flow diagram represented in Figure 5.5. The following is a guide to the simulation model process flow and in addition to this the relevant data model section is noted.

As shown in Figure 5.5, calls come in to the call centre and can be either an Adult or Children's call. The arrival rates and split of calls is described in more detail in section 5.6.3 (pp.171-175). The model has been built to take into consideration that some calls are abandoned (terminated) before they are served. The data in support of the process of abandonment is discussed in section 5.6.5 (pp.176-178). If the caller does not abandon their call they hold on until they are served.

As already mentioned, three call types have been modelled (Table 5.1). The processes for each of the call types have been described in Figures 5.1 to 5.4. Each call type represents a different probability of occurrence. The simulation model has been designed with all the three call types and their different probability of occurrence. The probabilities are noted in the data section 5.6.4 (pp.175-176). Each of the call types follows different service time distributions, calls which only require some information are significantly quicker to deal with than somebody who is requesting a needs assessment in order to receive a care service. This logic has been built into the Simul8 model. Once a call is finished the caller terminates the call.

Not only has the service time been modelled but so has the wrap up time. The wrap up time is the time spent on administrative activities relating to the call but performed after the call itself is terminated, enabling the call handler to finish the case. Each of the call types fits different types of wrap up service distributions. A lot of information needs to be captured for calls that are more complex in nature and therefore require more time to be spent completing the call than a call merely requiring information or a transfer to their key worker. Both the service and wrap up distributions are described in section 5.6.6 (pp.178-182) and Appendix 10. The service and wrap up distributions were captured based on observations and then fitted to theoretical distributions using the software BestFit for Windows (Palisade, 2010). If a theoretical distribution could not be statistically fitted, an empirical distribution was chosen. Simul8 caters for the use of empirical distributions. This is described in section 5.6.6 (pp.178-182).

Some calls require the caller to be phoned back to complete the service. For example, additional information is required that can be sought without having to keep the caller waiting on the line. This logic has been added into the simulation model. The data to support this is described in section 5.6.7 (pp.182-183).

Another important process that has been modelled is other forms of contact received by Hantsdirect, such as faxes and emails. The distributions that fit other forms of contact are described in section 5.6.8 (p.183).

An important additional input of the simulation model is the number of staff. This is for both agents and advisors. The model has been constructed so that the number of staff can vary throughout the day based on the staffing roster. The data used to create the staffing roster is described in section 5.6.2 (p.170).

5.5.2 Simul8 Model Inputs

As described there are many inputs that needed to run the simulation model. The data to support the inputs are described in full in section 5.6 (pp.163-183). They are all based on either system data from Hantsdirect, expert opinion or observations. As a result of this both theoretical and empirical distributions have been used. Table 5.2 comprises a list of all the model inputs. The data inputs cover the following areas:

- Call Arrivals
- Call Type Profiles
- Abandonment
- Call Backs
- Other Forms of Contact
- Service Distributions
- Wrap Up Distributions
- Staff Profiles

The inputs are entered into the simulation model using Microsoft Excel which was used as a user interface to control the model inputs.

<table>
<tr><th>Parameter</th><th>Data Collection</th><th colspan="3">Mean</th><th>Distribution type</th></tr>
<tr><td>Adult Services Calls: mean inter-arrival times</td><td>Existing Data</td><td colspan="3">Table 5.6</td><td>Exponential</td></tr>
<tr><td>Children's Services Calls: Mean inter-arrival times</td><td>Existing Data</td><td colspan="3">Table 5.7</td><td>Exponential</td></tr>
<tr><td>Adults' Call Type Profile</td><td>Existing Data, Expert Opinion</td><td colspan="3">Table 5.8</td><td>Empirical</td></tr>
<tr><td>Children's Call Type Profile</td><td>Existing Data, Expert Opinion</td><td colspan="3">Table 5.8</td><td>Empirical</td></tr>
<tr><td>Abandonment</td><td>Existing Data, Expert Opinion</td><td colspan="3">Figure 5.8</td><td>Empirical</td></tr>
<tr><td>Call Backs</td><td>Existing Data, Expert Opinion</td><td colspan="3">Table 5.9</td><td>Empirical</td></tr>
<tr><td rowspan="2">Other forms of contact arrival rate</td><td rowspan="2">Existing Data</td><td colspan="2">Lower Bound</td><td>Upper Bound</td><td rowspan="2">Uniform</td></tr>
<tr><td colspan="2">3.00</td><td>12.00</td></tr>
<tr><td rowspan="2">Other forms of contact service time</td><td rowspan="2">Existing Data</td><td colspan="2">Lower Bound</td><td>Upper Bound</td><td rowspan="2">Uniform</td></tr>
<tr><td colspan="2">20.00</td><td>30.00</td></tr>
<tr><td rowspan="2">Adults' Advisor Service Type Distribution Call Type 1</td><td rowspan="2">Observation</td><td colspan="2">Average</td><td>Standard Deviation</td><td rowspan="2">Log Normal</td></tr>
<tr><td colspan="2">3.29</td><td>3.22</td></tr>
<tr><td rowspan="2">Adults' Advisor Service Type Distribution Call Type 2</td><td rowspan="2">Observation</td><td colspan="2">Alpha</td><td>Beta</td><td rowspan="2">Gamma</td></tr>
<tr><td colspan="2">5.17</td><td>0.85</td></tr>
<tr><td rowspan="2">Adults' Advisor Service Type Distribution Call Type 3</td><td rowspan="2">Observation</td><td colspan="2">Alpha</td><td>Beta</td><td rowspan="2">Gamma</td></tr>
<tr><td colspan="2">3.50</td><td>2.33</td></tr>
<tr><td rowspan="2">Adults' Advisor Wrap Type Distribution Call Type 1</td><td rowspan="2">Observation</td><td>Alpha 1</td><td>Alpha 2</td><td>Beta</td><td rowspan="2">Pearson VI</td></tr>
<tr><td>0.79</td><td>2.73</td><td>2.59</td></tr>
<tr><td rowspan="2">Adults' Advisor Wrap Type Distribution Call Type 2</td><td rowspan="2">Observation</td><td>Alpha 1</td><td>Alpha 2</td><td>Beta</td><td rowspan="2">Pearson VI</td></tr>
<tr><td>3.01</td><td>3.24</td><td>1.24</td></tr>
<tr><td rowspan="2">Adults' Advisor Wrap Type Distribution Call Type 3</td><td rowspan="2">Observation</td><td colspan="2">Alpha</td><td>Beta</td><td rowspan="2">Gamma</td></tr>
<tr><td colspan="2">0.90</td><td>3.29</td></tr>
<tr><td>Adults' Agent Service Type Distribution Call Type 1</td><td>Observation</td><td colspan="3">Figure A10.8</td><td>Empirical</td></tr>
<tr><td rowspan="2">Adults' Agent Service Type Distribution Call Type 2</td><td rowspan="2">Observation</td><td colspan="2">Alpha</td><td>Beta</td><td rowspan="2">Pearson V</td></tr>
<tr><td colspan="2">4.21</td><td>17.4</td></tr>
<tr><td rowspan="2">Adults' Agent Service Type Distribution Call Type 3</td><td rowspan="2">Observation</td><td colspan="2">Alpha</td><td>Beta</td><td rowspan="2">Gamma</td></tr>
<tr><td colspan="2">1.91</td><td>6.37</td></tr>
<tr><td>Adults' Agent Wrap Type Distribution Call Type 1</td><td>Observation</td><td colspan="3">Figure A10.9</td><td>Empirical</td></tr>
<tr><td rowspan="2">Adults' Agent Wrap Type Distribution Call Type 2</td><td rowspan="2">Observation</td><td colspan="2">Average</td><td>Standard Deviation</td><td rowspan="2">Log Normal</td></tr>
<tr><td colspan="2">2.98</td><td>2.87</td></tr>
<tr><td rowspan="2">Adults' Agent Wrap Type Distribution Call Type 3</td><td rowspan="2">Observation</td><td>Alpha</td><td>Beta</td><td>Min</td><td rowspan="2">Weibull</td></tr>
<tr><td>0.77</td><td>5.41</td><td>0.00</td></tr>
</table>

Parameter	Data Collection	Mean				Distribution type
Children's Advisor Service Type Distribution Call Type 1	Observation	Average		Standard Deviation		Log Normal
		3.29		3.22		
Children's Advisor Service Type Distribution Call Type 2	Observation	Alpha		Beta		Gamma
		5.17		0.85		
Children's Advisor Service Type Distribution Call Type 3	Observation	Alpha 1	Alpha 2	Min	Max	Beta
		0.67	1.64	5.23	26.92	
Children's Advisor Wrap Type Distribution Call Type 1	Observation	Alpha 1	Alpha 2	Beta		Pearson VI
		0.79	2.73	2.59		
Children's Advisor Wrap Type Distribution Call Type 2	Observation	Alpha 1	Alpha 2	Beta		Pearson VI
		3.01	3.24	1.24		
Children's Advisor Wrap Type Distribution Call Type 3	Observation	Alpha		Beta		Gamma
		1.57		5.70		
Children's Agent Service Type Distribution Call Type 1	Observation	Figure A10.8				Empirical
Children's Agent Service Type Distribution Call Type 2	Observation	Alpha		Beta		Pearson V
		4.21		17.44		
Children's Agent Service Type Distribution Call Type 3	Observation	Alpha 1	Alpha 2	Min	Max	Beta
		0.58	0.88	3.49	19.38	
Children's Agent Wrap Type Distribution Call Type 1	Observation	Figure A10.9				Empirical
Children's Agent Wrap Type Distribution Call Type 2	Observation	Average		Standard Deviation		Log Normal
		2.98		2.87		
Children's Agent Wrap Type Distribution Call Type 3	Observation	Figure A10.15				Empirical
Advisor Needed Service Distribution	Observation	Alpha		Beta		Gamma
		2.03		5.35		
Advisor Needed Wrap Distribution	Observation	Alpha 1	Alpha 2	Min	Max	Beta
		0.34	0.46	0.13	17.77	
Complex Case: Agent and Advisor Needed Distribution	Observation	Figure A10.16				Empirical
Agent Staff Profile	Existing Data	Appendix A8				N/A
Advisor Staff Profile	Existing Data	Appendix A8				N/A

Table 5.2 Simulation Model Inputs

5.5.3 Simulation Run Time

The model is run for 40 replications and each simulation run is for one month. The outputs are outputted into Microsoft Excel for analysis. The contact centre model takes around four minutes to run on a laptop with an Intel® Core™ i3 CPU 2.13 GHz with 4.00 gigabytes of RAM. This time can vary depending on the input configuration.

5.5.4 Simulation Outputs

Simul8 can output a large range of outputs. For the Hantsdirect simulation model there are seven key outputs of interest shown in Table 5.3.

Parameter	Unit
Average time in the system	Time
Percentage of calls answered	Percentage
Percentage of calls answered within twenty seconds	Percentage
Advisor Utilisation	Percentage
Agent Utilisation	Percentage
Average number of call arrivals	Number of calls
Average number of abandoned calls	Number of calls

Table 5.3 Simulation Model Outputs

These outputs were firstly used to test the validity of the simulation model. The outputs of the simulations model were compared to real-life output for all the outputs apart from the advisor and agent utilisation. This process is described in section 5.7.4 (pp.188-190).

5.5.5 Experimentation

The simulation model has been used as part of the hybrid framework and a number of experiments have been run by changing the number of agents and advisors. This was to ensure that both the percentage of calls answered and the percentage of calls answered within twenty seconds met the required standards. These experiments are described in detail in section 6.5 (pp.198-201) and the results are presented in section 7.2 (pp.255-261).

5.6 Model data

In this section we present the data used for the model and describe the process for collecting data and fitting probability distributions for the various activities in the model.

5.6.1 Call durations

There are two types of call handlers with social services skills, agents and advisors. Agents and advisors take broadly the same types of calls but advisors are generally more skilled and experienced. As mentioned previously, there is one fundamental difference between their roles: agents cannot deal with complicated children's calls (Children's call type 3).

The call time data were collected manually by the researcher, by direct observation in the contact centre during the study. A total of 467 calls were observed and the durations recorded. Inspection of these data revealed an apparent difference between agents and advisors in terms of the time they spent dealing with different call types. A chi-square test was carried out to test whether this was statistically significant. The hypothesis was that if there was a significant difference between the two call-handler types then they would be treated separately in the modelling. If there was not a significant difference, then a further decision would be made about the possibility of modelling only one staff type.

The t-test is used to test whether there is a statistically significant difference between the means of the two populations. The t-statistic is calculated as follows:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

where $\bar{x}$ is the sample mean, S is the standard deviation and n is the sample size. The degrees of freedom are calculated as follows:

$$(n_1+n_2) - 2$$

where n_1 is the total number of values in the first population, and n_2 is the total number of values in the second population. The critical value is read from the t-distribution table using the relevant number of degrees of freedom. If the test statistic is greater than the critical value, we reject the null hypothesis and accept the alternative hypothesis. A two-tail test was carried out, as we were testing only whether the two populations differ and not the direction of the difference. A t-test is appropriate in this case as both sample sizes were greater than 30.

The t-test was carried out a) for the call itself, b) for the "wrap time" and c) for the total call duration. The wrap time is the time spent on administrative activities relating to the call but performed after the call itself is terminated, enabling the call handler to finish the case. The t-test was carried out for Call Type 1, Call Type 2 and Adult Service Call Type 3. Children's Services call type 3 could not be compared as the processes are different. An independent samples t-test was carried out and equal variances were not assumed. For each test the following hypotheses were tested:

Null hypothesis (H_o): There is no difference between the mean length of time an agent and advisor take to deal with calls, and any observed difference in the sample is simply due to chance.

Alternative hypothesis (H_1): There is a difference between the mean length of time an agent and advisor take to deal with calls received, and the observed difference in the sample is not due to chance.

The first test was carried out for the call duration on all the calls received. The data are summarised in Table 5.4.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	258	356.907	343.33	117873.99
Advisors	209	337.2919	296.63	87988.18

Table 5.4: Data for t-test for all calls received call durations

The test statistic is 0.662 and there are 465 degrees of freedom. As this value is less than the critical value of 1.96 the null hypothesis cannot be rejected at the 5% level of significance, in other words we can be 95% certain that we have not made a Type 1 error and rejected the null hypothesis when in fact it is true. Identical tests were carried out for the wrap up time and the total call duration. The test was carried for Call Type 1, Call Type 2 and Adult Service Call Type 3. Full details of all the tests can be found in Appendix A6 and are summarised in Table 5.6.

The second test used was the chi-square test, which tests whether paired samples come from the same distribution or not. The test checks whether there is a significant difference between the call times for agents and advisors, and a comparison is made between the "observed" and "expected" data.

Null hypothesis (H_o): There is no significant difference in the distributions of call durations between agents and advisors.

Alternative hypothesis (H_1): There is a statistically different difference in the distributions of call durations between agents and advisors.

For this test the agents' call total were taken to be the "observed" data and the advisor call data were taken to be the "expected" data. The observed data for each test were the numbers of calls observed for each grouped value of the call time for agents and advisors. From this the expected call data were generated. The null hypothesis will be true if the differences between the observed and expected call frequencies are similar, as tested using the Chi-square test statistic.

The test statistic χ^2 is calculated as follows:

$$\chi^2 = \sum_{\text{cells}} \frac{(\text{observed - expected})^2}{\text{expected}}$$

The expected frequencies are calculated by multiplying the column total by the row total and dividing by the grand total. The degrees of freedom is calculated by the following formula

$$(r - 1)(c - 1)$$

where r is the number of rows and c is the number of columns. The χ^2 value calculated above is then compared with the critical value from the chi-square table. If the test statistic is greater than the critical value then we reject the null hypothesis and accept the alternative hypothesis. The χ^2 test was carried out at both the 1% and 5% levels of confidence.

The first test was carried out for the call duration on all the calls received. The data are summarised in Table 5.5, which shows the expected and observed call count proportions for all calls in the sample.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-0:59	11.24	10.05
1:00-1:59	13.95	11.00
2:00-2:59	10.08	12.92
3:00-3:59	10.85	13.40
4:00-4:59	6.98	9.57
5:00-5:59	7.36	8.61
6:00-6:59	8.91	5.26
7:00-7:59	8.14	7.66
8:00-8:59	5.81	3.35
9:00-9:59	2.71	3.83
10:00-11:59	1.94	4.31
12:00-12:59	3.10	2.87
13:00-15:59	2.71	3.35
16:00 +	6.20	3.83

Table 5.5: The expected and observed call count proportions

The test statistic for the data is 10.539 and there are 13 degrees of freedom. The test statistic is less than the critical value (22.36) at the 5% level. We accept the null hypothesis and conclude that there is no statistically significant difference in call times between agent and advisors. To be more conclusive, the test was applied to the wrap and total call durations of the same data. An investigation into the three call types used for the t-test was also carried out. Identical tests were carried out for the wrap up time and the total call duration, for Call Type 1, Call Type 2 and Adult Service Call Type 3. The tests results can be found in Appendix A7 and are summarised in Table 5.6.

Table 5.6 summarises the results from all the statistical tests. There is no statistically significant difference between agent and advisors when looking at the total set of calls. However, differences appear when looking at the three individual call types: there are statistically significant differences in all three call types.

All Calls	Talk Duration	Wrap Duration	Total Duration
T-Test	None	None	None
Chi-Square	None	None	None

NFA/ Signposting/ Information	Talk Duration	Wrap Duration	Total Duration
T-Test	None	Significant (5%)	Significant (1%)
Chi-Square	Significant (1%)	Significant (5%)	Significant (1%)

Passed to key team or key worker	Talk Duration	Wrap Duration	Total Duration
T-Test	Significant (1%)	Significant (1%)	Significant (1%)
Chi-Square	Significant (5%)	Significant (1%)	Significant (1%)

Passed to PAT	Talk Duration	Wrap Duration	Total Duration
T-Test	Significant (5%)	Significant (5%)	Significant (1%)
Chi-Square	Significant (1%)	Significant (1%)	Significant (1%)

Table 5.6: Summary of the results from the T-Tests and Chi-Square Tests

As a result of the significant differences in the three call types as well as the difference in the process of dealing with Children's complex calls, it was decided to model two staff types in the simulation model.

5.6.2 Staffing data

A variety of sources were used to create a staff roster that could be used in the model. We were given access to the paper records of the real-life staff roster. As well as this, data were provided showing how many staff members were logged onto the system to handle social service calls in fifteen minute segments. Unfortunately this did not have the agent/advisor split. Moreover there were discrepancies between the paper and the electronic records. This issue was discussed with the operations manager of Hantsdirect, and it was considered that the number logged into the system was more accurate than the paper records. To overcome the issue of not knowing how many agents and advisors there were, the paper staff roster was used. The ratio of agents and advisors per fifteen minute segment was used to calculate the likely number of agents and advisors logged onto the system.

The final staff roster used in the model was based on two weeks' data. One week was taken from June 2009 and the other from July 2009. These two weeks were considered by the Hantsdirect staff to be representative of two typical working weeks. The average number of staff in each fifteen minute slot was calculated and used to create the final staff roster. This was validated with two senior members of staff at Hantsdirect and was considered as acceptable for modelling purposes. The final staff profiles that are used in the simulation model can be found in Appendix A8.

An additional advisor was used in the model, to reflect the real-life situation in which one extra advisor is rostered to deal with other forms of contact such as emails and faxes. When there are no other forms of contact to deal with, this additional advisor is able to take calls.

From direct observations in the contact centre, it was clear that staff are not available 100% of the time. There are other factors which reduce the availability of call handlers to answer calls. Following discussions with Hantsdirect, the staff availability was set to 80% for both agents and advisors. The staff availability within the Simul8 model was therefore set to 80%.

5.6.3 Call arrival rates

Three weeks' data were provided by the Operations Manager of the contact centre. These data were produced by the call centre software. From these, two "typical" working weeks were chosen by the Operations Manager. One week was taken from June 2009 and the other from July 2009. Call arrivals were provided in fifteen minute blocks for each day of the week. However, after discussion with the Operations Manager and the Project Manager, it became apparent that the reported split of calls between Adult and Children's was incorrect. The current process for identifying the type of call on entry into the system was not accurate. Following discussion with the Project Manager a solution was determined. Call arrivals for Adult and Children's Service would be combined. On the basis of a previous study carried out by the Project Manager and his team, it was decided to assume that 45% of calls are for Adult Services and 55% of calls are for Children's Services.

Assumption ten: 45% of calls are for Adult Services and 55% for Children's Services.

The total number of calls by day of week is given in Table 5.7.

	Adult Service Calls	Children’s Service Calls
Monday	377	458
Tuesday	312	382
Wednesday	279	344
Thursday	294	364
Friday	253	308

Table 5.7: Call counts by day

Monday is clearly the busiest day and the number of calls decreases thereafter on a day-by-day basis. Not only is there a difference in the total number of calls, but the distribution of calls throughout the day is also different for each day of the week. This is shown graphically in Appendix A9. There is significant variation between each day. These differences are accounted for in the model. It was decided that the arrivals in the simulation model would follow an exponential distribution, as this is a good model for events which occur at random and independently of each other, and is commonly used to model arrival rates. This allows for each run of the model to include variability in the number of arrivals as expected with the real world system. The mean inter-arrival times for Adult and Children’s calls used in the model can be found in Tables 5.8 and 5.9. The mean inter-arrival time is altered every fifteen minutes in the model, to reflect the time-dependence of the real-world data

Assumption eleven: Call arrivals follow an exponential distribution.

	Monday	Tuesday	Wednesday	Thursday	Friday
08:30:00-08:44:59	4.17	5.56	4.76	3.33	5.13
08:45:00-08:59:59	4.76	5.56	5.13	3.92	3.51
09:00:00-09:14:59	1.01	1.80	2.30	1.59	1.75
09:15:00-09:29:59	2.08	1.23	1.45	1.31	1.42
09:30:00-09:44:59	1.06	1.48	1.36	1.39	1.63
09:45:00-09:59:59	1.06	1.13	1.13	1.39	1.42
10:00:00-10:14:59	1.06	1.52	1.11	1.06	2.15
10:15:00-10:29:59	0.89	1.31	1.39	1.45	1.23
10:30:00-10:44:59	1.04	1.15	1.63	1.85	1.80
10:45:00-10:59:59	1.45	1.33	1.15	1.17	1.71
11:00:00-11:14:59	1.00	1.00	1.33	1.55	1.42
11:15:00-11:29:59	0.94	1.33	1.23	1.33	1.26
11:30:00-11:44:59	0.90	1.90	1.96	2.02	1.42
11:45:00-11:59:59	1.42	1.52	1.45	1.45	1.63
12:00:00-12:14:59	1.31	1.52	2.30	1.55	1.75
12:15:00-12:29:59	1.55	1.39	2.78	1.85	1.59
12:30:00-12:44:59	1.42	1.90	2.38	2.90	2.22
12:45:00-12:59:59	1.31	1.71	1.90	1.67	2.15
13:00:00-13:14:59	1.67	2.56	3.03	1.96	1.90
13:15:00-13:29:59	1.17	1.71	2.15	2.22	2.67
13:30:00-13:44:59	1.67	2.02	3.17	3.17	2.22
13:45:00-13:59:59	1.67	1.71	1.71	1.59	2.22
14:00:00-14:14:59	1.75	2.78	1.71	1.67	2.02
14:15:00-14:29:59	1.36	1.31	1.71	1.63	1.67
14:30:00-14:44:59	1.01	1.19	1.63	1.90	1.90
14:45:00-14:59:59	1.55	2.30	1.67	1.26	1.63
15:00:00-15:14:59	1.71	1.52	1.96	1.71	1.48
15:15:00-15:29:59	1.15	1.26	2.78	2.08	1.52
15:30:00-15:44:59	1.33	1.55	1.75	1.80	3.92
15:45:00-15:59:59	1.15	2.02	2.08	1.85	4.76
16:00:00-16:14:59	1.96	2.22	1.71	1.90	3.70
16:15:00-16:29:59	1.52	1.63	1.80	1.80	4.76
16:30:00-16:44:59	1.75	1.63	2.90	2.02	
16:45:00-16:59:59	3.17	2.78	2.78	2.47	

Table 5.8: Adult Services Calls: mean inter-arrival times

	Monday	Tuesday	Wednesday	Thursday	Friday
08:30:00-08:44:59	3.41	4.55	3.90	2.73	4.20
08:45:00-08:59:59	3.90	4.55	4.20	3.21	2.87
09:00:00-09:14:59	0.83	1.47	1.88	1.30	1.44
09:15:00-09:29:59	1.70	1.01	1.19	1.07	1.16
09:30:00-09:44:59	0.87	1.21	1.11	1.14	1.33
09:45:00-09:59:59	0.87	0.92	0.92	1.14	1.16
10:00:00-10:14:59	0.87	1.24	0.91	0.87	1.76
10:15:00-10:29:59	0.73	1.07	1.14	1.19	1.01
10:30:00-10:44:59	0.85	0.94	1.33	1.52	1.47
10:45:00-10:59:59	1.19	1.09	0.94	0.96	1.40
11:00:00-11:14:59	0.81	0.81	1.09	1.27	1.16
11:15:00-11:29:59	0.77	1.09	1.01	1.09	1.03
11:30:00-11:44:59	0.74	1.56	1.60	1.65	1.16
11:45:00-11:59:59	1.16	1.24	1.19	1.19	1.33
12:00:00-12:14:59	1.07	1.24	1.88	1.27	1.44
12:15:00-12:29:59	1.27	1.14	2.27	1.52	1.30
12:30:00-12:44:59	1.16	1.56	1.95	2.37	1.82
12:45:00-12:59:59	1.07	1.40	1.56	1.36	1.76
13:00:00-13:14:59	1.36	2.10	2.48	1.60	1.56
13:15:00-13:29:59	0.96	1.40	1.76	1.82	2.18
13:30:00-13:44:59	1.36	1.65	2.60	2.60	1.82
13:45:00-13:59:59	1.36	1.40	1.40	1.30	1.82
14:00:00-14:14:59	1.44	2.27	1.40	1.36	1.65
14:15:00-14:29:59	1.11	1.07	1.40	1.33	1.36
14:30:00-14:44:59	0.83	0.97	1.33	1.56	1.56
14:45:00-14:59:59	1.27	1.88	1.36	1.03	1.33
15:00:00-15:14:59	1.40	1.24	1.60	1.40	1.21
15:15:00-15:29:59	0.94	1.03	2.27	1.70	1.24
15:30:00-15:44:59	1.09	1.27	1.44	1.47	3.21
15:45:00-15:59:59	0.94	1.65	1.70	1.52	3.90
16:00:00-16:14:59	1.60	1.82	1.40	1.56	3.03
16:15:00-16:29:59	1.24	1.33	1.47	1.47	3.90
16:30:00-16:44:59	1.44	1.33	2.37	1.65	
16:45:00-16:59:59	2.60	2.27	2.27	2.02	

Table 5.9: Children's Services Calls: Mean inter-arrival times

To ensure no arrivals are lost during the changeover every fifteen minutes, the *re-sample over-run times to next slot* facility in Simul8 was used. This is a function in Simul8 used with time-dependent distributions, to deal with the case when the next sampled arrival time falls into the following period.

5.6.4 Call profile data

The frequency distributions associated with each call type in Table 5.10 were derived from a variety of sources. There was no single dataset available that made this process simple. The Operations Manager of the contact centre provided a “classification tree” which included a count of all calls received for Adult and Children’s Services and showed how they were classified. This was not a reliable source from which to allocate frequencies. Because of technical difficulties with the information system at the contact centre, not all calls that were answered were actually recorded in the classification tree. Agents and advisors have to get through to a certain part of the script for the calls to be recorded. There are times when the call handler does not get as far as this part of the script, so there is no record of the outcome. With the help of a Project Manager from Adult Services, we investigated the likely number of calls missing from the classification tree and it turned out that a significant number of calls were missing. The other issue with this dataset is that call handlers at times misclassify calls, once again reducing the reliability of the data. However, after discussions with the Operations Manager it became clear that the dataset was of use after all. The number of type 2 calls per month could be calculated from this report. This enabled us to calculate the probability of a call being of type 2. Expert judgement and additional reports had to be used to ensure that the final probability used was sufficiently accurate.

The frequency of call type 3 was calculated from different sources. A variety of reports and expert judgement was used to calculate the values for both Adult and Children’s

Services. The frequency for call type 1 was then easily derived from the other two by subtracting the percentages of call types 2 and 3 from 100%. Table 5.8 shows the final probabilities used in the simulation model.

Adults Call Type Profile (%)		
Information/ Signposting/ No Further Action	Passed to Key Worker	Passed to the Professional Advisory Team
40.00	30.00	30.00

Children's Call Type Profile (%)		
Information/ Signposting/ No Further Action	Passed to Key Worker	Complex
63.45	16.55	20.00

Table 5.10: Call Type Proportions

5.6.5 Abandonment data

A call is *abandoned* if the caller rings off without completing the call. This may occur at any stage during the call. Clearly this is undesirable in a general call centre, as it means a potential customer is lost or unsatisfied, but in the case of Hantsdirect it may mean that a person does not gain access to a service which they genuinely need. For most call centres, abandonment rates are a key performance indicator of service quality. More formally, abandonment is defined as: *"… whenever the waiting time of a call exceeds its (random) patience time*." (Cezik et al ,2008, p310)

Ideally, in order to fit an abandonment distribution one would like the individual wait times for each abandoned call. Unfortunately the call centre software system did not record this. The only data that were available were the following four outputs, for each fifteen minute segment: the total number of calls arriving, the total number of calls abandoned, the total sum of caller wait times of abandoned calls, and the maximum time between call arrival and abandonment. Using advice from a member of staff at Adult Service with a considerable amount of experience in call centre management, a dummy set of data were "reverse engineered" by utilising the available real data in order to build a dataset for time to abandonment. The data reflected the observed effect that the probability of abandonment increases with the wait time. No callers in the sample waited for more than three minutes and this is reflected in the abandonment distribution. This was an iterative process to get to the final abandonment data. The final abandonment data were validated by members of Hantsdirect and were considered sufficiently accurate for modelling purposes.

Another effect had to be captured within the model relating to call termination. It is known after discussion with Hantsdirect management that a number of calls are abandoned within a second, probably because the caller realises that they have got through to a call centre and they immediately put the phone down. The following assumption was made.

Assumption twelve: 1% of call arrivals are abandoned immediately.

The new dataset did not fit well with any theoretical parametric distribution, but Simul8 caters for the use of empirical user-input distributions. Figure 5.8 illustrates the empirical distribution used to model abandonment.

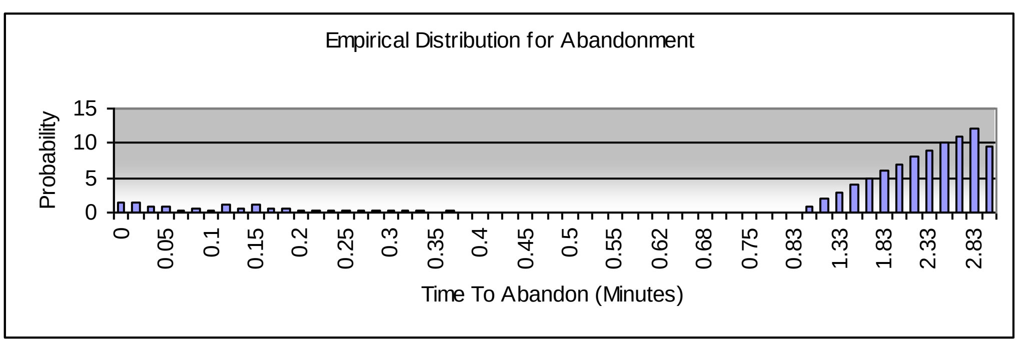

Figure 5.8: Empirical Abandonment Distribution

The abandonment distribution and assumption twelve were considered as sufficiently accurate for modelling purposes by the management team at Hantsdirect

5.6.6 Call durations

Service time distributions were required for the simulation model. This data was required for both agents and advisors. Two types of times were required, not just the call duration of the time spent talking to the client but for the “wrap time” - the time spent afterwards that the call handler needed to finish the case. This information was needed for each call type for each service. Despite the wealth of performance data available from the call centre software, these raw individual service time data were not stored. Therefore the researcher spent three weeks in the contact centre timing calls. Calls were timed by observing various members of staff. Both the call duration as well as the wrap time was timed. The researcher spent half a day with each member of staff, and in some cases he was allowed to sit with the same member of staff again. We are extremely grateful for the generosity, tolerance and patience shown by Hantsdirect staff, which enabled us to collect this very valuable dataset. Obviously, the researcher did not listen to the content of any calls and was only observing the actions of the agents and advisors when initiating and terminating calls.

At the end of three weeks eleven agents and nine advisors had been observed. This resulted in 258 calls taken by agents and 209 by agents. The 467 calls were broken down into the following call types. The call counts are provided in parentheses after each call type.

Calls taken by an agent

1) Information calls, signposting calls or calls requiring no further action (118 calls)
2) Calls passed to a key worker (69 calls)
3) Adult calls passed to the Professional Advisory Team (39 calls)
4) Children’s complex calls passed to an advisor (21 calls)

Calls taken by an advisor

1) Information calls, signposting calls or calls requiring no further action (83 calls)
2) Calls passed to a key worker (50 calls)
3) Adult calls passed to the Professional Advisory Team (34 calls)
4) Children's complex call (23 calls)

Both the call duration and wrap were timed. The data were presented to various members of Hantsdirect and they were accepted as a reliable representation of call time durations. There were no data available with which to make any statistical comparison.

The following distributions were generated and used in the model. The distributions were generated using the commercial software, BestFit for Windows (Palisade, 2010). For each distribution generated within the software, a graph has been created comparing the empirical data with the parametric distribution. The distribution was chosen using the Chi-Square test as well as an inspection of the statistical outputs of the various distributions under consideration. For some of the call types, the distribution that ranked highest using the Chi-Square test was not chosen, for two possible reasons: firstly, because the particular distribution was not available within Simul8, and secondly because upon manual inspection of the means of the distributions we felt it was better to use an alternative distribution in the model. The chosen distributions were input into the Simul8 model where service times are sampled from the specific distribution.

For the first two call types it was decided not to split the calls into Adults and Children's as the sample would have become too small. On discussion with Hantsdirect and through the observations it was decided that they are essentially the same process, regardless of the nature of the call, so they were not split down by service type.

For each service and wrap time distribution the distribution parameters have been provided in Appendix A10. These could essentially be used as a basis for modelling other similar call centres in other counties. Calls taken by an advisor that required information, signposting or no further action fitted well with the lognormal distribution. Whilst the average call time is three minutes and fifteen seconds, one of the calls in the sample lasted eleven minutes and thirty seconds. The minimum call time was twenty-eight seconds. The majority of calls for this type of call can be quickly dealt with, but some calls require some complicated information to be found. The call times are skewed to the left as shown in Figure 5.9. Figure 5.9 is a comparison of the empirical data and the parametric distribution. A similar graph is presented in Appendix A10 for each distribution where a parametric distribution can be fitted to the empirical data.

The goodness of fit between the sample and theoretical distribution were tested using the Chi-Square test. In this case, the test statistic with 9 degrees of freedom is 8.734. The lognormal distribution was not rejected at both the 1% level with a critical value of 21.666 and the 5% level with a critical value of 16.919. The average of the distribution was 3.29 and the standard deviation was 3.23.

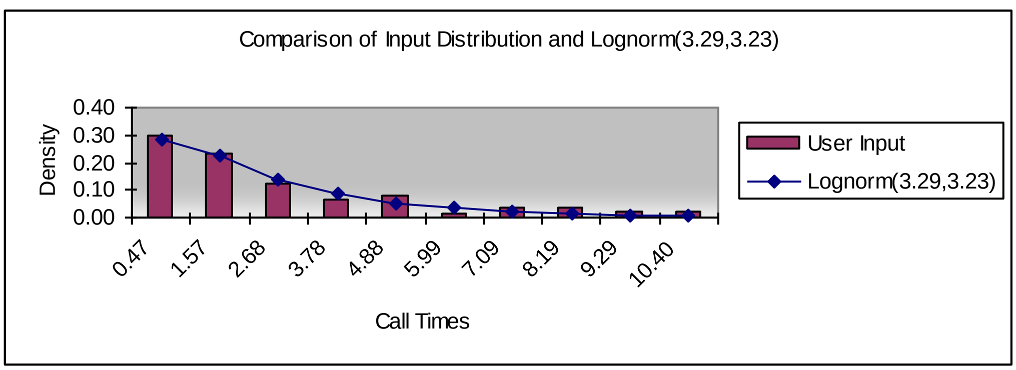

Figure 5.9: Advisor Service Type Distribution Call Type 1

The probability-probability (P-P) plot and the Q-Q plots are a graphical check of the goodness-of-fit of the theoretical distribution. Law and Kelton (1991) describe the P-P plot as a graph to model the model probability against the sample probability, in this case, the lognormal distribution against the call observations for advisors taking Type 1 calls. Law and Kelton note that a perfect fit would produce a linear plot with intercept at 0 and gradient 1. A manual inspection of the P-P plot (Figure 5.10) shows a fairly straight line which leads to the conclusion that the lognormal distribution is a good representation of the sample data.

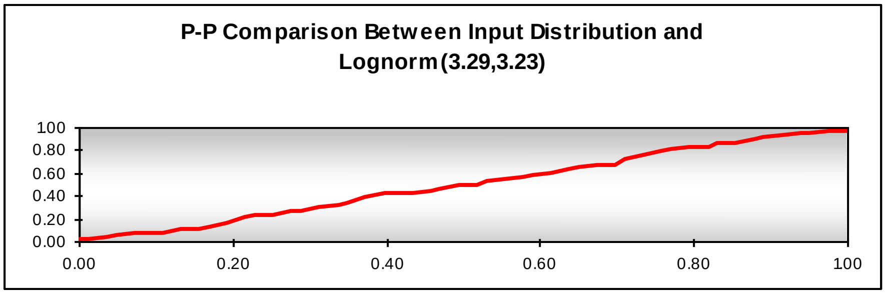

Figure 5.10: Advisor Service Type Distribution Call Type 1 P-P Plot

Law and Kelton note that the P-P plot amplifies differences between the middle of the two distributions. They discuss a second test, the Q-Q plot which tests differences between the tails of the theoretical and sample distributions. A good fitting distribution will produce a similar shape to the P-P plot.

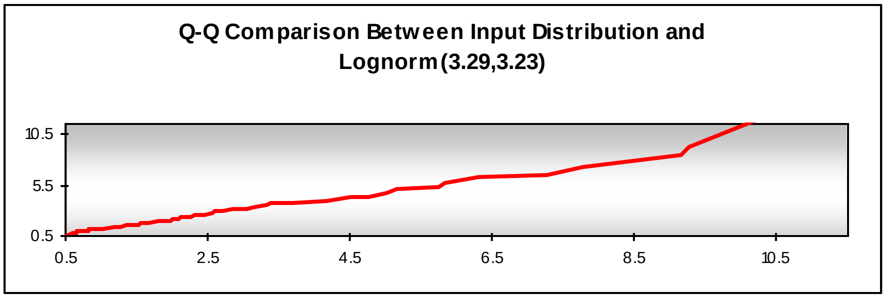

Figure 5.11: Advisor Service Type Distribution Call Type 1 Q-Q Plot

The key point of the Q-Q plot is that while the lognormal distribution is considered to be a good fit there are differences between it and the sample distribution in the right hand side of the tail.

The P-P and Q-Q plots for the rest of the distributions can be found in Appendix A11.

5.6.7 Call backs

Some calls require the client to be called back. This could be for the following reasons. Firstly, the agent or advisor needs time to find information that the client is looking for and feels it unnecessary to keep the client on hold. Secondly, clients requiring information regarding schools might have got through to an agent or advisor who does not have the training to access the specialist program to help them find the information they need. The case will be passed onto an advisor who possesses these skills and they will call the client back.

There were no readily available data to work out the number of call backs. Calls backs are usually carried out by one person. The person taking on this role is usually an advisor and is not always the same person who originally took the call. The advisors who do call-backs kindly agreed to keep a record of the number of call backs they carry out as well as the associated times. This was carried out for approximately four working weeks. The final count in the sample was 105 calls. We were allowed to observe this process and realised that call times alone are a good measure for the full process. The advisor would spend a period of time researching the case and would be able fairly quickly to complete the case while on the phone with the client. The following assumption was then made:

Assumption thirteen: Call back durations follow the service and wrap time distributions of an advisor.

On further inspection of the data and following informal interviews with advisors, it became evident that call backs do not fall into a single call type category. It was therefore decided that a certain percentage of calls will be assumed to require a call back. This probability was calculated from the data collected by the advisors. Table 5.11 summarises the final probabilities used in the simulation model.

	Probability	
	Requiring a call back	Not requiring a call back
Adults Call Backs	1.15	98.85
Children's Call Backs	1.15	98.85

Table 5.11: Call Back Probabilities

5.6.8 Other forms of contact

The contact centre also receives contact in the form of faxes and emails. We were able to find out the average time it took to process each case from paper records and this also provided information on the number of other forms of contact received each day. Based on a combination of limited data and expert opinion, the number of other forms of contact that arrived each day was modelled by a uniform distribution with a lower bound of 3 and an upper bound of 12. The service time for each case was modelled using the uniform distribution with a lower bound of 20 and an upper bound of 30. This was accepted as being realistic by members of Hantsdirect.

5.7 Verification and validation

Definitions of verification and validation were provided in section 4.8 (p.143), together with a useful set of guidelines from Law and McComas (2001), in section 4.8.2 (p.144), which were applied for the DES model as well. Sargent (2008) notes the importance of deciding at an early stage the degree of accuracy required. We decided that the model would be considered valid once it passed the standard tests and was accepted as accurate for modelling purposes by members of Hantsdirect.

The modelling of the contact centre was initiated by the Adult Services Project Manager. Through a series of meetings with the Project Manager the problem area was defined and objects of the simulation model were agreed upon. Various members of Adult Services and Hantsdirect were interviewed so the design of the contact centre simulation could be accurately captured to incorporate all the real world features. This is an important feature of the validation process. We made regular contact with the decision maker to make sure there was "buy in" for the final product and to make sure that any changes to the system were included in the modelling. This again is an important part of the validation process. The assumptions and logic of the model were discussed on a regular basis with the Project Manager and Operations Manager.

The conceptual map was documented and shown to the decision-makers to ensure it represented the real world system. This was an iterative process and underwent many changes through the modelling process. This process involved a structured walk-through every time a new a change was made. A sensitivity analysis was carried out, along the lines of extreme value tests, not to determine the important factors, but rather to test the model was reacting in the expected way. The model output was shown to HCC staff for face validity tests, which are discussed later in this chapter. However no formal statistical tests could be carried out between the simulation and system outputs, due to the lack of system outputs against which the model could be tested. This will be discussed later in this chapter.

5.7.1 Sargent's tests

Sargent (2008) provides a discussion of the validation and verification process. He notes that often a subjective decision is made by the model developer to determine the validity of the simulation. Another approach Sargent recommends is the "independent verification and validation" approach (Sargent, 2008, p158). This is just for large scale projects where an independent party decides upon the validity of the model. For the call centre model the project supervisors were shown the model outputs and validity tests before the model was considered valid. Sargent also notes the importance of the conceptual model validation like Law and McComas (2001). This was carried out with members of Hantsdirect.

Sargent discusses two additional forms of validation: operational validation and data validation. The first tests the accuracy of the model's behaviour; this was carried out and is discussed in the next part of this chapter. The second test is to ensure that data used is adequate. There were many data issues but the research used the best available data in the construction of the model. Sargent provides fifteen techniques for validating and verifying a simulation model: most of these were implemented here, as listed below.

1) Animation: The simulation animation was closely observed to ensure the model behaviour was as expected. This led to the discovery of two errors. Some of the shifts were not running at the correct time and on some days arrivals were still arriving after the call centre was meant to stop receiving calls.
2) Degenerate test: The model was tested so that the mean service time was longer than the mean inter-arrival time, and this resulted in the average number in the queue increasing as expected.
3) Event validity: The number of events created in the simulation model was compared to the real system. The number of call arrivals, abandonments and call backs and other forms of contact compared well.

4) Extreme condition tests: The model was tested under a variety of extreme conditions and the model behaved as expected. The model was tested with zero arrivals, and various levels of higher arrivals. The call profiles and staff profiles were also altered.
5) Face validity: The model was tested with members of Hantsdirect through interviews and group meetings to examine the behaviour of the model. The model was accepted by members of Hantsdirect.
6) Historical methods:
   - Rationalism: Everybody involved in the model was made aware of all assumptions explicitly throughout the modelling process.
   - Empiricism: This requires that all assumptions are empirically validated as well as the outcomes. The assumptions are not empirically tested but are created from empirical investigations where possible.
7) Internal validity: This test is used to test the variability of the model. The model was run 40 times and while there was variability from run to run it was not large enough to call into question the validity of the model's ability to output performance. This is discussed in more detail later in this chapter.
8) Parameter variability – sensitivity analysis: Sensitivity analysis was carried out. The inputs were altered to test the behaviour of model. There was no real world data to test this against. The outputs were judged to be valid by the domain experts.
9) Traces: The path followed by an individual entity is traced stepwise through the model. The entity in the contact centre model is the call. Various calls were traced through the system and the correct logic was being carried out.

5.7.2 Verification of model logic

Following careful checking of the model code and logic, some errors were found and were resolved.

1. The arrival rate distributions were checked to ensure the right distributions were being used at the right time. This led to one error being found and corrected.
2. All the shifts were checked to make sure the right times were assigned to each shift for each day for each staff type. Two extra shifts were deleted.
3. The arrival point and work centre for other forms of contact were examined to ensure the right settings were in place. The arrival rate was altered so only one batch of emails, faxes and texts would arrive each day.
4. All the work exit points were replaced with queues. At the end of the model run the contents of each queue was examined to ensure the right type of call was in the queue. It was realised that the calls requiring a call back were not included in these queues. This meant that the first call was not included in the final results for average time in the system with and without the wrap up part of the call.
5. The simulation was set up so that one work item with certain characteristics would be followed through the simulation. This brought up a serious error. For calls requiring a call back, the agent resource was never released and the advisor resource was released at the wrong point in the simulation.
6. The priority settings in each of the work centres were checked. The priority setting in the work centre for other forms of contact was altered so that it had a higher priority than the work centres.
7. All the advice from the inbuilt Simul8 help assistant was carried out. There were no issues. There are still two pieces of advice shown in the model but the researcher has examined the advice and there is no issue to be dealt with.

5.7.3 Number of replications

There is always a trade-off between accuracy and runtime considerations. The Garbage-In, Garbage-Out (GIGO) principle is also noted: the outputs are only as accurate as the inputs. The automatic Simul8 trial calculator was used to determine the number of runs in a trial.

The Simul8 trail calculator was based on research by Dr.Kathy Hoad and Professor Stewart Robinson (Hoad et al., 2010). The trial calculator works out the number of runs required to achieve different levels of precision of the confidence limits around the estimated mean of the various outputs. By “n% accuracy” in the following, we mean that the 95% confidence intervals were within n% of the estimated mean. The Simul8 trail calculator is based on an algorithm which runs the model for three replications and stops if the required precision has been met. If it has not, then the algorithm keeps running until it is. The inputs and outputs were sufficiently accurate for the intended purpose of the model. To achieve 1% accuracy for a few of the outputs, a very large number of runs would have been required. Moreover, since many trials are needed as part of the hybrid framework, the accuracy requirement was lower.

The model was run for 40 replications. Many of the key outputs reported by the model achieved at least 1% accuracy within 40 replications. These include the following outputs: average time in the system, agent utilisation, advisor utilisation, call entry points for both services, average time in the system including wrap, as well many of the individual call times. Most of the outputs achieve 2% accuracy within 40 replications. A few outputs required many more replications, but fortunately these are not the key performance indicators. It should be noted that percentage of calls answered and percentage of calls answered within 20 seconds are not calculated in the Simul8 trial calculator, but within the Excel user interface.

5.7.4 Numerical validation: comparison with the real system

First, two numerical outputs were compared with the real system. The average number of arrivals was calculated and compared with the expected number of arrivals. The average number of arrivals generated in the simulation model compared well. In reality, the average number of calls per month on average is 13,456 and the model was able to produce an average of 13,471. The 95% confidence interval was [13,437 , 13,504].

Secondly, the average number of abandoned calls was calculated and compared with the expected number of abandoned calls. The average number of abandoned calls generated in the simulation model compared well. In reality, the number of abandoned calls per month on average is 592 and the model was able to produce an average of 601. The 95% confidence interval was [586 , 617].

The Operations Manager provided several performance reports which enabled the simulation outputs to be compared with the real world outputs. The outputs that are of importance were not used as inputs. For example, the number of call arrivals is an input, whereas the percentages of calls answered within 20 seconds, the percentage of calls answered, staff utilisation and average time in the system are outputs. Unfortunately, direct comparison of staff utilisation could not be made as these data were not available from the real-life system. Firstly, in the real system agents and advisors are not distinguished from each other. Secondly, the staff utilisation included agents that take other types of calls.

The real-world value of the percentage of calls answered was 95.60%, and the baseline run of the model gave an average of 95.54% with 95% confidence interval [95.43% , 95.65%]. The real-world value of the percentage of calls answered within 20 seconds was 92.37%, whereas the baseline run of the model gave an average of 92.76%, with 95% confidence interval [92.56 , 92.95]. The real world value for the “average time in the system” (the elapsed time between a call arriving in the system and being finally terminated) could be obtained only for social service calls for the same time period as the simulation models. Calls on average were in the real world system for 5 minutes 37 seconds. Calls on average were in the simulation model for 5 minutes 45 seconds, with 95% confidence interval [5’44”, 5’47”].

Sufficient confidence can be taken in the simulation model as a result of this comparison. The best data available was used as an input into the simulation. This considerably reduces the chance of this result occurring by chance. This comparison as well as the other tests that have been carried out has led the researcher to conclude that the model is valid for modelling purposes. On top of this, the simulation model was accepted as valid by the Project Manager of Adult Services as well as senior staff members at Hantsdirect. The model was therefore considered as fully validated and verified for modelling purposes, and can be used as part of the hybrid model to calculate performance under varying demand over time. The results of the model are discussed in detail in Chapter 7.

6. Hybrid Model Methodology

In this chapter the cell-based model and the discrete-event simulation model are combined to create a hybrid framework. This framework is useful from both a theoretical and a practical perspective. The benefits of creating a hybrid framework from existing research are discussed in section 3.3.4 (pp.111-112).

6.1 Hybrid framework research questions

The hybrid framework was used to address the following two research questions (see section 1.5, p.4):

3. How could a detailed tactical model for the contact centre benefit from the additional use of a long-term dynamic demographic model for population change?
4. What benefits and insights would result from a combined approach based on these two different models?

6.2 Evolution of the hybrid framework

The methodology used for the hybrid framework changed over the period of the research. As discussed in detail in Chapter 4, the original plan was to develop a system dynamics "whole system" model to generate the number of initial contacts, which would have formed the input to the discrete-event simulation model. The initial idea for this hybrid framework is illustrated in Figure 6.1. The model would have been run on a monthly basis and would have formed the top half of the loop shown in Figure 6.1. A highly detailed initial contact profile could thus have been developed, which would have allowed for the tracking of individuals through the discrete-event simulation model. These individuals would then be aggregated and fed back into the detailed system dynamics model. The original high level population model would have included all elderly people, together with information about their care provision. The outcomes of each individual call to Hantsdirect could have been recorded and then used to adjust the populations of the various types of care provision. As well as this, the impact of the contact centre performance upon the whole system of long-term care could have been explored. This would have completed the bottom half of the loop as shown in Figure 6.1. This would then create a new set of initial contacts which would once again be fed into the discrete-event simulation model. This cycle could be repeated indefinitely.

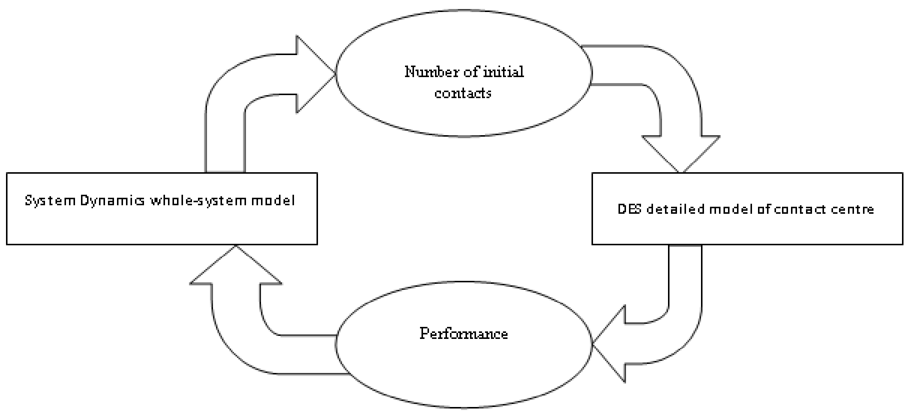

Figure 6.1: Original Hybrid Framework

The key benefit of this approach would have been the incorporation of feedback effects into the DES model. The simplest feedback effect relates the number of calls to centre performance. It is reasonable to assume that as the number of call arrivals increase over time, the performance of the contact centre will fall in terms of its main key performance indicators (KPIs). Equally, it is sensible to assume that as it becomes known in the community that the call centre is performing well, the number of calls will increase. This results in a balancing loop, as shown in Figure 6.2.

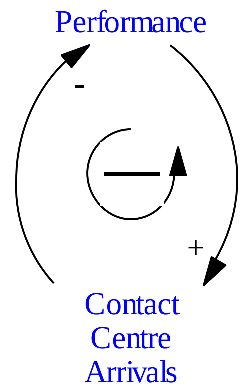

Figure 6.2: Impact of performance

However an additional feedback effect occurs as a result of abandoned calls. Discussion with various members of Hantsdirect revealed that some callers who initially abandon their call will try to call again at some point; others may not call back, but may get the support or help they need from another organisation. However, a third group of callers will end up not calling again and not getting any care or support from any other organisation or person. It is clearly possible that because people in this third category would not have their needs met at the time they made the original call, their situation could deteriorate and they could potentially end up requiring more intensive (and expensive) care in the future. This is illustrated in Figure 6.3 and results in a positive feedback loop or vicious circle. As the number of call arrivals increases, so does the proportion of abandoned calls, which results in a larger number of people who receive no care or support. Moreover a proportion of people who abandoned their calls will call again the following month. Thus the number of calls increases over time. This leads to a decrease in performance of the contact centre, leading to a further number of abandoned calls. This “vicious circle” effect is likely to have a significant impact upon performance. The hybrid model explores this feedback effect, showing the impact of allowing a fraction of callers to call back after one month.

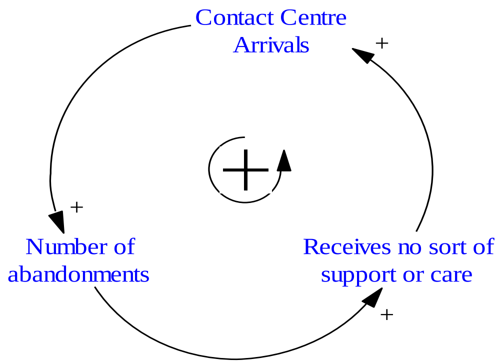

Figure 6.3: Impact of abandonments

Unfortunately there are too many unknown parameters in this model to populate a quantitative system dynamics model. Although useful insights can be obtained from the qualitative influence diagram in Figure 6.3, developing a stock-flow model would require many assumptions about the numerical relationship between call abandonments and care needs status, for which no data were available and approximations based on expert judgment would not be sufficient. Therefore, a simpler approach was adopted, based on the cell-based model presented in Chapter 4. This model essentially has the same deterministic compartmental flow structure as a system dynamics model, although implemented as an Excel spreadsheet. This led to the final choice of a hybrid framework, which has many of the same benefits as the original framework. Figure 6.4 illustrates the chosen hybrid framework.

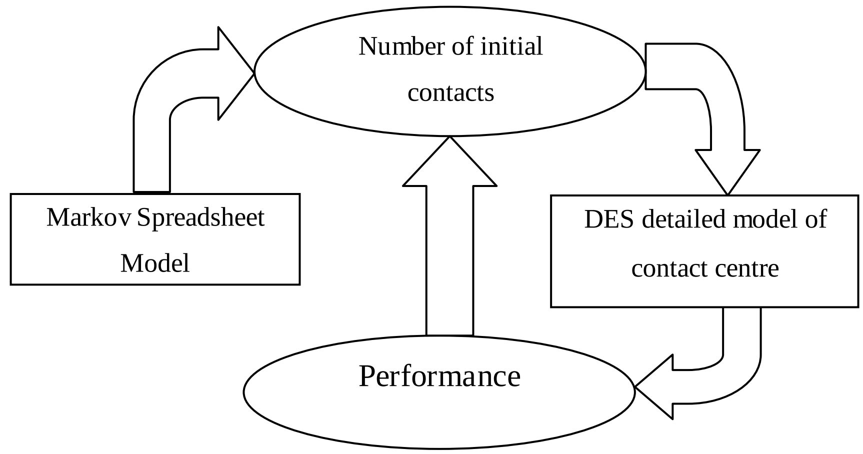

Figure 6.4: Final Hybrid Model

The cell-based model presented in Chapter 4 only generates the number of initial contacts for the contact centre for people aged 65 and above. A new spreadsheet model has been created which includes the rest of the population, as the contact centre receives calls from all age groups. The DES contact centre model presented in Chapter 5 is used to analyse performance for all social service calls.

The modified spreadsheet model also includes people aged sixty-five and over and who are not members of the household population, i.e. are living in an institution. Calls can be received from people in institutional care. For example, an elderly resident of a residential or nursing home might require a change in their care package as a result of a change in personal circumstances. This would require the person in question to have a new assessment so their needs can be reassessed. These initial contacts are fed into the contact centre model to complete the top half of the loop shown in Figure 6.4. Each month a number of key performance measures are reported from the DES contact centre model. The main ones are the number of calls answered, the number of calls answered within 20 seconds, and the number of abandoned calls. These are the key measures of importance in the hybrid framework. These measures were chosen because they are the key performance measures reported by Hantsdirect. Staff utilisation rates are also analysed to see the impact of various staffing scenarios.

As already discussed, a proportion of callers who abandoned their calls would subsequently experience deterioration in their condition. This proportion is unknown but it has important implications for both the contact centre (as shown in Figure 6.3) and the welfare of the people concerned. The hybrid framework accounts for the people whose situation has deteriorated and who call back later requesting help, by including them in the new initial number of client profiles. This completes the bottom half of the loop illustrated in Figure 6.4. These people are added in a month later. However, as a consequence of the delay in getting the support they need, the model assumes that disability level for people aged 65 and over will be altered. People with a slight disability will have their disability status altered to moderate, and people with a moderate disability will have their disability status altered to severe.

6.3 Hybrid framework experiments

Experiment 1: Model is run with no inclusion of feedback. The aim was to provide a baseline, against which a number of scenarios could be compared. Since the true proportion of people who abandon their calls and then have their situation deteriorate is unknown, the following experiments were carried out.

- *Experiment 2: 2% of callers have their situation deteriorate and call back after one month.*
- *Experiment 3: 5% of callers have their situation deteriorate and call back after one month.*
- *Experiment 4: 10% of callers have their situation deteriorate and call back after one month.*

These three experiments accounting for feedback allow a realistic range of possibilities to be explored, and provide a useful set of results. These experiments were carried out for the years 2010, 2015 and 2020. Five year intervals were chosen to allow for significant changes in the population to occur.

Hantsdirect aspire to meet the following two targets: that 95% of their calls are answered and 80% of their calls are answered within 20 seconds. If in any of the experiments these targets are not met, an additional two experiments will be carried out, in each of which an additional intervention will be made. The first intervention is to increase the number of agents to the point where the KPIs are achieved and the second is to increase the number of advisors to the point where the KPIs are once again achieved. This gives a total of 9 experiments (experiments 2, 3 and 4, each for the years 2010, 2015 and 2020). This number will increase if any staffing interventions are required.

6.4 Additional effects not included in the model

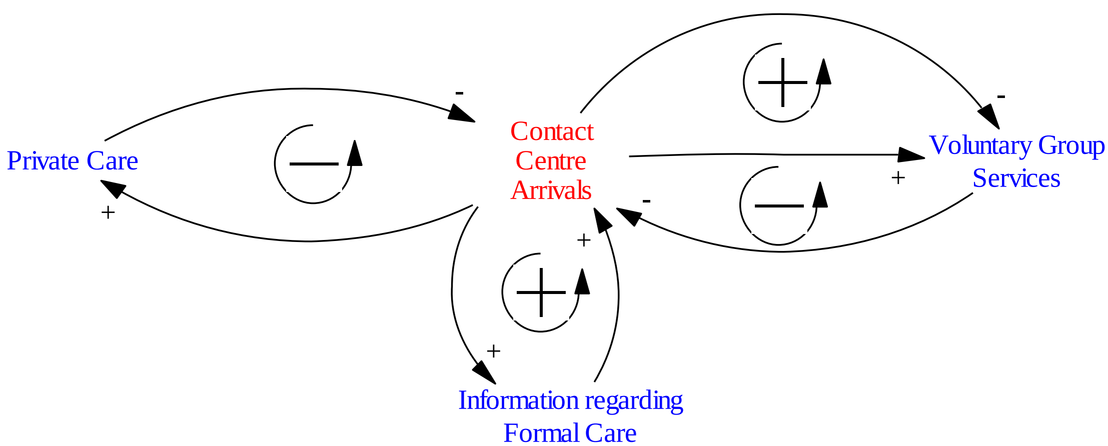

Figure 6.5: Additional Feedback

An important feedback effect is shown in Figure 6.5. One of the key reasons for establishing a contact centre was to serve as an information provider, and hopefully increase the number of people obtaining care from the private sector and voluntary groups rather than the statutory services. This should eventually lead to a decrease in calls, if people obtain care elsewhere. However there is an opposing force in place as well. Firstly, many voluntary organisations will not be able to help people clients whose level of need is high, and this in turn will lead to many of these people making contact with the contact centre again. Secondly, some clients will be able to find out information about statutory services provided by Hampshire County Council of which they were previously unaware. This will lead to them calling Hantsdirect again to try and access the service (so-called "supply induced demand"). There was no empirical evidence of these effects so they were not included in the quantitative modelling, yet once again they illustrate the power of qualitative system dynamics to give insights into potential unanticipated effects.

Finally, seasonality could possibly have an impact upon call arrivals. However, as the contact centre is new, there was not sufficient evidence over time to study this effect and therefore it was not included in the model.

6.5 The hybrid model experimentation process

Figure 6.6 depicts the hybrid experimental process. The process involves a monthly interaction between the cell-based model and the simulation model. For each of three years under investigation and for all four experiments the adapted spreadsheet model generates the demand for the contact centre for the first month. The reason for using the adapted spreadsheet model is that it includes data for the whole population.

The call profile for the first month is used as an input for the simulation model. The process to create the call profile is discussed in detail in section 6.5.1 (p.201). The call centre simulation is run with the new call arrival configuration. As discussed in Chapter 4, the simulation is run for one month and the outputs are reported after 40 trials. The simulation is a terminating simulation. The inputs of the cell-based models have been fully integrated into the simulation user interface which has been built in Microsoft Excel.

For experiment one for all three of the experiment years, the same process is carried out for each of the remaining 12 months. The call profiles vary each month due to changes in the number of people in the Hampshire population. For each of the months the DES model uses this demand to generate a range of performance figures. As already noted, the performance figures of importance are:

- Percentage of calls answered
- Percentage of calls answered within 20 seconds
- Number of abandoned calls
- Agent utilisation
- Advisor utilisation

Experiment 1 is the baseline experiment which can then be compared with the other three experiments to measure the impact of including feedback generated by the number of abandoned calls.

Experiments 2, 3 and 4 allow for the inclusion of feedback. As already noted, the adapted spreadsheet model generates the demand for the contact centre for the first month for all three of the experiment years. After the first month, the process changes for the remaining months. A second spreadsheet is used to generate the call profiles for the remaining eleven months. The original adapted spreadsheet model generates call profiles on a monthly basis but the second spreadsheet allows for the profiles to be altered to include the impact of feedback. Once again, the second spreadsheet model is fully integrated into the simulation user interface.

In month 2 of experiments 2, 3 and 4 the call profiles include a certain percentage of additional calls. These additional calls are a percentage of abandoned calls from the previous month. For experiment 2 it is 2%, experiment 3 it is 5% and experiment 4 it is 10%. This is the same for all three years. For each of the remaining eleven months the call profiles are altered to account for the number of abandoned calls from the previous months. Therefore, each month the call profile varies due to changes in the population and as a result of including abandoned call feedback.

If for any of the years in any of the experiments the KPIs are not achieved, a staffing intervention takes place. The experiment in question is rerun with the staffing intervention until the KPIs are met.

The two KPIs that need to be met are:

- 95% of calls need to be answered
- 80% of calls must be answered within 20 seconds

Two additional experiments are run: one where the number of agents is increased until the KPI targets are satisfied; and another where the number of advisors are increased until the KPI targets are achieved. This staffing configuration is kept the same for the remaining months of the experiment year. For example, if the staffing intervention occurred in February 2015, the remaining 10 months of 2015 would have the same staffing configuration as February after the intervention. An intervention for both agents and advisors is made allowing Hantsdirect to see the impact of the change with either staffing type. To help with this process, the impact of staff utilisation is reported.

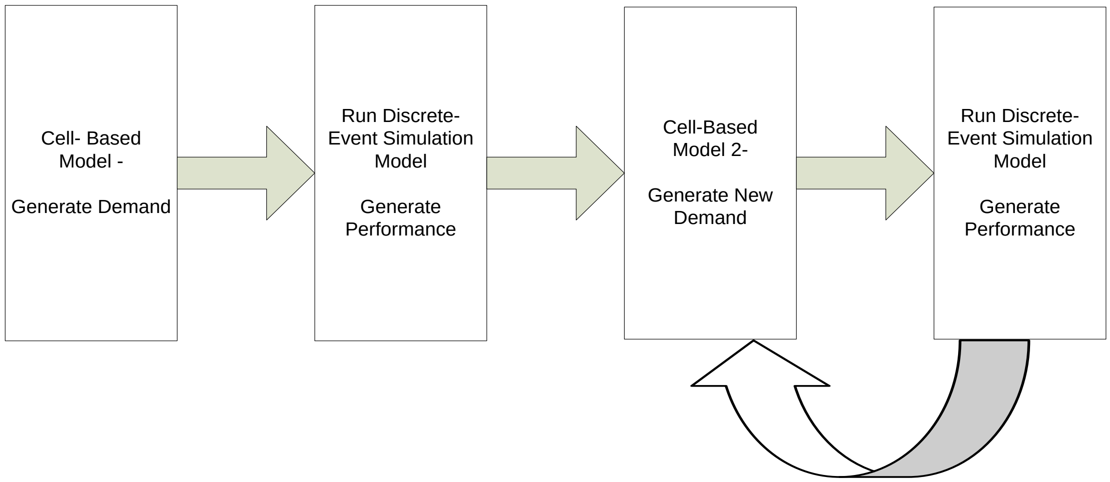

Figure 6.6: The Hybrid Process

6.5.1 Predicting the number of initial contacts

In order to carry out the experimentation, the number of initial contacts must be known for each month of the experimentation years. The first step in forecasting the number of initial contacts was to create an initial call profile from which call projections could be made. Unfortunately, such a detailed call profile was not available from Hantsdirect. One of the key issues with the data available is that the only information that is known is the number of calls received in fifteen minute segments. No other information was available. The following steps were taken to address this situation. The first step was to create a detailed call profile for July 2009 and then to use population projection rates to forecast call arrivals from July 2009 through to December 2020. This will provide the data that is required for the years under investigation.

6.5.2 Detailed call categories

The next step was to identify the categories of call arrivals. The selected categories are shown in Table 6.1. The population was broken down by gender and into the following seven age groups: 0-17, 18-64, 65-69, 70-74, 75-79, 80-84, and 85 and over.

Table 6.1 contains three population types:

1) Whole – the data is based on whole population data
2) Household – the data is based on household population data only
3) Whole-Household – this is the number of people who are not in the household population. The majority of these people are in residential and nursing care. Others are likely to be either homeless or part of the prison population.

One of the main advantages of the hybrid framework is that a more detailed call projection can be made for people aged 65 and over. This requires approximating how many calls are likely to be made by people aged 65 and over. A further dimension that will be explored is a breakdown by disability: slight, moderate and severe. It is assumed that people with no disability will not need to call the contact centre.

Age Group	Gender	Population Type	Call Type	Disability
0-17	Males	Whole	Children	
18-64	Males	Whole	Adults	
65-69	Males	Household	Adults	Slight
65-69	Males	Household	Adults	Moderate
65-69	Males	Household	Adults	Severe
65-69	Males	Whole-Household	Adults	
70-74	Males	Household	Adults	Slight
70-74	Males	Household	Adults	Moderate
70-74	Males	Household	Adults	Severe
70-74	Males	Whole-Household	Adults	
75-79	Males	Household	Adults	Slight
75-79	Males	Household	Adults	Moderate
75-79	Males	Household	Adults	Severe
75-79	Males	Whole-Household	Adults	
80-84	Males	Household	Adults	Slight
80-84	Males	Household	Adults	Moderate
80-84	Males	Household	Adults	Severe
80-84	Males	Whole-Household	Adults	
85+	Males	Household	Adults	Slight
85+	Males	Household	Adults	Moderate
85+	Males	Household	Adults	Severe
85+	Males	Whole-Household	Adults	
0-17	Females	Whole	Children	
18-64	Females	Whole	Adults	
65-69	Females	Household	Adults	Slight
65-69	Females	Household	Adults	Moderate
65-69	Females	Household	Adults	Severe
65-69	Females	Whole-Household	Adults	
70-74	Females	Household	Adults	Slight
70-74	Females	Household	Adults	Moderate
70-74	Females	Household	Adults	Severe
70-74	Females	Whole-Household	Adults	
75-79	Females	Household	Adults	Slight
75-79	Females	Household	Adults	Moderate
75-79	Females	Household	Adults	Severe
75-79	Females	Whole-Household	Adults	
80-84	Females	Household	Adults	Slight
80-84	Females	Household	Adults	Moderate
80-84	Females	Household	Adults	Severe
80-84	Females	Whole-Household	Adults	
85+	Females	Household	Adults	Slight
85+	Females	Household	Adults	Moderate
85+	Females	Household	Adults	Severe
85+	Females	Whole-Household	Adults	

Table 6.1: Call Profile Categories

There are two call types, calls for Adult Services and calls for Children's Services. There are three disability categories for people aged 65 and over: Slight, Moderate and Severe. People with a slight, moderate and severe disability are the candidates to make contact. One of the benefits of using the cell-based model is the ability to remove people with no incapacity. The number of people aged over 65 who contact Hantsdirect can be predicted with greater accuracy using the cell-based model.

6.5.3 Call category population totals and proportions

The next step was to assign likely population totals to each category in Table 6.1 for July 2009. July 2009 is the base month from which projections will be made. The reason for the choice of the base month is due to the availability of call arrival data. Once a detailed call profile for July 2009 was created, this was projected forward up to December 2020 using population projection rates. Once the population totals for each of the categories in Table 6.1 were estimated, proportions were calculated for each of the categories. These were then used to work out a detailed breakdown of calls in July 2009. The population total and proportions for July 2009 are shown in Table 6.2.

Population Type	Call Type	Gender	Age Group	Disability	Population Total	Proportion
Whole	Adults	Males	18-64		377,445	
Household	Adults	Males	65-69	Slight	8139	48.08%
Household	Adults	Males	65-69	Moderate	6372	37.65%
Household	Adults	Males	65-69	Severe	2,271	13.42%
Whole-Household	Adults	Males	65-69		144	0.85%
Household	Adults	Males	70-74	Slight	6,788	38.54%
Household	Adults	Males	70-74	Moderate	8,276	46.99%
Household	Adults	Males	70-74	Severe	2,322	13.19%
Whole-Household	Adults	Males	70-74		225	1.28%
Household	Adults	Males	75-79	Slight	5,240	31.47%
Household	Adults	Males	75-79	Moderate	8,274	49.69%
Household	Adults	Males	75-79	Severe	2,758	16.56%
Whole-Household	Adults	Males	75-79		380	2.28%
Household	Adults	Males	80-84	Slight	3,215	26.83%
Household	Adults	Males	80-84	Moderate	6,144	51.28%
Household	Adults	Males	80-84	Severe	2,072	17.29%
Whole-Household	Adults	Males	80-84		550	4.59%
Household	Adults	Males	85+	Slight	1,509	15.12%
Household	Adults	Males	85+	Moderate	4,124	41.34%
Household	Adults	Males	85+	Severe	3,018	30.25%
Whole-Household	Adults	Males	85+		1,326	13.29%
Whole	Adults	Females	18-64		388,341	
Household	Adults	Females	65-69	Slight	8,521	42.02%
Household	Adults	Females	65-69	Moderate	8,914	43.95%
Household	Adults	Females	65-69	Severe	2,687	13.25%
Whole-Household	Adults	Females	65-69		158	0.78%
Household	Adults	Females	70-74	Slight	6,877	31.67%
Household	Adults	Females	70-74	Moderate	10,079	46.41%
Household	Adults	Females	70-74	Severe	4,446	20.47%
Whole-Household	Adults	Females	70-74		316	1.46%
Household	Adults	Females	75-79	Slight	4,673	22.92%
Household	Adults	Females	75-79	Moderate	9,858	48.36%
Household	Adults	Females	75-79	Severe	5,129	25.16%
Whole-Household	Adults	Females	75-79		727	3.57%
Household	Adults	Females	80-84	Slight	2,953	16.65%
Household	Adults	Females	80-84	Moderate	8,346	47.05%
Household	Adults	Females	80-84	Severe	5,008	28.23%
Whole-Household	Adults	Females	80-84		1,433	8.08%
Household	Adults	Females	85+	Slight	774	3.93%
Household	Adults	Females	85+	Moderate	6,195	31.43%
Household	Adults	Females	85+	Severe	7,400	37.54%
Whole-Household	Adults	Females	85+		5,344	27.11%

Table 6.2 : Population total and proportions – July 2009

6.5.4 Call category population totals and proportions methodology

The population totals and proportions for July 2009 were calculated in the following way. Data provided by personal communication from the National Statistics Subnational Population Projections Unit were used to calculate population totals for the seven age groups for each of the years 2009 to 2020. This was done for both male and females for each district. The sum of all the eleven districts created a total for the county.

The next step was to estimate the number of people in the household population for the following five age groups; 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 and over. The data were derived from a dataset provided by Communities and Local Government Department by personal communication. This was done in order to calculate the number of elderly people who are not part of the household population. This was once again done for both male and females for each district. The sum of all the eleven districts created a total for the county. The non-household population was calculated by simply subtracting the household population from the overall population for Hampshire. This was done for each of the years in question for the five age groups for people aged 65 and over.

The next step was to estimate the number of elderly people with some level of disability (slight, moderate or severe) for each gender. This was calculated for each of the years. This was calculated using data from the 2001 General Household Survey (Economic and Social Data Service, 2001). This is discussed in detail in Chapter 4. The population totals for each the categories are firstly tabulated for each year between 2008 and 2020. The next stage in the analysis required the calculation of the yearly difference for each category. The result of this was divided by 12 to work out the average monthly difference. Monthly variations are not accounted for. The monthly difference figures are used to calculate the monthly population totals. From this we get the final result of importance from this stage of the data analysis from the hybrid framework. The monthly rates of change have been calculated. This is what will be used to calculate the call arrivals over time.

Now that the monthly rates of change for the various categories are known, the next step in the analysis is to create a detailed call profile for July 2009.

6.5.5 Monthly call arrivals

Call arrivals for July 2009 were calculated in the following way. Call arrivals for two representative weeks from June and July 2009 were used to work out the number of potential call arrivals for July 2009. Using the techniques discussed in Chapter 5, a weekly profile was created. This has been assumed for modelling purposes to be a typical week in July 2009. The monthly call arrivals (Table 6.4) were calculated by multiplying the weekly call arrival profile (Table 6.3) by 4.

	Adult Service Calls	Children's Service Calls
Monday	377	458
Tuesday	312	382
Wednesday	279	344
Thursday	294	364
Friday	253	308

Table 6.3: July 2009 Weekly Call Arrival Profile

Monthly	Adult Service Calls	Children's Service Calls
Monday	1508	1832
Tuesday	1248	1528
Wednesday	1116	1376
Thursday	1176	1456
Friday	1012	1232

Table 6.4: July 2009 Monthly Call Arrival Profile

Summing the total call arrivals for each day gives 6,060 Adult Service call arrivals and 7,424 Children Service call arrivals in July 2009.

6.5.6 Detailed call profile

Now that the number of calls for July 2009 is known, the next step is to distribute these calls across the various call categories. There is no information available to split Adult Service calls for people aged 18 to 64 and people aged 65 and over. The only potential source of information was a report produced by Hampshire County Council's Performance and Business Management team that identifies clients on SWIFT (Northgate, 2011) who have the Professional Advisory Team (PAT) as their contact team. Adult Services keep information on people callers who go through to PAT for a potential assessment. Unfortunately, the report does not include all callers who go through the PAT process, but the sample was large enough to base assumptions upon. The data was checked to ensure that it did not double-count a client who might have called more than once during the month. There were many problems with the data for July 2009, and better data was available for January 2010. It has been assumed that information from January 2010 can be used for the July 2009 call profile breakdown. Based on discussions with members of Hampshire County Council, the rates are likely to be very similar between the two months.

The report was used to work out the probable proportions of callers aged between 18 and 64 and people aged 65 and over. The data also allowed a split between the genders and five-year age groups for people aged 65 and above.

	Gender		
Client Age Category	Female	Male	Grand Total
18-64	34	38	72
65-69	13	9	22
70-74	20	15	35
75-79	32	18	50
80-84	71	39	110
85+	115	58	173
Unknown	2		2
Grand Total	287	177	464

Table 6.5: Call totals for the PAT – January 2010

The data from Table 6.5 were used to calculate the proportions shown in Tables 6.6 and 6.7. Two unknown callers were removed from the sample and so the sample size is 462.

Client Age Category	Proportion (%)
18-64	15.58
65-69	4.76
70-74	7.58
75-79	10.82
80-84	23.81
85+	37.45

Table 6.6: Call proportions for the PAT, January 2010

Table 6.5 shows the call proportions for each of the six age groups for people aged 18 and over. Once the number of calls for each of the age groups was known, the calls could then be broken down by gender using the proportions in Table 6.6.

	Proportion (%)	
Client Age Category	Female	Male
18-64	47.22	52.78
65-69	59.09	40.91
70-74	57.14	42.86
75-79	64.00	36.00
80-84	64.55	35.45
85+	66.47	33.53

Table 6.7: Call proportions by gender for the PAT, January 2010

As it is assumed that these calls are representative of all Adult Service calls, the next step was to multiply the proportions shown in Table 6.6 by the number of callers for July 2009, known to be 6060. This results in the likely number of callers for each of the six age groups. These numbers were then in turn multiplied by the proportions in Table 6.7. The final results are summarised in Table 6.8.

	Gender	
Client Age Category	Female	Male
18-64	446	498
65-69	171	118
70-74	262	197
75-79	420	236
80-84	931	512
85+	1,508	761

Table 6.8: Final call total for Adult Services – July 2009

The next step in the analysis was to break down the call totals shown in Table 6.8 into the detailed call categories shown in Table 6.1. This was calculated using the proportions shown in Table 6.2. The results for the detailed call profile for July 2009 are shown in Table 6.9.

Population Type	Call Type	Gender	Age Group	Disability	Population Total
Whole	Adults	Males	18-64		498
Household	Adults	Males	65-69	Slight	57
Household	Adults	Males	65-69	Moderate	44
Household	Adults	Males	65-69	Severe	16
Whole-Household	Adults	Males	65-69		1
Household	Adults	Males	70-74	Slight	76
Household	Adults	Males	70-74	Moderate	92
Household	Adults	Males	70-74	Severe	26
Whole-Household	Adults	Males	70-74		3
Household	Adults	Males	75-79	Slight	74
Household	Adults	Males	75-79	Moderate	117
Household	Adults	Males	75-79	Severe	39
Whole-Household	Adults	Males	75-79		5
Household	Adults	Males	80-84	Slight	137
Household	Adults	Males	80-84	Moderate	262
Household	Adults	Males	80-84	Severe	88
Whole-Household	Adults	Males	80-84		23
Household	Adults	Males	85+	Slight	115
Household	Adults	Males	85+	Moderate	315
Household	Adults	Males	85+	Severe	230
Whole-Household	Adults	Males	85+		101
Whole	Adults	Females	18-64		446
Household	Adults	Females	65-69	Slight	72
Household	Adults	Females	65-69	Moderate	75
Household	Adults	Females	65-69	Severe	23
Whole-Household	Adults	Females	65-69		1
Household	Adults	Females	70-74	Slight	83
Household	Adults	Females	70-74	Moderate	122
Household	Adults	Females	70-74	Severe	54
Whole-Household	Adults	Females	70-74		4
Household	Adults	Females	75-79	Slight	96
Household	Adults	Females	75-79	Moderate	203
Household	Adults	Females	75-79	Severe	106
Whole-Household	Adults	Females	75-79		15
Household	Adults	Females	80-84	Slight	155
Household	Adults	Females	80-84	Moderate	438
Household	Adults	Females	80-84	Severe	263
Whole-Household	Adults	Females	80-84		75
Household	Adults	Females	85+	Slight	59
Household	Adults	Females	85+	Moderate	474
Household	Adults	Females	85+	Severe	566
Whole-Household	Adults	Females	85+		409

Table 6.9 :Adult Service Call Totals – July 2009

The call totals are projected forward using the rates of change in the population. The input for the simulation model is the total number of calls for each month. The distribution of calls throughout the day and week in the model are based on the spread of the calls during representative weeks from June and July 2009.

The next step is to calculate the number of Children's Service calls for July 2009. It is known that there are 7,424 of these. As there is no information available in relation to the gender split, it is assumed that the split of calls between females and males is the same as the whole children's population for Hampshire. Of the population aged 17 and under, 48.13% are female and 51.81% are male. The results are shown in Table 6.10.

Population Type	Call Type	Gender	Age Group	Total
Whole	Children	Males	0-17	3851
Whole	Children	Females	0-17	3573

Table 6.10: Children's Service Call totals July 2009

The call totals are projected forward using the rates of change in the whole population. The input for the simulation model is the total number of calls for each month. The distribution of calls throughout the day and week in the model are based on the spread of the calls during representative weeks from June and July 2009.

The data to carry out the simulation experiments are now all available. The only element which remains to be accounted for is the impact of feedback created from abandoned calls. For the experiments where feedback is included, the following methodology is applied.

6.5.7 Inclusion of feedback

The number of abandoned calls each month is split between Adult and Children's Services as follows: 55% of abandoned calls are for Children's Service and 45% are for Adult Services. This assumption is held to be true for all the experiments. Children's Service abandoned calls are split by gender based on the current gender proportions of the call inputs for Children's calls. These inputs change for each of the experiments. Adult Service abandoned calls are split by age group and gender based on the proportions shown in Tables 6.6 and 6.7. This assumption is held to be true for all the experiments. The abandoned calls are then distributed into the more detailed caller categories based on updated call proportions which change depending on the current Adult Service call input. These inputs change for each of the experiments. One noteworthy change is that when the abandoned calls are fed back into the new call profile, the disability status is changed for people with a slight and moderate disability. The status of people with a slight disability is changed to moderate and people with a moderate disability are change to severe.

6.5.8 Staffing interventions

If any staffing interventions are required in the experimentation, one full-time member of staff will be added to the staffing roster. The agent or advisor will be based upon a real member of staff's weekly schedule. This process will be continued until the performance requirements are satisfied.

6.5.9 Verification and Validation

The adopted cell-based model was fully validated. The same process of validating and verifying the cell-based model in Chapter 4 was applied. All the logic was checked and no errors were found. The processes described in this chapter were fully tested and passed all tests. No errors were found.

The simulation model of the contact centre has been tested and the process of verified and validated. The process is described in Chapter 5. The process to create new call arrival profiles based on the number of abandoned calls from the previous month was fully tested and passed all tests. No errors were found.

The results of all the simulation experiments are presented in Chapter 7 and the findings and implications discussed in Chapter 8.

7. Results

In this chapter we first present the projections derived from the standalone cell-based model (see Chapter 4), followed by the results obtained from the hybrid combination of this model with the DES contact centre model (see Chapter 6). For the cell-based model, three scenarios are explored in detail. Firstly, a baseline scenario is considered. The second scenario explores the impact of altering the rates of moderate and severe disability as there is much uncertainty associated with these two variables. The third scenario looks at the potential number of future local authority clients based on current numbers. The results of the hybrid model framework are then presented and the implications explored for each experimentation year. The evolution of the contact centre is explored over the next ten years by focusing in depth on three specific years. As a result the following three research questions are addressed.

1. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people with a disability?

2. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people requiring long-term care?

3. How could a detailed tactical model for the Contact Centre benefit from the additional use of a long-term dynamic demographic model for population change?

All the results, including additional experiments not reported in this section, can be found on the CD accompanying this thesis.

7.1 Results from the Cell-Based Model

The results of the cell-based model (see Chapter 4) are now discussed. The results of the adapted cell-based model (see Chapter 6) are presented as part of the hybrid framework in section 7.2 (pp.255-263).

7.1.1 Population projections

In the following projections, population numbers have been rounded to the nearest hundred[2]. These projections are the main drivers for the future need for long-term care. The numbers of people each year have been multiplied by the associated disability rates created from responses from the 2001 General Household Survey in order to create the estimated number of people in each disability category. This is the baseline scenario: the results from this scenario are presented in section 7.1.4 (pp.224-247).

Firstly, the data for the whole elderly household population are analysed. Secondly, the male and female sub-populations are examined and a comparison made between the two sub-populations in terms of the implications for Hampshire.

[2] There are potential issues with the rounding. For example, adding the male population figure to the female population figure does not necessarily yield the reported total population figure. The figures add up correctly before the rounding was applied.

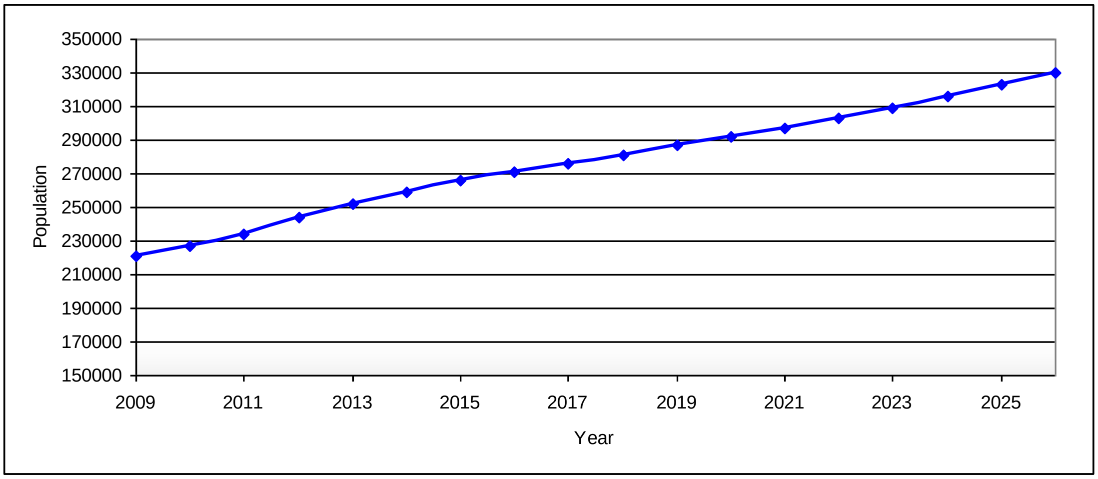

Figure 7.1: Hampshire Elderly Population

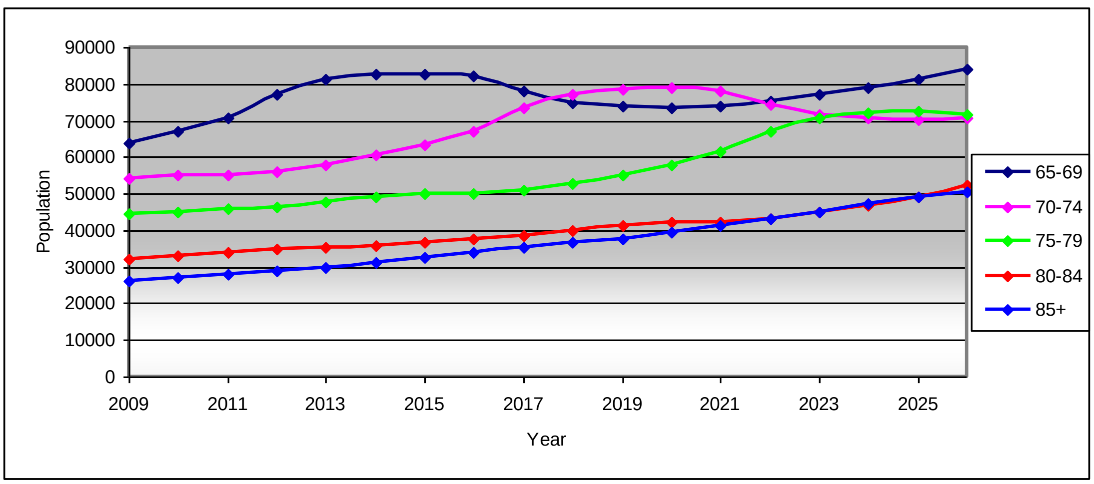

Figure 7.21: Hampshire Elderly Population by Age Group – 2009-2026

As illustrated in Figure 7.2, it is evident that there is predicted to be an increase in the household population for each age group. There are, however, striking differences between the various age groups in how the population evolves over time. The model predicts that the total number of older people will increase by 49.55% over the whole period. This is a significant increase with many implications for the provision of long-term care. While not all older people will require care, a large proportion will, as shown in section 7.1.4 (pp.224-247).

For people aged 65-69, the projected increase over the same period is expected to be 31.34%. For people aged 70-74 it is slightly less, at 30.59%. The increase is even more striking in the older age groups. The model predicts that the number of people aged 75-79 will increase by 61.39%; the number of people aged 80-84 is predicted to increase by 63.84%, and the number of people aged 85 and over is predicted to increase by 92.93%. The increases are very significant and are likely to lead to large increases in the number of disabled people. It is shown later in this Chapter that these people make the greatest demand upon formal care.

As illustrated in Figure 7.1, a steady year on year increase can be observed in the growth of Hampshire's elderly household population. A different pattern is observed for the three younger age groups. The population increases from 2009 to 2017, but then a year on year decrease is projected until 2021. For the following five years the population is once again projected to increase. Through the years 2018 to 2021, the model predicts more people aged 70-74 than people aged 65-69. On average the number of people aged 65-69 is predicted to increase by 1.67% each year. The greatest year on year increase is in 2012, when the number is predicted to increase by 9%. From 2013 until 2016 a plateau in the age group becomes apparent.

For people aged 70-74, the model predicts a population increase until the year 2020. The population is then predicted to decrease over the next five years until 2026 where a marginal increase is expected. The year on year increase on average over the total period is 1.64%. This is very similar to the first age group. For people aged 75-79, an increase occurs each year until 2026 where the model predicts a slight decrease. On average, the increase year on year is 2.88%. Much higher increases are predicted from 2019 until 2023 where the average is 5.92%. In 2022, the increase is predicted to be 9.19%. There is a constant increase in the population for the two oldest age groups. For people aged 80-84, the year on year increase is expected to be 2.96%, whilst for the oldest age group it is predicted to be 3.94%.

7.1.2 Male population projections

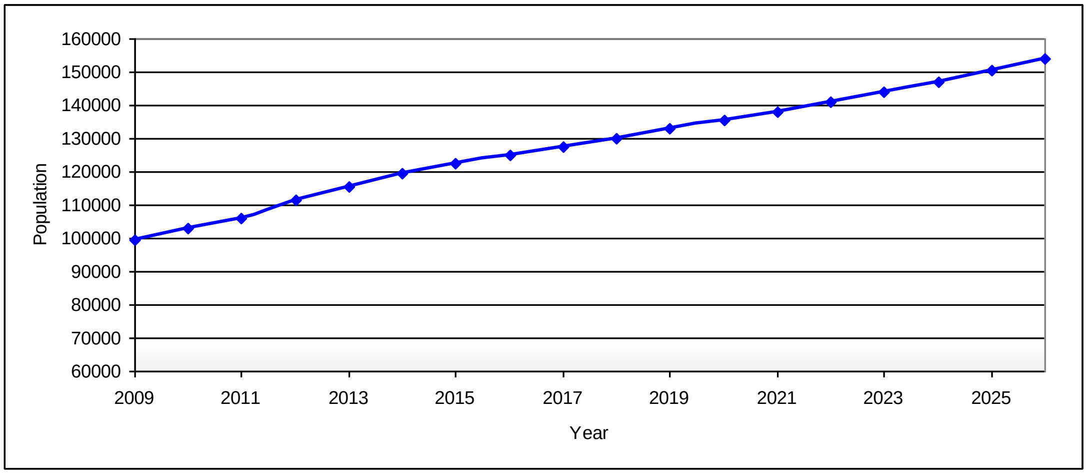

Figure 7.3: Hampshire Male Elderly Population – 2009-2026

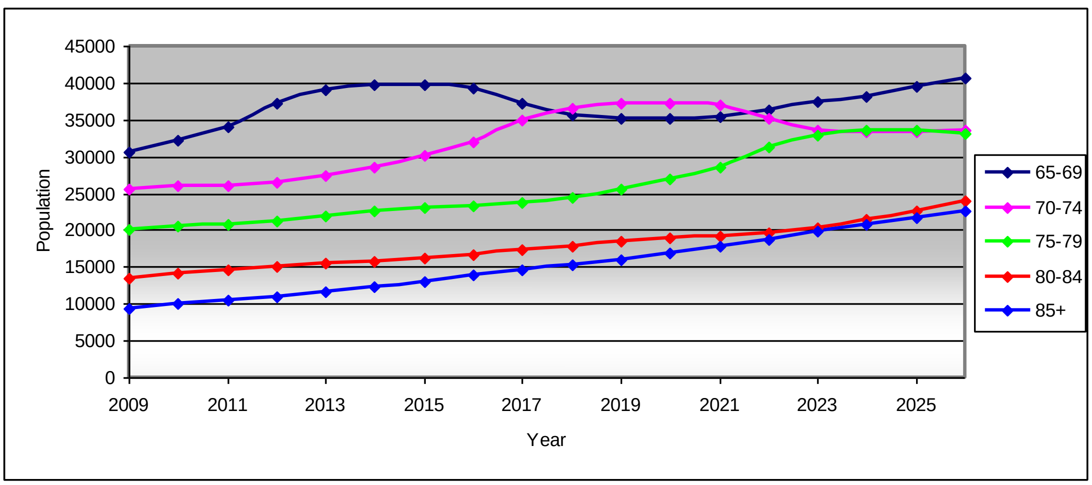

Figure 7.4: Hampshire Male Elderly Population by Age Group – 2009-2026

As shown in Figure 7.3, the model predicts an increase of 54.69% in the total number of older males over the whole period. The increase is higher than the expected change in the total population. For males aged 65-69, the projected increase over the same period is 32.26% and for males aged 70-74 slightly less, at 31.02%. There is not much difference in comparison to the total population. However, once again the increase is more striking when examining the older male age groups. The number of men aged 75-79 is projected to increase by 65.36%; the number of men aged 80-84 will increase by 76.20% and the number of men aged 85 and over will increase by 138.11%. The increase for men aged 85 and over is very significant and will more than double over the period. This increase is much greater than that of the total population and will have many implications when planning both health and social care services for the future. The patterns observed in the individual age groups are very similar to patterns in the population as a whole.

7.1.3 Female population projections

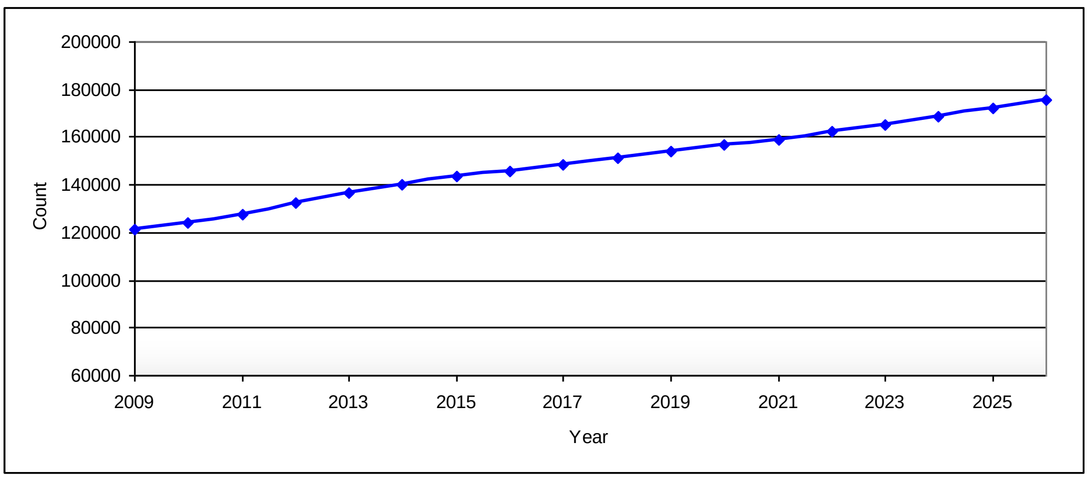

Figure 7.5: Hampshire Female Elderly Population – 2009-2026

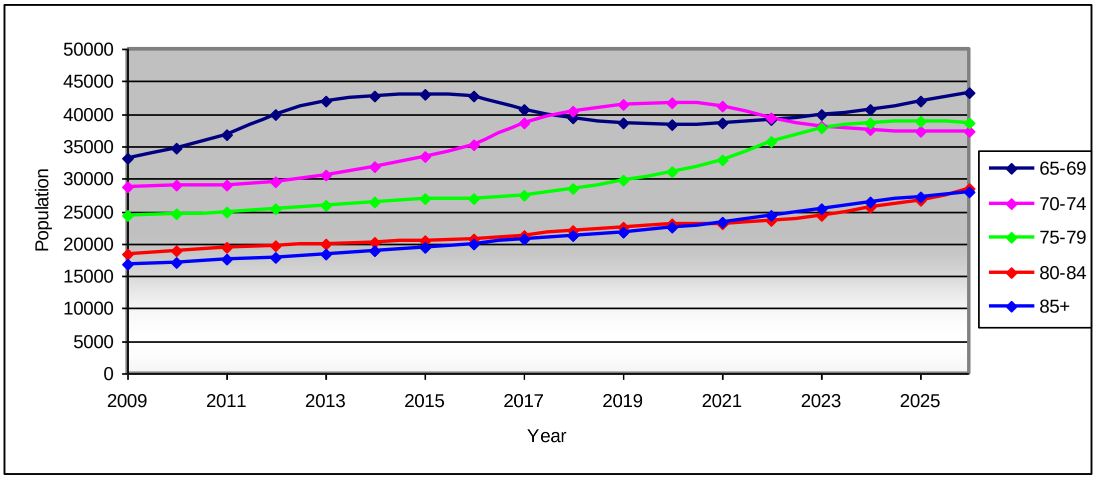

Figure 7.6: Hampshire Female Elderly Population Age Group – 2009-2026

As shown in Figure 7.5, the total number of older females is predicted to increase by 44.75% over the whole period. The increase is lower than the expected change in the total population. It is significantly lower than the predicted increase for all older men living in the household population in Hampshire. The model predicts an increase of 30.49% in females aged 65-69 and a slightly smaller increase (30.2%) of women aged 70-74. There is not much difference when compared to the total and male older populations.

Once again the increase is even more acute when examining the older female age groups. The number of women aged 75-79 is projected to increase by 58.13%; the number of women aged 80-84 is predicted to increase by 54.70% and for women aged 85 and over the expected increase is 67.46%. The increase in women aged 85 and over is once again considerable, although lower than that of the total population. The increase in the three older age groups is substantial, but smaller than the predicted increase in men. For women aged 85 and over it is much smaller. It is important to note that there are considerably more females than males throughout the period. There are nearly 22,000 more females than males in 2009 and this difference is not expected to change by much over the period even though the male population will increase by a significant amount. The greatest percentage age increases can be seen at the oldest ages, which only represent a small proportion of the total population. The gap between the male and female population is only predicted to decrease for people aged 80 and above. The gap is predicted to decrease by nearly 24% for people aged 85 and over. However, the gap is predicted to increase by approximately 24% for people aged 70-74 and 75-79.

These population projections are very relevant to baseline disability and service provision projections. The changes over the eighteen-year period in the five age groups just discussed, directly impact upon the next set of projections.

7.1.4 Baseline scenario results

The baseline results are based on disability and service provision rates generated from the 2001 General Household Survey. No alterations were made to any of the rates or the population data. 2009 disability levels are assumed throughout the modelling period. Any person with some level of disability is a likely candidate to require long-term care. Respondents in the survey were asked about their service provider in relation to the following activities: bathing, washing and using the shower. As noted previously, the activities are based upon what is the main form of service provision. A more accurate exploration of formal care provision is explored in the third scenario.

7.1.4.1 Total population disability projections

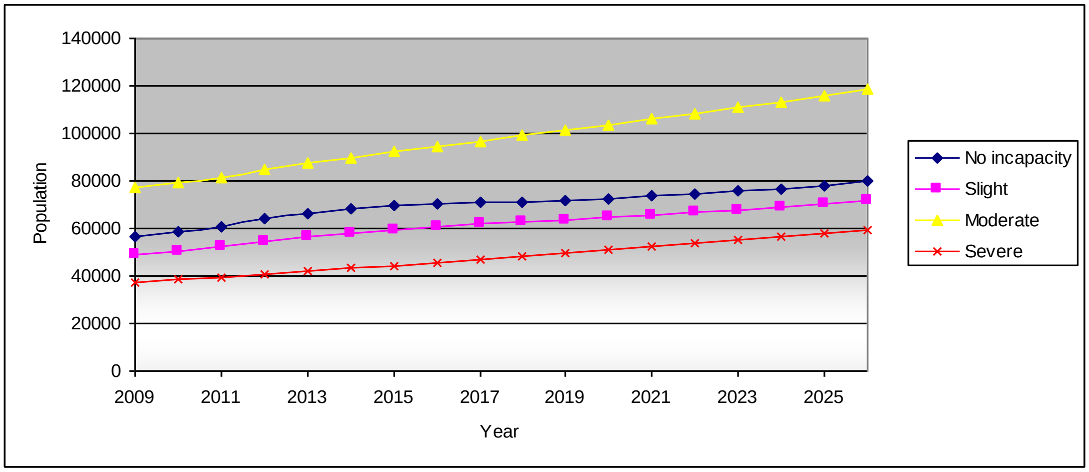

Figure 7.7: Total Population – Disability Categories

Figure 7.7 illustrates the model projections of the total population broken down by the four disability categories. The largest category is people with a moderate disability. In 2009, 56,800 people aged over 65 were classified as having no incapacity. The model predicts that this number will have increased by 16.89% in 2013, by 25.60% in 2018 and by 40.61% in 2026. On average, 33.92% of people each year are predicted to have no incapacity, and all the others are likely to have some sort of disability.

In 2009, 49,200 people were estimated as having a slight disability: the model predicts that this number will have increased by 15.11% in 2013, by 27.31% in 2018 and by 45.63% in 2026. The change over the whole period is greater than for people with no disability. In 2009, 77,400 people were estimated to have a moderate level of disability, considerably more than the number of people with no incapacity or a slight disability: the model predicts that this number will have increased by 12.93% in 2013, by 28.23% in 2018 and by 53.10% in 2026. In 2009, 37,500 people were estimated to have a severe disability: the model predicts that this number will have increased by 12.13% in 2013, by 28.62% in 2018 and by 59.01% in 2026, a very significant increase. Since people with a severe disability are the most likely candidates to seek care from Social Services, this will have a considerable impact upon Hampshire County Council. The considerable increase in the number of people with a disability will also have a significant impact upon the demand for the contact centre. The impact of this is discussed in section 7.2 (pp.255-263).

A breakdown of these results by district is not presented here, but these detailed results have been provided to Hampshire County Council and will prove to be a useful aid in planning future social care services. The full set of results can be found on the accompanying CD.

The number of elderly disabled people living in their homes is expected to increase considerably in both the short- and long-term. People with a severe disability are likely to require a considerable amount of care and will be a concern for all the providers of social care in the home and community. There will also be pressure on the providers of residential and nursing care. It is likely that as the number of people with a severe disability increases, many of them will be potential candidates for institutional care at some point.

There are gender differences in the projected increases in the numbers of disabled people, and significant differences between the age groups. It is important to consider gender differences as they will impact upon the demand for long-term care. Males and females are likely to have acquired a different set of skills as they survive into old age. It is known from speaking to members of Adult Services in Hampshire and other academics that many older men will not have the necessary skills to live on their own and will be more likely to require full-time assistance or require to be placed in institutional care, in comparison with females. Females are more likely to have acquired skills, such as cooking, over their life course. A detailed analysis of the breakdown by gender can be found in Appendix A12. The key findings are discussed in section 7.1.4.6 (pp.240-247).

7.1.4.2 Disability projections for people aged 65-69

We now discuss the disability classes and the main care provisions for each of the five age groups. We present our findings for the age group 65-69; the results for the other four groups can be found in Appendix A13. The key findings are discussed in section 7.1.4.6 (pp.240-247).

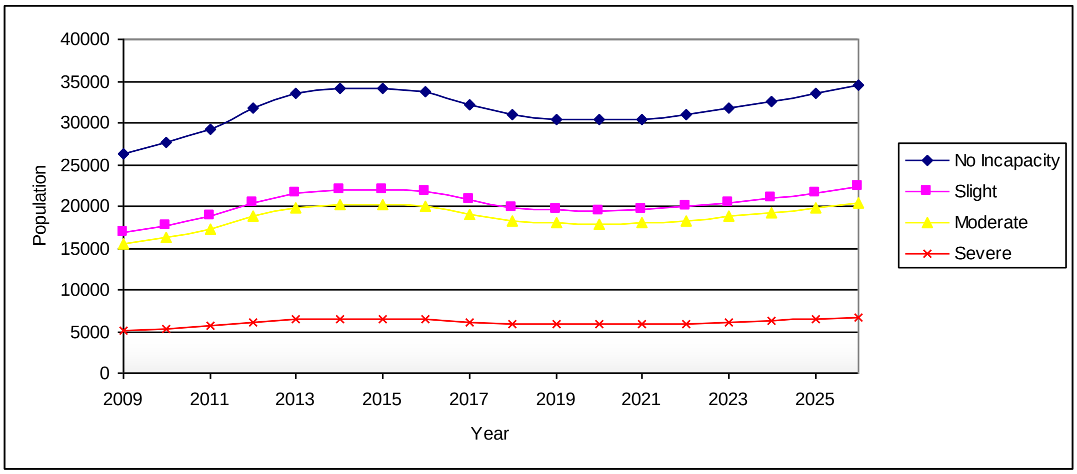

Figure 7.8: Total Population aged 65-69 – Disability Categories

Over the eighteen year period the model predicts an increase of 31.43% in the number of people aged 65-69. In 2009, an estimated 26,300 people in this age group have no incapacity. The model predicts this number will have increased by 7,100 in 2013, by a further 4,600 in 2018 and a further 8,300 in 2026. The model predicts that by 2026, the number of people aged 65-69 with some level of disability will have increased by 11,700 from the 2009 figure of 37,500. As shown in Figure 7.8, for the first seven years the number is predicted to increase, but then falls for the following five years, before increasing again for the rest of the period. The model predicts that the total number of disabled people aged 65-69 will have increased by 10,100 in 2013, and in 2018 the number of people with some sort of disability will be 6,600 more than in 2009.

In 2009, an estimated number of 16,900 people aged 65-69 had a slight disability, 15,600 had a moderate disability and 5,000 had a severe disability. The model predicts that the number of people with a slight disability in this age group will increase by 5,300 over the whole period. The number of people with a moderate level of disability is predicted to increase by 4,900, and the number of people with a severe level of disability is predicted to increase by 1,600. These are noteworthy changes but not as considerable as the other age groups.

7.1.4.3 Key findings of population data broken down by disability

Table 7.1 presents a summary of Hampshire household population broken down by disability category.

		Population in 2009	Population Change by Year		
Age Group	**Disability Group**		**2013**	**2018**	**2026**
65-69	No Incapacity	26,300	7,100	4,600	8,300
	Slight	16,900	4,600	2,900	5,300
	Moderate	15,600	4,200	2,700	4,900
	Severe	5,000	1,400	900	1,600
70-74	No Incapacity	15,200	1,000	6,400	4,600
	Slight	13,800	900	5,800	4,200
	Moderate	18,500	1,300	7,800	5,700
	Severe	6,800	500	2,800	2,100
75-79	No Incapacity	8,400	600	1,600	5,200
	Slight	9,900	800	1,900	6,200
	Moderate	18,200	1,400	3,500	11,200
	Severe	7,900	600	1,500	4,800
80-84	No Incapacity	4,000	400	1,000	2,600
	Slight	6,200	700	1,600	4,100
	Moderate	14,600	1,600	3,600	9,300
	Severe	7,100	700	1,600	4,400
85+	No Incapacity	2,900	400	1,000	2,400
	Slight	2,300	400	1,200	2,700
	Moderate	10,500	1,600	4,300	10,000
	Severe	10,600	1,400	3,900	9,300

Table 7.1 : Hampshire Population Disability Breakdown

As shown in Table 7.1, the largest disability group for people aged 70-74, 75-79 and 80-84 is the moderate disability group. It has been assumed in this thesis that the Local Authority Services are only available to people with a severe disability, it is therefore important for the local authority that preventative services are put in place to limit the number of people becoming severely disabled and therefore potentially clients of Adult Services. This is also beneficial for the individual’s wellbeing. Preventative services are a key priority of local governments as highlighted in Chapter 2. Across the five age groups, there were an estimated total number of 77,400 people with a moderate disability in 2009. This is higher than the other disability groups. For people aged 85 and over, the severe disability group is largest in number. The number of people with a moderate disability is very similar for people in that age group. Analysis of client data for Hampshire County Council showed that people aged 85 and over are the highest consumers of Adult Social Care.

The fact that so many people are predicted to have a moderate disability is an important point for Adult Services. Many of these people are likely candidates for long-term care. If they are not supported at this stage, they could end up having their situation deteriorate and end up being classified as having a severe disability at some point in the future. Depending on their financial status, they are likely candidates for formal care service from the local authority. The large numbers of people with some level of disability is likely to be a strain on all providers of care services.

Tables 7.2 and 7.3 break down the data in Table 7.1 by gender. The patterns in Tables 7.1 and 7.3 are very similar, i.e. the female population follows the same disability profile as the total population. In contrast, Table 7.2 shows there are more males in the moderate disability category than the severe category. It should be noted that in 2009 there are estimated to be over 6,400 more females than males in the moderate and severe disability categories.

Unsurprisingly, the number of people with no incapacity decreases with age. In 2009, only 10.97% of people aged 85 and over were estimated to have no incapacity and the largest disability group was people with a moderate disability. This is true for both the male and female populations. However, there are estimated to be 10,200 more females than males with a moderate disability.

As shown in Table 7.1, in 2009, the age group with the largest number of disabled people are people aged 70-74 with 39,100 people. The 65-69 and 75-79 age groups contain slightly fewer disabled people. The absolute numbers of disabled people fall significantly for the two oldest age groups, partly due to mortality rates as one would expect but also because the proportion of people receiving residential or nursing home care increases with age. The same results are found for both the male and female populations. The numbers of males with disability aged 65-69 and 70-74 are very similar.

		Population	Population Change by Year		
Age Group	**Disability Group**	**in 2009**	**2013**	**2018**	**2026**
65-69	No Incapacity	13,700	3,700	2,200	4,400
	Slight	8,300	2,300	1,300	2,700
	Moderate	6,500	1,800	1,000	2,100
	Severe	2,300	600	400	700
70-74	No Incapacity	8,100	600	3,500	2,500
	Slight	6,900	500	3,000	2,100
	Moderate	8,400	600	3,600	2,600
	Severe	2,300	200	1,000	700
75-79	No Incapacity	3,700	400	800	2,400
	Slight	5,300	500	1,200	3,400
	Moderate	8,300	800	1,800	5,400
	Severe	2,800	300	600	1,800
80-84	No Incapacity	2,000	300	600	1,500
	Slight	3,300	500	1,000	2,500
	Moderate	6,200	900	2,000	4,800
	Severe	2,100	300	700	1,600
85+	No Incapacity	600	100	400	900
	Slight	1,500	400	1,000	2,100
	Moderate	4,200	1,000	2,600	5,800
	Severe	3,100	700	1,900	4,300

Table 7.2: Hampshire Male Population Disability Breakdown

		Population in 2009	Population Change by Year		
Age Group	Disability Group		2013	2018	2026
65-69	No Incapacity	12,700	3,400	2,300	3,900
	Slight	8,700	2,300	1,600	2,600
	Moderate	9,100	2,400	1,700	2,800
	Severe	2,700	700	500	800
70-74	No Incapacity	7,100	500	2,900	2,100
	Slight	6,900	400	2,800	2,100
	Moderate	10,200	600	4,200	3,100
	Severe	4,500	300	1,800	1,400
75-79	No Incapacity	4,700	300	800	2,700
	Slight	4,700	300	800	2,700
	Moderate	9,900	600	1,600	5,700
	Severe	5,100	300	800	3,000
80-84	No Incapacity	2,000	200	400	1,100
	Slight	3,000	200	600	1,600
	Moderate	8,400	700	1,600	4,600
	Severe	5,000	400	1,000	2,800
85+	No Incapacity	2,300	200	600	1,500
	Slight	800	100	200	500
	Moderate	6,300	600	1,700	4,200
	Severe	7,500	700	2,000	5,000

Table 7.3: Hampshire Female Population Disability Breakdown

In 2009, whilst people aged 85 and over have the lowest number of disabled people in terms of absolute numbers, 80.23% of them are estimated to have a moderate or severe disability. This proportion is considerably higher than the other age groups. The proportions of people with a moderate or severe disability increases with age. As expected, the same results can be found when considering the male and female populations separately. 77.66% of males aged 85 and over are estimated to have moderate or severe level of disability, whilst the equivalent female proportion is 81.66%.

Tables 7.4, 7.5 and 7.6 illustrate the change in the number of disabled older people in 2013, 2018 and 2026.

Total population	Change in the number of disabled people by year		
Age Group	**2013**	**2018**	**2026**
65-69	10,200	6,500	11,800
70-74	2,700	16,400	12,000
75-79	2,800	6,900	22,200
80-84	3,000	6,800	17,800
85+	3,400	9,400	22,000

Table 7.4: Hampshire Population: Change in the number of disabled people

Male	Change in the number of disabled people by year		
Age Group	**2013**	**2018**	**2026**
65-69	4,700	2,700	5,500
70-74	1,300	7,600	5,400
75-79	1,600	3,600	10,600
80-84	1,700	3,700	8,900
85+	2,100	5,500	12,200

Table 7.5: Hants Male Population: Change in the number of disabled people

Female	Change in the number of disabled people by year		
Age Group	**2013**	**2018**	**2026**
65-69	5,400	3,800	6,200
70-74	1,300	8,800	6,600
75-79	1,200	3,200	11,400
80-84	1,300	3,200	9,000
85+	1,400	3,900	9,700

Table 7.6: Hants Female Population: Change in the number of disabled people

As shown in Table 7.4, the model projections show that the impact of an ageing population can be seen in the next few years. By 2013, the number of people with some level of disability is predicted to increase by 22,100, with the greatest increase being for people with a moderate disability (10,100).

By age group, the greatest predicted increase in the number of disabled people by 2013 is for people aged 65-69, predicted to rise by 10,200. Tables 7.5 and 7.6 show a similar pattern of results for both males and females. The number of males with some level of disability is predicted to increase by 11,400 by 2013. The equivalent number of females is 10,600. In both percentage terms and absolute numbers, the greatest increases in the overall population are for people aged 65-69. There are significant percentage increases for people aged 85 and over. The greatest increase in severe disability, in percentage terms, by 2013 is seen for people aged 65-69, but in absolute numbers the largest increase is for people aged 85 and over. The largest increase in absolute numbers is for people aged 65-69 with a moderate disability. The results are different for the female population; the increase in the number of females with a severe disability is slightly higher for ages 65-69 in comparison to ages 85 and over.

Tables 7.5 and 7.6 show a similar result for the male population. The increase in the number of males with a disability is predicted to be 23,100 by 2018. The equivalent figure for females is 22,900. However, the increase in women aged 70-74 with a disability is predicted to be 8,800, over double the increase in the other age groups. In percentage terms, the greatest gain for men is for ages 85 and over (61.79%) whilst for females it is for women aged 70-74 (40.91%). The number of males aged 85 and over with a severe disability is predicated to increase by 1,900: the equivalent figure for females is 2,000.

Table 7.4 shows that all age groups are predicted to increase over the 18-year period. Across all five age groups the number of people with disability is predicted to increase by 85,800. Once again, the greatest increase is in the moderate disability group, predicted to increase by 41,100. The greatest increases in the number of disabled people are for people aged 75-79 and people aged 85 and over. The model has predicted that both groups will increase by 22,200 and 22,000 respectively. In percentage terms, the largest increases are in people aged 85 and over, with an average percentage increase of 99.44% in the slight, moderate and severe disability groups. This is a very significant result; the model predicts that the number of people aged 85 and over with a disability will more than double in the next 18 years. In percentage terms, the number of men with a disability aged 85 and over will increase by 138.11%.

Based on the proportions created from the 2001 General Household Survey, many interesting results have been generated by the model and can provide many useful insights into the future demand for long-term care. The impact of an ageing population is evident both in the short- and long-term future.

7.1.4.4 Total population service rate projections

The following graphs show the predicted number of people who respectively report no care or support, local authority care, informal care or private care as their main source of care provision. 2009 main service receipt levels are assumed throughout the modelling period, i.e. it is assumed that people with a given level of disability will receive the same level of service, from the same source, throughout the entire modelling period. Elderly people who are classified as having no incapacity are predicted to receive no care or support based on the results of the General Household Survey as shown in Figure 7.9.

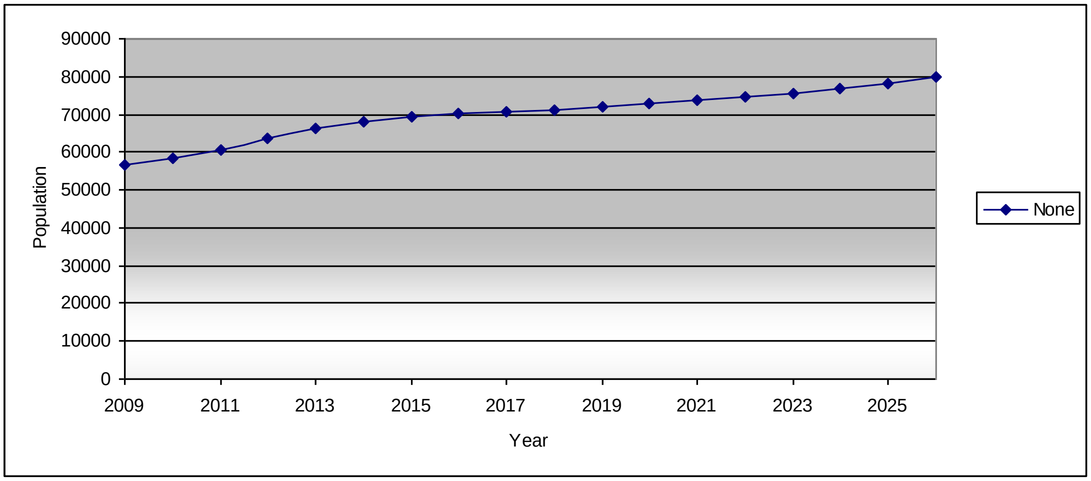

Figure 7.9: Total Population with No Incapacity

It is important to note that these results are based on what the client perceives to be their main form of care provision, and therefore this does not necessarily reflect the number of people who actually receive these provisions of care. The most reliable data concern people who report that they receive no care or support: the majority of these people are genuinely likely to be receiving no other form of care provision.

The majority of elderly people who are classified as having a slight disability receive no care or support based on the results of the 2001 General Household Survey as shown in Figure 7.10. A small number of people are predicted to report informal care as their main care provision.

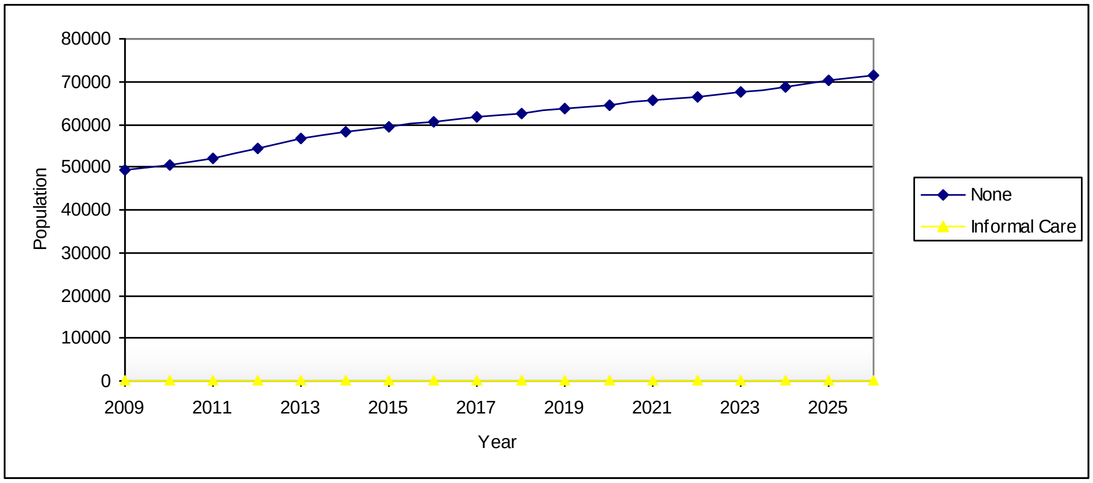

Figure 7.10: Total Population with a Slight Disability

Once again, the majority of elderly people who are classified as having a moderate disability receive no care or support based on the results of the 2001 General Household Survey as shown in Figure 7.11. A small number of people are predicted to report informal care or local authority care as their main care provision.

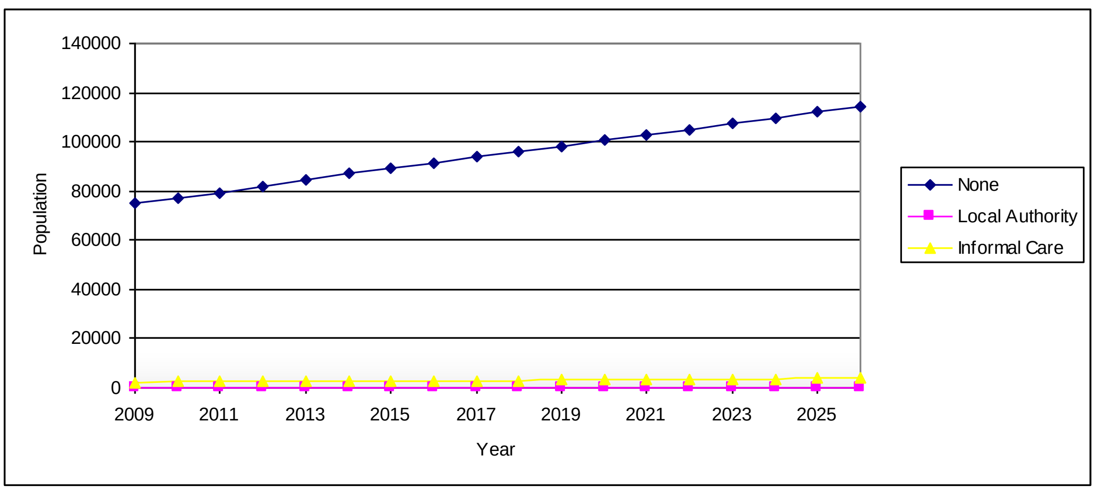

Figure 7.11: Total Population with a Moderate Disability

Figure 7.12 shows that the majority of elderly people predicted to have a severe disability will receive no care or support. On average, each year 29,700 people are predicted to receive no care or support; 3,600 people are predicted to receive local authority care as their main source of care provision; 12,500 people are predicted to receive informal care as their main source of care provision; and 2,100 people are predicted to receive private care as their main source of care provision.

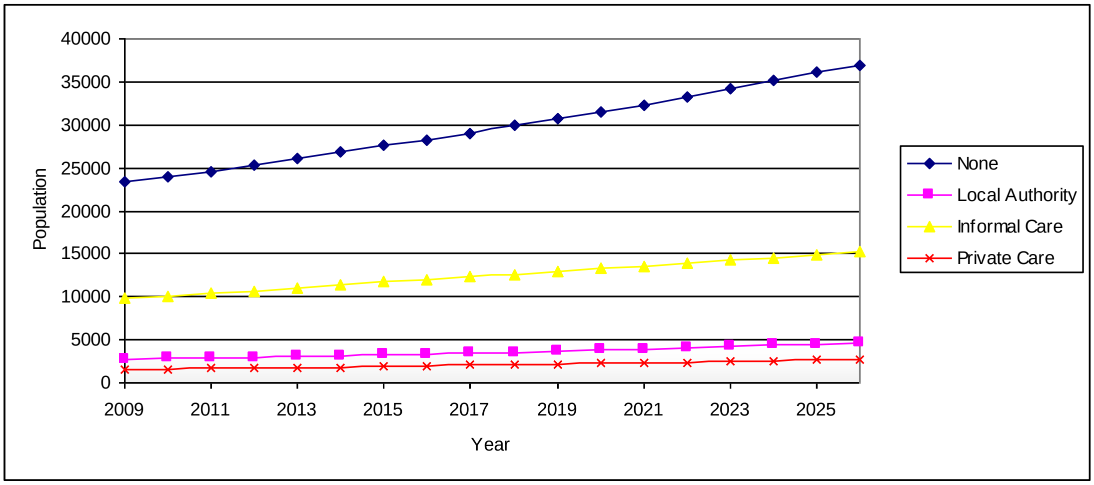

Figure 7.12: Total Population with a Severe Disability

There are differences in the increases in the number of disabled people between the genders. A detailed analysis of the breakdown by gender can be found in Appendix A14. The key findings are discussed in section 7.1.4.6 (pp.240-247).

7.1.4.5 Service receipt projections for people aged 65-69

We now discuss the disability classes and the main source of care provision for each of the five age groups. We present our findings for the age group 65-59; the results for the other four groups can be found in Appendix A13. The key findings are discussed in section 7.1.4.6 (pp.240-247).

Based on the results of the 2001 General Household Survey, people in this age group with no disability or a slight disability are expected to receive no care or support at all. The majority of people classified as having a moderate disability, are predicted to have no care or support as their main form of care provision as shown in Figure 7.13. On average 600 people each year in the period are predicted to report informal care as their main provision type.

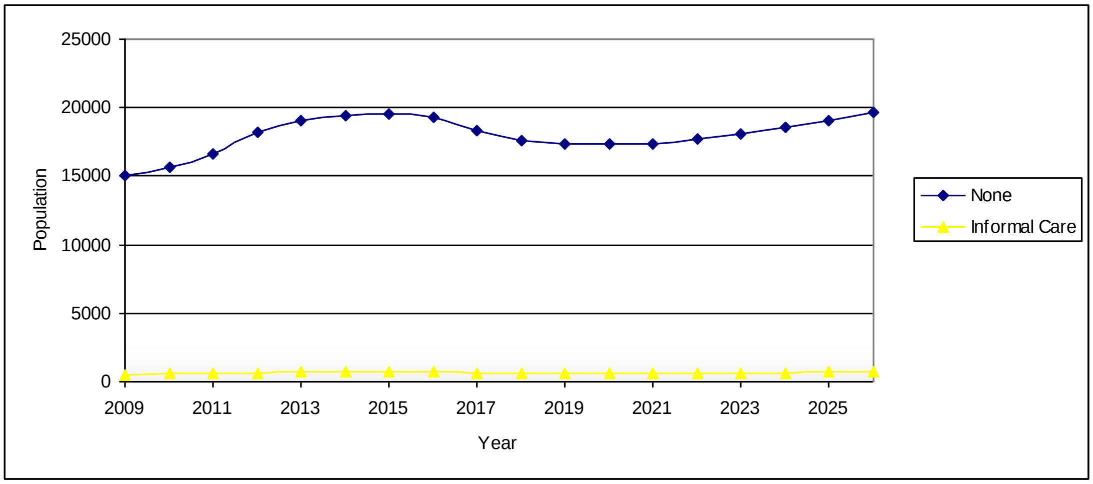

Figure 7.13: Total population aged 65-69 with a Moderate Disability

As illustrated in Figure 7.14, once again, the majority of people in the household population aged 65-69 with a severe disability do not receive any care or support. On average, 2,100 people each year are predicted to report informal care as their main form of provision. Around 80 people are expected to report on average each year that the local authority is their main form of care provision. The same numbers of people are predicted to report that the private sector is their main form of care provision.

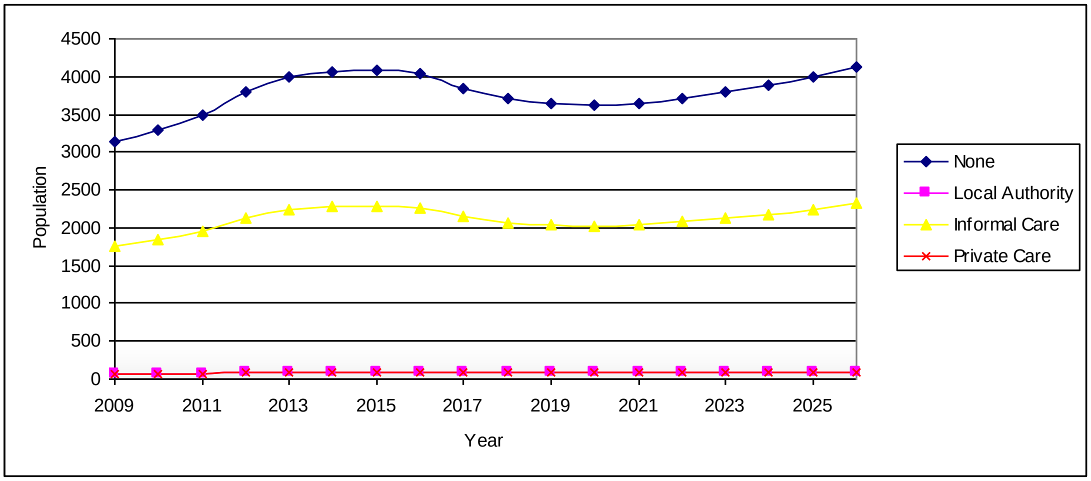

Figure 7.14: Total population aged 65-69 with a Severe Disability

7.1.4.6 Key findings of the population data by service receipt

As shown in Table 7.7, in 2009 only a small percentage of people aged 65-69 with a moderate disability are likely to need informal care. Even for people with a severe disability, the majority (61%) manage without any care or support. The number of people in this category is predicted to increase by 32% by 2026 and it is estimated that 21% of people in this category will receive informal care in 2026. A small number of people are estimated to report formal care or private care at their main source of care provision.

The results are similar for people aged 70-74. The majority of people (62%) with a severe disability receive no care or support, predicted to increase by 31% in population numbers over the whole modelling period. One noteworthy difference is for people with a severe disability, it is estimated that the number of people who report informal care as their main care source will have increased by 32% over the whole period.

Age Group	Disability Category	Service Receipt	Population in 2009	Population Change by Year		
				2013	2018	2026
65-69	Moderate	None	15,000	4,100	2,600	4,700
		Local Authority	0	0	0	0
		Informal Care	500	200	100	200
		Private Care	0	0	0	0
	Severe	None	3,100	900	600	1,000
		Local Authority	100	0	0	0
		Informal Care	1,800	400	300	500
		Private Care	100	0	0	0
70-74	Moderate	None	18,300	1,200	7,600	5,600
		Local Authority	0	0	0	0
		Informal Care	200	100	100	100
		Private Care	0	0	0	0
	Severe	None	4,200	300	1,700	1,300
		Local Authority	200	100	100	100
		Informal Care	2,200	200	900	700
		Private Care	200	0	100	0
75-79	Moderate	None	17,800	1,300	3,300	10,900
		Local Authority	0	0	0	0
		Informal Care	400	100	100	300
		Private Care	0	0	0	0
	Severe	None	5,500	400	1,000	3,400
		Local Authority	400	100	100	300
		Informal Care	1,900	100	300	1,100
		Private Care	100	0	0	0
80-84	Moderate	None	13,900	1,500	3,500	8,900
		Local Authority	0	0	0	0
		Informal Care	700	100	200	500
		Private Care	0	0	0	0
	Severe	None	4,400	400	1,000	2,600
		Local Authority	400	0	100	200
		Informal Care	2,100	200	500	1,300
		Private Care	300	0	0	100
85+	Moderate	None	10,000	1,400	4,000	9,400
		Local Authority	100	0	0	0
		Informal Care	400	100	300	600
		Private Care	0	0	0	0
	Severe	None	6,100	800	2,200	5,300
		Local Authority	1,600	200	500	1,300
		Informal Care	1,800	300	800	1,800
		Private Care	1,000	100	400	900

Table 7.7: Hampshire Population Disability and Service Receipt Breakdown

For people aged 75-79 with a severe disability, the majority (69%) get on with their lives with no care or support, but this is predicted to increase by 62% in absolute numbers over the whole modelling period – significantly higher than the younger age groups. Another significant difference is for people with a severe disability; it is estimated that the number of people who report informal care as their main care provision will have increased by 5% by 2013, and by 58% by 2026. Moreover, slightly more people are likely to report local authority care as the main source of care provision in comparison with the two younger age groups. The results are very similar for people aged 80-84.

58% of people aged 85 and over with a severe disability do not require any care or support. This is predicted to increase by 87% over the whole modelling period in absolute numbers. Around 41% of people are predicted to require one of the other sources of care provision. The split is very similar between the three care types.

Table 7.8 presents the same data, for the male population only. Significant differences from the general population as a whole are discussed below.

Age Group	Disability Category	Service Receipt	Population in 2009	Population Change by Year		
				2013	2018	2026
65-69	Moderate	None	6,400	1,800	1,100	2,100
		Local Authority	0	0	0	0
		Informal Care	100	0	0	0
		Private Care	0	0	0	0
	Severe	None	1,300	400	300	500
		Local Authority	0	0	0	0
		Informal Care	1,000	200	100	300
		Private Care	0	0	0	0
70-74	Moderate	None	8,200	600	3,600	2,600
		Local Authority	0	0	0	0
		Informal Care	100	0	100	100
		Private Care	0	0	0	0
	Severe	None	1,700	200	800	600
		Local Authority	100	0	0	0
		Informal Care	400	100	200	200
		Private Care	100	0	100	100
75-79	Moderate	None	8,100	800	1,800	5,300
		Local Authority	0	0	0	0
		Informal Care	200	0	100	100
		Private Care	0	0	0	0
	Severe	None	1,900	100	400	1,200
		Local Authority	200	0	100	100
		Informal Care	700	100	100	400
		Private Care	0	0	0	0
80-84	Moderate	None	6,100	900	1,900	4,700
		Local Authority	0	0	0	0
		Informal Care	100	100	100	200
		Private Care	0	0	0	0
	Severe	None	1,100	100	300	800
		Local Authority	100	0	0	0
		Informal Care	900	100	200	600
		Private Care	100	0	0	0
85+	Moderate	None	3,800	900	2,400	5,300
		Local Authority	0	0	0	0
		Informal Care	400	100	300	600
		Private Care	0	0	0	0
	Severe	None	1,700	500	1,100	2,500
		Local Authority	300	100	200	400
		Informal Care	700	200	500	1,000
		Private Care	300	100	200	400

Table 7.8: Hampshire Male Population Disability and Service Receipt Breakdown

The model predicts that the number of men aged 70-74 with a severe disability who report informal care as their main care provision will increase by 25% by 2013, and by 50% by 2026. This is significantly higher than for the general population. Similarly, for men aged 75-79 with a severe disability, it is estimated that the number of people who report informal care as their main care provision will increase by 14% by 2013, and by 57% by 2026. In 2009, 57% of men aged 85 and over with a severe disability received no care, and this category is predicted to increase by 147% in absolute numbers by 2026. This is a significant increase.

The same results for the female population are presented in Table 7.9. The model predicts that the number of women aged 70-74 with a severe disability who report informal care as their main care provision will increase by 6% by 2013, and by 28% by 2026. This is significantly lower than the changes in the male population. Another significant difference is for women aged 75-79 with a severe disability; the model predicts that the number of women in this category who report informal care as their main care provision will increase by 8% by 2013, but by 58% by 2026. The majority of women aged 85 and over who require some form of support will obtain it from the local authority as their main from of care provision.

Age Group	Disability Category	Service Receipt	Population in 2009	Population Change by Year		
				2013	2018	2026
65-69	Moderate	None	8,600	2,300	1,600	2,600
		Local Authority	0	0	0	0
		Informal Care	500	100	100	100
		Private Care	0	0	0	0
	Severe	None	1,800	500	300	600
		Local Authority	100	0	0	0
		Informal Care	800	200	100	200
		Private Care	100	0	0	0
70-74	Moderate	None	10,000	700	4,200	3,100
		Local Authority	0	0	0	0
		Informal Care	100	0	100	100
		Private Care	0	0	0	0
	Severe	None	2,500	100	1,000	700
		Local Authority	200	0	100	0
		Informal Care	1,800	100	700	500
		Private Care	100	0	0	0
75-79	Moderate	None	9,700	600	1,500	5,600
		Local Authority	0	0	0	0
		Informal Care	200	0	100	200
		Private Care	0	0	0	0
	Severe	None	3,700	200	600	2,100
		Local Authority	200	0	100	200
		Informal Care	1,200	100	200	700
		Private Care	100	0	0	0
80-84	Moderate	None	7,800	700	1,500	4,300
		Local Authority	0	0	0	0
		Informal Care	600	0	100	300
		Private Care	0	0	0	0
	Severe	None	3,300	300	600	1,800
		Local Authority	300	0	100	200
		Informal Care	1,200	100	300	700
		Private Care	200	0	0	100
85+	Moderate	None	6,200	500	1,600	4,100
		Local Authority	100	0	0	0
		Informal Care	0	0	0	0
		Private Care	0	0	0	0
	Severe	None	4,300	500	1,200	3,000
		Local Authority	1,300	100	300	900
		Informal Care	1,100	100	300	800
		Private Care	700	100	200	500

Table 7.9: Hampshire Female Population Disability and Service Receipt Breakdown

One of the interesting results of the breakdown by service receipt for each age group for people with either a moderate or severe disability is that the majority of people are likely to report that they receive no care or support as their main form of care provision. The results are illustrated in Table 7.10. The results are very similar in 2026.

Age Group	**Receives no care or support (%)**
65-69	88%
70-74	89%
75-79	89%
80-84	84%
85 and over	77%

Table 7.10: Receives no care or support (%) in 2009.

Source: Economic and Social Data Service (2001)

This is potentially a very valuable piece of information for the Adult Services Department. This is source of information they did not have before and could be useful in planning future services. It is important that they plan to implement preventative service to minimise the number of people having their situation worsen and as result end up requiring care.

Another interesting point is that based on responses of the 2001 General Household Survey, a noteworthy percentage of people in the moderate and severe disability groups are likely to report informal care as their main form of care provision. The results are very similar for 2026.

Age Group	Receives informal care (%)
65-69	11%
70-74	9%
75-79	9%
80-84	9%
85 and over	13%

Table 7.11: Receives informal care (%) in 2009.

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

7.1.5 Scenario 2: Changes to the moderate and severe disability proportions

Research by Batljan and Lagergren (2005) in Sweden found a decline in the proportion of older people (65-84yrs) with severe ill-health based on survey data from 1975 to 1999. It should be noted that there was no data for those aged 85 and over. On the basis of this research, it is likely that in the future the proportion of people with a severe disability will be lower and, in turn, the number of people with a moderate disability will increase. The following scenarios were explored.

1) Increase the proportion of people with a moderate disability by 1% and reduce the proportion of people with a severe disability by 1%;
2) Increase the proportion of people with a moderate disability by 2% and reduce the proportion of people with a severe disability by 2%.

These percentage changes were decided after a discussion with Professor Maria Evandrou, an expert in Gerontology and Demography. The change is made for each of the 18 years in the experiment. Table 7.12 present the results for the whole population, against a baseline of 0% change. Appendix A15 present the same data for each gender.

The number of older people with a moderate disability is estimated to increase by 2,100 (and the number with a severe disability decrease correspondingly) if the probability of having a moderate disability is altered by 1%. There is not much difference in the changes across the age groups. The two greatest increases are in the age groups 65-69 and 70-74 which increase/decrease by 600 people respectively. These are not significant changes in absolute numbers relative to the size of the population. One of the main effects of this reduction in the number of people with a severe disability is that it is likely to reduce the number of people who require formal care services.

For the 2% scenario, the number of older people with a moderate/severe disability is estimated to increase/decrease by 4,400, with the largest increase being in age group 65-69, which is estimated to change by 1,200. This is once again not a significant change in absolute numbers in comparison to the size of the population but like the 1% scenario, there is likely to be an additional strain on the informal and private care sector to provide care to this group.

Percentage Change	Age Group	Disability Category	Population in 2009	Population Change by Year		
				2013	2018	2026
0%	65-69	Moderate	15,600	4,200	2,700	4,900
1%	65-69	Moderate	16,200	4,400	2,800	5,100
2%	65-69	Moderate	16,800	4,500	2,900	5,300
0%	65-69	Severe	5,000	1,400	900	1,600
1%	65-69	Severe	4,400	1,200	800	1,400
2%	65-69	Severe	3,800	1,000	700	1,200
0%	70-74	Moderate	18,500	1,300	7,800	5,700
1%	70-74	Moderate	19,100	1,300	8,000	5,800
2%	70-74	Moderate	19,600	1,300	8,200	6,000
0%	70-74	Severe	6,800	500	2,800	2,100
1%	70-74	Severe	6,300	400	2,600	1,900
2%	70-74	Severe	5,700	400	2,400	1,700
0%	75-79	Moderate	18,200	1,400	3,500	11,200
1%	75-79	Moderate	18,600	1,400	3,600	11,500
2%	75-79	Moderate	19,100	1,500	3,600	11,700
0%	75-79	Severe	7,900	600	1,500	4,800
1%	75-79	Severe	7,500	500	1,400	4,500
2%	75-79	Severe	7,000	500	1,300	4,300
0%	80-84	Moderate	14,600	1,600	3,600	9,300
1%	80-84	Moderate	14,900	1,600	3,700	9,500
2%	80-84	Moderate	15,300	1,600	3,800	9,800
0%	80-84	Severe	7,100	700	1,600	4,400
1%	80-84	Severe	6,800	700	1,600	4,200
2%	80-84	Severe	6,500	600	1,500	3,900
0%	85+	Moderate	10,500	1,600	4,300	10,000
1%	85+	Moderate	10,700	1,600	4,400	10,300
2%	85+	Moderate	11,000	1,700	4,500	10,500
0%	85+	Severe	10,600	1,400	3,900	9,300
1%	85+	Severe	10,300	1,400	3,800	9,100
2%	85+	Severe	10,000	1,400	3,700	8,800

Table 7.12: Scenario 2 Hampshire population by moderate and severe disability

The number of older men with a moderate disability is estimated to increase by 1,000 (and the number with a severe disability decrease by 900) if the probability of having a moderate disability is altered by 1%. For the 2% scenario, the number of older men with a moderate disability is estimated to increase by 2,000, with the largest increase being in age group 65-

69. The number of older women with a moderate disability is estimated to increase by 1,100 in the 1% scenario and by 2,200 in the 2% scenario. There is not much difference in the changes across the age groups. This is not a significant change in absolute numbers in comparison to the size of the female population.

The change in the number of older people with moderate and severe disability is not significantly large in comparison to the total population but it is likely to have an impact upon the provision of long-term care services. Any change to the number of people with a moderate level of disability will potentially increase the burden upon the informal and private care sector as these people are no longer candidates for formal care. This in turn reduces the burden upon formal care services as the number of potential clients could be reduced. It is of importance that the Local Authority supports the other sectors to provide care to the people with a moderate disability if they require it. If they do not, they could end being recipients of formal care.

It is important to note that these numbers are likely to be small and that over the next 18 years in both the short and long term the local authority (as well as the other care services) need to put plans in place to meet the likely increases in demand.

7.1.6 Scenario 3: Local Authority Home and Community Care Projections

This scenario explores in more detail the projections for the number of people receiving Local Authority care. The service receipts are adjusted in this scenario to take into account data provided by the Local Authority. In this scenario the proportion of people receiving formal care are based on the proportions of Hampshire residents in March 2009 who received either day care or domiciliary care. By definition, the eligibility status for such people was either “substantial” or “critical”. Anybody who is classified as having substantial or critical status is entitled to formal care subject to means testing, as described in Chapter 4. Separate proportions were created for all the Hampshire districts, but for the purposes of presentation in this thesis, only the Hampshire totals are discussed.

Assumption fourteen: It is assumed the service rate proportions are constant throughout the projection period.

In other words, changes over time in the number of people receiving formal care arise only as a result of demographic change, and not because of changes in policy regarding who is, or is not, entitled to care. The first results are for the total Hampshire population.

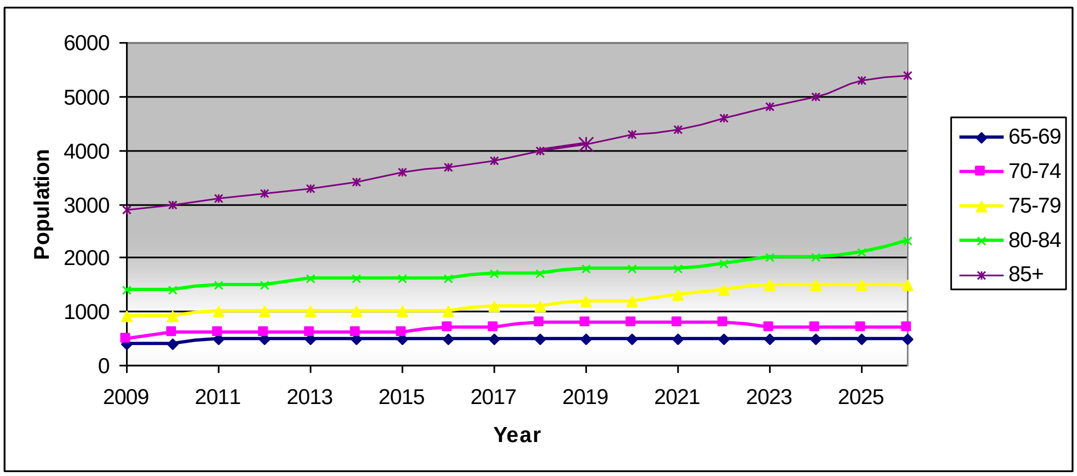

Figure 7.15: Hampshire Total Population Local Authority Care Projections

Over the whole period, the total number of people receiving formal care services in the home and community is predicted to increase by 70% to 10,400. By 2013, an extra 900 people will receive this care and by 2018, an extra 2,000. Broken down by age group, the projected increases in absolute numbers over the whole period are 100 people aged 65-69, 200 people aged 70-74, 600 people aged 75 -79 (a 67% increase by 2026), 900 people aged 80-84 (a 64% increase by 2026) and a massive 2,500 people aged 85 and above. For this oldest group this equates to a predicted increase of 14% by 2013, 38% by 2018 and 86% over the whole period.

Results broken down by gender can be found in Appendix A16.

It has been shown that the impact of demographic change can be seen both in the short- and long-term. Hampshire County Council will need to ensure the right resources are in place to provide for the expected increases in the demand for both day care and domiciliary care. The intensity of these services has not been explored in this scenario but is considered in Scenario 3. The Local Authority procure many services from the private sector, it is of importance that the Adult Services Department works with private sector so it is able to meet this demand or they will have consider providing more services in-house if this is not the case. The model created in this thesis allows for the Local Authority to explore this issue at the district level. In discussion with members of the local authority, it is likely that there are going to be regional differences in the ability to provide care from the private sector.

The same results are now explored to take into account the “intensity” of care provision. This means the amount of care a person receives, in terms of hours per week. The results presented in Figure 7.16 below are for people who receive domiciliary care for at least five hours a week.

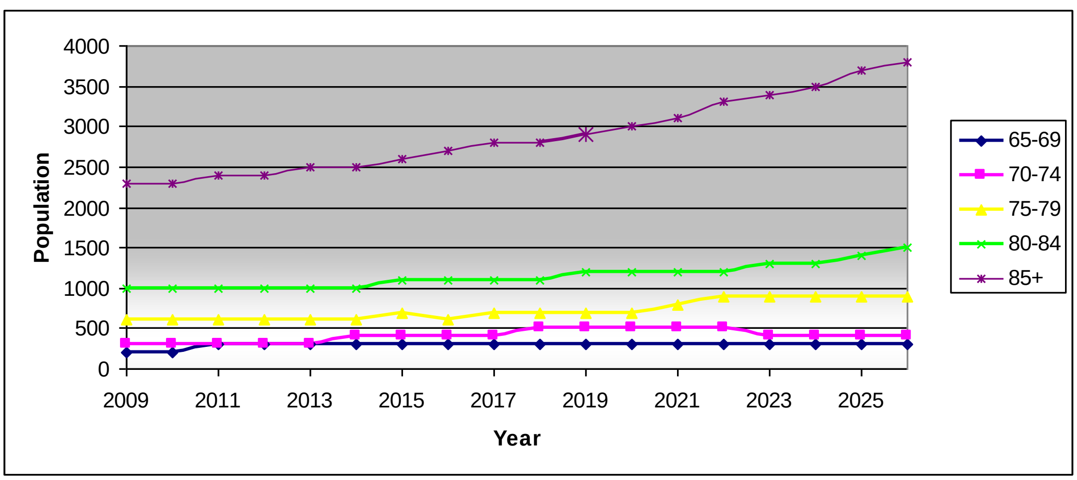

Figure 7.16: Hampshire Total Population Local Authority Domiciliary Care Projections

Over the whole period, the number of people receiving domiciliary care services at this intensity level is predicted to increase by 2,700. This is equivalent to a 64% increase. This is similar to the predicted increase in the number of people receiving home and community care. The greatest changes in both absolute and percentage terms are predicted to be experienced by people aged 85 and over. By 2026 the number of people in this category is predicted to increase by 1,700. In percentage terms, this equates to a predicted increase of 15% by 2013, 35% by 2018 and 85% over the whole period. This is similar to the predicted increase in the number of people receiving home and community care.

Like the changes in the number of people receiving home and community care, it has been shown that the impact of demographic change can be seen both in the short- and long-term. Hampshire County Council will need to ensure the right resources are in place to provide for the expected increases in the demand for domiciliary care. Many more people are likely to need to need at least five hours of care a week, and many people will need more than this.

The care needs of the male population are predicted to increase even more steeply.

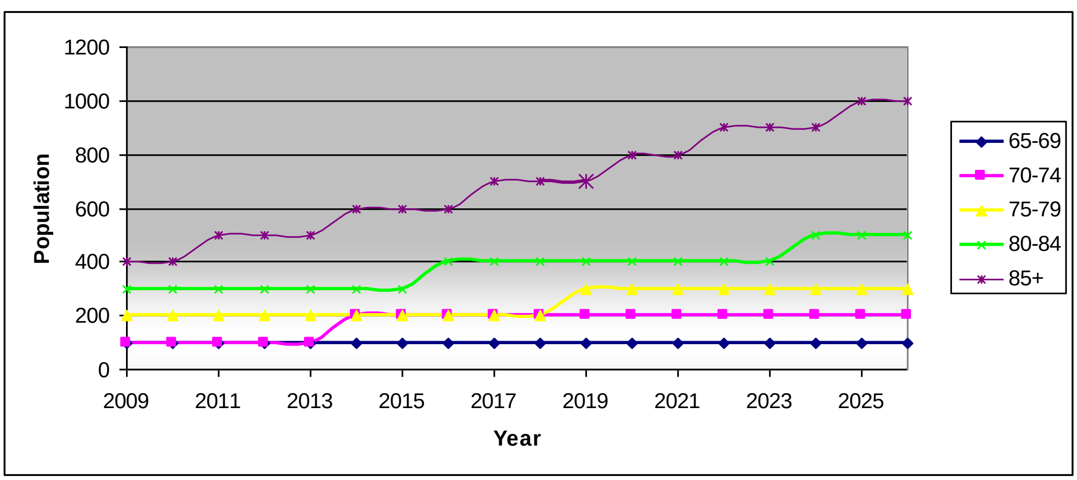

Figure 7.17: Hampshire Male Population Local Authority Domiciliary Care Projections

Over the whole period, the number of males receiving domiciliary care services is predicted to increase by 1,000. This is equivalent to a 91% increase. This is greater than the increase in the male population receiving home and community care. As for the general population, the greatest changes in both absolute and percentage terms are predicted to be experienced by men aged 85 and over. Over the projection period the number of males is predicted to increase by 600. In percentage terms, this equates to a predicted increase of 25% by 2013, 75% by 2018 and 150% over the whole period.

The results for women are shown in Figure 7.18 below.

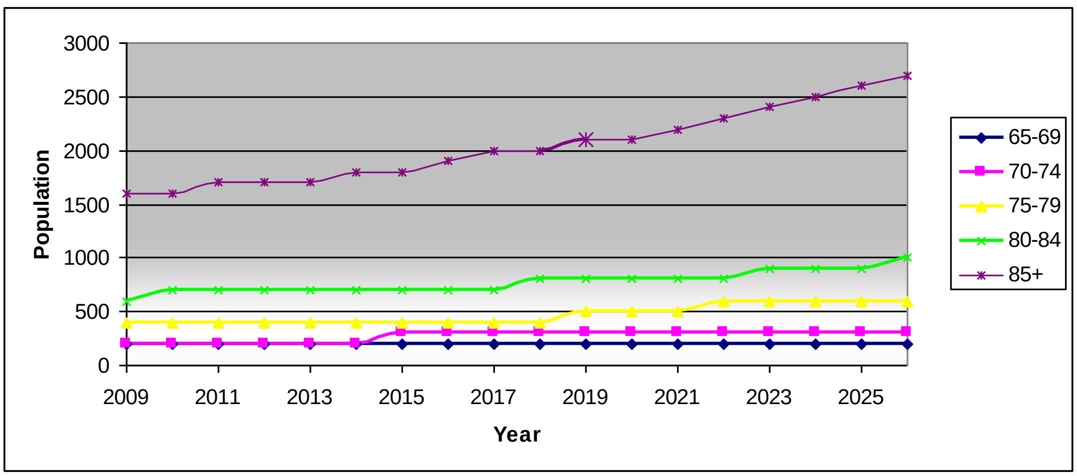

Figure 7.18: Hampshire Female Population Local Authority Domiciliary Care Projections

Over the whole period, the number of women receiving formal care services in the home and community is predicted to increase by 1,800. This is equivalent to a 60% increase. For age groups 65-69 and 70-74, the increase over the projection period is very small. For age group 80-84, the change over the whole period is the same as the change in the male population. Once again, the greatest changes in both absolute and percentage terms are in age group 85 and over. Over the projection period the number of women is predicted to rise by 1,100. This is considerably larger than the increase in the number of males. In percentage terms, this equates to a predicted increase of 6% by 2013, 25% by 2018 and 69% over the whole period: much less than the percentage increase in the male population.

It has once again been shown that in both absolute and percentage terms there are differences between the genders within each age group both in the short- and long-term. The local authority will need to take this account when planning future domiciliary care services as it is quite likely that the services required by the two genders could differ. The gender differences can be explored at the district level in the cell-based model. Another important point is that many of the services provided in the home and community are provided as domiciliary care with at least five hours of care provided.

7.2 Hybrid Model Results

The hybrid framework has shown to be a useful method of exploring both the short-term as well as the long-term performance of the contact centre. The results of the hybrid framework will potentially prove to be useful in aiding the managers of the contact centre in planning future resource needs.

It is important that the contact centre has the capabilities in place deal with any changes in demand. It is of the highest importance that any person in need of social care is able to access it through the contact centre. The experimentation that has been carried out in this thesis potentially can help to ensure that this goal is met. There are further advantages of better call centre performance in terms of increased customer satisfaction as well potential future cost savings. If both Adult and Children’s Services can identify a future client at the early stages of his/her welfare requirements, they can help the person to achieve a better quality of life and slow down any deterioration in that person’s needs. The potential cost saving element arises from not having to help this person at a later stage where their care package is likely to be more intensive as well as more expensive. Therefore, as a good performing first point of contact, the contact centre is beneficial for both the individual and the local authority.

The hybrid experiments were carried out for the three years 2010, 2015 and 2020. For each year four experiments were carried out, as discussed in detail in Chapter 6.

Each discrete-event simulation trial (results for one month) takes 4 or 5 minutes to run on a standard desktop PC. This is dependent on the input configuration. For example, longer run times occurred as a result of increased arrival rates, which result in more events that are scheduled into the simulation calendar. Results from the spreadsheet model (see Chapter 6, p.191) are instantaneous. The results of the four experiments discussed in Chapter 6 (p.191) are presented below, as well as the staffing interventions when one or both of the key performance measures are not met.

The cell-based models were used to calculate the number of call arrivals for each month from January 2010 through to December 2020, as illustrated in Figure 7.19.

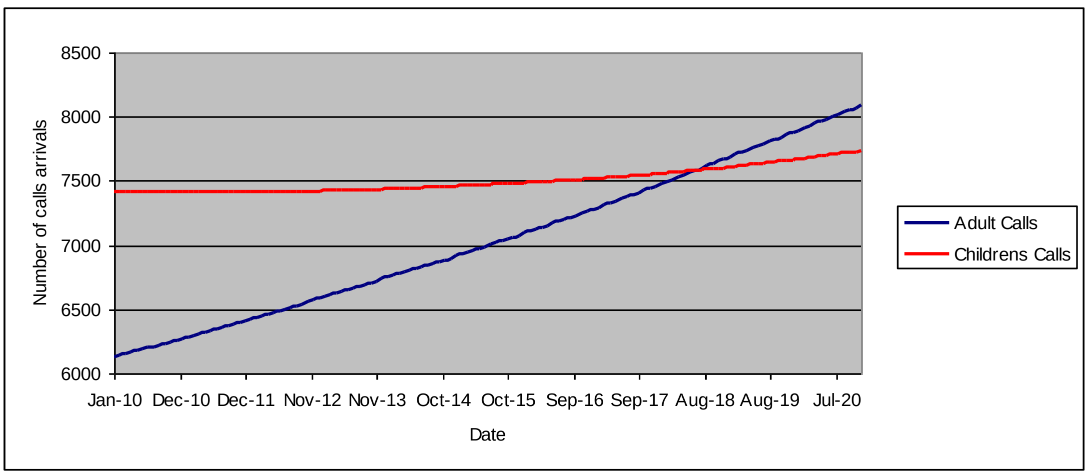

Figure 7.19: Call Arrivals 2010-2020

The increases are much greater in the adult population, due to population ageing which outweigh the effect of birth rates in the younger population. Over the ten year period the model predicts that the total number of calls will increase by 16.81%, but the number of Adult Service calls will increase by 32.05%, whilst the number of Children's Service calls only increases by 4.23%. In January 2010 there were 1,293 more Children's Service calls compared with Adult Service calls. The two types of calls reach parity in July 2018. By December 2020 there will be 357 more Adult Service calls than Children's Service calls. These increases in call arrivals will potentially cause a decrease in the performance of the contact centre in terms of the two key performance measures. The impact of the increased numbers of calls is explored in experiments for each of the three years under investigation.

Experiments two, three and four increase the call arrivals further by introducing the impact of feedback from abandoned calls into the system. It should be noted that the number of calls answered in each of the main call categories is not studied. While the key performance measures are discussed in great detail, no mention will be given to the individual satisfaction of each caller. Twenty-eight experiments were carried out in total. Each experiment is discussed in detail in Appendix A17 and summarised in Table 7.13.

In summary, as noted in section 6.3 (p.196), for each year (2010, 2015 and 2020) four experiments are carried out:

- *Experiment 1: Model is run with no inclusion of feedback.*
- *Experiment 2: 2% of callers have their situation deteriorate and call back after one month.*
- *Experiment 3: 5% of callers have their situation deteriorate and call back after one month.*
- *Experiment 4: 10% of callers have their situation deteriorate and call back after one month.*

Hantsdirect aim to meet two targets, that 95% of their calls are answered and 80% of their calls are answered within 20 seconds. If in any of the experiments these targets are not met, an additional two experiments will be carried out. Firstly, the number of agents is adjusted to the point where the KPIs are achieved. This is then repeated by increasing the number of advisors to the point where the KPIs are once again achieved.

Experiment Number	Year	Feedback	Intervention	Average number of abandoned calls (95% CI)	Average % of calls answered (95% CI)	Average % of calls answered within 20 secs (95% CI)
1	2010	0%	-	630 (614 to 646)	95.37% (95.26% to 95.49%)	92.48% (92.27% to 92.68%)
2	2010	2%	-	630 (613 to 647)	95.38% (95.26% to 95.50%)	92.41% (92.19% to 92.62%)
3	2010	5%	-	634 (617 to 651)	95.36% (95.24% to 95.47%)	92.36% (92.14% to 92.59%)
4	2010	10%	-	639 (621 to 656)	95.33% (95.21% to 95.45%)	92.34% (92.12% to 92.57%)
5	2015	0%	-	802 (783 to 822)	94.46% (94.33% to 94.58%)	90.62% (90.39% to 90.85%)
6	2015	2%	-	805 (786 to 824)	94.44% (94.32% to 94.57%)	90.56% (90.33% to 90.78%)
7	2015	5%	-	813 (794 to 832)	94.40% (94.28% to 94.52%)	90.49% (90.26% to 90.71%)
8	2015	10%	-	819 (800 to 838)	94.37% (94.25% to 94.50%)	90.46% (90.23% to 90.69%)
9	2015	0%	One more agent	688 (670 to 705)	95.25% (95.14% to 95.36%)	92.14% (91.89% to 92.39%)
10	2015	2%	One more agent	693 (675 to 710)	95.22% (95.10% to 95.33%)	92.06% (91.84% to 92.27%)
11	2015	5%	One more agent	696 (679 to 714)	95.20% (95.09% to 95.32%)	92.01% (91.80% to 92.22%)
12	2015	10%	One more agent	702 (684 to 721)	95.17% (95.05% to 95.29%)	91.94% (91.74% to 92.15%)
13	2015	0%	One more advisor	673 (655 to 690)	95.35% (95.24% to 95.47%)	92.44% (92.23% to 92.65%)
14	2015	2%	One more advisor	677 (660 to 695)	95.32% (95.21% to 95.44%)	92.37% (92.16% to 92.58%)
15	2015	5%	One more advisor	679 (662 to 696)	95.32% (95.20% to 95.43%)	92.35% (92.14% to 92.56%)
16	2015	10%	One more advisor	684 (667 to 702)	95.30% (95.18% to 95.41%)	92.30% (92.10% to 92.50%)
17	2020	0%	-	1125 (1101 to 1148)	92.84% (92.70% to 92.98%)	87.48% (87.23% to 87.73%)
18	2020	2%	-	1131 (1108 to 1154)	92.80% (92.66% to 92.94%)	87.39% (87.14% to 87.63%)
19	2020	5%	-	1141 (1118 to 1165)	92.76% (92.61% to 92.90%)	87.33% (87.10% to 87.57%)
20	2020	10%	-	1158 (1136 to 1180)	92.67% (92.54% to 92.81%)	87.20% (86.96% to 87.44%)
21	2020	0%	Three more agents	741 (723 to 759)	95.28% (95.17% to 95.39%)	92.10% (91.89% to 92.31%)
22	2020	2%	Three more agents	741 (723 to 759)	95.28% (95.17% to 95.39%)	92.12% (91.90% to 92.33%)
23	2020	5%	Three more agents	744 (727 to 762)	95.27% (95.16% to 95.38%)	92.05% (91.83% to 92.26%)
24	2020	10%	Three more agents	754 (736 to 771)	95.22% (95.12% to 95.33%)	91.99% (91.77% to 92.21%)
25	2020	0%	Two/ three more advisors[3]	703 (686 to 721)	95.52% (95.41% to 95.62%)	92.79% (92.59% to 92.98%)
26	2020	2%	Two/ three more advisors[3]	708 (690 to 726)	95.50% (95.38% to 95.61%)	92.76% (92.55% to 92.97%)
27	2020	5%	Two/ three more advisors[3]	694 (676 to 711)	95.59% (95.48% to 95.70%)	92.96% (92.76% to 93.15%)
28	2020	10%	Two/ three more advisors[3]	710 (693 to 728)	95.49% (95.39% to 95.60%)	92.77% (92.57% to 92.98%)

Table 7.13: Summary of Hybrid Experiments

[3] Two additional staff where needed for part of the year and three for the rest.

In experiments 1 to 4, for the year 2010, the two key performance measures were met. In experiments 5 to 8, for the year 2015, the percentage of calls answered fell below the acceptable 95% level although the percentage of calls answered with 20 seconds met the required performance level. As result two interventions were carried out. Experiments 9 to 12 explored the impact of adding additional agents: by adding one additional agent to the staff roster, the percentage of calls answered returned to acceptable levels. As a result of this change in the number of agents, there is also an additional impact upon utilisation. Table 7.14 shows that the average utilisation of both agents and advisors in experiments 9 to 12 is lower, compared with the baseline experiments.

Average Agent Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
5	78.51% (78.25% to 78.76%)	9	76.66% (76.41% to 76.92%)
6	78.52% (78.25% to 78.78%)	10	76.71% (76.46% to 76.97%)
7	78.69% (78.43% to 78.94%)	11	76.78% (76.52% to 77.03%)
8	78.73% (78.47% to 78.98%)	12	76.86% (76.60% to 77.13%)

Average Advisor Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
5	72.50% (72.30% to 72.69%)	9	71.13% (70.94% to 71.31%)
6	72.55% (72.37% to 72.73%)	10	71.15% (70.96% to 71.35%)
7	72.64% (72.44% to 72.83%)	11	71.21% (71.02% to 71.40%)
8	72.77% (72.58% to 72.96%)	12	71.30% (71.11% to 71.49%)

Table 7.14: 2015 Utilisation Changes - One Additional Agent

Experiments 13 to 16 explored the impact of adding additional advisors and by adding one additional advisor to the staff roster, the percentage of calls answered returned to acceptable levels. As a result of the increase advisors, staff utilisation falls, as before.

Average Agent Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
5	78.51% (78.25% to 78.76%)	13	77.12% (76.86% to 77.38%)
6	78.52% (78.25% to 78.78%)	14	77.15% (76.86% to 77.43%)
7	78.69% (78.43% to 78.94%)	15	77.17% (76.90% to 77.45%)
8	78.73% (78.47% to 78.98%)	16	77.28% (77.01% to 77.55%)

Average Advisor Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
5	72.50% (72.30% to 72.69%)	13	70.83% (70.65% to 71.00%)
6	72.55% (72.37% to 72.73%)	14	70.88% (70.69% to 71.07%)
7	72.64% (72.44% to 72.83%)	15	70.92% (70.73% to 71.10%)
8	72.77% (72.58% to 72.96%)	16	70.99% (70.80% to 71.18%)

Table 7.15: 2015 Utilisation Changes - One Additional Advisor

In experiments 17 to 20, for the year 2020, the percentage of calls answered falls below the acceptable 95% level although the percentage of calls answered with 20 seconds met the required performance level. As result two interventions were carried out. Experiments 21 to 24 explored the impact of adding additional agents and by adding three additional agents to the staff roster, the percentage of calls answered returned to acceptable levels. As result of the change in the number of agents, there is once again an additional impact upon utilisation, which is again lower.

Average Agent Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
17	81.84% (81.61% to 82.07%)	21	76.55% (76.30% to 76.81%)
18	81.85% (81.60% to 82.10%)	22	76.61% (76.37% to 76.85%)
19	81.96% (81.72% to 82.19%)	23	76.68% (76.44% to 76.91%)
20	82.11% (81.87% to 82.35%)	24	76.75% (76.52% to 76.99%)

Average Advisor Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
17	75.89% (75.71% to 76.07%)	21	71.87% (71.68% to 72.06%)
18	75.96% (75.78% to 76.14%)	22	71.87% (71.68% to 72.06%)
19	76.05% (75.88% to 76.22%)	23	71.95% (71.77% to 72.13%)
20	76.20% (76.03% to 76.38%)	24	72.07% (71.88% to 72.26%)

Table 7.16: 2020 Utilisation Changes - Three Additional Agents

Experiments 25 to 28 explored the impact of adding additional advisors. In each experiment, initially two advisors were required but later on three were needed in order to return the percentage of calls answered to an acceptable level. The expected impact upon staff utilisation is shown in Table 7.17.

Average Agent Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
17	81.84% (81.61% to 82.07%)	25	78.33% (78.09% to 78.57%)
18	81.85% (81.60% to 82.10%)	26	78.32% (78.05% to 78.58%)
19	81.96% (81.72% to 82.19%)	27	78.19% (77.94% to 78.43%)
20	82.11% (81.87% to 82.35%)	28	78.34% (78.09% to 78.60%)

Average Advisor Utilisation (%)			
Experiment	Baseline (95% CI)	Experiment	Intervention (95% CI)
17	75.89% (75.71% to 76.07%)	25	71.37% (71.19% to 71.54%)
18	75.96% (75.78% to 76.14%)	26	71.39% (71.21% to 71.58%)
19	76.05% (75.88% to 76.22%)	27	71.19% (71.02% to 71.36%)
20	76.20% (76.03% to 76.38%)	28	71.43% (71.25% to 71.60%)

Table 7.17: 2020 Utilisation Changes - Three Additional Advisors

7.3 Summary

When the contact centre conditions are kept the same, the model predicts that the number of staff needs to be increased in both 2015 and 2020, although vast changes to the staffing numbers are not potentially required. Surprisingly enough, there is not predicted to be much difference between the impact of both agent and advisor interventions upon performance.

The hybrid model enabled us to investigate the impact of feedback between the performance of the contact centre and the future demand in terms of call arrivals and client needs. The true level of this feedback is unknown in reality, but has been tested for three different assumptions. Feedback does have a slight impact upon the system for all three years. The impact increases as the number of call arrivals increases. The true impact upon performance over the test period is likely to be due to changes in call arrivals due to changes in the population of Hampshire. This is especially due to changes in the number of Adult Service calls as a result of the ageing population.

Feedback does increase the number of abandoned calls. This is significant due to the fact that it could increase the chance that the caller is likely to end up without any care or support at all. This is not a good outcome for the individual, and a small correction to the staffing profile could reduce the likelihood of this occurrence. This is an important result of the hybrid framework.

Hantsdirect is well prepared to cope with future increases in demand. The staffing profile tested was the average number of staff of two representative weeks. This means that they can call upon additional staff if required when deciding on future staffing policies. It is known that Hantsdirect have taken on additional staff members so they can cope with unexpected increases in demand. This is shown with low utilisation rates of staff.

The issue of hiring agents and advisors is one for managers at Hantsdirect to deal with. There are many issues to be considered when making this choice. Whilst it is more cost effective to hire agents, there are many advantages of hiring additional advisors. By hiring advisors, they reduce the number of call hand offs which is one of the main bottlenecks in the system and they have a greater performance in terms of call times as previously discussed. As advisors are paid a higher salary, it is quite likely that it will be easier for Hantsdirect to retain their services. This will reduce a key sunk cost of training. By reducing the staff turnover rate, the cost of having to train new staff will be reduced.
The hybrid framework has shown to be a useful toolkit in examining the impact of increasing demand upon the performance of the contact centre. It should be noted that the results for 2015 and 2020 are highly theoretical. Much can change over the next ten years. There are many unknown future parameters. This in no way should undervalue the importance of the experiments. It is a means of validating the decisions of the Hantsdirect

manager’s current staffing policies. It also highlights the importance of modelling other issues such as the impact of feedback from abandoned calls. Most call and contact studies in the literature take a very short-term view. This research shows that discrete-event simulation models can be used to take a long-term view of the situation and are not limited to short-term performance issues.

8. Conclusions

Chapter 8 contains a discussion of the research questions addressed in this thesis and a summary of the key findings, as well as a discussion about the implementation of the models, the limitations of the study and, finally, areas for potential future work.

8.1 Aims of the study

The overarching aim of this thesis was to investigate the use of Operational Research modelling in the field of social care, and to combine demographic analysis methods with OR modelling in order to estimate the future demand for long-term care in the region of Hampshire. More explicitly, the aim of this thesis was to address the following research questions:

1. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people with a disability?

2. How can Operational Research modelling assist Hampshire County Council in predicting the future number of people requiring long-term care?

3. How could a detailed tactical model for the Contact Centre benefit from the additional use of a long-term dynamic demographic model for population change?

4. What benefits and insights would result from a combined approach based on these two different models?

8.1.1 Methodological contribution of the study

The hybrid framework has made both an academic contribution and has had a practical impact for Hampshire County Council. The latter is discussed in section 8.4 (pp.275-276).

There have been no existing papers of the hybrid approach in the area of social care or the modelling of contact centres. The hybrid framework allows a long-term perspective to be taken and answers questions that existing modelling techniques alone cannot answer alone. More strengths of the hybrid framework are presented in section 8.3 (pp.273-275).

Compartmental models and discrete-event simulation models alone have proven to work successfully across many application areas but the hybrid model presented in this thesis demonstrates that that by having a combined framework a more robust modelling technique can be formed. The new framework has all the strengths of the original methodologies but also allows the researchers to address new questions that could not have been answered with one model alone. In this research, the performance of the contact centre has been evaluated in light of an ageing population. This technique can be applied to many other problem areas.

A stand-alone simulation model could be run by simply inflating the number of call arrivals but the cell-based model created in this research provides a more sophisticated method of doing this. The demand profile excludes people with no incapacity. As well as this, the framework incorporates feedback from the abandoned calls from the previous month.

The hybrid framework was able to demonstrate the impact of an ageing population upon the contact centre in both the short- and long-term term over the period of 2010 to 2020. Traditional OR studies have not attempted to take this long-term view which has been achieved by the hybrid framework. The technique was able to present the outcomes of changes to the staff roster in the long-term. Existing call-centre studies only take a short-term view in regards to staffing decisions. It is important to allow call centre managers to make long-term decisions especially due to the economic climate where local government budgets are being cut.

8.2 The cell-based spreadsheet model

The main aim of this thesis was achieved through the use of a compartmental cell-based model (see Chapter 4). Projections were made until 2026. This thesis took a novel approach to modelling long-term care at the regional level of Hampshire, in comparison with the models reviewed in the literature review (see Chapter 3) which were created at the national level in the United Kingdom. The first and second research questions were addressed through the use of this model. The model was built to project disability levels in the household population across the following four categories: no incapacity, slight disability, moderate disability and severe disability. The model utilised population data provided by the Communities and Local Government Department and National Statistics Subnational Population Projections Unit. Disability rates were generated with data from the 2001 General Household Survey. The survey was also used to create a set of service level receipts. Additional service level receipts were created using data provided by Hampshire County Council.

8.2.1 Cell-Based Spreadsheet model: key findings

The model predicted significant increases in the number of older people (i.e. aged 65 and over) over the next eighteen years as a result of demographic change. The total number of older people is predicted to increase by about half over the whole 18-year period. The predicted increase in people aged 85 and over was approximately 92%. The total number of older males is predicted to increase by over fifty per cent. The total number of older females is predicted to increase by about 44%. As a result of these significant changes, the number of people with some level of disability is likely to increase in the future. Anyone with disability is a likely candidate for long-term care from any of the main providers of care.

Whilst many people have no incapacity, the majority of elderly people have some form of disability. Across the total population, the largest category is people with a moderate disability. It is estimated that in 2009, across the five age-groups, there were 77,400 people with a moderate disability in Hampshire. This is higher than the other disability groups. However, there are estimated to be 10,200 more females than males with a moderate disability, a considerably larger number.

Changes can be seen both in the short and long term. The number of people with a disability is predicted to increase by 22,100 in 2013, with the greatest increase being for people with a moderate disability. Over the whole modelling period, across all five age groups, the number of people with some level of disability is predicted to increase by 85,800. Once again, the greatest increase is in the moderate disability group, which is predicted to increase by 41,100. The greatest increases are for people aged 75 to 79, and for people aged 85 and over. The model predicted that both groups will increase by 22,200 and 20,000 respectively. In percentage terms, the greatest increases are among people aged 85 and over, with an average percentage increase of about 100% in the slight, moderate and severe disability groups. This is a significant result: the number of people with a disability aged 85 and over is predicted to more than double in the 18-year modelling period. It is known (from analysing care provision data from Hampshire County Council) that people aged over 85 represent their largest client group, and this is likely to remain the case as a result of demographic change. The number of people with a moderate disability is predicted to have increased by half in eighteen years' time. Approximately 60% is the predicted increase in the male population is much greater than the predicted change in the female population.

The total number of people with a severe disability is predicted to increase by nearly 60% by 2026. Once again, this is much greater for the male population, where it is predicted to increase by about 70%. The change in the female population is less than the general population: it is predicted to increase by half. It is assumed that people with a severe disability are the likely candidates for care from social services. The increases in the number of people requiring care is likely to have a considerable impact upon Hampshire County Council.

8.2.2 Implications for HCC and other care providers

The fact that the model predicts such a large number of people to have a moderate disability is very important for Hampshire's Adult Services. If these people are not supported, their situation could potentially deteriorate and they could end up being classified with a severe disability at some point in the future. This could potentially entitle them to long-term care provided by the Council. The implementation of preventative services is a critical part of this.

Preventative services are an important part of both national and local policy, as shown in section 2.2 (pp.39-50). Equipment to help prevent falls, better use of technology and programmes to reduce social isolation are just some examples of the programmes that can help reduce the demand on the main formal care services. There are also benefits for the acute health care system as well. For example, reducing the number of falls should reduce the number of people ending up in hospital. This is an example of a case where it is better to spend (a little) in the short-term in order to save (a lot) in the long-term. The contact centre should also prove to be a useful preventative service too. It will be able to provide advocacy and support to elderly people who are not eligible for formal care services, and direct them to other providers of care.

All care providers need to start planning now to ensure the resources are in place to meet the future changes in demand. The results of the cell-based model could help inform this. Failure to ensure the right finances and resources are in place could have a considerable impact upon the individual's welfare if the right care is not provided to them. If a person's needs are not addressed, the situation is likely to only get worse. This will have an impact upon services down the line.

It is important that all the main care providers work together, to ensure the future levels of demand can be met and people receive the right services at the right time. This will help to make sure that the system is sustainable in the long-term.

8.2.3 The impact of changes in disability rates

The second scenario explored the impact of adjusting the proportions of people with a moderate and severe disability. The proportion of people with a moderate disability was increased by first 1% and then 2%, and the proportion with a severe disability was correspondingly decreased by 1% and 2%. The change in the number of older people with moderate and severe disability is not significantly large in comparison to the total population, but it is likely to have an impact on the provision of care. It is likely if these changes were to occur that the burden upon the informal and private care sector would increase as these people are no longer candidates for formal care. This, in turn, reduces the burden upon formal care services as the number of potential clients could be reduced.

The second research question was addressed in a number of ways. Firstly, the model was able to predict the number of people with some disability. It is these people who are candidates for long-term care services. One of the responsibilities of the Adult Services Department is to ensure that the market for long-term care services has adequate resources in place to meet any changes in demand. Disability projections could potentially prove to be a useful source of information in helping meet this requirement. This is a source of data that the Council did not have before, and will help them to allocate the appropriate resources and funding in terms of planning services, in both the home and community, both in the short- and long-term. This has become an increasing challenge in light of the budget cuts and the economic downturn. Secondly, the number of people who are likely to report one of the main providers of care as their main source of care is based on responses to the 2001 General Household Survey. Thirdly, the model was able to predict the number of people requiring long-term care from Hampshire County Council in the form of day and domiciliary care based on 2009 levels.

Service receipt provision was explored in the model using people's responses to the 2001 General Household Survey in terms of their main care provider. It is important to remember that the majority of older people are able to live independently, with an estimated average of 85% people aged over 65 reporting in 2001 that they do not need care or support. The results for 2026 are very similar. However, it should be noted that the absolute number of people requiring care is predicted to increase due to demographic change. Many people who received a care service reported in the 2001 GHS that it came from an informal care provider. The informal care sector already plays an important role in the provision of care to elderly people and due to demographic change they will have to continue this. It is important that HCC continues to provide support to them to enable them to continue this important role. Services such as respite care are critical to this. At the national level, support in terms of benefits needs to be maintained and this will be a challenge as the money raised from taxation will be reduced as the number of people in the working population decreases. The budget cuts will also have an impact upon the amount of money that is made available for benefits. Many people will have to consider entering the workforce if adequate levels of benefits cannot be maintained. If they do, this will further reduce the number of carers.

The third and fourth scenarios explored in more detail the number of people that are predicted to receive home and community care from the local authority in terms of day and domiciliary care. The third scenario explored the impact the number of people predicted to receive day and domiciliary care and classified as having a substantial or critical eligibility status. Over the whole period, the number of people receiving formal care services in the home and community is predicted to increase by 70% to 10,400. Scenario four explored the impact of predicting the number of people who are likely to receive at least five hours of domiciliary care per week. Over the whole period, the number of people receiving domiciliary care services is predicted to increase by 64% to 6,900. For both scenarios three and four, significant increases are predicted to occur in both the short and long term.

The model has shown that many significant changes are predicted in the number of older people across all the disability categories. All the main providers of care need to gear up for these changes now, as it is likely the impact will be felt not just in the long term but within the next five years. There is going to be considerable fiscal pressure placed upon the local authority as the number of people requiring care in the home and community increases over time. It is important that services are available to help elderly people live independent lives in their own homes. Not only does HCC need to prepare to meet demand for its own services, but it is essential that it supports the informal care market to meet its own demand. If the informal care market fails to meet its own demand, the burden could then fall upon the formal care market. It is also important that private care groups are able to share the burden. Hampshire's Adult Services Department procures many services from the private sector, so these have a very important role to play in the future. If they are unable to do so, many formal care services will have to be provided in-house.

8.3 The Hybrid model framework

Research questions 3 and 4 were addressed through the hybrid framework. The hybrid model is a novel approach in health care OR modelling. Discrete-event simulation was used to model the contact centre. This was then combined with the cell-based model to form the hybrid framework (see Chapter 6). This framework was able to capture the important interactions between the two models. For the purposes of the hybrid framework, an adapted cell-based model was used which included the whole Hampshire population. The cell-based model was used to predict the increase in demand (in terms of the number of calls received) due to demographic change over the next ten years. Based on this demand, the monthly performance of the contact centre was explored through the discrete-event simulation model. This performance (in terms of abandoned calls) was then fed back into subsequent runs of the DES model, by assuming that a fraction of abandoned calls would lead to increased demand in future months. The hybrid framework proved to be a useful method of exploring both the short-term as well as the long-term performance of the contact centre. The performance was tested for various levels of feedback, allowing different percentages of abandoned calls to lead to additional demand in the next month.

Experiments were carried out for the years 2010, 2015 and 2020. The results showed that the contact centre has the capability to deal with the likely increase in demand due to demographic change and the feedback created from abandoned calls in 2010. However, the model predicted that in both 2015 and 2020, staffing interventions would be required in order to enable the contact centre to perform at an acceptable level, in terms of the percentage of calls answered and the percentage of calls answered within 20 seconds.

There are many benefits and insights of this combined approach. The two models provided very useful results as standalone models: both models addressed their own distinct problem area, and allowed different problems to be addressed. However the benefits of each of the modelling approaches are combined in the hybrid framework. The cell-based model was able to model the Hampshire population at a higher, more strategic level to investigate the future demand for long-term care, whilst the discrete-event simulation model was able to model at the tactical level.

The cell-based model was an ideal choice for modelling the Hampshire population to project future levels of disability and service receipt. The model is able to produce results almost instantaneously at the population level. This model can easily be used by the Local Authority, as it was built in Microsoft Excel, software which HCC already own and with which HCC staff are comfortable and familiar. This allows the Council to run their own experiments and also increases user acceptance of the model. As shown in section 8.2 (p.267), the cell-based model is able to create many useful results. It would not have been useful to provide the Council with the hybrid model: in addition to requiring the purchase of the Simul8 software and training in its use, the hybrid model requires considerable technical expertise to run.

Discrete-event simulation models are ideal for modelling queuing systems (such as call centres) in order to understand performance under varying conditions. The cell-based model would not have been able to model the contact centre in sufficient detail and capture the stochastic aspects of the real-world system. Since the DES model was developed as a research tool and was not intended to be used by the Council, there was no need to develop a user interface or train HCC staff how to use the Simul8 software. The model was used to explore various staffing scenarios that were not part of the hybrid framework. Hantsdirect requested these additional experiments over and on top of the modelling that was carried out to address the research questions in this thesis. Since the DES model was separate from the hybrid framework, these experiments were rapidly and easily carried out. The results can be potentially useful for resource planning.

As the two models have shown to be useful on their own, it was not considered important to explore the possibility of building the model in one environment. This would have been a time-consuming programming task, and only of value if HCC had requested a user-friendly software tool which did this. Moreover, by validating the models separately, we did not need to worry about validating the combined model. The two individual models were validated using standard validation and verification approaches. Much time would be needed to ensure that the single environment model is fully validated before the results could be relied on. The process of combining the two models in this thesis was validated and verified to ensure that correct logic was carried out.

It was clear from the literature review (see section 3.2, pp.81-99) that many existing simulation models of contact centres only look at short-term issues. Such models typically do not account for factors in the external environment. The combination of the two models permitted the exploration of performance issues as a result of long-term demographic change. Typically, in the literature such longer-term change in demand is modelled crudely by simply increasing the arrival rate of calls by some fixed proportion. As shown in the work of Rabelo et al. (2005a), the hybrid approach allowed for both short- and long-term planning. By including the dynamics of population change in the hybrid model, a much more sophisticated and realistic "arrival rate" is derived. This is one of the main advantages of the combined approach. The hybrid framework potentially helps decision-making in a number of issues which would not have been possible through the use of either one of these models on their own, through its ability to address both strategic and operational issues, and provides a more robust approach.

8.4 Implementation

The results of the cell-based model are going to be used to potentially support future service planning by the Hampshire County Council's Adult Service Department. Moreover, the model is going to be potentially used as part of the joint strategic framework that has recently been created between Hampshire County Council and Hampshire's Primary Care

Trust (NHS Hampshire, 2011). Hampshire County Council have taken ownership of the cell-based model.

The results of the hybrid model can potentially help with future planning for the contact centre service. The Council is currently investigating what the future service should look like and the results of the hybrid framework could inform this process. The results of the hybrid framework are being used by the Programme Manager within the Adult Services Department as part of this process.

The stand-alone discrete-event simulation model was used to run various staffing scenarios for Hantsdirect. The results of these scenarios can potentially be useful for Hantsdirect. The data collected and observations made by the researcher as part of the modelling process also proved to be useful for the Council, augmenting the standard performance data output by the call centre system with real-life observational data.

8.5 Limitations

Like any other study, the research in this thesis has its limitations. Modelling assumptions had to be made and these have been clearly described in the relevant chapters (see Chapters 5, 6 and 7). Assumptions have been explicitly stated in the following sections: 4.3.2 (p.120), 4.3.4 (p.123), 4.4 (p.125 and p.130), 4.7.1.2 (pp.141-142), 5.3 (p.149), 5.6.3 (p.171), 5.6.5 (p.177), 5.6.7 (p.182), and 7.1.6 (p.251).

However, these assumptions are not sufficiently restrictive as to impact on the overall usefulness of the results presented in this thesis. These limitations are summarised below.

- The spreadsheet model is deterministic and does not take account of any uncertainty around the projections which potentially means the results could be wrong in either direction.
- Arbitrarily quantified how contact centre performance affects future demand, meaning the results could be wrong in either direction. Assumptions around the methodology had to be made for modelling purposes.

- Arbitrarily chosen three particular future years to model the contact centre. However, the years under investigation do cover a period which allows for both the short- and long-term performance to be captured.

- The actual day-to-day operation of the contact centre in the DES model was considerably simplified. However, for modelling purposes a sufficient level of detail was accounted for.

- Assumptions were made in the simulation model concerning:

    - *Call types* (Assumption 9, p.147). The call centre receives hundreds of different types of calls. For modelling purposes these calls were grouped into three categories.
    - *Duration of calls*. Activity durations were based on limited (observational) data and were not able to guarantee their statistical validity.

- The model assumes age-related patterns of disability will remain the same in the future as they are now; this is almost certainly not the case as many people are living longer without disability. It is likely that the total expected duration of disability is probably going to be about the same as it is now but just lived at an older age; meaning the results underestimate the age at which people need care.

- Survey data collected at a national level was used at a regional level (i.e. for Hampshire) to model: a) the number of people with disability, and b) service level receipts. However, the data provided in the 2001 General Household Survey was the best source of information available, and there is no reason to believe that Hampshire is out of line with the general UK population for the purposes of this thesis.

- This national survey data dated back to 2001. However, the 2001 General Household Survey is the most up-to-date survey that contained the relevant information on elderly people that was required for this study.

- Household data was not provided by individual year of age, but only in five-year age bands. This was overcome using the techniques discussed in section 4.3 (pp.116-124).

- No mortality or migration data were available at the household level of disaggregation. This was overcome using the techniques discussed in section 4.3 (pp.116-124).

- The General Household Survey is based on self-assessment, rather than an objective method of data collection. In particular, the service receipt data is based on the respondent's self-assessment of what they consider their main service provider to be. This is a potential source of bias, but the data provided in the General Household Survey are generally considered to be the best available. These data still provide useful insight into the provision of long-term care services, by identifying the number of people who are likely to receive no care or support at all. Additional information about service receipt rates in Hampshire was created with the use of Local Authority data.

- The General Household survey could have potentially underestimated the number of older people with cognitive impairment, such as those with Alzheimer's Disease. However, it is likely older people with severe cognitive impairment would be more likely to have been living in residential institutions than in private households in the community. Some elderly people with a cognitive impairment could have had a family member answer the questions in the survey for them.

- The model only considers home and community care, because these were the only aspects covered by the General Household Survey. However, home and community care is a key part of the system for long-term care provision.

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- Future policies on the provision of local authority care were not included. However, the system of long-term care in Hampshire is currently an ongoing debate and no decision has been made. Nevertheless, formal care services provided in the home and community are unlikely to change in the future. Moreover, formal care services were modelled at a high level of aggregation, e.g. specific domiciliary care services were not considered.

- There may be a “supply-induced demand” effect, i.e. the existence of the contact centre might lead to more people accessing formal care services, but there is no evidence of this as yet. While this effect could be modelled, for example through the use of system dynamics as discussed in Chapter 6, there were no available data to support such a model and this was beyond the scope of the research in this thesis.

8.6 Further Research

Over the course of the research, a number of areas were identified as potential areas of future research. Some of what follows addresses some of the limitations identified in the previous section.

A number of potential areas for future work have been identified to further develop the long-term care model. As the spreadsheet model was deterministic, future work could involve using probabilistic models which would give confidence intervals rather than potentially misleading exact numbers. The cell-based model assumed age-related disability rates will remain the same in the future. Future work would incorporate the effect of these changing age patterns.

As the modelling arbitrarily quantified how contact centre performance affects future demand, further research would involve testing this hypothesis using actual call data (very difficult) or carrying out a sensitivity analysis study.

As mentioned above, this study used national UK data from the 2001 General Household Survey. A future project could involve creating a survey specific to Hampshire and the collection of local primary data. This would not only enable local differences (if any) to be identified but would also permit more detailed modelling to include all forms of care, such as the informal care provided by family and friends. The modelling could be disaggregated to the level of marital status and ethnicity.

As described in the final point in section 8.5 (p.279), a system dynamics model could be developed to take into account additional environmental factors. This approach was not adopted in this research, mainly due to the lack of data but also due to time constraints. Although a system dynamics model could be based on expert judgement, this was not pursued. However, a survey of elderly residents in Hampshire could provide the relevant information. This would involve additional questions to the survey identified in the previous paragraph.

Based on the collection of new survey data at the Hampshire level, agent-based simulation could be considered in order to explore the interactions of people and different care services over time. This could be expanded to model the contact centre as well as to include all the features of Hantsdirect.

The research in this thesis does not consider the cost aspects. This was outside the scope of this project, but the future costs of long-term care services at regional level could be studied to allow policy planners to account for the additional costs when planning future budgets. This is very important given the budget cuts local authorities across the country are facing.

A future study could study the impact upon the NHS of demographic change and changes in the social care system. A future model could be built to study the interactions between the social care system and the health care system, of which there are many.

Finally, further research could consider care provision from voluntary organisations as a separate category as this was not considered as part of this research.

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Appendix A1 Model User Guide

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4.0 Document Information

Document purpose: User guide for Microsoft Excel spreadsheet model

Title: Model User Guide

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5.0 Background

The following is a user guide for the spreadsheet model created as part of Mitul Desai's PhD. The PhD is title is "Modelling the future demand for long-term care".

The "ageing population" presents many significant challenges for health and social care services at both a national and local level, one of which is to meet the demand for long-term care. The population of people aged over sixty-five will continue to grow for some time as the baby boom generation ages.

In response to this a toolkit has been developed as a planning device to help project forward the potential demand for long-term care amongst those aged sixty-five years and over. The model has been created in Microsoft Excel

It is highly recommended that you read the whole user guide before using the model. It is also beneficial to attempt each step in the model itself.

6.0 Additional Support

For additional support or further explanation on any part of the model please email the author.

7.0 Loading the Model

Please save a copy of the Excel file, 'Population Model' to your hard drive from the compact disc.

8.0 Changes

It is recommended that you change the name of the Excel file before making any changes. This will allow you to have access to a model with preloaded data on your hard drive.

9.0 Loading the File

Load Microsoft Excel and then open the file 'Population Model'. When prompted, select 'Enable Macros'.

You will also be prompted to enter a password to access the file. If you do not already have this password, please contact Kevin Andrews or Mark Houston for access.

10.0 Front Screen

The first worksheet (Figure 1) requires you to accept the Terms and Conditions laid out on the front screen.

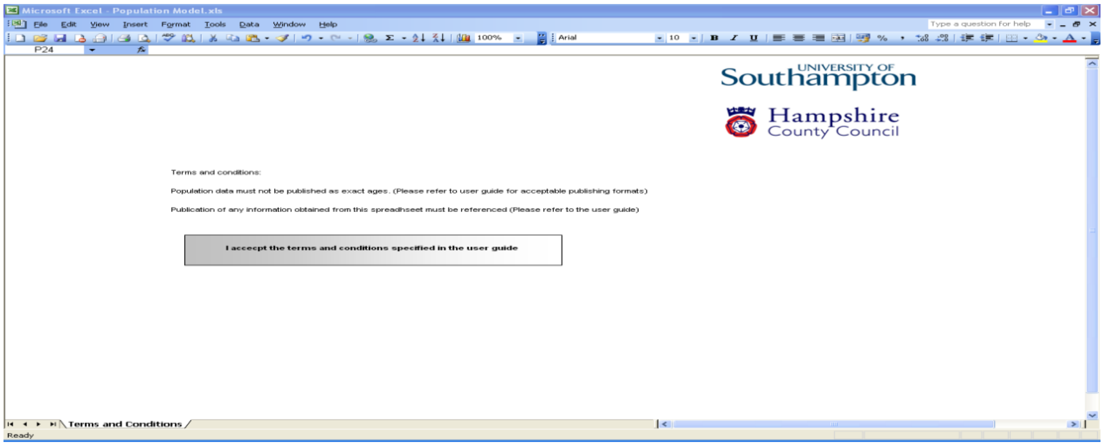


Figure 1: Terms and Conditions

If you require any additional information in relation to the Terms and Conditions, please send an email to the author.

10.1 Main Menu

In the Excel workbook, the second worksheet is the main menu (the user interface) (Figure 2).

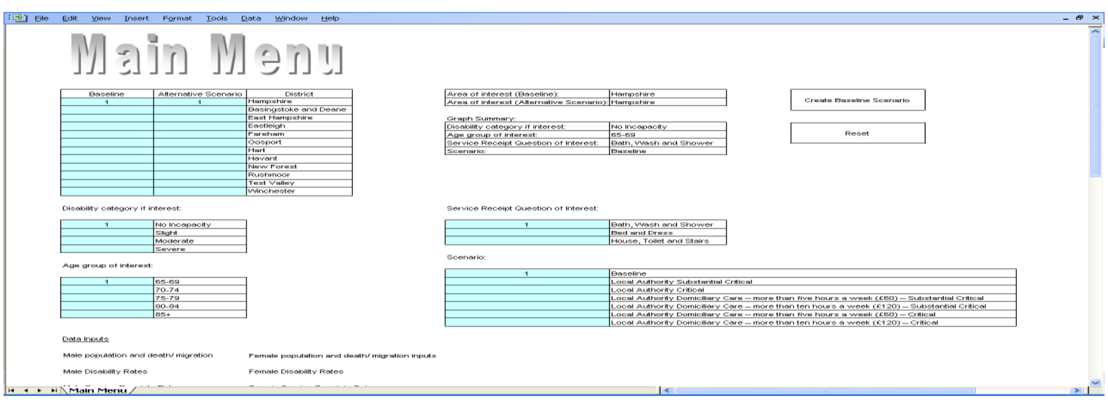


Figure 2: Main Menu

From here you will be able to navigate around the interface.

From each additional sheet accessed, you can return to the Main Menu by clicking the *Return to main menu* button (Figure 3) at the top right of each sheet.

Figure 3: Return to Main Menu Button

After any changes you make in the user interface, please wait until all the cells have been calculated before you proceed.

Figure 4: Calculating Cells

Figure 4 illustrates the calculating cells percentage shown within Excel. When you make a change in the user interface, the image in Figure 4 will appear in the bottom left-hand corner. Please wait until it has disappeared before you proceed.

Depending on your processor speed, you might not even see it at all.

11.0 Inputting the Data

The spreadsheet is preloaded with data. All the inputs can be altered.

11.1 Six Inputs

There are six inputs which can be altered:

1) Male population and death/migration inputs
2) Male disability rates
3) Male service receipts rates
4) Female population and death/migration inputs

5) Female disability rates
6) Female service receipts rates

Table 1: Six Inputs

They can be found under the *Data Input* section (Figure 5) of the user interface (Figure 2).

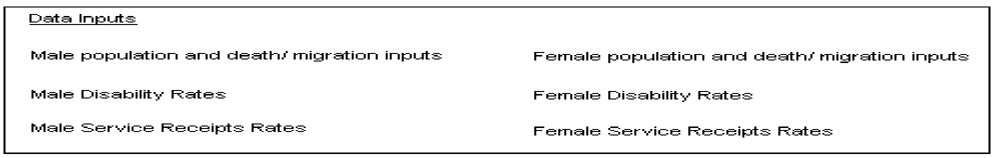


Figure 5: Data Inputs

Each of the inputs is a button. To view and alter the input, just click on the words. Once you click on the button, you will be navigated to the associated input screen.

11.2 Population and Death/Migration Inputs

For inputs one and four (Table 1), you can alter the initial population and the net population change (a combination of the death and net migration). Inputs can be altered for both males and females.

It is recommended that changes made to the net population changes value are made in the *Scenario Runner* (Section 12).

Population data is based on the household population.

You can make alterations for any of the eleven districts.

Population Data																				
	Year / Age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Basingstoke and Deane	64	818	812	892	1085	1016	962	909	881	861	812	874	846	877	948	952	992	1067	1067	1098
	65	763	795	790	867	1057	990	937	885	858	839	792	851	823	854	923	928	967	1039	1040
	66	649	744	775	771	846	1032	967	914	865	838	819	774	831	805	835	903	908	945	1016
	67	585	638	731	761	758	832	1014	950	898	849	824	806	762	818	792	822	888	894	930
	68	620	575	627	718	749	746	817	996	934	883	835	810	793	751	805	781	810	875	881
	69	614	608	565	616	706	736	733	802	979	918	868	821	796	780	739	793	769	797	861
	70	594	597	592	550	600	687	717	714	782	957	897	849	803	779	763	722	775	752	780
	71	524	582	585	579	539	587	673	702	701	767	938	881	832	788	765	749	710	761	739
	72	533	511	567	571	566	526	574	659	688	686	751	918	863	815	771	749	734	696	746
	73	485	517	497	552	556	551	514	561	643	671	671	732	898	843	796	754	732	717	681
	74	435	468	498	480	532	537	534	497	542	623	651	650	711	871	818	772	731	710	697
	75	425	419	451	481	465	515	520	517	482	526	604	630	630	689	844	793	749	711	690
	76	390	406	402	433	462	447	497	502	499	466	508	583	610	610	666	817	768	725	688
	77	393	373	389	386	417	445	431	479	485	482	451	492	564	590	591	644	791	744	703
	78	349	378	359	376	373	403	431	419	464	470	468	438	478	548	574	575	626	770	724
	79	332	330	359	343	358	356	386	414	402	447	453	451	422	460	529	553	554	605	743
	80	288	316	316	343	329	345	345	373	400	391	433	440	440	413	450	515	539	542	590
	81	257	264	290	291	317	305	320	321	348	373	366	406	412	413	387	422	484	507	510
	82	231	239	245	271	272	297	287	301	302	327	353	346	384	390	390	366	400	458	481
	83	210	211	218	225	248	250	274	265	279	280	304	328	322	358	364	365	341	373	428
	84	166	185	185	193	199	221	223	245	237	250	252	275	298	293	326	331	332	310	339
	85+	715	752	802	849	898	947	1010	1071	1145	1207	1277	1343	1425	1521	1605	1713	1816	1911	1979

Figure 6: Population Data Inputs for Basingstoke and Dean

Figure 3 illustrates the male population data inputs for Basingstoke and Dean. Any cells with a turquoise background can be altered. Each cell in the number of people expected for each age by year. Population data is provided for individual years from 2008 until 2026.

Number of Deaths and Net Migration																			
	Year / Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Basingstoke and Deane	65	-23	-22	-25	-28	-26	-25	-24	-23	-22	-20	-23	-23	-23	-25	-24	-25	-28	-27
	66	-19	-20	-19	-21	-25	-23	-23	-20	-20	-20	-18	-20	-18	-19	-20	-20	-22	-23
	67	-11	-13	-14	-13	-14	-18	-17	-16	-16	-14	-13	-12	-13	-13	-13	-15	-14	-15
	68	-10	-11	-13	-12	-12	-15	-18	-16	-15	-14	-14	-13	-11	-13	-11	-12	-13	-13
	69	-12	-10	-11	-12	-13	-13	-15	-17	-16	-15	-14	-14	-13	-12	-12	-12	-13	-14
	70	-17	-16	-15	-16	-19	-19	-19	-20	-22	-21	-19	-18	-17	-17	-17	-18	-17	-17
	71	-12	-12	-13	-11	-13	-14	-15	-13	-15	-19	-16	-17	-15	-14	-14	-12	-14	-13
	72	-13	-15	-14	-13	-13	-13	-14	-14	-15	-16	-20	-18	-17	-17	-16	-15	-14	-15
	73	-16	-14	-15	-15	-15	-12	-13	-16	-17	-15	-19	-20	-20	-19	-17	-17	-17	-15
	74	-17	-19	-17	-20	-19	-17	-17	-19	-20	-20	-21	-21	-27	-25	-24	-23	-22	-20
	75	-16	-17	-17	-15	-17	-17	-17	-15	-16	-19	-21	-20	-22	-27	-25	-23	-20	-20
	76	-19	-17	-18	-19	-18	-18	-18	-18	-16	-18	-21	-20	-20	-23	-27	-25	-24	-23
	77	-17	-17	-16	-16	-17	-16	-18	-17	-17	-15	-16	-19	-20	-19	-22	-26	-24	-22
	78	-15	-14	-13	-13	-14	-14	-12	-15	-15	-14	-13	-14	-16	-16	-16	-18	-21	-20
	79	-19	-19	-16	-18	-17	-17	-17	-17	-17	-17	-17	-16	-18	-19	-21	-21	-21	-27
	80	-16	-14	-16	-14	-13	-11	-13	-14	-11	-14	-13	-11	-9	-10	-14	-14	-12	-15
	81	-24	-26	-25	-26	-24	-25	-24	-25	-27	-25	-27	-28	-27	-26	-28	-31	-32	-32
	82	-18	-19	-19	-19	-20	-18	-19	-19	-21	-20	-20	-22	-22	-23	-21	-22	-26	-26
	83	-20	-21	-20	-23	-22	-23	-22	-22	-22	-23	-25	-24	-26	-26	-25	-25	-27	-30
	84	-25	-26	-25	-26	-27	-27	-29	-28	-29	-28	-29	-30	-29	-32	-33	-33	-31	-34
	85+	-129	-135	-138	-144	-150	-158	-162	-171	-175	-180	-186	-193	-202	-209	-218	-228	-237	-242

Figure 7: Population Change Inputs for Basingstoke and Dean

Figure 4 illustrates the male population change data inputs for Basingstoke and Dean. Any cells with a turquoise background can be altered. Each cell is the net effect of the number of deaths and net migration for each age and year. Population change data is provided for individual years from 2008 until 2026.

The data is based on population data provided by the Government and Communities Department and the National Statistics Subnational Population Unit.

The data was manipulated by the author. Please contact him if you require further information on the methodology with regards to population data.

Population data must not be published as exact ages as these numbers imply an accuracy that does not exist. Percentage changes and population data rounded to the nearest hundredth person that is grouped in age groups (65-69, 70-74, 75-79, 80-84 and 85+) are considered acceptable. This format is considered the most robust by the Office for National Statistics.

There are limitations of the dataset. The National Statistics Subnational Population Unit provides a discussion of these on the following website.

http://www.statistics.gov.uk/downloads/theme_population/SNPP_Issues_and_Guidance.pd
f

11.3 Disability Rates

Disability rates can be altered for both males and females for any of the eleven districts. The rates can be altered by both month and year. Rates are provided for five age groups and four disability groups.

1) 65-69
2) 70-74
3) 75-79
4) 80-84
5) 85+

Table 2: Five Age Groups

1) No Incapacity
2) Slight

3) Moderate
4) Severe

Table 3: Disability Groups

Figure 8 is an illustration of the male disability rate inputs for Basingstoke and Dean. Any cells with a turquoise background can be altered.

Each cell is the probability that somebody in the age group in question (Table 2) falls into one of the four disability categories (Table 3).

An error warning will appear if your probabilities do not add up to one.

			2009																	
Basingstoke and Deane	Age	Disability Group	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	Jur
	65-69	No Incapacity	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.4
		Slight	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.2
		Moderate	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.2
		Severe	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.0
	70-74	No Incapacity	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.3
		Slight	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.2
		Moderate	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.3
		Severe	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.0
	75-79	No Incapacity	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.1
		Slight	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.2
		Moderate	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.4
		Severe	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.1
	80-84	No Incapacity	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.1
		Slight	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.2
		Moderate	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.4
		Severe	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.1
	85+	No Incapacity	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.0
		Slight	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.1
		Moderate	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.4
		Severe	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.3

Figure 8: Male Disability Rate Inputs for Basingstoke and Dean

Disability rates have been calculated from the 2001 General Household Survey.

When publishing disability rates, the PhD thesis must be referenced in compliance with the Economic and Social Data Service.

The default rates are the same for each district and for each year. They differ for each gender.

An additional feature for changing the rates is discussed in section 12.2.

11.4 Service Receipt Rates

Service receipt rates can be altered for both males and females for any of the eleven districts. The rates can be altered by both month and year. Rates are provided for the five age groups and four disability groups (Tables 2 and 3). There is one additional dimension in comparison to the disability rate inputs: Service Provider.

1) None
2) Local Authority
3) Informal Care
4) Private Care

Table 4: Service Receipt Categories

Private care includes care provided by voluntary organisations.

The current service receipts inputs have been calculated from the 2001 General Household Survey.

When publishing service receipt rates the PhD model must be referenced in compliance with the Economic and Social Data Service.

The current data is based on the survey participants' main form of service receipt in the last month. For example, while somebody might answer that informal care is their main receipt of care it does not mean they are not receiving care from other sources.

Figure 9 is an illustration of the male service receipts rate inputs for Basingstoke and Dean for those aged sixty-five to sixty-nine. Any cells with a turquoise background can be altered.

Each cell is the probability that somebody in the age group and disability group in question falls into one of the four service receipt categories (Table 4).

An error warning will appear if your probabilities do not add up to one.

Return to main menu			2009																	
Basingstoke and Deane	Age	Disability Group	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	Ju
	65-69	No Incapacity	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.4
		Slight	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.2
		Moderate	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.2
		Severe	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.0
	70-74	No Incapacity	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.3
		Slight	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.2
		Moderate	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.3
		Severe	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.0
	75-79	No Incapacity	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.1
		Slight	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.2
		Moderate	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.414	0.4
		Severe	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.1
	80-84	No Incapacity	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.1
		Slight	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.2
		Moderate	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.4
		Severe	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.1
	85+	No Incapacity	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.0
		Slight	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.1
		Moderate	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.4
		Severe	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.326	0.3

Figure 9: Male Service Receipt Rate Inputs for Basingstoke and Dean

The preset rates are the same for each district and for each year. They differ for each gender.

There are alternative scenarios which are discussed in section 14.

Please note that the current service receipt rates cells contain formula; you can overwrite these manually. Please take note of Section 8 before you make any changes here.

12.0 Scenario Runner

12.1 Net Population Changes

It is easier to make changes to net population change values in the Scenario Runner.

The scenario runner can be accessed via the Scenario Runner (Figure 10) section of the user interface (Figure 2).

Figure 10: Scenario Runner Buttons

By clicking on *Male Scenario Runner* and *Female Scenario Runner* you can navigate to relevant input pages.

Adjustment

	AGE	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Basingstoke and Deane	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 11: Population Adjustment for Basingstoke and Dean

Figure 11 illustrates the inputs for Basingstoke and Dean in the scenario runner. You can enter a value into any of the calls that are highlighted in yellow or green.

These inputs allow you to make changes to either the death or net migration rate. The value you enter is the net effect of the two.

The value you enter will adjust the population for the following year. For example, if you were to enter 15 in the yellow cell for those aged 65 in 2009, this would add an additional fifteen people to those aged 65 in 2009. If you were to input -15 into the yellow cell for those aged 65 in 2009, this would remove fifteen people from those aged 65 in 2009.

Caution should be taken when making large changes. Making large changes could cause the population to go negative for future year projections. If you do make a large change it is recommended that you check the population tables and graphs to manually observe the population to ensure it has not gone negative at some point in the future.

12.2 Disability Rate Changes

An additional feature of the scenario runner is the ability to alter the moderate and severe disability rates (Figure 12).

	Moderate/ Severe Disability Adjustment (Percentage)
Basingstoke and Deane	0
East Hampshire	0
Eastleigh	0
Fareham	0
Gosport	0
Hart	0
Havant	0
New Forrest	0
Rushmoor	0
Test Valley	0
Winchester	0

Figure 12: Moderate/ Sever Disability Adjustment (Percentage)

You can alter the disability rates for any district. Any cells with a turquoise background in Figure 12 can be altered. The value you enter will increase the proportion of those with a moderate disability and reduce the number with a severe disability.

For example, to make a two percent adjustment, simply type a value of 0.02 into the relevant district cell. This will increase the number of people with a moderate disability by two percent and reduce the number of people with a severe disability by two percent.

To make the same change to all of the districts, simply type in the value in the Basingstoke and Dean cell and click the button *Copy Down* (Figure 13) which is found on the left-hand side of inputs (Figure 12).

Figure 13: Copy Down Button

13.0 Results

13.1 Tables

Once you have set up the inputs, there are a variety of graphs and tables that you can access.

If you make any changes to the preloaded inputs or in the scenario runner, please click the *Create Baseline Scenario* button (Figure 14) which can be found in the user interface (Figure 2).

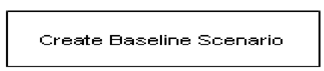


Figure 14: Create Baseline Scenario

You must ensure you click on this every time you make changes to the inputs (not including graph inputs discusses in section 13.2) otherwise the relevant tables and graphs will not update. There is one exception to the rule, please see section 13.1.2.

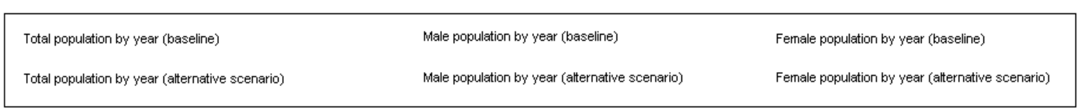


Figure 15: Tables

Halfway down the user interface (Figure 2) you can access the first set of tables (Figure 15). There are six buttons which, once pressed, will navigate you to the correct table.

The first row is the baseline tables for the total male and female populations. The second row is the alternative scenario data tables.

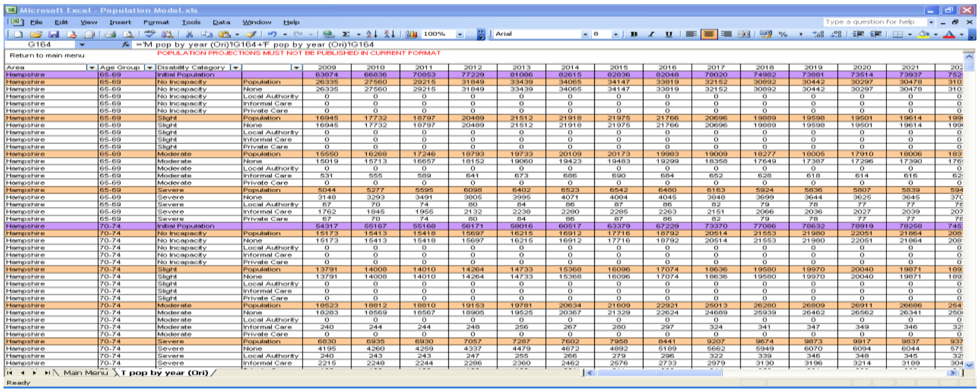


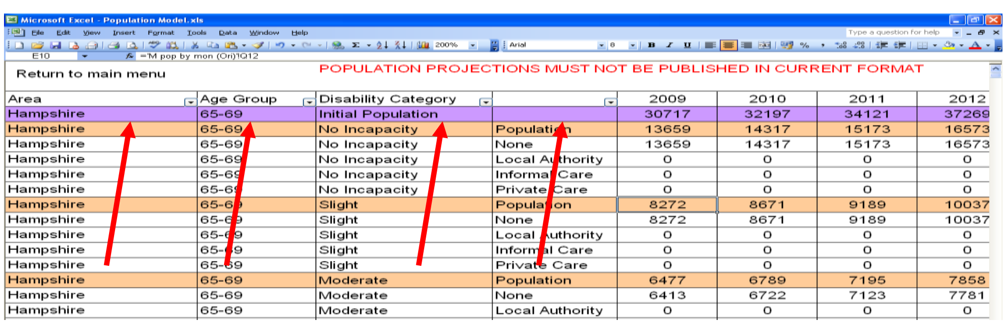
Figure 16: Male Population by Year (Baseline) Table

Figure 16 is an example of the results table.

Data is provided in the following categories:

1. Area
2. Age Group
3. Disability Category
4. Population or service receipt

An additional feature is the ability to filter the data to a finer level by clicking on the buttons illustrated with red arrows in Figure 17.



Return to main menu

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Area	Age Group	Disability Category		2009	2010	2011	2012
Hampshire	65-69	Initial Population		30717	32197	34121	37269
Hampshire	65-69	No Incapacity	Population	13659	14317	15173	16573
Hampshire	65-69	No Incapacity	None	13659	14317	15173	16573
Hampshire	65-69	No Incapacity	Local Authority	0	0	0	0
Hampshire	65-69	No Incapacity	Informal Care	0	0	0	0
Hampshire	65-69	No Incapacity	Private Care	0	0	0	0
Hampshire	65-69	Slight	Population	8272	8671	9189	10037
Hampshire	65-69	Slight	None	8272	8671	9189	10037
Hampshire	65-69	Slight	Local Authority	0	0	0	0
Hampshire	65-69	Slight	Informal Care	0	0	0	0
Hampshire	65-69	Slight	Private Care	0	0	0	0
Hampshire	65-69	Moderate	Population	6477	6789	7195	7858
Hampshire	65-69	Moderate	None	6413	6722	7123	7781
Hampshire	65-69	Moderate	Local Authority	0	0	0	0

Figure 17: Filters

13.1.2 Comparison

If you make any changes to any of the inputs at this point, a comparison can be made to the original configuration.

The new tables can be accessed in the second row of tables in Figure 14. These are the alternative scenario tables.

If you were to click on the “Create Baseline Scenario”, the alternative scenario data will become your baseline scenario data. You can now make further changes to inputs to make further comparisons.

13.2 Graphs

Graphs for the same sets of data can be easily accessed from the user interface (Figure 2).

You must set up the graphs that you would like to view first.

There are three inputs (Figures 18 – 20) which you can alter in the user interface (Figure 2).

Baseline	Alternative Scenario	District
1	1	Hampshire
		Basingstoke and Deane
		East Hampshire
		Eastleigh
		Fareham
		Gosport
		Hart
		Havant
		New Forest
		Rushmoor
		Test Valley
		Winchester

Figure 18: Graph Input One

Figure 18 illustrates the inputs for choosing the area you want to produce graphs for.

You simply delete the number 1 and type it again (1) in any turquoise cells. After you type 1, press ‘Enter’ to confirm the change. Each cell corresponds to the district in the far-right column.

You do not need to alter it if the area(s) you want to view are already selected.

There are two input columns: the first column is the baseline district, the second is alternative area. You can view graphs with one district or two. If you only want to see one area, you only need to alter the first column.

Disability category if interest:

1	No Incapacity
	Slight
	Moderate
	Severe

Figure 19: Graph Input Two

Figure 19 illustrates the inputs for choosing the disability category you want to produce graphs for.

You simply delete the number 1 and type it (1) again in any turquoise cells. After you type 1, press ‘Enter’ to confirm the change. Each cell corresponds to a disability category in the far-right column.

You do not need to alter it if the disability category you want to view is already selected.

Age group of interest:

1	65-69
	70-74
	75-79
	80-84
	85+

Figure 20: Graph Input Three

Figure 20 illustrates the inputs for choosing the age group for which you want to produce graphs.

You simply delete the number 1 and type it (1) again in any turquoise cells. After you type 1, press ‘Enter’ to confirm the change. Each cell corresponds to the age group in the far right side column.

You do not need to alter it if the age group you want to view is already selected.

You are now ready to view the graphs (Figure 21) which can be accessed from the user interface (Figure 2).

You can change the settings in Figures 18 to 20 as many times as you want to create various graphs.

If you change any of the initial inputs (Figure 5) or the any of the scenario runners or any of the inputs in section 14, the alternative scenario data will change. To change the baseline scenario data remember to click the create baseline scenario button (Figure 14).

Figure 21 shows the graphs for the baseline scenario, e.g. they only display one area.

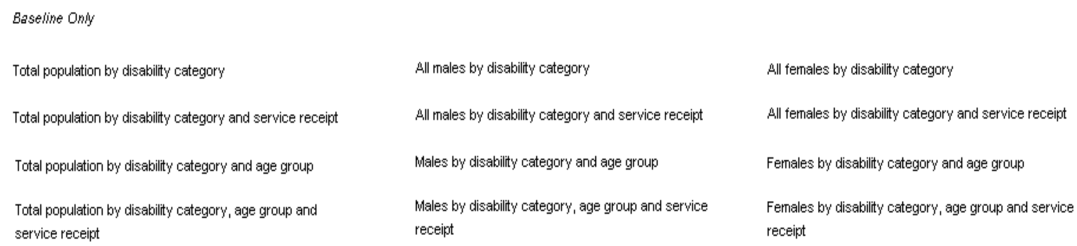

Figure 21: Graphs Section in the User Interface

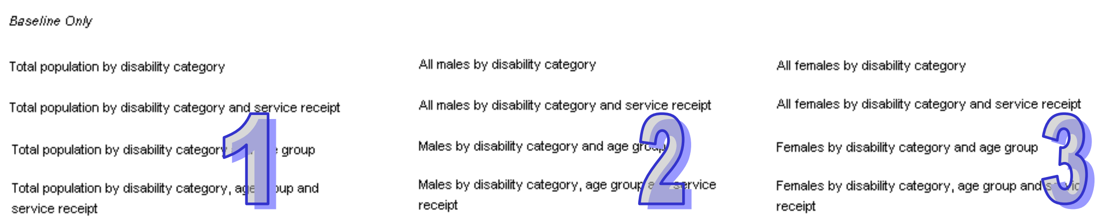

Figure 22: Graphs Section in the User Interface with Number Code

In Figure 22, Section 1 is for the total population, section 2 is for the male population and section 3 is the graph for the female population.

Four types of graphs can be accessed for the total population and each gender: the first is population by disability category, the second is the population by disability category and service receipt, the third is the population by disability category and age group and finally the population by disability category, age group and service receipt.

You can now access the graphs by clicking on the relevant button in Figure 21.

On each graph you will find a summary of the data you have selected (Figure 23). Please make sure the inputs are correct. On rare occasions, Excel will not update the formula. If this is the case, please return to the user interface (Figure 2) and manually change some of the inputs to force Excel to resolve the formula. If this does not work, please email the author.

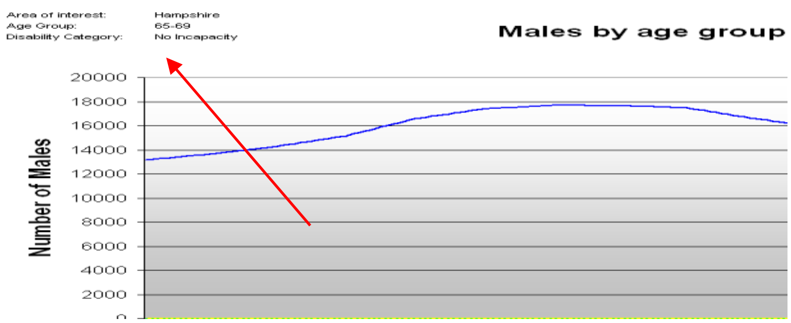

Figure 23: User Inputs

Another good check to ensure the right data is in the graph is a manual inspection to see if a change has occurred. Again, on very rare occasions, you might notice that the graphs are not changing even though you have changed the inputs. Please repeat the steps to force Excel to resolve the formulas.

The same graphs are available under the section *Baseline and alternative scenario* (Figure 24) in the user interface (Figure 2) that display two areas (the areas you choose in Figure 18) or the same area with different service receipts (see section 14).

Baseline and alternative scenario

Total population by disability category	All males by disability category	All females by disability category
Total population by disability category and service receipt	All males by disability category and service receipt	All females by disability category and service receipt
Total population by disability category and age group	Males by disability category and age group	Females by disability category and age group
Total population by disability category, age group and service receipt	Males by disability category, age group and service receipt	Females by disability category, age group and service receipt

Figure 24: Baseline and Alternative Scenario Graphs

You can use the raw data from the tables to create your own graphs. To do this, copy and paste special the data into a new workbook (go to Edit, Paste Special, Values, OK).

One note of caution is that if two lines are identical, one is likely to be hidden behind the other. You will have to manually alter the graph design to show both or use the raw data to create your own graph in a new Excel workbook.

13.3 Tables 2

At the bottom of the user interface you will find the final set of tables (Figure 25).

Percentage Tables

Male District Populations as a percentage of the total male population

Male District Populations as a percentage of the total population

Male Results - Percentage change in comparison to 2009

Female District Populations as a percentage of the total male population

Female District Populations as a percentage of the total population

Female Results - Percentage change in comparison to 2009

District Populations as a percentage of the total population

Whole Population Results - Percentage change in comparison to 2009

Figure 25: Percentage Tables

These tables are available for both the baseline and alternative scenarios.

There are eight tables to view. The first table is the male district populations as a percentage of the total male population. The second table is the male district populations as a percentage of the whole population. The third table illustrates the percentage increase in the population in relation to 2009. The next three tables are the same except they are for the female population. The seventh table is the total district populations as a percentage of the total population. The final table illustrates the percentage increase in the total population in relation to 2009.

14.0 Other Service Receipt Scenarios

14.1 Service Receipt Question of Interest

There are other scenarios which you can run.

Firstly, you can change the service receipt question of interest. The services receipt responses in the 2001 General Household Survey differs depending on what activities were being discussed. There are three groups of activities for you to choose from.

1) Bath, wash and shower
2) Bed and dress
3) House, Toilet and Stairs

For example, when discussing activity one, the respondent would answer who was their main form of help in the last month in aiding them with bathing, washing and showering.

If you want to change the service receipt question of interest, you can do this from the user interface (Figure 2) and alter the activity in Figure 26.

Service Receipt Question of Interest:

1	Bath, Wash and Shower
	Bed and Dress
	House, Toilet and Stairs

Figure 26: Service Receipt Question of Interest

You simply delete the number 1 and type it (1) again in any turquoise cells. After you type 1, press 'Enter' to confirm the change. Each cell corresponds to the activities in the far-right side column.

You do not need to alter it if the activities you want to view are already selected.

14.2 Six Additional Scenarios

For each of the three groups of activities discussed in section 14.1, you can alter the rates for local authority care using rates based on data on current clients using formal care from Hampshire County Council. The data is based on March 2009 levels.

There are six additional scenarios.

1	Baseline
	Local Authority Substantial Critical
	Local Authority Critical
	Local Authority Domiciliary Care – more than five hours a week (£60) – Substantial Critical
	Local Authority Domiciliary Care – more than ten hours a week (£120) – Substantial Critical
	Local Authority Domiciliary Care – more than five hours a week (£60) – Critical
	Local Authority Domiciliary Care – more than ten hours a week (£120) – Critical

Figure 27: Local Authority Rate Scenarios

As a default, the baseline scenario is selected (Figure 27).

You simply delete the number 1 and type it (1) again in any turquoise cells. After you type 1, press ‘Enter’ to confirm the change. Each cell corresponds to the scenario in the far-right side column.

You do not need to alter it if the scenario you want to view is already selected.

Each time you alter the formal care percentage, the other service receipts percentages automatically adjust as well.

The rates differ for each district.

It is assumed that only people with a severe disability are entitled to formal care and thus only the rates for those with a severe disability are changed.

Scenario one changes the formal care percentage so that it is based on the number of clients receiving domiciliary and day care who have an eligibility criteria that is either substantial or critical.

Scenario two changes the formal care percentage so that is based on the number of clients receiving domiciliary and day care who have an eligibility criteria that is critical.

It is assumed that on average an hour's worth of domiciliary care costs £12. The next scenarios are based on data for clients who receive at least five hours (costing £60) or ten hours (costing £120) of domiciliary care a week.

Scenario three changes the formal care percentage so that it is based on the number of clients receiving domiciliary care who have an eligibility criteria that is either substantial or critical and the cost of their domiciliary care costs at least £60.

Scenario four changes the formal care percentage so that it is based on the number of clients receiving domiciliary care who have an eligibility criteria that is critical and the cost of their domiciliary care costs at least £60.

Scenario five changes the formal care percentage so that it is based on the number of clients receiving domiciliary care who have an eligibility criteria that is either substantial or critical and the cost of their domiciliary care costs at least £120.

Scenario six changes the formal care percentage so that it is based on the number of clients receiving domiciliary care who have an eligibility criteria that is critical and the cost of their domiciliary care costs at least £120.

15.0 Graph Summary

On the user interface (Figure 2) you will find a graph summary (Figure 28).

Graph Summary:

Area of interest (Baseline):	Hampshire
Area of interest (Alternative Scenario):	Hampshire

Graph Summary:

Disability category if interest:	No Incapacity
Age group of interest:	65-69
Service Receipt Question of Interest:	Bath, Wash and Shower
Scenario:	Baseline

Figure 28: Graph Summary

Please ensure that your selections are correct and #N/A does not appear anywhere.

16.0 Reset

An additional feature of the spreadsheet is the ability to reset certain inputs back to their default status.

All the inputs on the user interface (Figure 2) and the scenario runners (Section 12) are reset by simply clicking on the reset button (Figure 29) on the user interface.

Figure 29: Reset Button

If you notice that during the reset that the cells are not being calculated (Figure 4), it is quite a possible that an error has occurred. Please restart the model without saving. If the same issue occurs, please email the author. Another solution is to use an original copy of the model from the compact disc.

17.0 Protection

The majority of the sheets in the workbook have been hidden so you cannot alter any of the formulas.

Each accessible worksheet is password protected as well with same password that protects the workbook.

18.0 Exiting

Upon exiting the model a message will appear informing you that there is a large amount of information is on the clipboard. Simply click on ‘no’ to close the Excel document.

19.0 Errors

If you notice any errors in the model, please email the author.

Appendix A2 General Household Questions

7. Stairs SHOW CARD TEL1
Do you usually manage to get up and down stairs or steps...

on your own	1
only with help from someone else	2
or not at all?	3

If manages on own
(Stairs = 1)
8. StrsEasy [*]
SHOW CARD TEL2
Do you find it ...

very easy	1
fairly easy	2
fairly difficult	3
or very difficult to do this on your own?	4

If needs help/cannot manage to get up and down steps or stairs, or finds it difficult
(Stairs = 2 or 3 or StrsEasy = 3 or 4)

11. House SHOW CARD TEL1
Do you usually manage to get around the house (except for any stairs) ...

on your own	1
only with help from someone else	2
or not at all?	3

If manages on own
(House = 1)

12. HousEasy [*]
SHOW CARD TEL2
Do you find it ...

very easy	1
fairly easy	2
fairly difficult	3
or very difficult to do this on your own?	4

If needs help/cannot manage to get up and down step or stairs, or finds it difficult
(Stairs = 2 or 3 or StrsEasy = 3 or 4)

19. Bed SHOW CARD TEL1
Do you usually manage to get in and out of bed…

on your own	1
only with help from someone else	2
or not at all?	3

If manages on own
(Bed = 1)

20. BedEasy [*]
SHOW CARD TEL2
Do you find it ...

very easy	1
fairly easy	2
fairly difficult	3

Ask all (except proxy informants)

33. Toenails Do you usually manage to cut your toenails yourself, or does someone else do it for you?

Self	1
Someone else	2

If cuts own toenails
(Toenails = 1)

34. TnailEas [*]
SHOW CARD TEL2
(Still looking at the card) do you find it…

very easy	1
fairly easy	2
fairly difficult	3
or very difficult to do this on your own?	4

Ask all (except proxy informants)

38. Bath SHOW CARD TEL1
Do you usually manage to bath, shower or wash all over…

on your own	1

only with help from someone else	2
or not at all?	3

If manages on own
(Bath = 1)

39. BathEasy [*]
SHOW CARD TEL2
Do you find it…

very easy	1
fairly easy	2
fairly difficult	3
or very difficult to do this on your own?	4

Ask all (except proxy informants)

57. Walk SHOW CARD TEL1
Do you usually manage to go out of doors and walk down the road…

on your own	1
only with help from someone else	2
or not at all?	3

If manages on own
(Walk =1)

58. WalkEasy [*]
SHOW CARD TEL2
Do you find it…

very easy	1
fairly easy	2
fairly difficult	3
or very difficult to do this on your own?	4

For the activities related to using the stairs, getting to the toilet and getting around the house, the following questions were asked in the 2001 General Household Survey. Questions 9 and 10 were needed as well in addition to questions 15, 16, 17 and 18.

If needs help/cannot manage to get up and down steps or stairs, or finds it difficult
(Stairs = 2 or 3 or StrsEasy = 3 or 4)

9. StairLoo ASK OR RECORD
May I just check, do you have to use stairs to get from the rooms you use during the daytime to the toilet?

Yes	1
No	2

10. StairBed ASK OR RECORD
And do you have to use stairs to get from the rooms you use during the daytime to your bedroom?

Yes	1
No	2

If finds it difficult to use stairs, get to the toilet or get around the house AND has not already
stated that they need help with stairs, getting to the toilet or getting around the house
(StrsEasy = 3 or 4 OR HouseEasy = 3 or 4 OR ToilEasy = 3 or 4
AND StairLoo ? 1 OR StairBed ? 1 OR House ? 2 OR Toilet ? 2)

The "?" means not equal to.

15. CanHlp1 Although you said you usually manage on your own, does anyone help you to get around the house/to the toilet/up and down stairs?

Yes	1
No	2

If needs help with stairs, getting to the toilet or getting around the house
(((Stairs = 2 AND StairLoo = 1 OR StairBed = 1) OR House = 2 OR Toilet = 2)
OR CanHlp1 = 1)

16. WhoHlp Who usually helps you to get around the house/to the toilet/up and down stairs? Is it someone in the household, or someone from outside the household?

Someone in the household	1
Someone from outside the household	2

18. WhoHlpB Who is the person from outside the household?

Son	2
Daughter	3
Brother	4
Sister	5
Other relation	6

Friend / Neighbour	7
Social Services	8
District Nurse / Health Visitor	9
Paid Help	10
Other	15

The same questions were asked to respondents who need help getting in and out of bed and dressing and undressing.

If find it difficult to get in and out of bed or to dress and undress
AND has not already stated they need help to get in and out of bed or to dress and undress
(Bed ? 2 OR Dress ? 2
AND BedEasy = 3 or 4 OR DresEasy = 3 or 4)

The "?" means not equal to.

23. CanHlp2 Although you said you usually manage on your own, does anyone help you get in and out of bed/dress and undress?

Yes	1
No	2

If needs help to get in and out of bed or to dress and undress
(Bed = 2 OR Dress = 2 OR CanHlp2 = 1)

24. BedHlp Who usually helps you to get in and out of bed/dress? Is it someone in the household, or someone from outside the household?

Someone in the household	1
Someone from outside the household	2

26. BedHlpB Who is the person from outside the household?

Son	2
Daughter	3
Brother	4
Sister	5
Other relation	6
Friend / Neighbour	7
Social Services	8
District Nurse / Health Visitor	9
Paid Help	10
Other	15

The same questions were asked to respondents who need help with bathing, showering and washing.

If finds if difficult to bath, shower or wash all over
(BathEasy = 3 or 4)

40. CanHlp4 Although you said you usually manage on your own , does anyone help you bath, shower or wash all over?

Yes	1
No	2

If needs help to bath, shower or wash all over
(Bath = 2 OR CanHlp4 =1)

41. BthHlp Who usually helps you? Is it someone in the household, or someone from outside the household?

Someone in the household	1
Someone from outside the household	2

If usually gets help from someone outside the household
(BthHlp = 2)

43. BthHlpB Who is the person from outside the household?

Son	2
Daughter	3
Brother	4
Sister	5
Other relation	6
Friend / Neighbour	7
Social Services	8
District Nurse / Health Visitor	9
Paid Help	10
Other	15

Appendix A3 Service Receipt Rates

Table A3.1 summarises the survey data in relation to primary service receipt for people who need help in carrying out the following activities: Getting in and out of bed and dressing.

Table A3.2 summarises the survey data in relation to primary service receipt for people who need help in carrying out the following activities: Getting up and down the stairs, getting around the house and walking to the toilet.

			Disability Classification			
			No Incapacity	Slight	Moderate	Severe
Male	65-69	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	2%	44%
		No Care	100%	100%	98%	56%
		Private Care	0%	0%	0%	0%
	70-74	Formal Care	0%	0%	0%	3%
		Informal Care	0%	0%	0%	15%
		No Care	100%	100%	100%	82%
		Private Care	0%	0%	0%	0%
	75-79	Formal Care	0%	0%	0%	5%
		Informal Care	0%	0%	0%	20%
		No Care	100%	100%	100%	75%
		Private Care	0%	0%	0%	0%
	80-84	Formal Care	0%	0%	0%	3%
		Informal Care	0%	0%	0%	31%
		No Care	100%	100%	100%	66%
		Private Care	0%	0%	0%	0%
	85+	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	0%	13%
		No Care	100%	100%	100%	87%
		Private Care	0%	0%	0%	0%
Female	65-69	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	0%	27%
		No Care	100%	100%	100%	71%
		Private Care	0%	0%	0%	2%
	70-74	Formal Care	0%	0%	0%	1%
		Informal Care	0%	0%	0%	17%
		No Care	100%	100%	100%	80%
		Private Care	0%	0%	0%	1%
	75-79	Formal Care	0%	0%	0%	3%
		Informal Care	0%	0%	0%	16%
		No Care	100%	100%	100%	81%
		Private Care	0%	0%	0%	0%
	80-84	Formal Care	0%	0%	0%	5%
		Informal Care	0%	0%	0%	14%
		No Care	100%	100%	99%	79%
		Private Care	0%	0%	1%	1%
	85+	Formal Care	0%	0%	1%	7%
		Informal Care	0%	0%	0%	10%
		No Care	100%	100%	99%	77%
		Private Care	0%	0%	0%	6%

Table A3.1: Service Rates - Getting in and out of bed and dressing

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

			Disability Classification			
			No Incapacity	Slight	Moderate	Severe
Male	65-69	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	31%
		No Care	100%	100%	99%	69%
		Private Care	0%	0%	0%	0%
	70-74	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	15%
		No Care	100%	100%	99%	79%
		Private Care	0%	0%	0%	5%
	75-79	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	23%
		No Care	100%	100%	99%	78%
		Private Care	0%	0%	0%	0%
	80-84	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	0%	28%
		No Care	100%	100%	100%	72%
		Private Care	0%	0%	0%	0%
	85+	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	0%	17%
		No Care	100%	100%	100%	83%
		Private Care	0%	0%	0%	0%
Female	65-69	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	29%
		No Care	100%	100%	99%	71%
		Private Care	0%	0%	0%	0%
	70-74	Formal Care	0%	0%	0%	1%
		Informal Care	0%	0%	1%	19%
		No Care	100%	100%	99%	80%
		Private Care	0%	0%	0%	0%
	75-79	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	3%	20%
		No Care	100%	100%	96%	80%
		Private Care	0%	0%	1%	0%
	80-84	Formal Care	0%	0%	0%	0%
		Informal Care	0%	0%	1%	14%
		No Care	100%	100%	99%	83%
		Private Care	0%	0%	0%	3%
	85+	Formal Care	0%	0%	0%	5%
		Informal Care	0%	0%	4%	13%
		No Care	100%	100%	96%	79%
		Private Care	0%	0%	0%	3%

Table A3.2: Service Rates - Getting up and down the stairs, around the house and walking to the toilet

(Source: using the 2001 GHS data, Economic and Social Data Service, 2001)

Appendix A4 - Eligibility Criteria Bands

The following is a description of the four eligibility criteria bands as provided by the Department of Health (2003). Source: Department of Health, 2003, p4-5.

Critical – when

- life is, or will be, threatened; and/or
- significant health problems have developed or will develop; and/or
- there is, or will be, little or no choice and control over vital aspects of the immediate environment; and/or
  serious abuse or neglect has occurred or will occur; and/or
- there is, or will be, an inability to carry out vital personal care or domestic routines; and/or
- vital involvement in work, education or learning cannot or will not be sustained; and/or
- vital social support systems and relationships cannot or will not be sustained; and/or
- vital family and other social roles and responsibilities cannot or will not be undertaken.

Substantial - when

- there is, or will be, only partial choice and control over the immediate environment; and/or
- abuse or neglect has occurred or will occur; and/or

- there is, or will be, an inability to carry out the majority of personal care or domestic routines; and/or
- involvement in many aspects of work, education or learning cannot or will not be sustained; and/or
- the majority of social support systems and relationships cannot or will not be sustained; and/or
- the majority of family and other social roles and responsibilities cannot or will not be undertaken.

Moderate - when

- there is, or will be, an inability to carry out several personal care or domestic routines; and/or
- involvement in several aspects of work, education or learning cannot or will not be sustained; and/or
- several social support systems and relationships cannot or will not be sustained; and/or
- several family and other social roles and responsibilities cannot or will not be undertaken.

Low – when

- there is, or will be, an inability to carry out one or two personal care or domestic routines; and/or
- involvement in one or two aspects of work, education or learning cannot or will not be sustained; and/or
- one or two social support systems and relationships cannot or will not be sustained; and/or
- one or two family and other social roles and responsibilities cannot or will not be undertaken.

Appendix A5 Services Receipt Rates 2

Tables A5.1 to A5.11 are the service receipt rates for clients who receive domiciliary or day care whose eligibility status is substantial or critical (scenario 1).

Area	Age Group	Care Provider	Males	Females
Basingstoke and Deane	65-69	None	53%	61%
		Local Authority	10%	10%
		Informal Care	38%	27%
		Private Care	0%	2%
	70-74	None	66%	52%
		Local Authority	14%	8%
		Informal Care	16%	38%
		Private Care	5%	1%
	75-79	None	60%	66%
		Local Authority	17%	12%
		Informal Care	22%	22%
		Private Care	0%	1%
	80-84	None	41%	56%
		Local Authority	23%	19%
		Informal Care	33%	21%
		Private Care	3%	3%
	85+	None	47%	48%
		Local Authority	26%	32%
		Informal Care	19%	12%
		Private Care	8%	8%

Table A5.1: Basingstoke and Deane Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
East Hampshire	65-69	None	54%	64%
		Local Authority	8%	6%
		Informal Care	39%	28%
		Private Care	0%	2%
	70-74	None	71%	53%
		Local Authority	7%	7%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	65%	65%
		Local Authority	11%	13%
		Informal Care	24%	21%
		Private Care	0%	1%
	80-84	None	44%	58%
		Local Authority	17%	17%
		Informal Care	35%	22%
		Private Care	3%	3%
	85+	None	50%	54%
		Local Authority	20%	24%
		Informal Care	21%	14%
		Private Care	9%	9%

Table A5.2: East Hampshire Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Eastleigh	65-69	None	55%	61%
		Local Authority	6%	10%
		Informal Care	39%	27%
		Private Care	0%	2%
	70-74	None	66%	50%
		Local Authority	13%	11%
		Informal Care	16%	37%
		Private Care	5%	1%
	75-79	None	60%	64%
		Local Authority	18%	14%
		Informal Care	22%	21%
		Private Care	0%	1%
	80-84	None	38%	51%
		Local Authority	29%	27%
		Informal Care	30%	19%
		Private Care	3%	3%
	85+	None	43%	41%
		Local Authority	32%	42%
		Informal Care	18%	11%
		Private Care	8%	7%

Table A5.3: Eastleigh Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Fareham	65-69	None	55%	64%
		Local Authority	5%	6%
		Informal Care	39%	28%
		Private Care	0%	2%
	70-74	None	69%	54%
		Local Authority	10%	5%
		Informal Care	17%	40%
		Private Care	5%	1%
	75-79	None	61%	68%
		Local Authority	16%	8%
		Informal Care	23%	22%
		Private Care	0%	1%
	80-84	None	40%	58%
		Local Authority	25%	17%
		Informal Care	32%	22%
		Private Care	3%	3%
	85+	None	45%	44%
		Local Authority	28%	38%
		Informal Care	19%	11%
		Private Care	8%	7%

Table A5.4: Fareham Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Gosport	65-69	None	54%	57%
		Local Authority	8%	16%
		Informal Care	38%	25%
		Private Care	0%	2%
	70-74	None	71%	51%
		Local Authority	7%	10%
		Informal Care	17%	37%
		Private Care	5%	1%
	75-79	None	67%	61%
		Local Authority	9%	18%
		Informal Care	25%	20%
		Private Care	0%	1%
	80-84	None	44%	55%
		Local Authority	19%	21%
		Informal Care	35%	20%
		Private Care	3%	3%
	85+	None	48%	49%
		Local Authority	24%	31%
		Informal Care	20%	13%
		Private Care	8%	8%

Table A5.5: Gosport Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Hart	65-69	None	55%	62%
		Local Authority	5%	8%
		Informal Care	39%	28%
		Private Care	0%	2%
	70-74	None	68%	54%
		Local Authority	11%	5%
		Informal Care	16%	40%
		Private Care	5%	1%
	75-79	None	66%	67%
		Local Authority	9%	9%
		Informal Care	24%	22%
		Private Care	0%	1%
	80-84	None	42%	57%
		Local Authority	22%	18%
		Informal Care	34%	21%
		Private Care	3%	3%
	85+	None	50%	51%
		Local Authority	21%	27%
		Informal Care	20%	13%
		Private Care	9%	8%

Table A5.6: Hart Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Havant	65-69	None	53%	61%
		Local Authority	9%	10%
		Informal Care	38%	27%
		Private Care	0%	2%
	70-74	None	68%	53%
		Local Authority	11%	8%
		Informal Care	16%	39%
		Private Care	5%	1%
	75-79	None	66%	67%
		Local Authority	9%	11%
		Informal Care	25%	22%
		Private Care	0%	1%
	80-84	None	45%	58%
		Local Authority	16%	17%
		Informal Care	36%	22%
		Private Care	3%	3%
	85+	None	50%	49%
		Local Authority	20%	30%
		Informal Care	21%	13%
		Private Care	9%	8%

Table A5.7: Havant Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
New Forest	65-69	None	54%	62%
		Local Authority	7%	9%
		Informal Care	39%	27%
		Private Care	0%	2%
	70-74	None	71%	53%
		Local Authority	7%	6%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	65%	66%
		Local Authority	11%	11%
		Informal Care	24%	22%
		Private Care	0%	1%
	80-84	None	43%	57%
		Local Authority	20%	19%
		Informal Care	34%	21%
		Private Care	3%	3%
	85+	None	50%	49%
		Local Authority	21%	31%
		Informal Care	20%	13%
		Private Care	9%	8%

Table A5.8: New Forest Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Rushmoor	65-69	None	53%	58%
		Local Authority	9%	14%
		Informal Care	38%	26%
		Private Care	0%	2%
	70-74	None	69%	51%
		Local Authority	10%	10%
		Informal Care	17%	38%
		Private Care	5%	1%
	75-79	None	65%	65%
		Local Authority	12%	12%
		Informal Care	24%	21%
		Private Care	0%	1%
	80-84	None	41%	59%
		Local Authority	23%	16%
		Informal Care	33%	22%
		Private Care	3%	3%
	85+	None	56%	53%
		Local Authority	11%	25%
		Informal Care	23%	14%
		Private Care	10%	8%

Table A5.9: Rushmoor Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Test Valley	65-69	None	54%	63%
		Local Authority	8%	6%
		Informal Care	38%	28%
		Private Care	0%	2%
	70-74	None	71%	54%
		Local Authority	7%	5%
		Informal Care	17%	40%
		Private Care	5%	1%
	75-79	None	64%	66%
		Local Authority	13%	11%
		Informal Care	24%	22%
		Private Care	0%	1%
	80-84	None	41%	56%
		Local Authority	24%	20%
		Informal Care	33%	21%
		Private Care	3%	3%
	85+	None	47%	53%
		Local Authority	26%	25%
		Informal Care	19%	14%
		Private Care	8%	8%

Table A5.10: Test Valley Service Receipt Rates (Scenario 1)

Area	Age Group	Care Provider	Males	Females
Winchester	65-69	None	54%	64%
		Local Authority	8%	5%
		Informal Care	38%	29%
		Private Care	0%	2%
	70-74	None	70%	52%
		Local Authority	9%	8%
		Informal Care	17%	38%
		Private Care	5%	1%
	75-79	None	64%	67%
		Local Authority	12%	10%
		Informal Care	24%	22%
		Private Care	0%	1%
	80-84	None	42%	58%
		Local Authority	22%	17%
		Informal Care	34%	22%
		Private Care	3%	3%
	85+	None	52%	53%
		Local Authority	18%	25%
		Informal Care	21%	14%
		Private Care	9%	8%

Table A5.11: Winchester Service Receipt Rates (Scenario 1)

Tables A5.12 to A5.22 are the service receipt rates for clients who receive at least five hours of domiciliary care a week and whose eligibility status is substantial or critical (scenario 3).

Area	Age Group	Care Provider	Males	Females
Basingstoke and Deane	65-69	None	54%	62%
		Local Authority	8%	8%
		Informal Care	38%	28%
		Private Care	0%	2%
	70-74	None	69%	53%
		Local Authority	9%	7%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	63%	68%
		Local Authority	13%	9%
		Informal Care	23%	22%
		Private Care	0%	1%
	80-84	None	45%	59%
		Local Authority	17%	16%
		Informal Care	36%	22%
		Private Care	3%	3%
	85+	None	49%	50%
		Local Authority	22%	29%
		Informal Care	20%	13%
		Private Care	9%	8%

Table A5.12: Basingstoke and Deane Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
East Hampshire	65-69	None	55%	64%
		Local Authority	5%	5%
		Informal Care	40%	28%
		Private Care	0%	2%
	70-74	None	73%	55%
		Local Authority	5%	4%
		Informal Care	18%	40%
		Private Care	5%	1%
	75-79	None	69%	68%
		Local Authority	5%	9%
		Informal Care	26%	22%
		Private Care	0%	1%
	80-84	None	47%	62%
		Local Authority	13%	12%
		Informal Care	37%	23%
		Private Care	3%	4%
	85+	None	54%	57%
		Local Authority	15%	19%
		Informal Care	22%	15%
		Private Care	9%	9%

Table A5.13: East Hampshire Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Eastleigh	65-69	None	57%	63%
		Local Authority	2%	7%
		Informal Care	41%	28%
		Private Care	0%	2%
	70-74	None	69%	53%
		Local Authority	10%	6%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	66%	68%
		Local Authority	10%	8%
		Informal Care	24%	22%
		Private Care	0%	1%
	80-84	None	44%	57%
		Local Authority	17%	18%
		Informal Care	35%	21%
		Private Care	3%	3%
	85+	None	51%	52%
		Local Authority	19%	27%
		Informal Care	21%	13%
		Private Care	9%	8%

Table A5.14 Eastleigh Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Fareham	65-69	None	56%	64%
		Local Authority	4%	5%
		Informal Care	40%	28%
		Private Care	0%	2%
	70-74	None	75%	55%
		Local Authority	2%	3%
		Informal Care	18%	40%
		Private Care	5%	1%
	75-79	None	68%	71%
		Local Authority	6%	4%
		Informal Care	25%	23%
		Private Care	0%	1%
	80-84	None	48%	64%
		Local Authority	11%	9%
		Informal Care	38%	24%
		Private Care	3%	4%
	85+	None	56%	53%
		Local Authority	11%	24%
		Informal Care	23%	14%
		Private Care	10%	9%

Table A5.15: Fareham Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Gosport	65-69	None	56%	64%
		Local Authority	5%	4%
		Informal Care	40%	29%
		Private Care	0%	2%
	70-74	None	73%	54%
		Local Authority	4%	5%
		Informal Care	18%	40%
		Private Care	5%	1%
	75-79	None	70%	66%
		Local Authority	4%	12%
		Informal Care	26%	22%
		Private Care	0%	1%
	80-84	None	46%	61%
		Local Authority	14%	13%
		Informal Care	37%	23%
		Private Care	3%	4%
	85+	None	55%	57%
		Local Authority	12%	19%
		Informal Care	23%	15%
		Private Care	10%	9%

Table A5.16: Gosport Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Hart	65-69	None	56%	63%
		Local Authority	3%	6%
		Informal Care	40%	28%
		Private Care	0%	2%
	70-74	None	70%	55%
		Local Authority	8%	4%
		Informal Care	17%	40%
		Private Care	5%	1%
	75-79	None	69%	68%
		Local Authority	6%	8%
		Informal Care	25%	22%
		Private Care	0%	1%
	80-84	None	45%	59%
		Local Authority	17%	16%
		Informal Care	36%	22%
		Private Care	3%	3%
	85+	None	52%	54%
		Local Authority	17%	23%
		Informal Care	22%	14%
		Private Care	9%	9%

Table A5.17: Hart Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Havant	65-69	None	55%	63%
		Local Authority	5%	6%
		Informal Care	39%	28%
		Private Care	0%	2%
	70-74	None	70%	54%
		Local Authority	8%	5%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	69%	69%
		Local Authority	6%	7%
		Informal Care	25%	23%
		Private Care	0%	1%
	80-84	None	49%	61%
		Local Authority	8%	13%
		Informal Care	39%	23%
		Private Care	3%	4%
	85+	None	54%	56%
		Local Authority	14%	21%
		Informal Care	22%	15%
		Private Care	10%	9%

Table A5.18: Havant Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
New Forest	65-69	None	56%	63%
		Local Authority	3%	6%
		Informal Care	40%	28%
		Private Care	0%	2%
	70-74	None	74%	55%
		Local Authority	3%	4%
		Informal Care	18%	40%
		Private Care	5%	1%
	75-79	None	68%	70%
		Local Authority	6%	6%
		Informal Care	25%	23%
		Private Care	0%	1%
	80-84	None	48%	62%
		Local Authority	11%	11%
		Informal Care	38%	23%
		Private Care	3%	4%
	85+	None	56%	58%
		Local Authority	11%	18%
		Informal Care	23%	15%
		Private Care	10%	9%

Table A5.19: New Forest Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Rushmoor	65-69	None	55%	62%
		Local Authority	6%	8%
		Informal Care	39%	28%
		Private Care	0%	2%
	70-74	None	71%	53%
		Local Authority	6%	8%
		Informal Care	17%	39%
		Private Care	5%	1%
	75-79	None	68%	67%
		Local Authority	7%	10%
		Informal Care	25%	22%
		Private Care	0%	1%
	80-84	None	43%	60%
		Local Authority	20%	14%
		Informal Care	34%	22%
		Private Care	3%	4%
	85+	None	59%	54%
		Local Authority	7%	23%
		Informal Care	24%	14%
		Private Care	10%	9%

Table A5.20: Rushmoor Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Test Valley	65-69	None	57%	65%
		Local Authority	3%	4%
		Informal Care	40%	29%
		Private Care	0%	2%
	70-74	None	74%	55%
		Local Authority	3%	4%
		Informal Care	18%	40%
		Private Care	5%	1%
	75-79	None	68%	71%
		Local Authority	7%	5%
		Informal Care	25%	23%
		Private Care	0%	1%
	80-84	None	45%	61%
		Local Authority	17%	12%
		Informal Care	36%	23%
		Private Care	3%	4%
	85+	None	52%	57%
		Local Authority	18%	19%
		Informal Care	21%	15%
		Private Care	9%	9%

Table A5.21: Test Valley Service Receipt Rates (Scenario 3)

Area	Age Group	Care Provider	Males	Females
Winchester	65-69	None	56%	65%
		Local Authority	4%	4%
		Informal Care	40%	29%
		Private Care	0%	2%
	70-74	None	72%	55%
		Local Authority	6%	4%
		Informal Care	17%	40%
		Private Care	5%	1%
	75-79	None	68%	69%
		Local Authority	7%	7%
		Informal Care	25%	23%
		Private Care	0%	1%
	80-84	None	47%	62%
		Local Authority	13%	11%
		Informal Care	37%	23%
		Private Care	3%	4%
	85+	None	57%	56%
		Local Authority	9%	20%
		Informal Care	24%	15%
		Private Care	10%	9%

Table A5.22: Winchester Service Receipt Rates (Scenario 3)

Appendix A6 T-Test

The second test was carried out for the wrap times on all the calls received. The data is summarised in Table A6.1.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	258	191.37	337.43	113856.05
Advisors	209	166.81	250.87	62935.22

Table A6.1: Data for t-test for all calls received wrap times

The test statistic when *Equation 1* is applied is 0.901 and there are 465 degrees of freedom. As this value is less than 1.96 we do not reject the null hypothesis. The test was carried out at the 5% level of significance.

The third test was carried out for the total call times on all the calls received. The data is summarised in Table A6.2.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	258	548.2779	543.83	295748.22
Advisors	209	504.1005	432.06	186674.18

Table A6.2: Data for t-test for all calls received total call duration

The test statistic when *Equation 1* is applied is 0.978 and there are 465 degrees of freedom. As this value is less than 1.96 we do not reject the null hypothesis. The test was carried out at the 5% level of significance.

The fourth test was carried out for the call durations on calls received that were considered to be of call type one in nature. The data is summarised in Table A6.3.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	118	239.6864	221.68	49143.62
Advisors	83	194.8193	162.19	26306.52

Table A6.3: Data for t-test for call type 1 call duration times

The test statistic when *Equation 1* is applied is 1.657 and there are 199 degrees of freedom. As this value is less than 1.96 we do not reject the null hypothesis. The test was carried out at the 5% level of significance.

The fifth test was carried out for the wrap times on calls received that were considered to be of call type 1 in nature. The data is summarised in Table A6.4.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	118	153.1924	348.74	121620.69
Advisors	83	68.60241	103.21	10651.78

Table A6.4: Data for t-test for call type 1 wrap times

The test statistic when *Equation 1* is applied is 2.485 and there are 199 degrees of freedom. As this value is greater than 1.96 we reject the null hypothesis. The test was carried out at the 5% level of significance. The difference is not due to chance.

The sixth test was carried out for the total call times received that were considered to be of call type 1 in nature. The data is summarised in Table A6.5.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	118	392.8788	444.97	197998.90
Advisors	83	263.4217	200.70	40279.00

Table A6.5: Data for t-test for call type 1 total call duration

The test statistic when *Equation 1* is applied is 2.783 and there are 199 degrees of freedom. As this value is greater than 2.576 we reject the null hypothesis. The test was carried out at the 1% level of significance. The difference is not due to chance.

The seventh test was carried out for the call durations on calls received that were considered to be of call type 2 in nature. The data is summarised in Table A6.6.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	69	326.3333	217.36	47244.70
Advisors	50	263.98	112.22	12594.39

Table A6.6: Data for t-test for call type 1 call duration times

The test statistic when *Equation 1* is applied is 2.037 and there are 119 degrees of freedom. As this value is greater than 1.98 we reject the null hypothesis. The test was carried out at the 5% level of significance. The difference is not due to chance.

The eighth test was carried out for the wrap times on calls received that were considered to be of call type 2 in nature. The data is summarised in Table A6.7.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	69	175.6232	165.70	27457.94
Advisors	50	95.14	83.97	7050.57

Table A6.7: Data for t-test for call type 2 wrap times

The test statistic when *Equation 1* is applied is 3.467 and there are 119 degrees of freedom. As this value is greater than 2.617 we reject the null hypothesis. The test was carried out at the 1% level of significance. The difference is not due to chance.

The ninth test was carried out for the total call times received that were considered to be of call type 2 in nature. The data is summarised in Table A6.8.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	69	501.9565	289.94	84067.04
Advisors	50	359.12	124.47	15492.84

Table A6.8: Data for t-test for call type 2 total call duration

The test statistic when *Equation 1* is applied is 3.654 and there are 119 degrees of freedom. As this value is greater than 2.617 we reject the null hypothesis. The test was carried out at the 1% level of significance. The difference is not due to chance.

The tenth test was carried out for the call durations on calls received that were considered to be of call type 3 for Adult Service calls. The data is summarised in Table A6.9.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	39	728.2308	519.53	269910.23
Advisors	34	489.5588	263.21	69279.04

Table A6.9: Data for t-test for Adult Services call type 3 call duration times

The test statistic when *Equation 1* is applied is 2.522 and there are 71 degrees of freedom. As this value is greater than 2.000 we reject the null hypothesis. The test was carried out at the 5% level of significance. The difference is not due to chance.

The eleventh test was carried out for the wrap times on calls received that were considered to be of call type 3 for Adult Service calls. The data is summarised in Table A6.10.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	39	373.9487	440.62	194147.10
Advisors	34	177.0588	186.98	34962.60

Table A6.10: Data for t-test for Adult Services call type 3 wrap times

The test statistic when *Equation 1* is applied is 2.54 and there are 71 degrees of freedom. As this value is greater than 2.000 we reject the null hypothesis. The test was carried out at the 5% level of significance. The difference is not due to chance.

The final T-Test was carried on the total call durations on calls received that were considered to be of call type 3 for Adult Service calls. The data is summarised in Table A6.11.

Staff Type	Number of calls in sample	Mean (Seconds)	Standard Deviation	Standard Deviation Squared
Agent	39	1102.179	731.29	534780.26
Advisors	34	666.6176	246.33	60680.55

Table A6.11: Data for t-test for Adult Services call type 3 total call duration

The test statistic when *Equation 1* is applied is 3.499 and there are 71 degrees of freedom. As this value is greater than 2.660 we reject the null hypothesis. The test was carried out at the 1% level of significance. The difference is not due to chance.

Appendix A7 Chi-square Test

The second test was carried out for the wrap times on all the calls received. The data is summarised in Table A7.1.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-0:59	38.37	48.33
1:00-1:59	24.42	18.18
2:00-2:59	8.91	7.18
3:00-3:59	8.53	3.83
4:00-4:59	5.04	5.74
5:00-6:59	4.65	4.31
7:00-11:59	3.88	6.70
12:00 +	6.20	5.74

Table A7.1: The expected and observed call count proportions for the wrap times

The test statistic for the data is 11.719 and there are seven degrees of freedom. The test statistic is less than the critical value (14.07) at the 5% level. We accept the null hypothesis and conclude that there is no difference in call times between agent and advisors.

The third test was carried out for the total call times on all the calls received. The data is summarised in Table A7.2.

	Call count proportions	
	Observed	Expected
Call Times	**Agent**	**Advisor**
0:00-0:59	6.98	8.13
1:00-1:59	8.14	7.18
2:00-2:59	6.98	7.18
3:00-3:59	6.98	6.22
4:00-4:59	8.14	10.53
5:00-5:59	5.43	8.61
6:00-6:59	7.75	5.74
7:00-7:59	7.75	8.13
8:00-8:59	7.36	4.78
9:00-9:59	5.81	4.78
10:00-10:59	2.71	2.87
11:00-11:59	4.26	2.87
12:00-12:59	2.71	3.35
13:00-13:59	1.94	2.87
14:00-15:59	3.88	2.87
16:00-18:59	2.33	4.31
19:00-23:59	3.49	5.74
24:00 +	7.36	3.83

Table A7.2: The expected and observed call count proportions for the total call times for all calls in the sample

The test statistic for the data is 10.968 and there are seventeen degrees of freedom. The test statistic is less than the critical value (27.59) at the 5% level. We accept the null hypothesis and conclude that there is no difference in call times between agent and advisors.

The fourth test was carried out for the call durations on calls received that were considered to be of call type 1 in nature. The data is summarised in Table A7.3.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-0:59	17.80	18.07
1:00-1:59	24.58	22.89
2:00-2:59	10.17	20.48
3:00-3:59	7.63	9.64
4:00-4:59	5.93	7.23
5:00-5:59	5.08	8.43
6:00-8:59	22.03	6.02
9:00 +	6.78	7.23

Table A7.3: The expected and observed call count proportions for the call duration for call type 1 calls

The test statistic for the data is 49.879 and there are eight degrees of freedom. The test statistic is greater than the critical value (20.09) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The fifth test was carried out for the wrap times on calls received that were considered to be of call type one in nature. The data is summarised in Table A7.4.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-0:59	52.54	66.27
1:00-1:59	23.73	18.07
2:00 +	23.73	15.66

Table A7.4: The expected and observed call count proportions for the wrap times for call type 1 calls

The test statistic for the data is 8.766 and there are two degrees of freedom. The test statistic is greater than the critical value (5.991) at the 5% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The sixth test was carried out for the total call times received that were considered to be of call type 1 in nature. The data is summarised in Table A7.5.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-0:59	9.24	14.46
1:00-1:59	17.65	15.66
2:00-2:59	9.24	14.46
3:00-3:59	11.76	9.64
4:00-4:59	5.04	13.25
5:00-5:59	4.20	7.23
6:00-6:59	7.56	7.23
7:00-8:59	11.76	6.02
9:00 +	23.53	12.05

Table A7.5: The expected and observed call count proportions for the total call time, call type 1

The test statistic for the data is 27.263 and there are eight degrees of freedom. The test statistic is less than the critical value (20.09) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The seventh test was carried out for the call durations on calls received that were considered to be of call type 2 in nature. The data is summarised in Table A7.6.

	Call count proportions	
	Observed	Expected
Call Times	Agent	Advisor
0:00-2:59	18.84	20.00
3:00-3:59	24.64	34.00
4:00-4:59	14.49	18.00
5:00-6:59	18.84	14.00
7:00 +	23.19	14.00

Table A7.6: The expected and observed call count proportions for call type 2 duration

The test statistic for the data is 11.033 and there are four degrees of freedom. The test statistic is greater than the critical value (9.488) at the 5% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The eight test was carried out for the wrap times on calls received that were considered to be of call type two in nature. The data is summarised in Table A7.7.

	Call count proportions	
	Observed	**Expected**
Call Times	**Agent**	**Advisor**
0:00-0:59	15.94	48.00
1:00-1:59	27.54	26.00
2:00-2:59	18.84	12.00
3:00 +	37.68	14.00

Table A7.7: The expected and observed call count proportions for Type 2 wrap times

The test statistic for the data is 65.458 and there are three degrees of freedom. The test statistic is greater than the critical value (11.34) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The ninth test was carried out for the total call times received that were considered to be of call type 2 in nature. The data is summarised in Table A7.8.

	Call count proportions	
	Observed	**Expected**
Call Times	**Agent**	**Advisor**
1:00-3:59	8.57	16.00
4:00-4:59	17.14	20.00
5:00-5:59	7.14	20.00
6:00-6:59	11.43	12.00
7:00-7:59	14.29	12.00
8:00-8:59	8.57	10.00
9:00 +	32.86	10.00

Table A7.8: The expected and observed call count proportions for the total call time, call type 2

The test statistic for the data is 65.034 and there are six degrees of freedom. The test statistic is greater than the critical value (16.81) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The tenth test was carried out for the call durations on calls received that were considered to be of call type 3 for Adult Service calls. The data is summarised in Table A7.9.

	Call count proportions	
	Observed	**Expected**
Call Times	**Agent**	**Advisor**
0:00-3:59	15.38	17.65
4:00-7:59	28.21	38.24
8:00-10:59	12.82	20.59
11:00 +	43.59	23.53

Table A7.9: The expected and observed call count proportions for the call duration for Adult Service call type 3 calls

The test statistic for the data is 22.955 and there are three degrees of freedom. The test statistic is greater than the critical value (11.34) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The eleventh test was carried out for the wrap times on calls received that were considered to be of call type three for Adults Service calls. The data is summarised in Table A7.10.

	Call count proportions	
	Observed	**Expected**
Call Times	**Agent**	**Advisor**
0:00-0:59	21.88	40.00
1:00-1:59	25.00	17.14
2:00-4:59	31.25	17.14
5:00 +	21.88	25.71

Table A7.10: The expected and observed call count proportions for the wrap times for Adult Service call type three calls

The test statistic for the data is 23.996 and there are three degrees of freedom. The test statistic is greater than the critical value (11.34) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

The final chi-square test was carried on the total call durations on calls received that were considered to be of call type three for Adult Service calls. The data is summarised in Table A7.11.

	Call count proportions	
	Observed	**Expected**
Call Times	**Agent**	**Advisor**
0:00-7:59	12.82	28.57
8:00-9:59	15.38	17.14
10:00-12:59	15.38	20.00
13:00-15:59	12.82	14.29
16:00 +	43.59	20.00

Table A7.11: The expected and observed call count proportions for the total call time for Adult Service call type 3 calls

The test statistic for the data is 37.903 and there are four degrees of freedom. The test statistic is greater than the critical value (13.28) at the 1% level. We reject the null hypothesis and conclude that there is a difference in call times between agent and advisors.

Appendix A8 Staff Profiles

Agent Staff Profile

Shift	Time	Monday	Tuesday	Wednesday	Thursday	Friday
1	08:30-08:44	1	1	1	1	1
2	08:45-08:59	2	2	2	1	1
3	09:00-09:14	3	3	3	2	3
4	09:15-09:29	5	5	5	3	4
5	09:30-09:44	7	7	7	6	5
6	09:45-09:59	7	8	8	6	6
7	10:00-10:14	7	8	7	7	6
8	10:15-10:29	7	7	6	6	6
9	10:30-10:44	7	7	6	5	5
10	10:45-10:59	6	6	4	5	5
11	11:00-11:14	6	6	5	5	5
12	11:15-11:29	7	6	5	5	4
13	11:30-11:44	6	7	5	5	5
14	11:45-11:59	7	7	6	5	5
15	12:00-12:14	7	8	6	6	6
16	12:15-12:29	7	8	7	6	6
17	12:30-12:44	6	6	5	4	4
18	12:45-12:59	5	5	4	4	4
19	13:00-13:14	6	5	5	5	4
20	13:15-13:29	5	5	5	4	4
21	13:30-13:44	5	5	4	4	4
22	13:45-13:59	6	6	5	5	5
23	14:00-14:14	6	7	6	6	5
24	14:15-14:29	5	6	5	5	4
25	14:30-14:44	5	5	5	5	4
26	14:45-14:59	5	6	5	5	4
27	15:00-15:14	5	5	3	4	3
28	15:15-15:29	4	4	4	4	2
29	15:30-15:44	4	5	4	5	3
30	15:45-15:59	5	5	5	5	4
31	16:00-16:14	5	5	5	5	3
32	16:15-16:29	6	6	5	6	3
33	16:30-16:44	6	5	4	6	4
34	16:45-16:59	5	5	5	5	2
35	17:00-17:14	4	4	4	4	
36	17:15-17:29	2	2	2	2	

Table A8.1: Agent Staff Profile

Advisor Staff Profile

Shift	Time	Monday	Tuesday	Wednesday	Thursday	Friday
1	08:30-08:44	9	9	8	7	8
2	08:45-08:59	9	9	9	7	8
3	09:00-09:14	13	11	13	8	10
4	09:15-09:29	13	13	14	9	11
5	09:30-09:44	20	18	20	16	14
6	09:45-09:59	20	20	20	17	15
7	10:00-10:14	17	19	15	15	13
8	10:15-10:29	17	17	13	14	14
9	10:30-10:44	20	18	16	14	12
10	10:45-10:59	19	18	13	14	15
11	11:00-11:14	16	17	13	13	12
12	11:15-11:29	19	18	15	14	12
13	11:30-11:44	19	21	15	16	14
14	11:45-11:59	19	20	17	14	14
15	12:00-12:14	17	18	14	13	13
16	12:15-12:29	16	18	14	12	13
17	12:30-12:44	19	19	15	13	13
18	12:45-12:59	17	16	13	12	11
19	13:00-13:14	15	12	13	12	9
20	13:15-13:29	16	16	14	12	12
21	13:30-13:44	16	17	14	13	12
22	13:45-13:59	15	16	13	13	12
23	14:00-14:14	15	16	13	13	11
24	14:15-14:29	16	17	13	14	11
25	14:30-14:44	15	16	16	16	12
26	14:45-14:59	15	16	13	14	11
27	15:00-15:14	15	16	11	14	12
28	15:15-15:29	13	13	12	12	7
29	15:30-15:44	13	16	13	14	9
30	15:45-15:59	14	14	14	13	10
31	16:00-16:14	15	14	16	16	8
32	16:15-16:29	17	17	14	17	8
33	16:30-16:44	11	10	9	10	7
34	16:45-16:59	10	10	10	11	7
35	17:00-17:14	7	7	7	7	
36	17:15-17:29	7	7	7	7	

Table A8.2: Advisor Staff Profile

Appendix A9 Call Arrivals

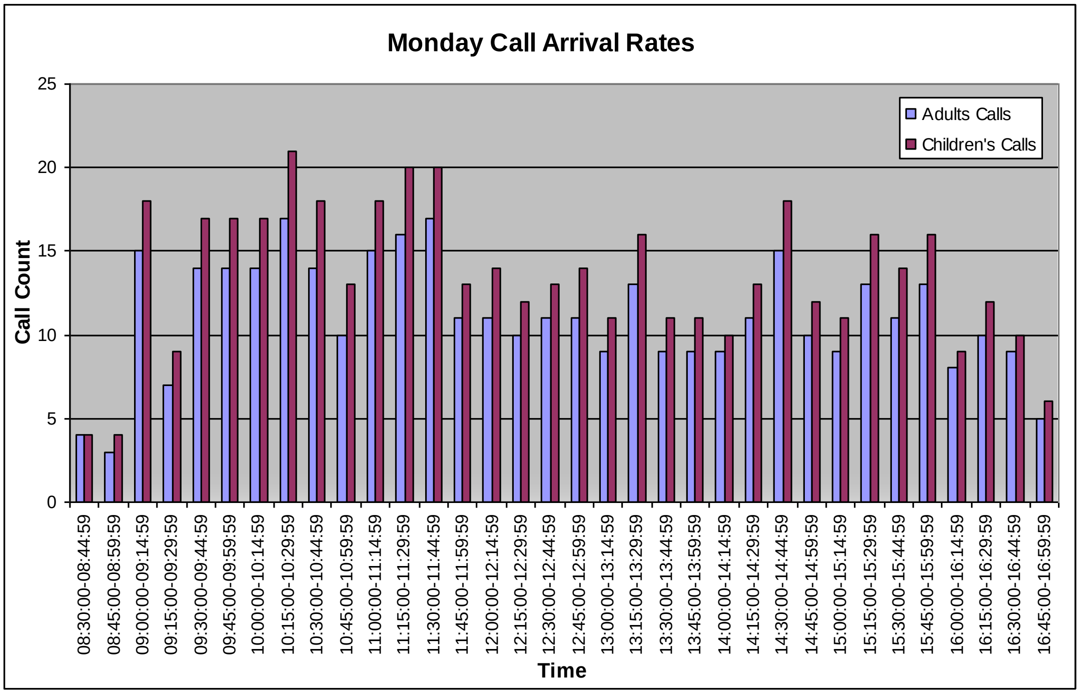

Figure A9. 1: Monday Call Arrival Rates

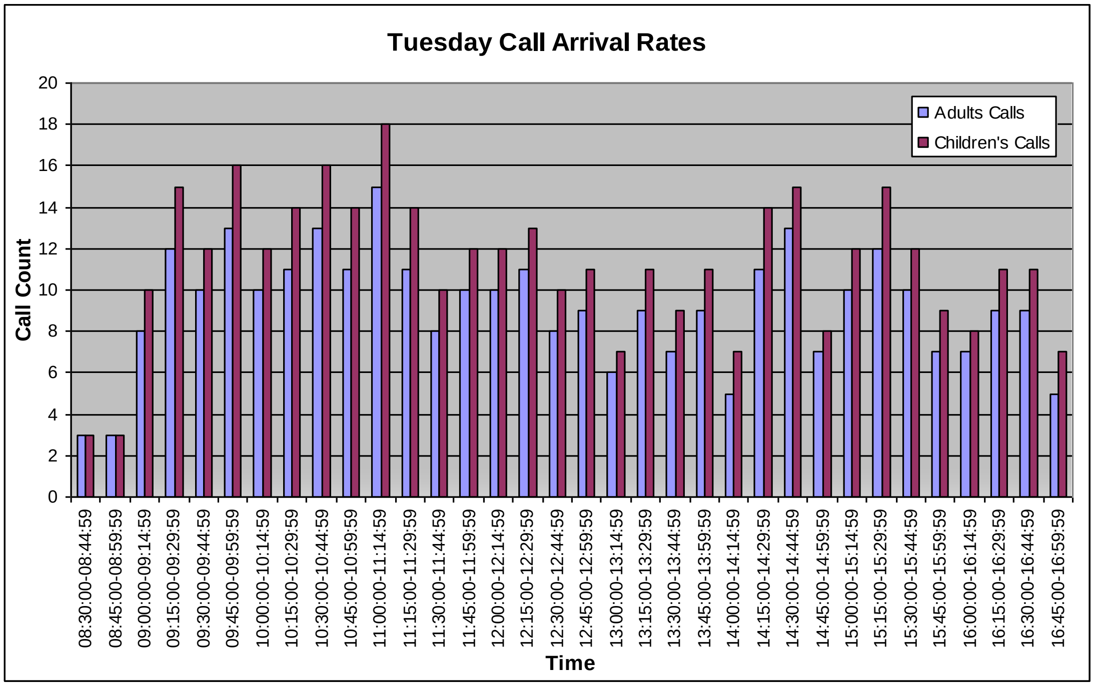

Figure A9.2: Tuesday Call Arrival Rates

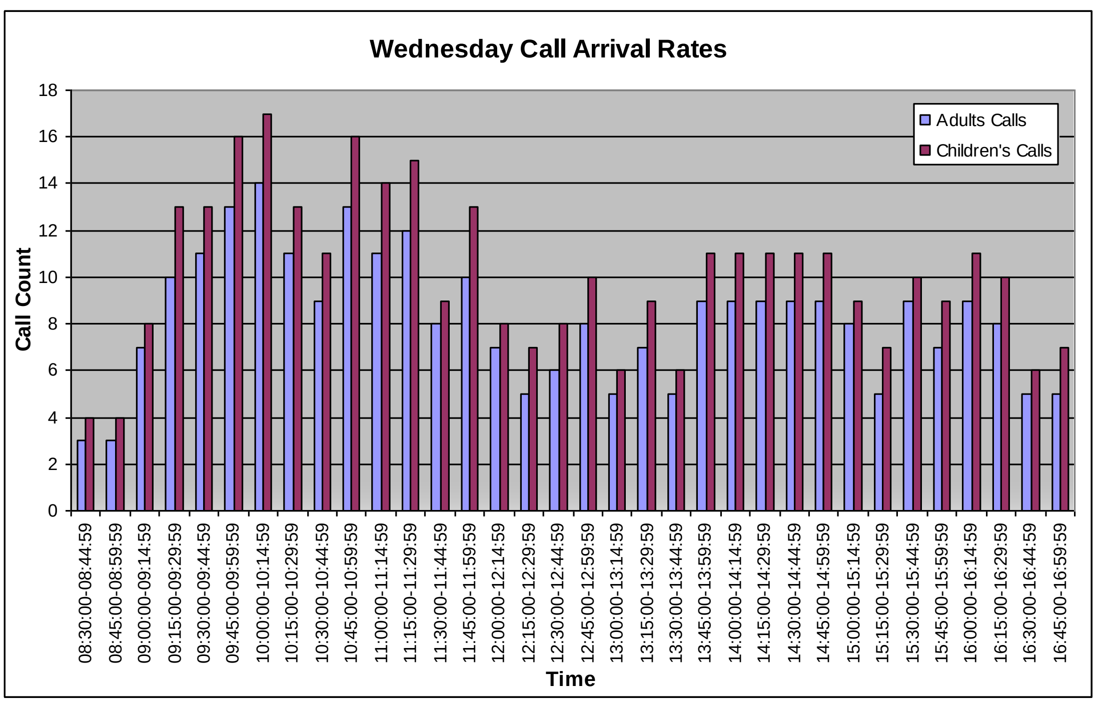

Figure A9.32: Wednesday Call Arrival Rates

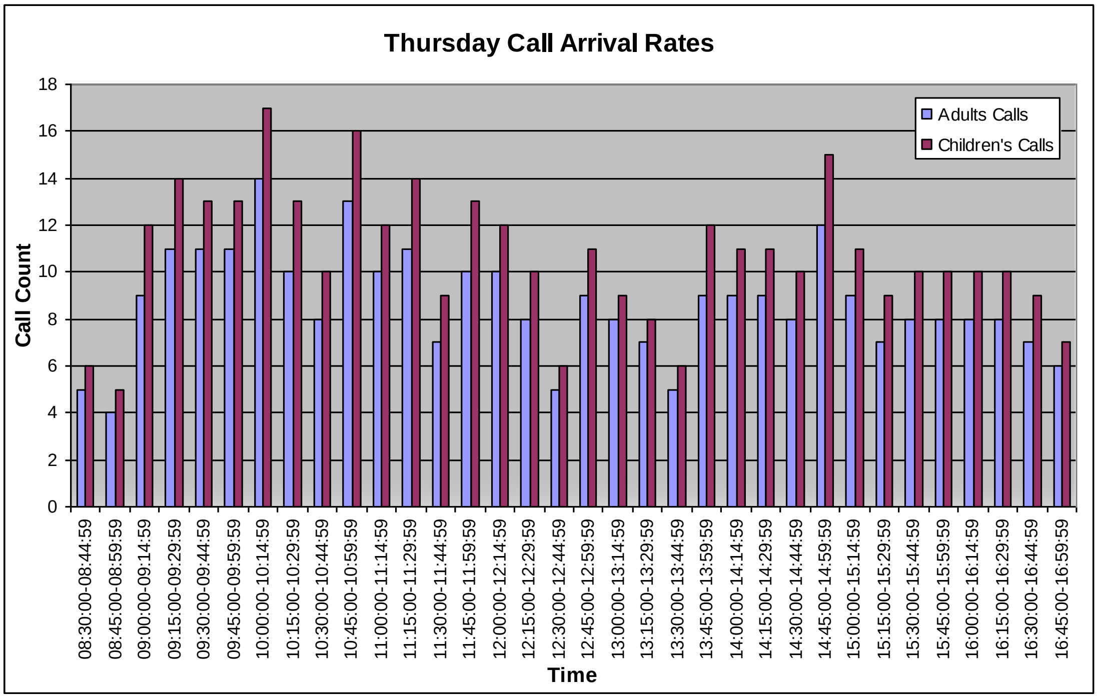

Figure A9.4: Thursday Call Arrival Rates

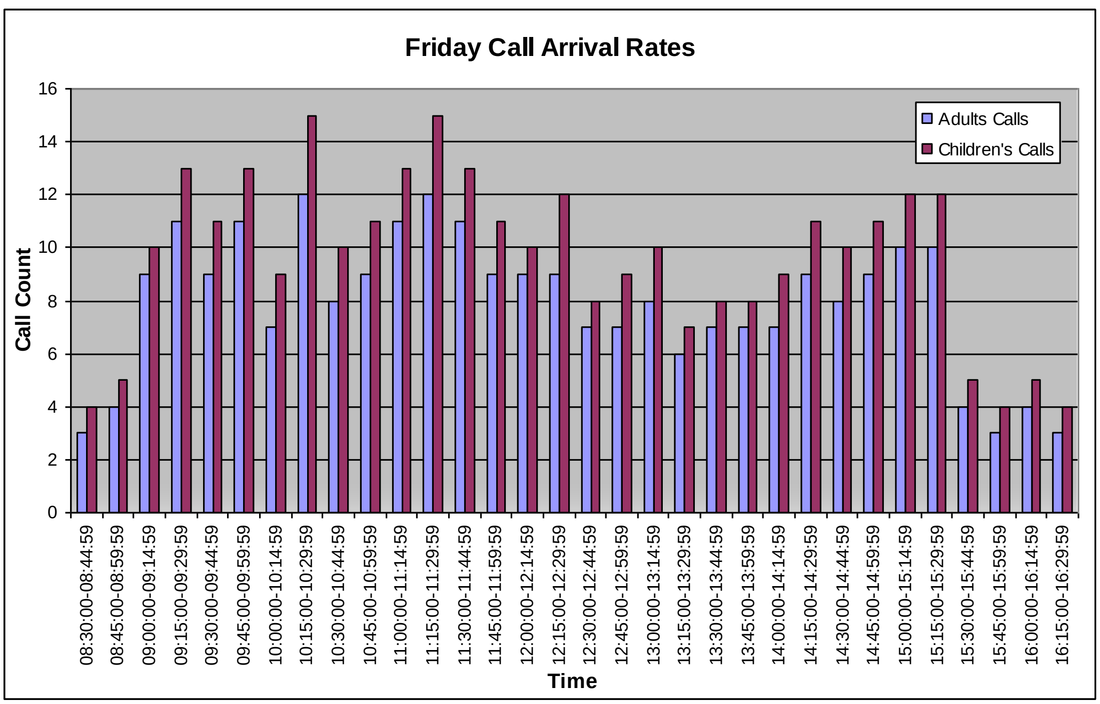

Figure A9.5: Friday Call Arrival Rates

Appendix A10 Call Distributions

The call type one wrap time for advisors fitted well with the PearsonVI distribution with an alpha one value of 0.79, an alpha 2 value of 2.73 and a beta value of 2.59.

The test statistic with nine degrees of freedom is 21.395 with the chi-square test. The Pearson VI distribution was not rejected at the 1% level with a critical value of 21.666 but was rejected at the 5% level with a critical value of 16.919.

The average wrap time from the sample is 1 minute and 9 seconds. The minimum call time was zero seconds and the maximum call time was 9 minutes and 22 seconds. The reason some of the calls take a fairly long time to wrap up is because the advisor might need to find some information and call the client back with the new information. The calls times are skewed to the left as shown in Figure A10.1.

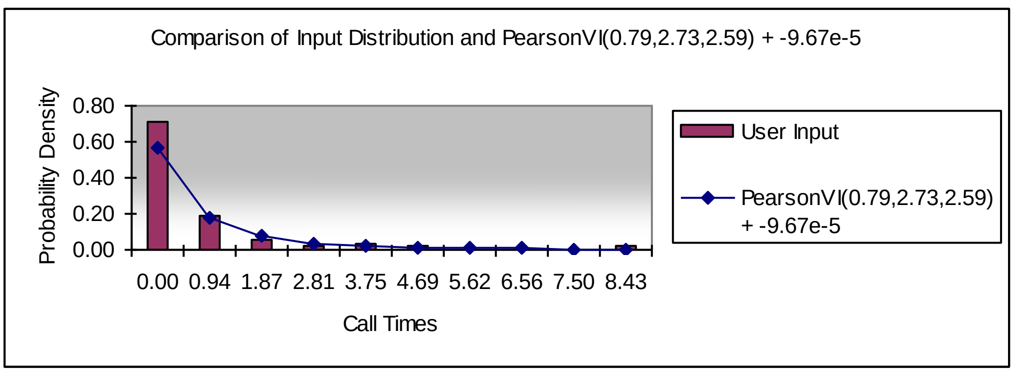

Figure A10.1: Advisor wrap distribution call type 1

Calls taken by an advisor that needed to be passed on to a key worker fitted well with the gamma distribution with an alpha value of 5.17 and a beta value of 0.85.

The test statistic with eight degrees of freedom is 13.194 with the chi-square test. The gamma distribution was not rejected at both the 1% level with a critical value of 20.090 and the 5% level with a critical value of 15.507.

The average call time from the sample is 4 minutes and 24 seconds from the sample calls. The minimum call time was 42 seconds and maximum is 8 minutes and 40 seconds. Some of the calls take a longer time than the others is because it might take a while to get hold of the key worker. This forms a bell shaped curve as shown in Figure A10.2.

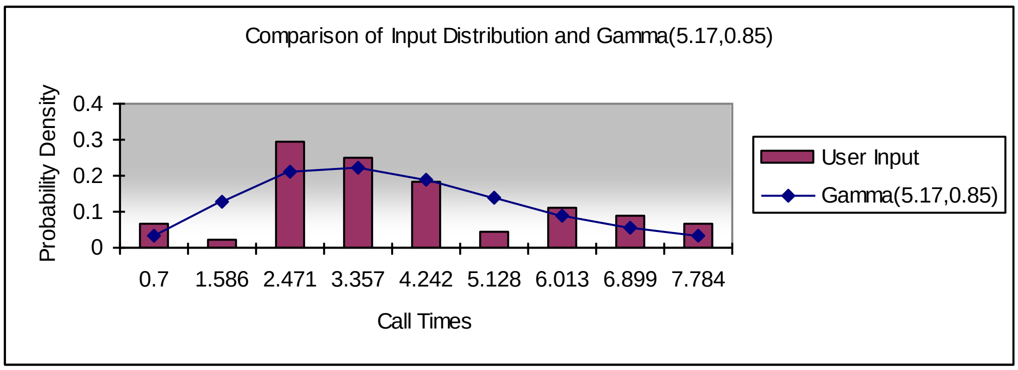

Figure A10.23: Advisor service distribution call type 2

The equivalent wrap time for the call fitted well with the PearsonVI distribution with an alpha one value of 3.01, an alpha 2 value of 3.24 and a beta value of 1.24.

The test statistic with eight degrees of freedom is 5.551 with the chi-square test. The Pearson VI distribution was not rejected at both the 1% level with a critical value of 20.090 and the 5% level with a critical value of 15.507.

The average wrap time from the sample is 1 minute and 35 seconds. The minimum call time was zero seconds and the maximum call time was 6 minutes and 48 seconds. Some of the calls take a long time to wrap is because the call handler might not be able to get hold of the key worker and might spend some time to leave a message with the key worker or the key team on behalf of the client. The calls times are skewed to the left as shown in Figure A10.3.

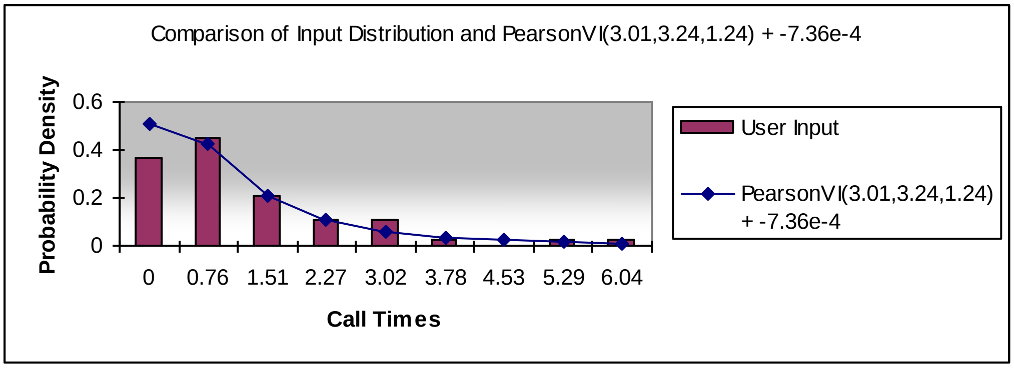

Figure A10.3: Advisor wrap distribution call type 2

Adult calls taken by an advisor that needed to be passed on to the professional advisory team fitted well with the gamma distribution with an alpha value of 3.50 and a beta value of 2.33.

The test statistic with six degrees of freedom is 2.806 with the chi-square test. The gamma distribution was not rejected at both the 1% level with a critical value of 16.812 and the 5% level with a critical value of 12.592.

The average call time from the sample is 8 minutes and 10 seconds from the sample calls. The minimum call time was 1 minute and 52 seconds and maximum is 18 minutes and 13 seconds. These calls require much more time to deal with than the first two types of calls as they are more in-depth and require a form to be filled in with the client. These forms require a lot of detail. Some calls are handed of to the PAT. The calls times are skewed to the left as shown in Figure A10.4.

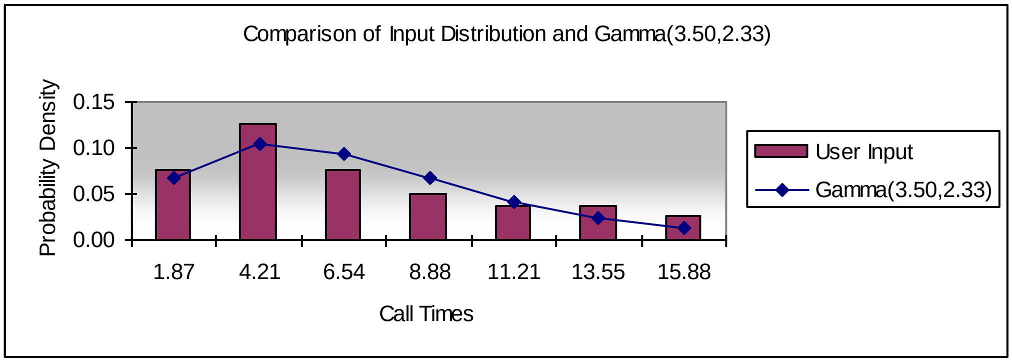

Figure A10.44: Advisor service distribution adults call type 3

The equivalent wrap time for the calls fitted well with the gamma distribution with an alpha value of 0.90 and a beta value of 3.29.

The test statistic with six degrees of freedom is 11.827. The gamma distribution was not rejected at both the 1% level with a critical value of 16.812 and the 5% level with a critical value of 12.592.

The average wrap time from the sample is 2 minutes and 57 seconds. The minimum call time was zero seconds and the maximum call time was 12 minutes and 10 seconds. The wrap times can last several minutes as the advisor is likely to be completing the form once they have completed talking to the client. If the case is urgent, a phone call is made to the PAT to let them know they have been passed a case. The calls times are skewed to the left as shown in Figure A10.5.

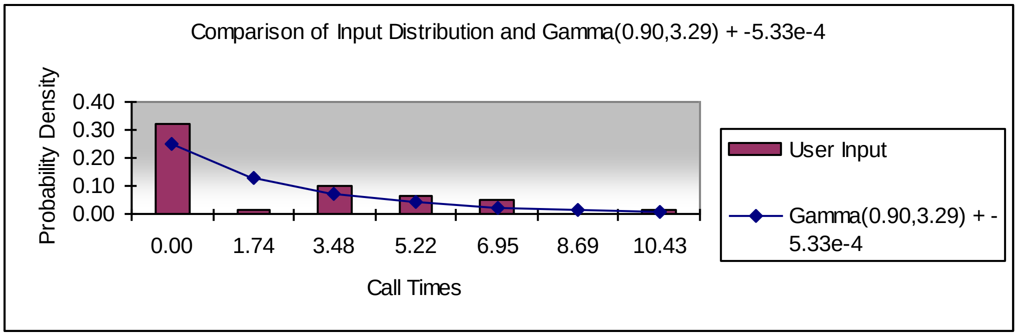

Figure A10.5: Advisor wrap distribution adults call type 3

Children's calls taken by an advisor that were complex in nature fitted well with the Beta distribution with an alpha one value of 0.67, an alpha two value of 1.64, a minimum value of 5.23 and a maximum value of 26.92.

The test statistic with five degrees of freedom is 2.295. The beta distribution was not rejected at both the 1% level with a critical value of 15.086 and the 5% level with a critical value of 11.071.

The average call time from the sample is 11 minutes and 30 seconds from the sample calls. The minimum call time was 5 minutes and 14 seconds and maximum is 26 minutes and 55 seconds. These calls take a long time to deal to with as they require a form to be filled in with the client and the case potentially might need to be passed to a key worker in Children's Services. The calls times are skewed to the left as shown in Figure A10.6.

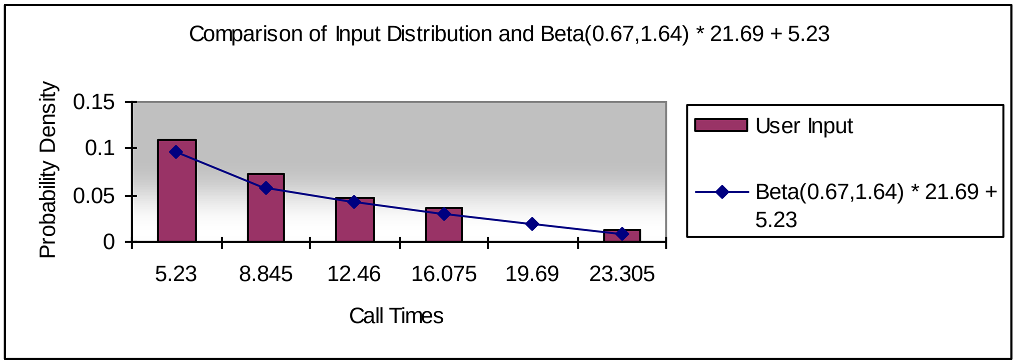

Figure A10.6: Advisor service distribution children's call type 3

The equivalent wrap time for the calls fitted well with the Gamma distribution with an alpha one value of 1.57 and a beta value of 5.70.

The test statistic with five degrees of freedom is 1.080. The Gamma distribution was not rejected at both the 1% level with a critical value of 15.086 and the 5% level with a critical value of 11.071.

The average wrap time from the sample is 8 minutes and 57 seconds. The minimum call time was 41 seconds and the maximum call time was 27 minutes and 28 seconds. The wrap times can last several minutes as the advisor is likely to be completing the form once they have completed talking to the client. They also might need to call Children's Services to pass the case onto them.

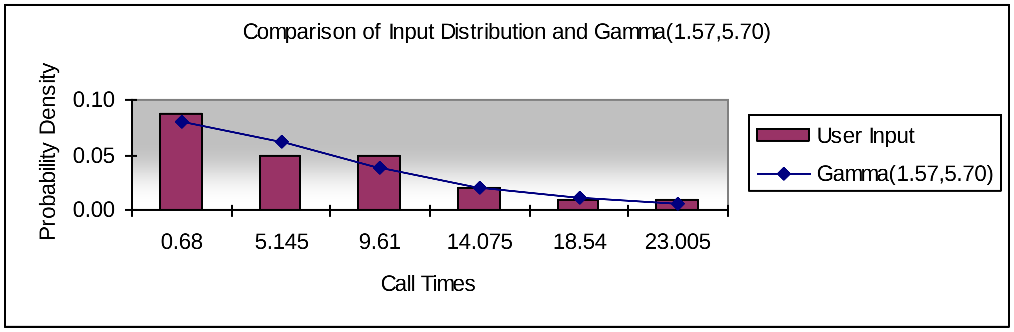

Figure A10.7: Advisor wrap distribution children's call type 3

The average call times for calls taken by agents are longer on average than the calls taken by advisors. The maximum calls times are also considerably higher than that of an advisor.

Calls taken by an agent that required information, signposting or no further action did not fit well any theoretical distribution. Figure A10.8 illustrates the empirical distribution used to model this call type.

The average call time is 4 minutes. The minimum call time was 23 seconds and the maximum call time was 22 minutes and 30 seconds. Like the advisors, the majority of calls for this type of call can be quickly dealt with but some calls require some complicated information to be found. The maximum call time is considerably higher than that of the advisors.

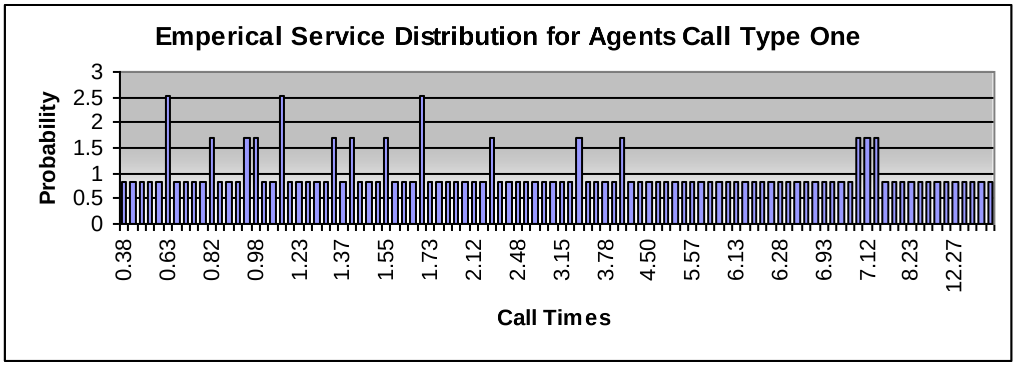

Figure A10.8: Agent service distribution call type 1

The equivalent wrap time did not fit well any theoretical distribution. Figure A10.9 illustrates the empirical distribution used to model this call type.

The average wrap time from the sample is 2 minutes and 33 seconds. The minimum call time was zero seconds and the maximum call time was 46 minutes and 31 seconds. The reason that the maximum call time was so long to wrap up is that the agent needed to find some complicated information and they were required to call the client back with the new information. The agent was also inexperienced and consulted with her duty manager on a number of issues.

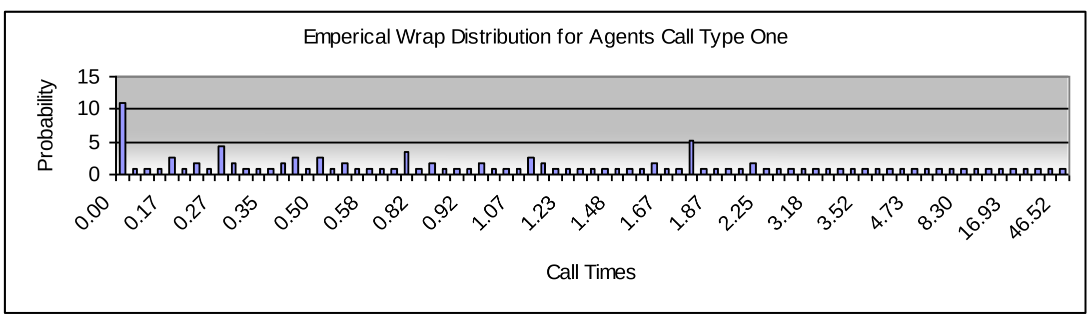

Figure A10.9: Agent wrap distribution call type 1

Calls taken by an agent that needed to be passed onto a key worker fitted well with the PearsonV distribution with an alpha value of 4.21 and a beta value of 17.4.

The test statistic with nine degrees of freedom is 17.117. The PearsonV distribution was not rejected at the 1% level with a critical value of 21.666, but was rejected at the 5% level with a critical value of 16.919.

The average call time from the sample is 5 minutes and 36 seconds from the sample calls. The minimum call time was 1 minute and 51 seconds and the maximum is 26 minutes and 15 seconds. Some of the calls take a longer time than the others because it might take a while to get hold of the key worker. The calls times are skewed to the left as shown in Figure A10.10.

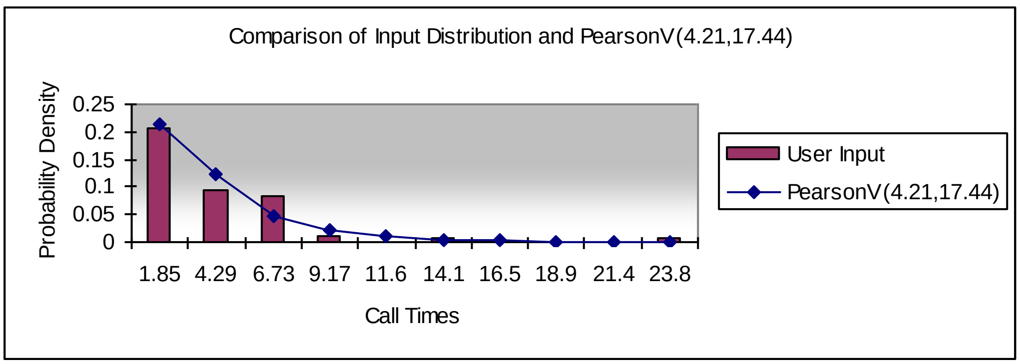

Figure A10.10: Agent service distribution call type 2

The equivalent wrap time for the call fitted well with the Lognormal distribution with an average of 2.98 and a standard deviation of 2.87.

The test statistic with nine degrees of freedom is 13.845. The lognormal distribution was not rejected at both the 1% level with a critical value of 21.666 and the 5% level with a critical value of 16.919.

The average wrap time from the sample is 2 minutes and 56 seconds. The minimum call time was 16 seconds and the maximum call time was 20 minutes and 11 seconds. Some of the calls take a long time to wrap up because the call handler might not be able to get hold of the key worker and might spend some time to leave a message with the key worker or the key team on behalf of the client. The maximum call time is significantly higher than that of advisor for the same type of call. The calls times are skewed to the left as shown in Figure A10.11.

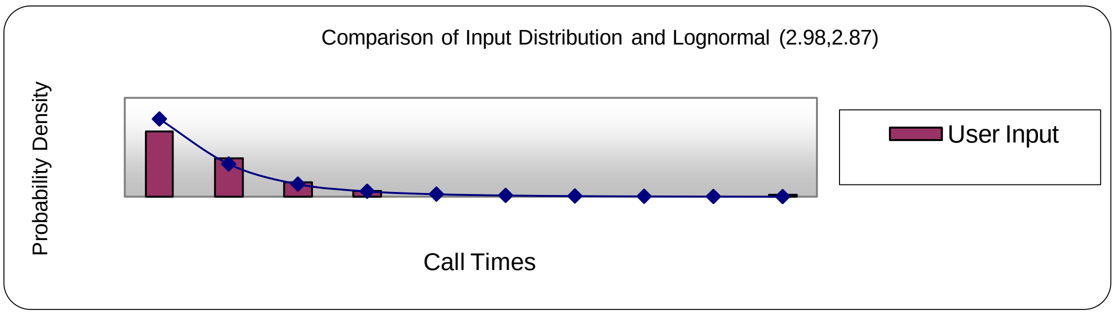

Figure A10.11: Agent wrap distribution call type 2

Calls taken by an agent that needed to be passed on to the professional advisory team fitted well with Gamma distribution with an alpha value of 1.91 and a beta value of 6.37.

The test statistic with seven degrees of freedom is 10.194. The Gamma distribution was not rejected at both the 1% level with a critical value of 18.475 and the 5% level with a critical value of 14.067.

The average call time from the sample is 12 minutes and 8 seconds from the sample calls. The minimum call time was 57 seconds and the maximum is 34 minutes. The maximum call time is once again significantly higher than that of advisor for the same type of call. These calls require much more time to deal with than the first two types of calls as they are more in-depth and require a form to be filled in with the client. These forms require a lot of detail. Some calls are handed to the PAT.

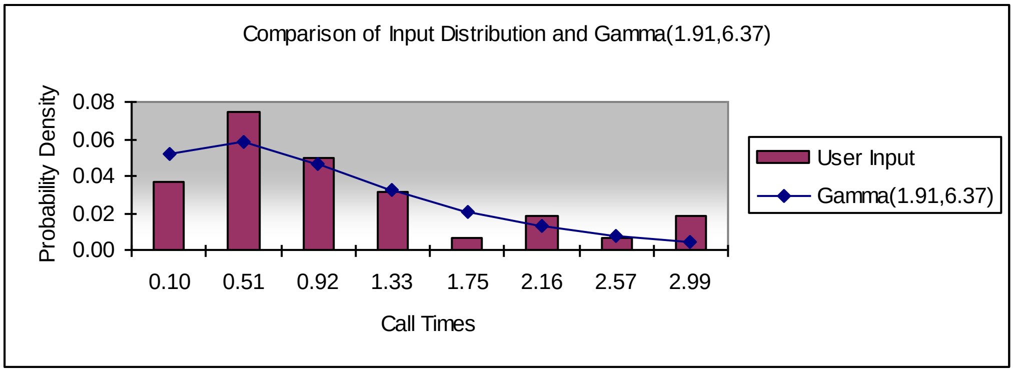

Figure A10.12: Agent service distribution adults call type 3

The equivalent wrap time for the call fitted well with the Weibull distribution with an alpha value of 0.77, a beta value of 5.41 and a minimum value of zero.

The test statistic with seven degrees of freedom is 6.923. The Weibull distribution was not rejected at both the 1% level with a critical value of 18.475 and the 5% level with a critical value of 14.067.

The average wrap time from the sample is 6 minutes and 14 seconds. The minimum call time was zero seconds and the maximum call time was 29 minutes and 11 seconds. The wrap times can last several minutes as the agent is likely to be completing the form once they have completed talking to the client. If the case is urgent, a phone call is made to the PAT to let them know they have been passed a case. The calls times are skewed to the left as shown in Figure A10.13.

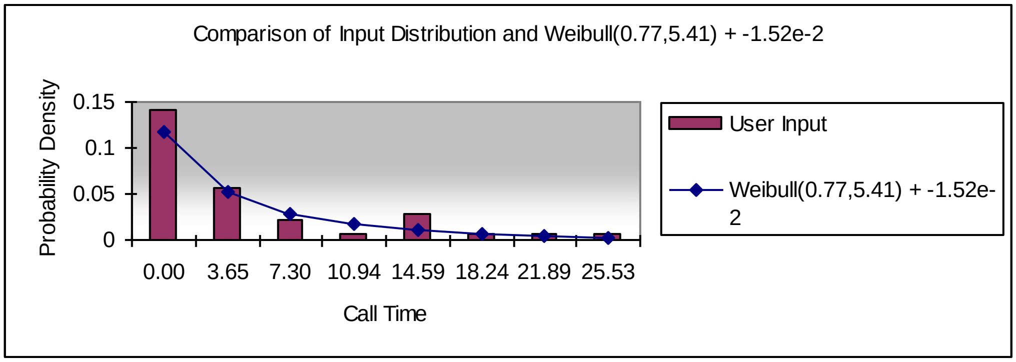

Figure A10.13: Agent wrap distribution adults call type 3

A children's complex call taken by an agent fitted well with the beta distribution with an alpha one value of 0.58, an alpha two value of 0.88, a minimum value of 3.50 and a maximum value of 19.38.

The test statistic with five degrees of freedom is 9.171. The beta distribution was not rejected at both the 1% level with a critical value of 15.086 and the 5% level with a critical value of 11.071.

The average call time from the sample is 10 minutes and 51 seconds from the sample calls. The minimum call time was 2 minutes and 40 seconds and maximum is 30 minutes and 9 seconds.

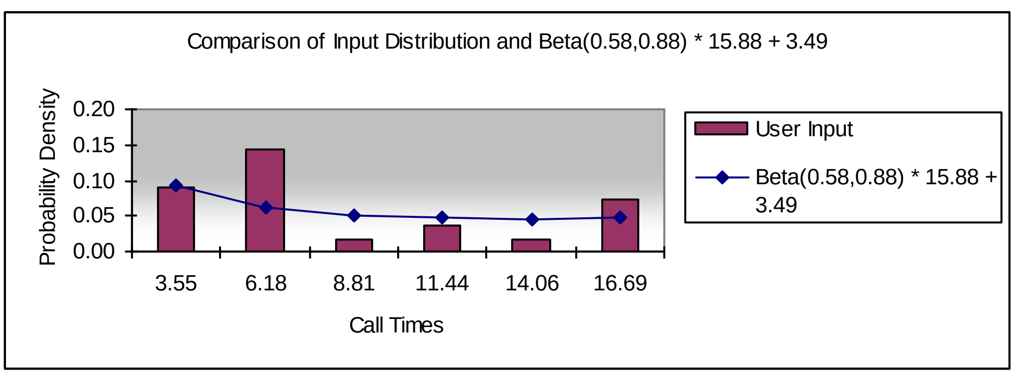

Figure A10.14: Agent service distribution children's call type 3

The equivalent wrap time did not fit any theoretical distribution well. Figure A10.15 illustrates the empirical distribution used to model this call type.

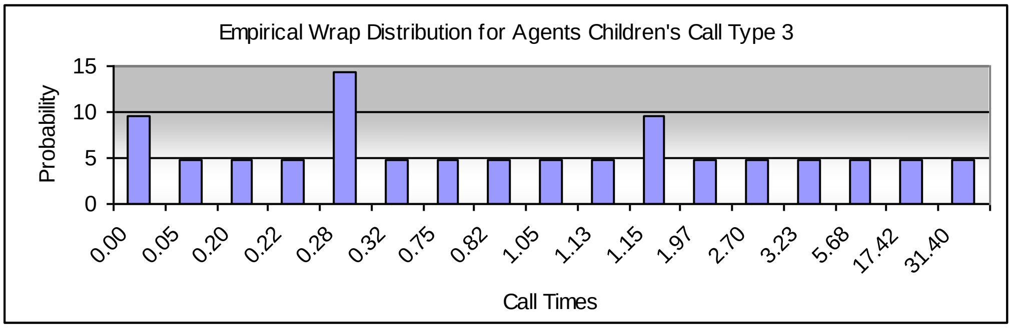

Figure A10.15: Agent wrap distribution children's call type 3

Another service distribution required was for the time spent transferring a children's complex call from an agent to an advisor. This time is once again based on the researcher's own call timings as well as discussions with both agents and advisors.

The equivalent wrap time did not fit any theoretical distribution well. Figure A10.16 illustrates the empirical distribution used to model this call type.

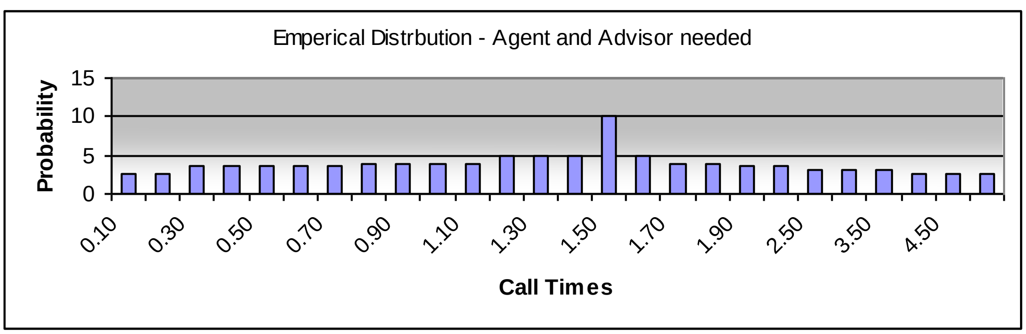

Figure A10.16: Agent and advisor needed distribution for children's complex case

The final service distribution required was for the time an advisor spent with a client after taking a call from agent for a children's complex call. There were 13 calls in this sample.

The service time distribution fitted well with a gamma distribution with an alpha one value of 2.03 and beta value of 5.35.

The test statistic with four degrees of freedom is 9.606. The gamma distribution was not rejected at the 1% level with a critical value of 13.277 but was rejected as the 5% level with a critical value of 9.488.

The average call time from the sample is 10 minutes and 51 seconds from the sample calls. The minimum call time was 2 minutes and 40 seconds and maximum is 30 minutes and 9 seconds.

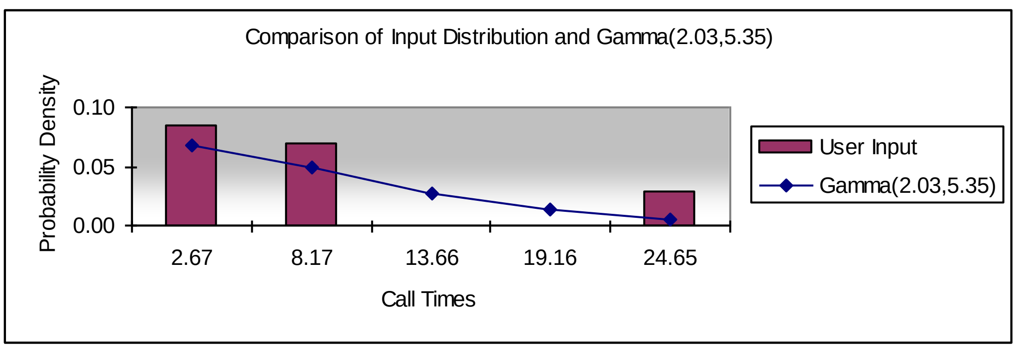

Figure A10.17: Advisor service distribution children's call type 3 taken from agent

The equivalent wrap time for the call fitted well with the beta distribution with an alpha one value of 0.34, an alpha two value of 0.46, a minimum value of 0.13 and a maximum value of 17.77.

The test statistic with four degrees of freedom is 2.396. The beta distribution was not rejected at the 1% level with a critical value of 13.277 but was rejected as the 5% level with a critical value of 9.488.

The average call time from the sample is 7 minutes and 38 seconds from the sample calls. The minimum call time was 10 seconds and the maximum is 17 minutes and 44 seconds.

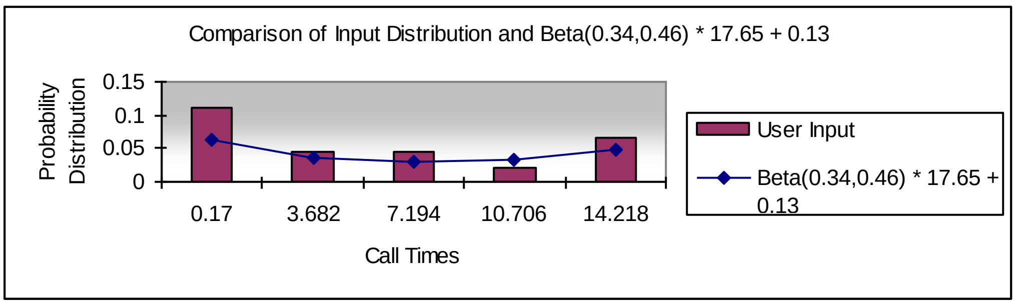

Figure A10.18: Advisor wrap distribution children's call type 3 taken from agent

Appendix A11 P-P and Q-Q Plots

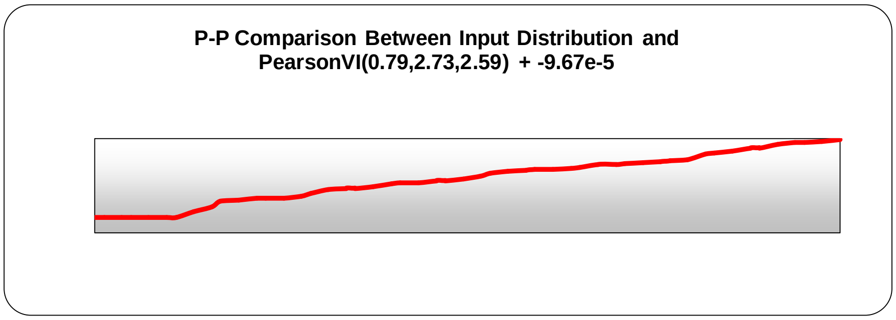

Figure A11.1: P-P plot, advisor wrap distribution call type 1

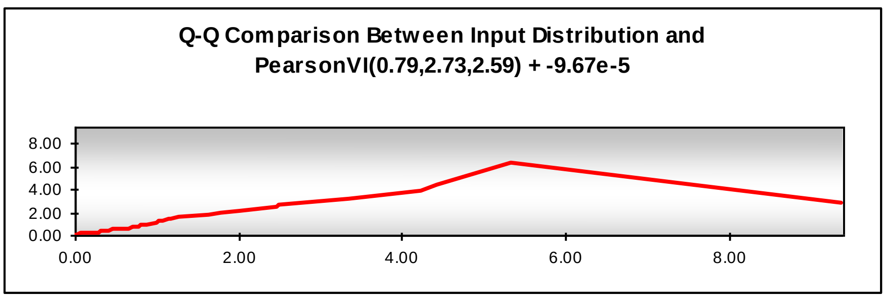

Figure A11.2: Q-Q Plot, advisor wrap distribution call type 1

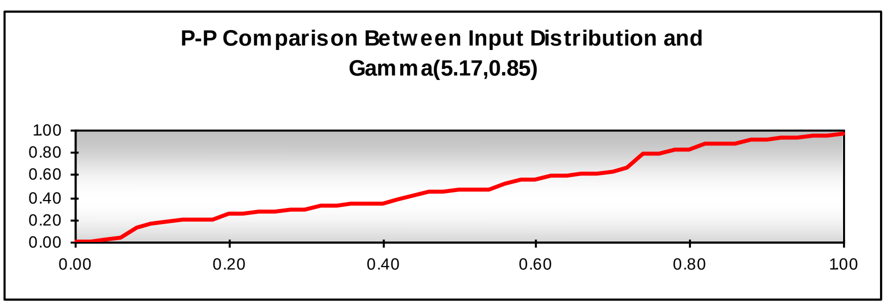

Figure A11.3: P-P plot, advisor service distribution call type 2

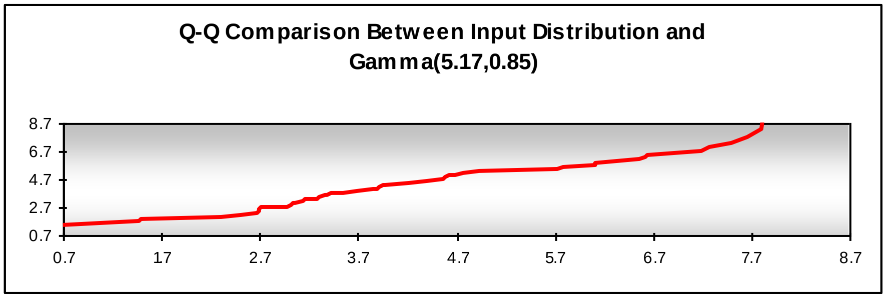

Figure A11.4: Q-Q Plot, advisor service distribution call type 2

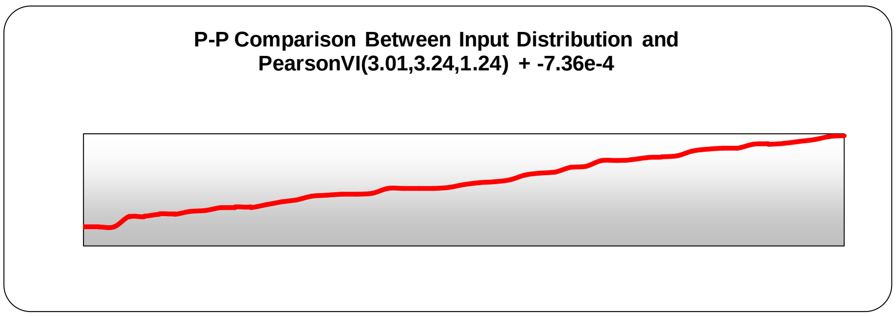

Figure A11.5: P-P plot, advisor wrap distribution call type 2

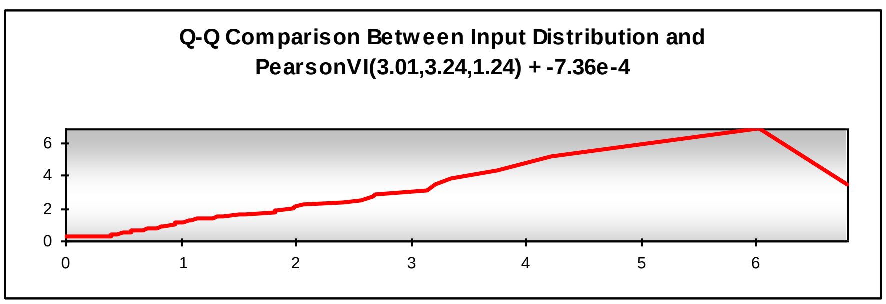

Figure A11.6: Q-Q Plot, advisor wrap distribution call type 2

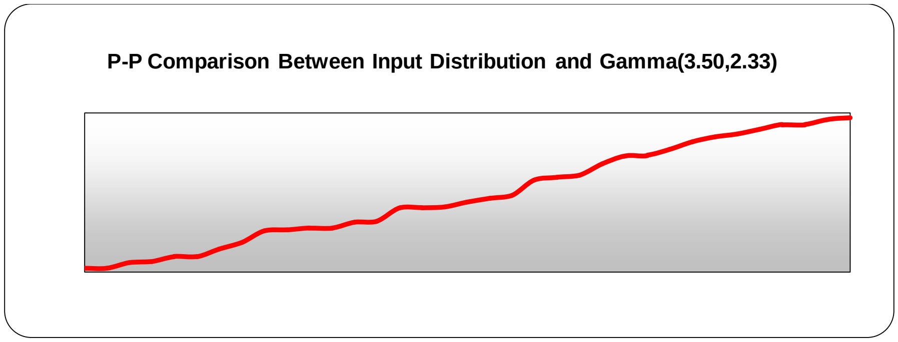

Figure A11.7: P-P plot, advisor service distribution adults call type 3

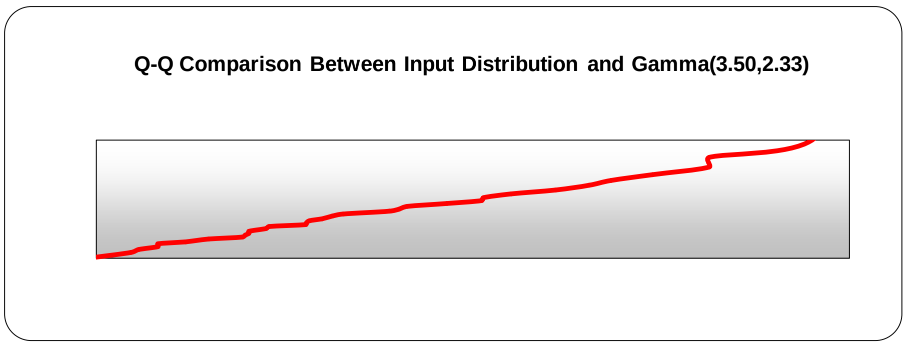

Figure A11.8: Q-Q Plot, advisor service distribution adults call type 3

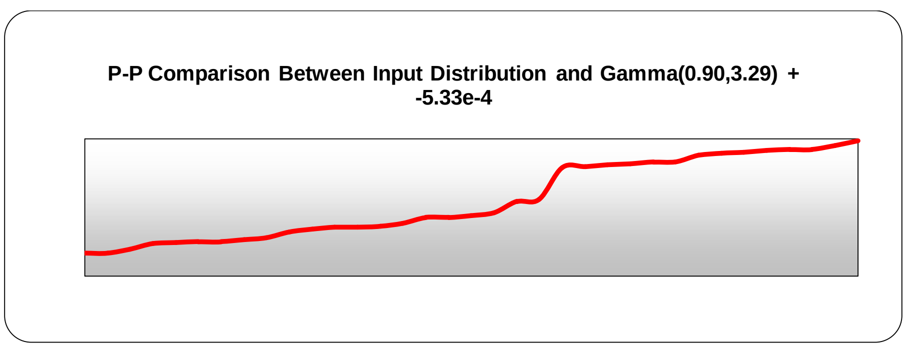

Figure A11.9: P-P plot, advisor wrap distribution adults call type 3

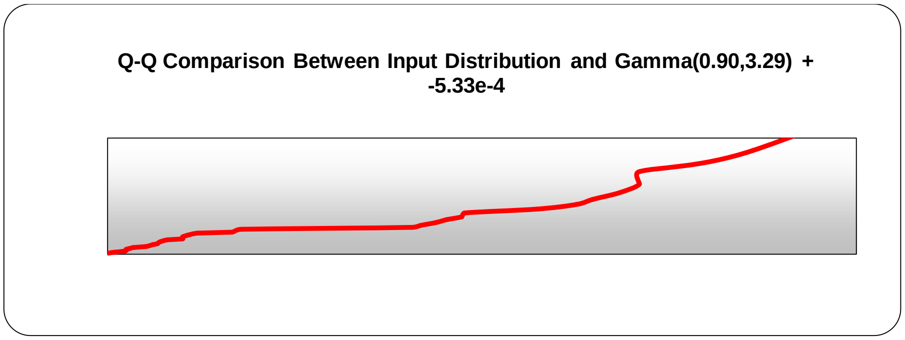

Figure A11.10: Q-Q Plot, advisor wrap distribution, adults call type 3

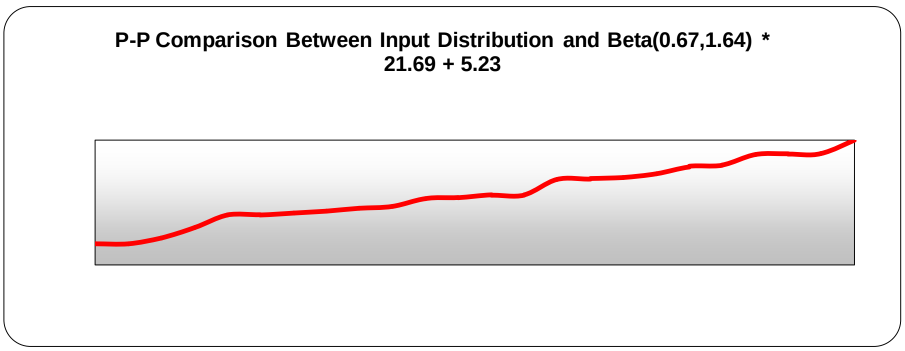

Figure A11.11: P-P plot, advisor service distribution children's call type 3

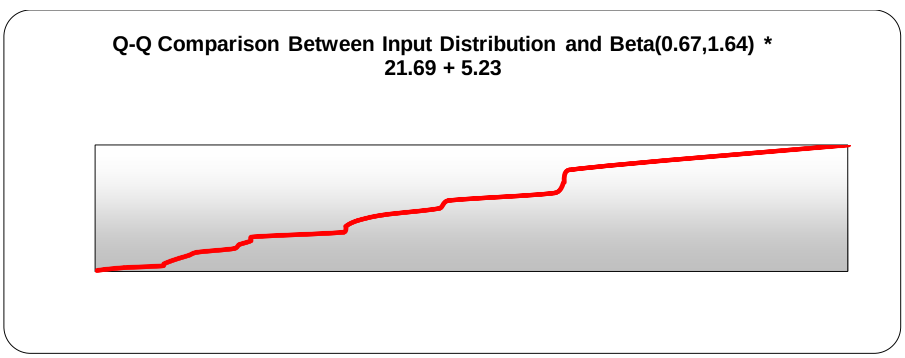

Figure A11.12: Q-Q Plot, advisor service distribution children's call type 3

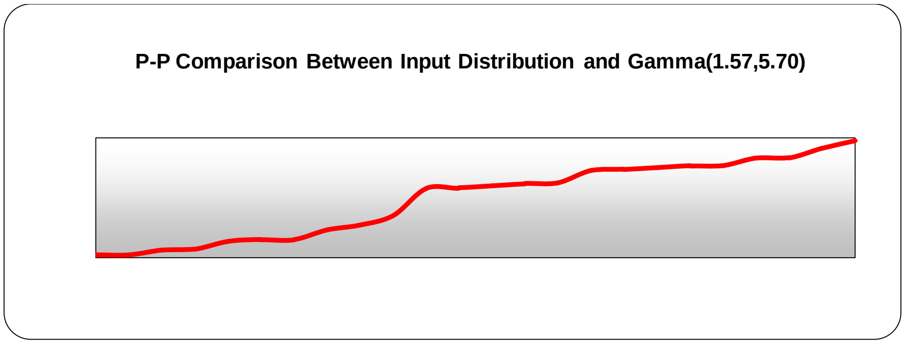

Figure A11.13: P-P plot, advisor wrap distribution, children's call type 3

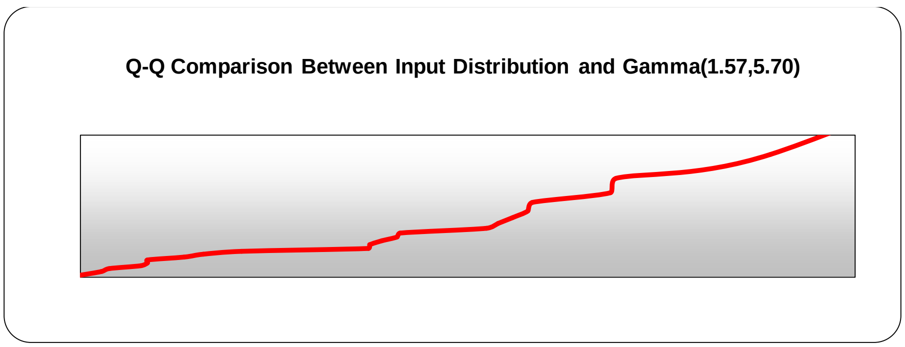

Figure A11.14: Q-Q Plot, advisor wrap distribution, children's call type 3

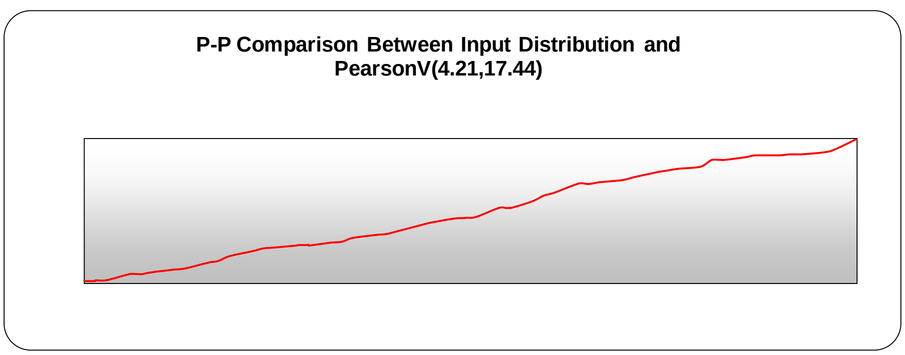

Figure A11.15: P-P plot, agent service distribution, call type 2

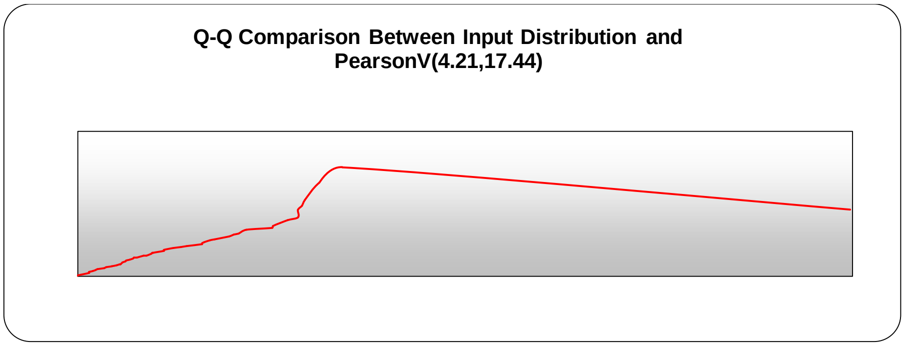

Figure A11.16: Q-Q Plot, agent service distribution call type 2

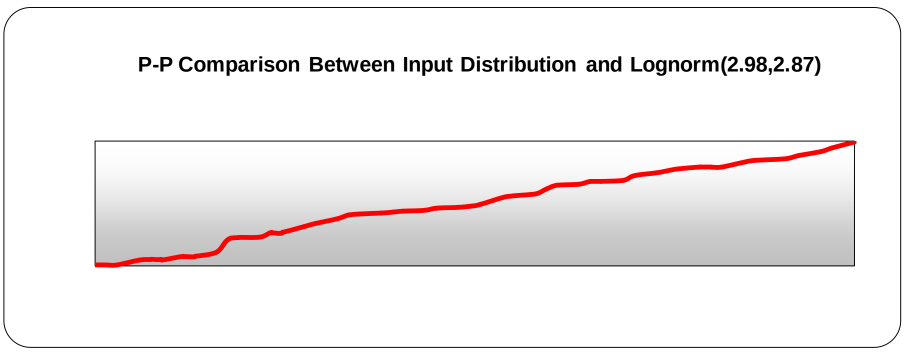

Figure A11.17: P-P plot, agent wrap distribution call type 2

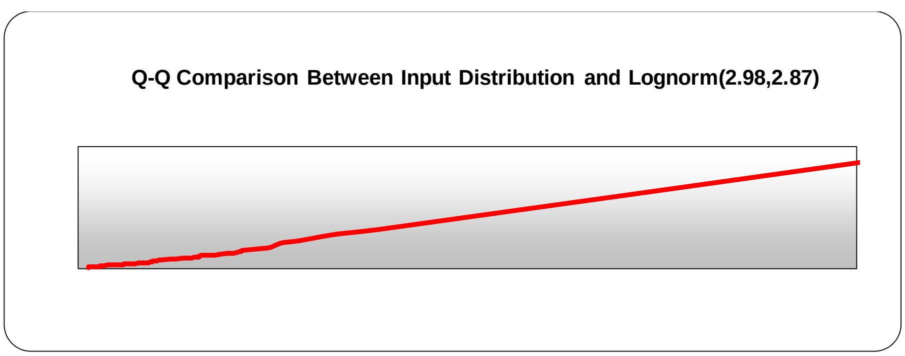

Figure A11.18: Q-Q Plot, agent wrap distribution call type 2

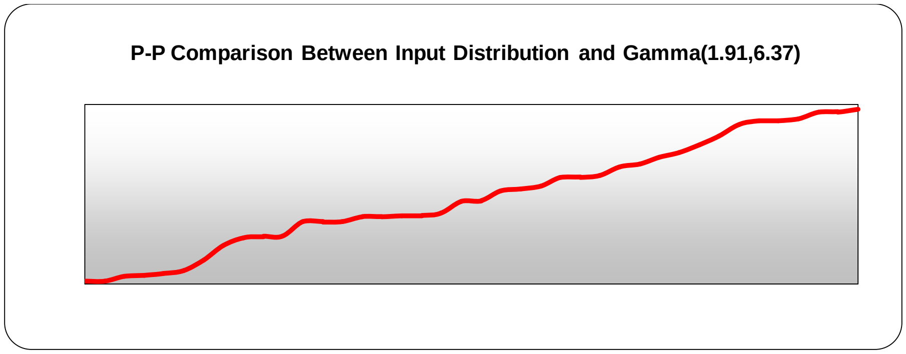

Figure A11.19: P-P plot, agent service distribution adults call type 3

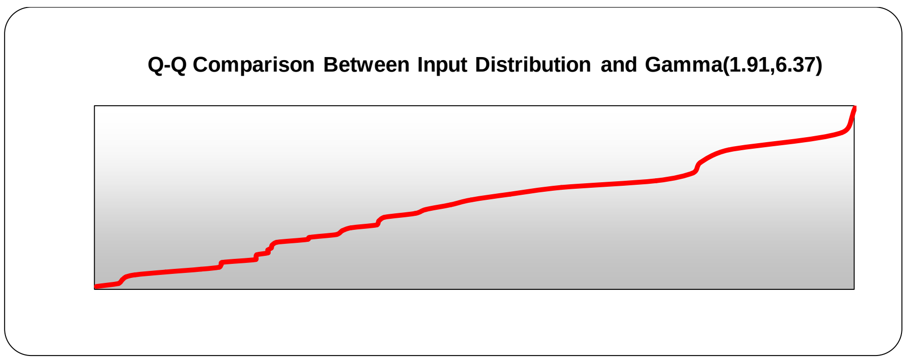

Figure A11.20: Q-Q Plot, agent service distribution adults call type 3

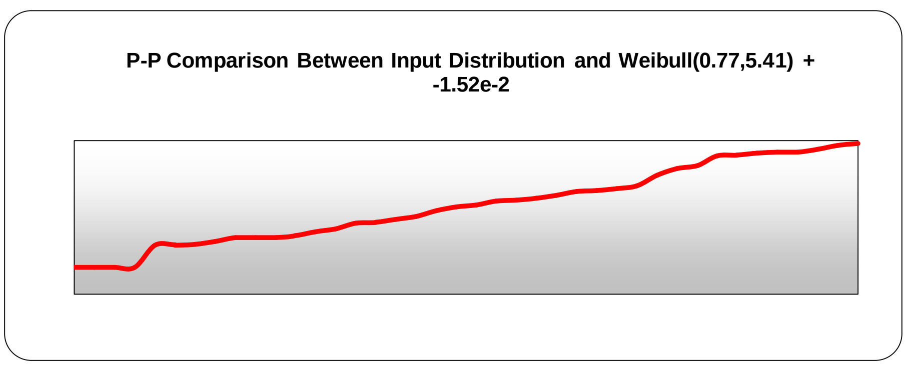

Figure A11.21: P-P plot, agent wrap distribution adults call type 3

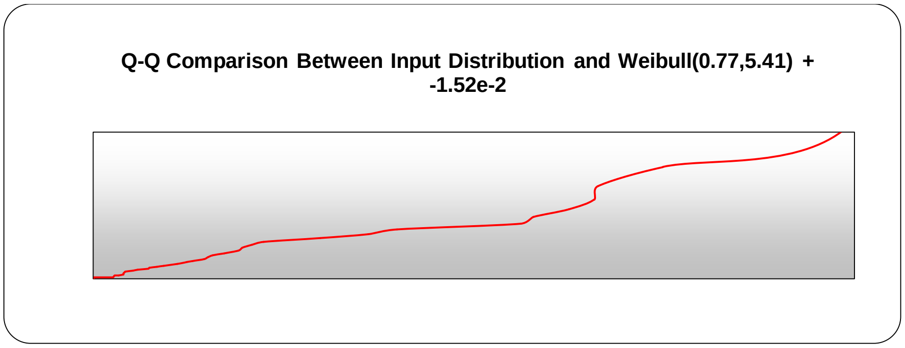

Figure A11.22: Q-Q Plot, agent wrap distribution adults call type 3

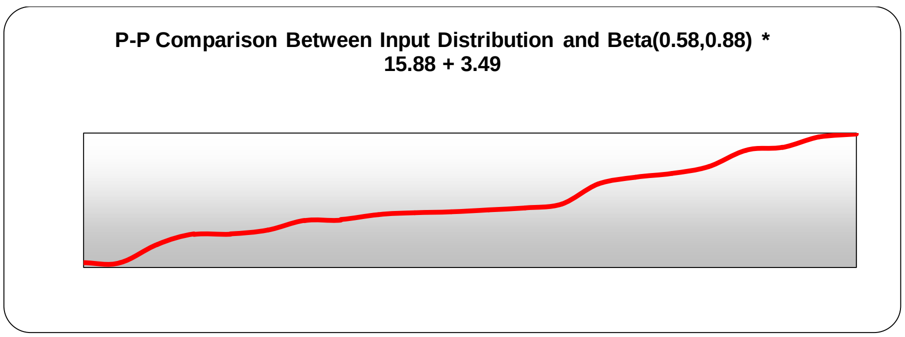

Figure A11.23: P-P plot, agent service distribution children's call type 3

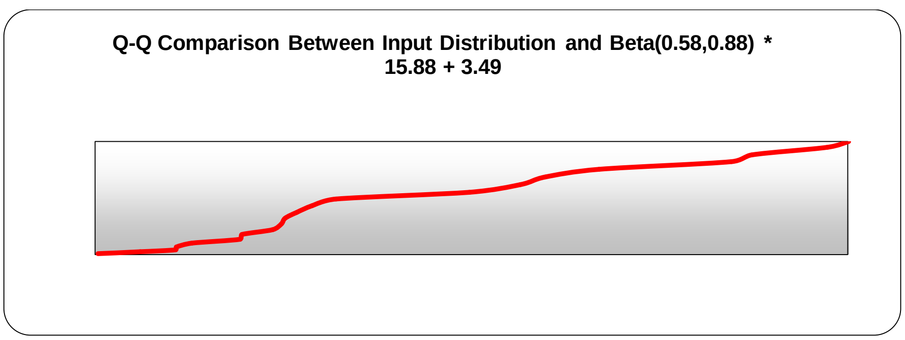

Figure A11.24: Q-Q Plot, agent service type distribution children's call type 3

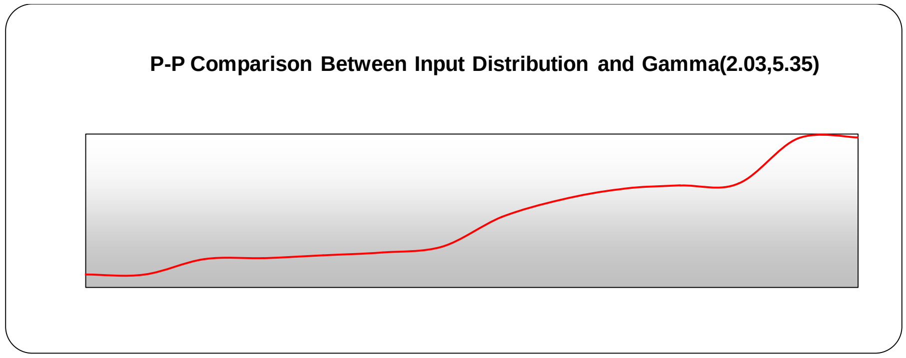

Figure A11.25: P-P plot, advisor service distribution children's call Type 3 taken from agent

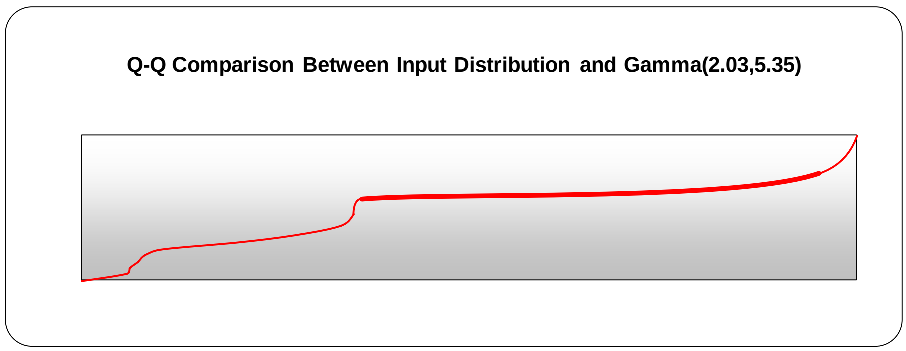

Figure A11.26: Q-Q Plot, advisor service distribution children's call type 3 taken from agent

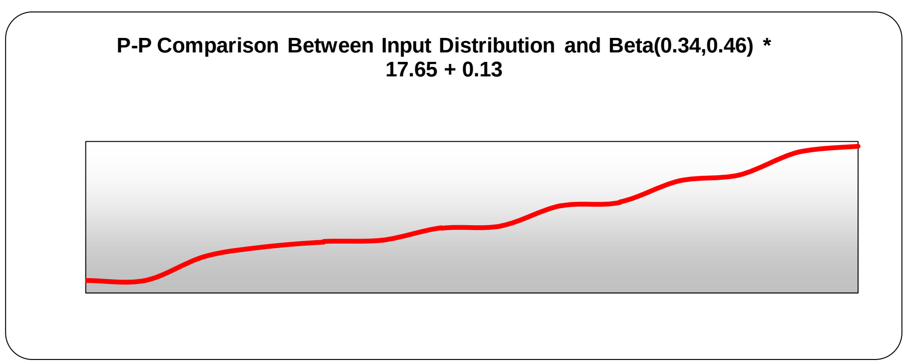

Figure A11.27: P-P plot, advisor wrap distribution children's call type 3 taken from agent

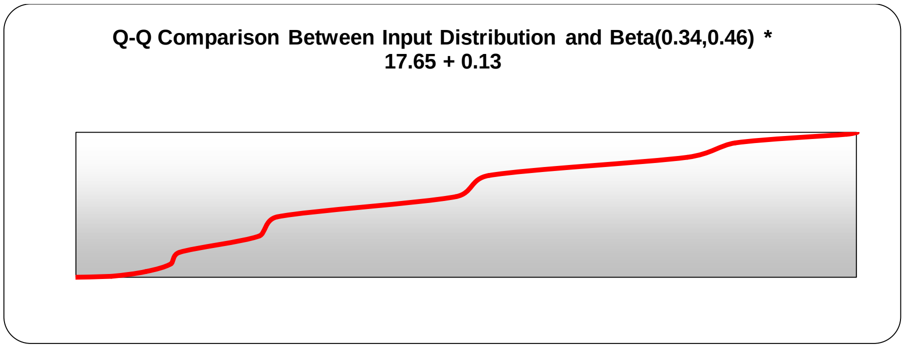

Figure A11.28: Q-Q Plot, advisor wrap distribution, children's call type 3 taken from agent

Appendix A12 Disability Projections by Gender

Male population disability projections

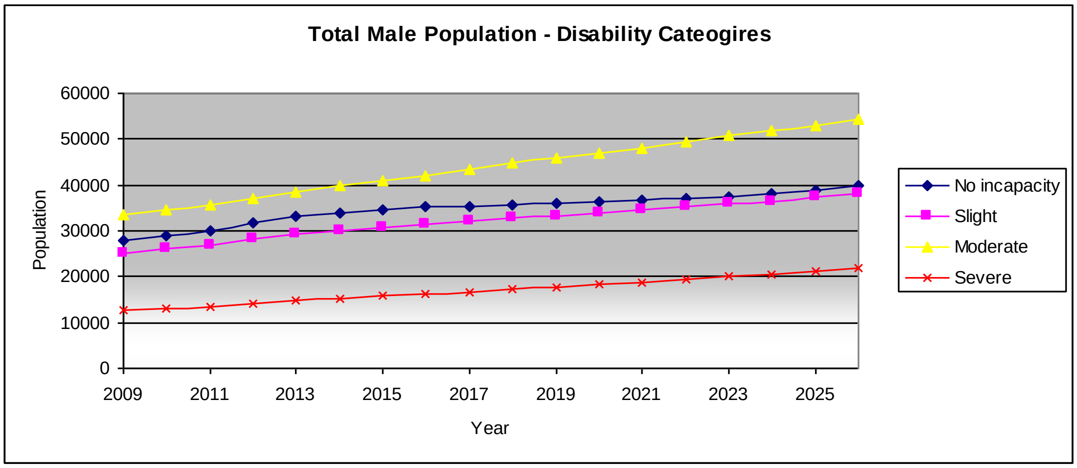

Figure A12.1: Total male population – disability categories

Figure A12.1 illustrates the model projections for the male population split down by the four disability categories. The largest category is those with a moderate disability.

In 2009, there are estimated to be 28,000 men aged over 65 who are classified as having no capacity. This is predicted to increase by 18.17% in 2013, 26.81% in 2018 and by 41.72% in 2026. These increases are very similar to the total population.

On average, 37.67% of men each year in the investigation period are likely to have no incapacity. The others will have a slight, moderate or severe disability.

In 2009, 25,200 men are estimated to have a slight disability. This is predicted to increase by 16.18% in 2013, 29.57% in 2018 and by 51.01% in 2016. This is greater than the expected increase in the total population. This is a higher rate of increase than those with no disability at all.

In 2009, 33,600 men are estimated to have a moderate level disability. This is also predicted to increase by a significant amount over the eighteen year period. This is predicted to increase by 14.97% in 2013, 32.98% in 2018 and by 61.58% in 2026. This is once again greater than the expected increase in the total population.

In 2009, 12,600 men are estimated to have a severe disability. This is predicted to increase by 16.54% in 2013, 36.26% in 2018 and by 72.51% in 2026. This is a considerable increase over the period and will have many implications for future social care provision. Services will need to be tailored to account for these significant changes.

Female population disability projections

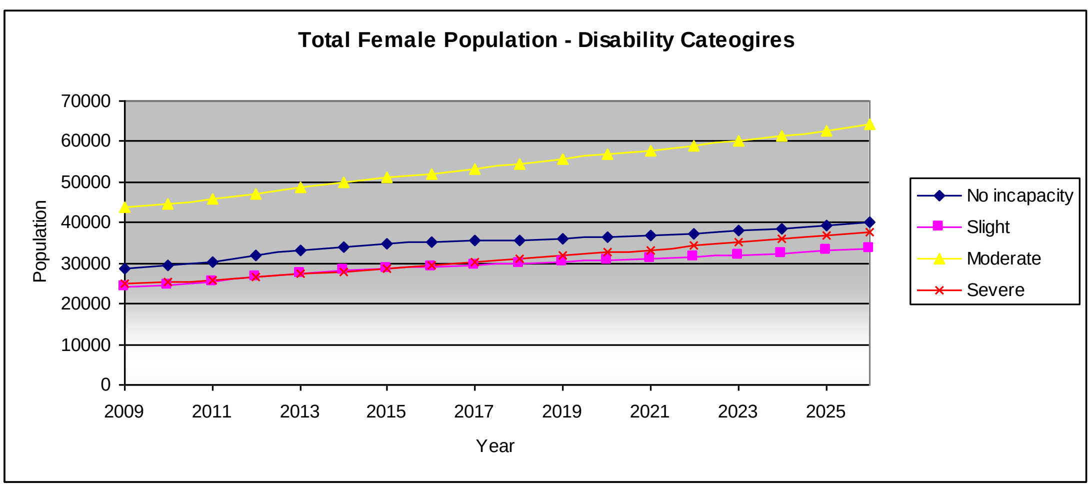

Figure A12.2: Total female population – disability categories

Figure A12.2 illustrates the model projections for the female population split down by the four disability categories. The most populated category is women with a moderate disability.

In 2009, 28,700 women aged over 65 are classified as having no capacity. This is predicted to increase by 15.65% in 2013, 24.42% in 2018 and by 39.51% in 2026. Like the projections for the male household population, these increases are very similar to the total population.

On average, 30.88% of women each year in the investigation period are likely to have no incapacity. The others will have a slight, moderate or severe disability.

In 2009, 24,000 women are estimated to have a slight disability. This is predicted to increase by 14.00% in 2013, 24.95% in 2018 and by 39.98% in 2026. Whilst this is a significant increase, the increase in the number of women with a slight disability is not as much as the increase in the number of men with a similar incapacity.

In 2009, 43,800 women are estimated to have a moderate level disability. This is predicted to increase by 11.36% in 2013, 24.58% in 2018 and by 46.59% in 2026. Once again, the increase is very noteworthy but not as much as the male increase.

In 2009, 24,900 women are estimated to have a severe disability. This is predicted to increase by 9.90% in 2013, 24.74% in 2018 and by 52.16% in 2026. This is a considerable increase in the number of women with a severe disability. However, the increase is much greater in the male population.

Appendix A13 Disability and Service Rate Projections

Disability projections for men aged 65-69

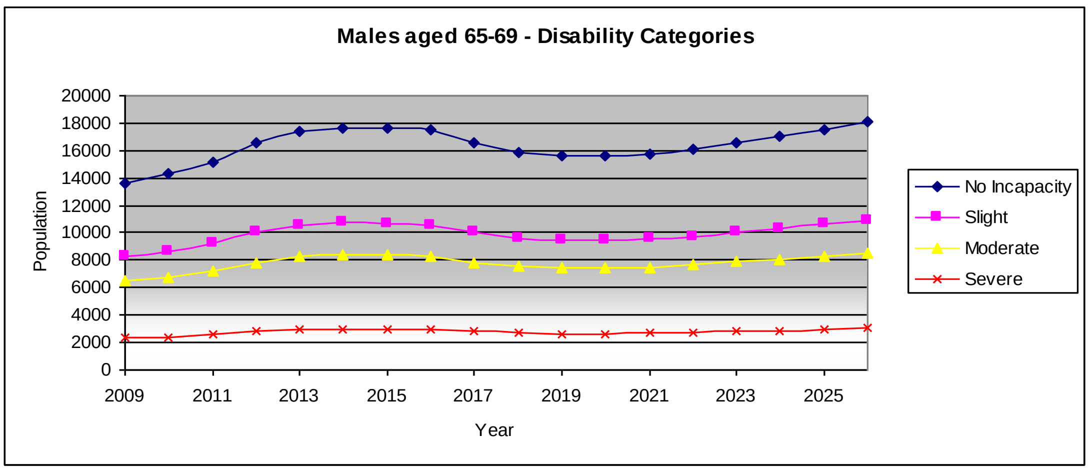

Figure A13.1: Men aged 65-69 by disability category

Over the eighteen year period there is predicted to be an increase of 33.26% in the number of men aged 65-69. This is slightly more than the increase in the total population. In 2009, 13,700 Men are estimated to have no incapacity. This is predicted to increase by 3,700 men in 2013, 2,200 men in 2018 and 4,400 in 2026 in comparison to 2009.

The number of men with some level of disability is estimated to be 17,000 in 2009. This is predicted to increase by 4,700 in 2013, an additional 2,800 in 2018 and a further 5,500 by 2026. In 2009, there are estimated to be 8,300 men with a slight disability, 6,500 with a moderate disability and 2,300 with a severe disability. Over the eighteen year period, the number of men with a slight disability is predicted to increase by 2,700. The number of men with a moderate level of disability is set to increase by 2100. Finally, those will a severe level of disability is predicted to increase by 700.

Service rate projections for men aged 65-69

Those with no incapacity and a slight disability are predicted to receive no care or support based on the results of the General Household Survey. For men who are classified as having a moderate disability, the majority of them based on survey responses are predicted to have no care or support as their main form of care provision as shown in Figure A13.2. On average, 100 men on average each year are predicted to report informal care as their main provision type.

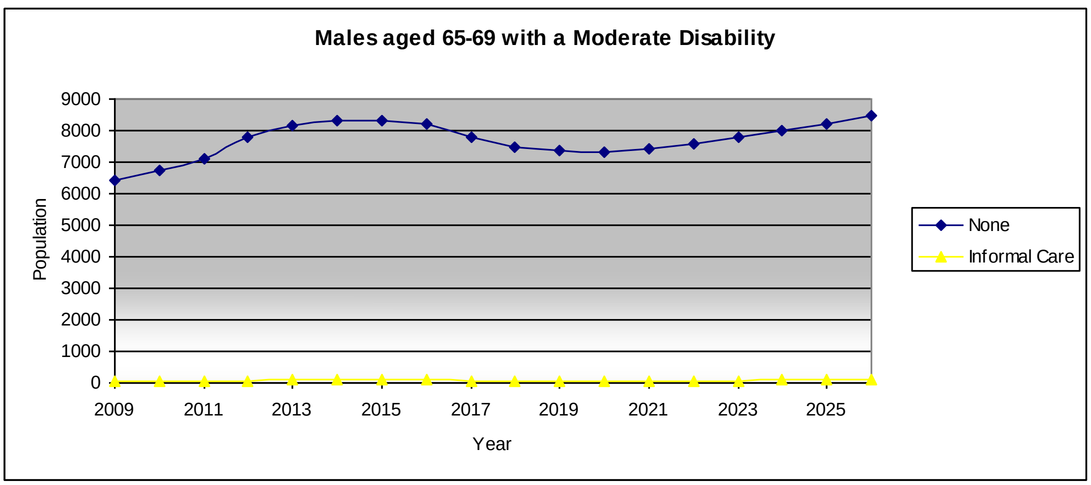

Figure A13.2: Care receipt for men aged 65-69 with moderate disability

As illustrated in Figure A13.2, many men living in the household population with a severe disability are predicted not receive any care or support. On average 1,200 men each year are predicted to report informal care as their main form of provision. No men are predicted to report the other two forms of care provision as their main source of care.

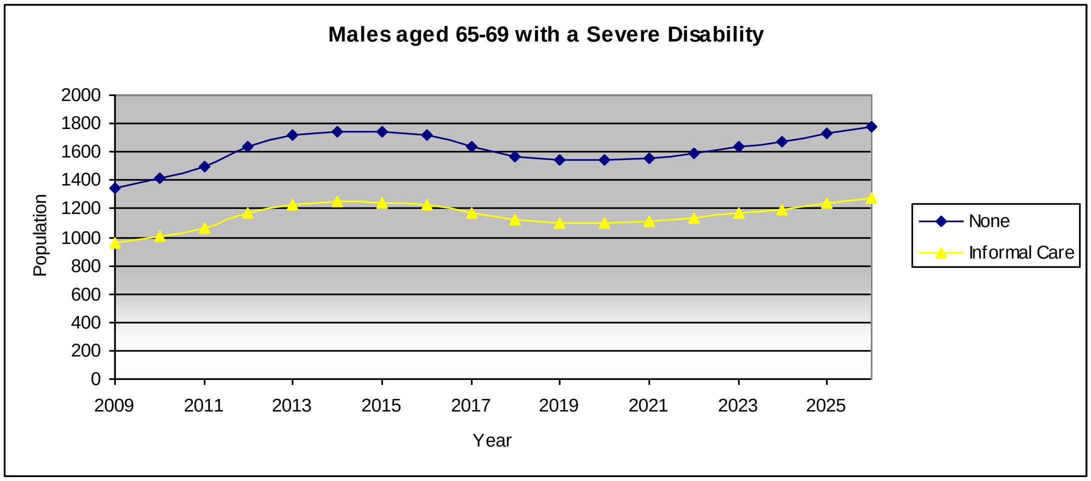

Figure A13.3: Care receipt for men aged 65-69 with severe disability

Disability projections for women aged 65-69

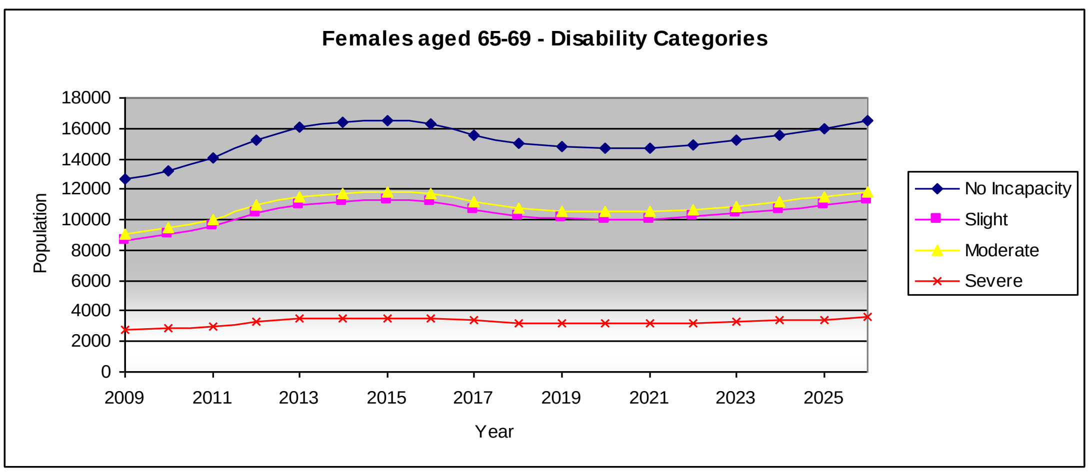

Figure A13.4: Women aged 65-69 by disability category

Over the eighteen year period there is predicted to be an increase of 30.49% in the number of women aged 65-69. This is slightly less than the increases in the equivalent male population. In 2009, 12,700 women are estimated to have no incapacity. There are more men who have no incapacity in the same age group. This is predicted to increase by 3,400 in 2013, 2,300 in 2018 and 3,900 in 2026 in comparison to 2009.

In 2009, 20,500 women are estimated to have some level of disability. There are estimated to be 3,400 more women with a disability than men in 2009. The number of women with a disability is predicted to increase by 5,400 in 2013, 3,800 in 2018 and by 6,200 in 2026 in comparison to 2009.

In 2009, there are estimated to be 8,700 women with a slight disability, 9,000 with a moderate disability and 2,800 with a severe disability. In 2009, there are considerably more women with a moderate disability in comparison to men in the same age group. Over the eighteen year period, the number of women with a slight disability is predicted to increase by 2,600. This is very similar to the increase in the male population. The number of women with a moderate level of disability is predicted to increase by 2,800. Finally, those with a severe level of disability are predicted to increase by 800. This is only slightly higher than the increase in the number of men in the same age group with a severe disability. For both men and women, the predicted increase in the number of people with a severe disability is insignificant in comparison to the increase in the number of people with a severe disability in the other age groups.

Service rate projections for women aged 65-69

Females who are classified as having no incapacity or a slight disability are predicted to receive no care or support based on the results of the General Household Survey. For women who are classified as having a moderate disability, the majority of women based on survey responses are predicted to have no care or support as their main form of care provision as illustrated in Figure A13.5. On average, 600 women each year in the period are predicted to report informal care as their main provision type. This is considerably higher than the number of men with a moderate disability reporting informal care as the main form of care provision.

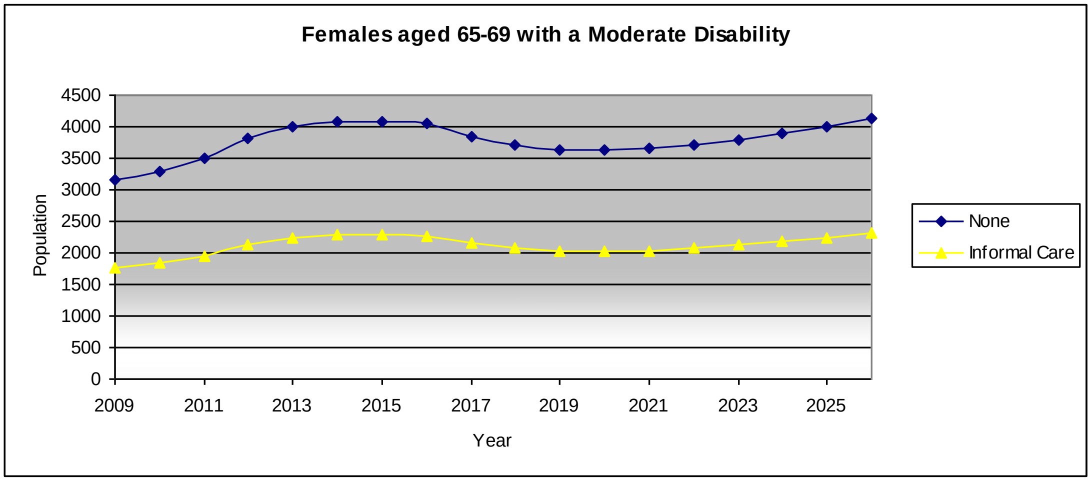

Figure A13.5: Care receipt, women aged 65-69 with moderate disability

Once again, the majority of women living in the household population with a severe disability are predicted to get on with their lives without any care or support as shown in Figure A13,6. On average, 1000 women each year are predicted to report informal care as their main form of provision. This is slightly less than the number of men who are expected to report informal care as the main source of care. On average, around 100 women are predicted to report each year that the local authority is their main form of care provision. The same numbers of women are predicted to report the private sector as their main form of care provision.

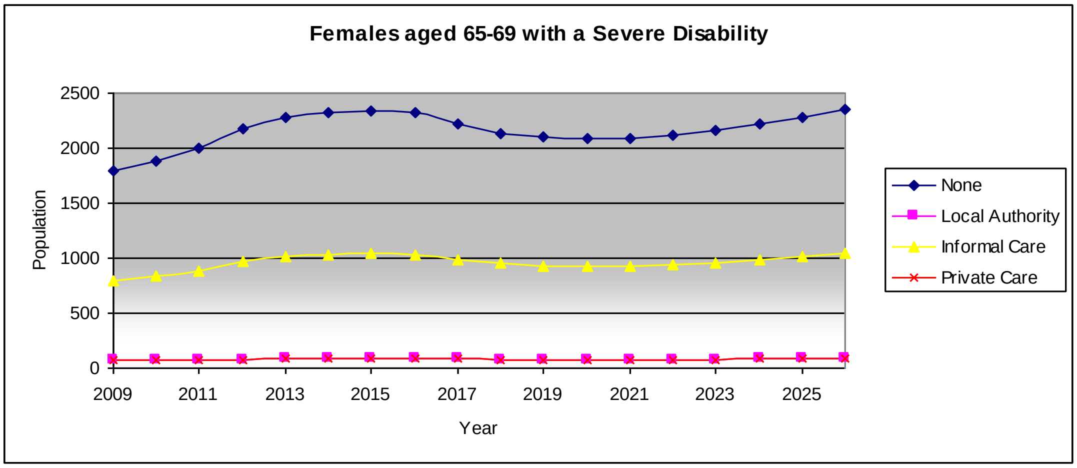

Figure A13.6: Care receipt, women aged 65-69 with severe disability

The next age group that will be explored are those who are aged 70-74.

Disability projections for all people aged 70-74

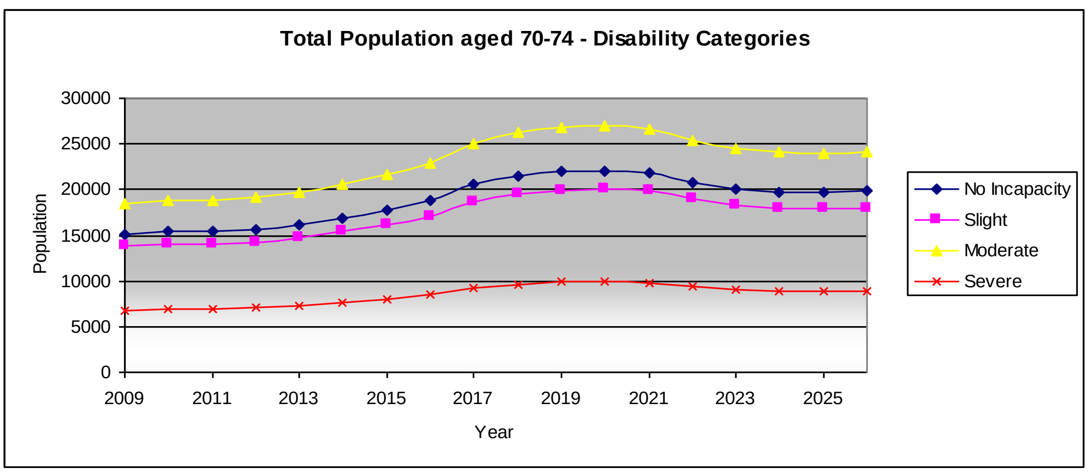

Figure A13.75: Total population aged 70-74 by disability category

As shown in Figure A13.7, people with a moderate disability are predicted to be the main disability category. This is a noteworthy difference in comparison to the last age group under discussion. Over the eighteen year period, there is predicted to be an increase of

30.59% in the number of people aged 70-74. This is only slightly less than the increase for those aged 65-69.

The number of elderly people over the period with no incapacity is estimated to be 15,200 people in 2009. This is predicted to increase by 1,000 in 2013, 6,400 in 2018 and 4,600 in 2026 in comparison to 2009. This increase is considerably less than the previous age group.

In 2009, there are estimated to be 39,100 people with some level of disability. There are estimated to be 1,600 more disabled people in 2009 in comparison to the previous age group. The number of disabled people is predicted to increase by 2,700 in 2013, 16,400 in 2018 and 12,000 in 2026 in comparison to 2009. This is only slightly higher than the increase in the previous age group over the whole period.

In 2009, there are estimated to be 13,800 people with a slight disability, 18,500 people with a moderate disability and 6,800 people with a severe disability. There are many more people with a moderate disability in contrast to the proceeding age group. There are important differences in the number of people with moderate and severe disabilities in comparison to those aged 65-69; they are both greater in number. Over the eighteen year period, the number of people with a slight disability is predicted to increase by 4,400. The number of people with a moderate level of disability is predicted to increase by 5,700. Finally, those with a severe level of disability are predicted to increase by 2,100. The increase in the number of people with a severe disability is slightly higher in comparison to the previous age group.

Service rate projections for people aged 70-74

Those with no incapacity and a slight disability are predicted to receive no care or support based on the results of the General Household Survey. As illustrated in Figure A13.8, for people who are classified as having a moderate disability, the majority of people based on survey responses are predicted to have no care or support as their main form of care provision. On average, 300 people each year in the period are predicted to report informal care as their main provision type. This number is about the half the number in comparison to the younger age group.

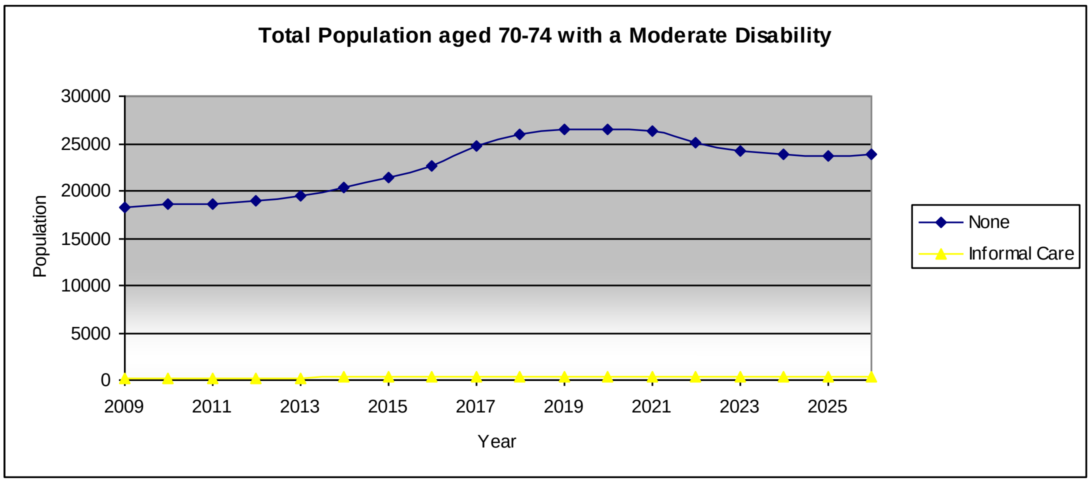

Figure A13.8: Total population aged 70-74 with moderate disability

Once again, the majority of people living in the household population with a severe disability get on with their lives without any care or support as shown in Figure A13.9. On average 2,700 people each year are predicted to report informal care as their main form of provision. This is considerably higher than the previous age group. 300 people are predicted to report on average each year that the local authority is their main form of care provision. 224 people are predicted to report that the private sector is their main form of care provision. This is a greater number than the previous age group.

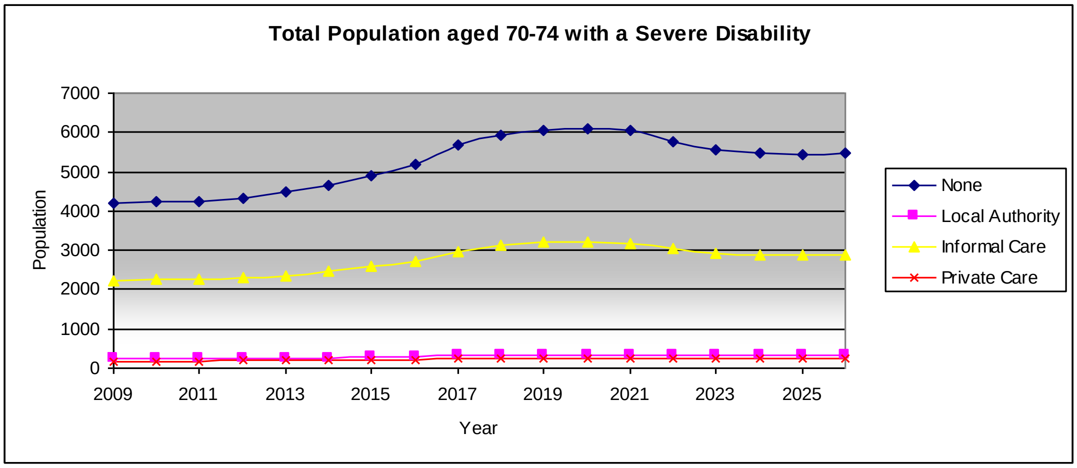

Figure A13.9: Total population aged 70-74 with severe disability

A breakdown for the same age group by gender is now explored.

Disability projections for men aged 70-74

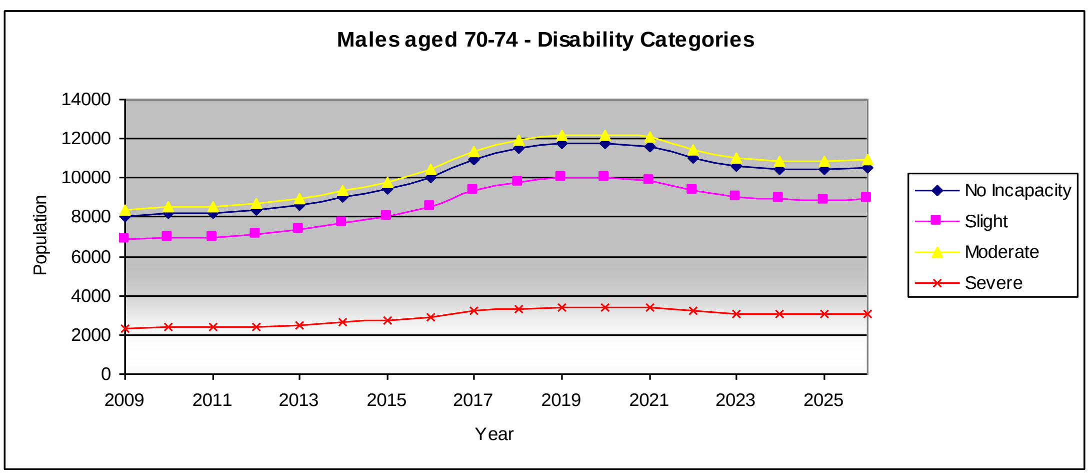

Figure A13.10: Men aged 70-74 by disability category

The moderate disability group is once again predicted to be the main group but the numbers are only slightly higher than those with no incapacity as shown in Figure A13.10. Over the eighteen year period there is predicted to be an increase of 31.02% in the number of men aged 70-74. In 2009, there are estimated to be 8,100 men with no incapacity. This is predicted to increase by 600 men in 2013, 3,500 men in 2018 and 2,500 men in 2026 in comparison to 2009. In 2009 there are estimated to be 5,600 more men in the previous age group with no incapacity.

The number of men with some level of disability in 2009 is estimated to be 17,600. This is very similar to the previous age group. This is predicted to increase by 1,300 men in 2013, 7,600 men in 2018 and 5,400 men in 2026 in comparison to 2009.

In 2009, there are estimated to be 6,900 men with a slight disability, 8,400 with a moderate disability and 2,300 with a severe disability. There are fewer men with a slight disability when compared to the previous male age group. There are considerably more men with a moderate disability in comparison to the previous age group. Over the eighteen year period, the number of men with a slight disability is predicted to increase by 2,100. The number of men with a moderate level of disability is predicted to increase by 2,600. This increase is considerably higher than the previous age group. Finally, those with a severe level of disability are predicted to increase by 700.

Service rate projections for men aged 70-74

Elderly men with no incapacity and a slight disability are predicted to receive no care or support based on the results of the General Household Survey. For men who are classified as having a moderate disability, the majority of people based on survey responses are predicted to have no care or support as their main form of care provision. On average, 200 men on average each year in the period are predicted to report informal care as their main provision type. This is about double the number in comparison to the previous age group.

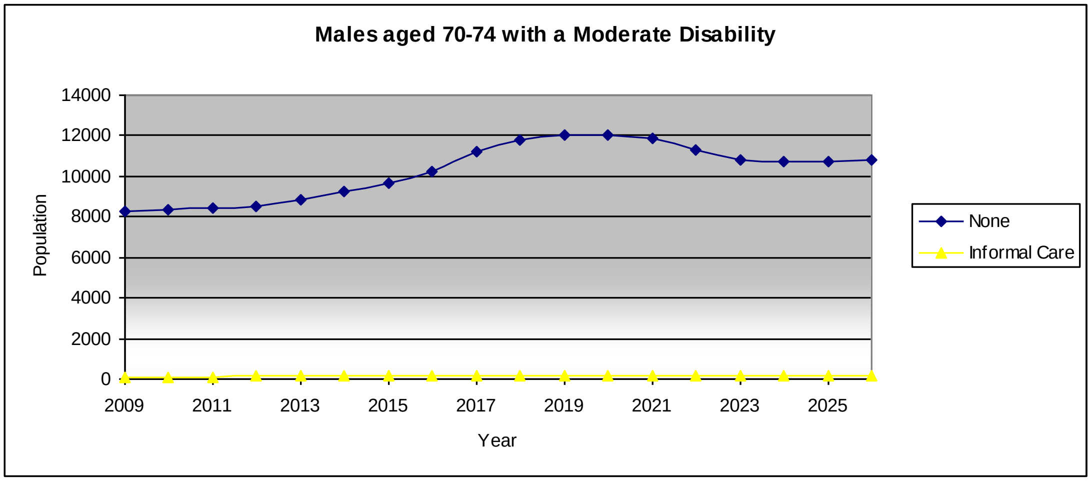

Figure A13.11: Care receipt for men aged 70-74 with moderate disability

As shown in Figure A13.12, many men living in the household population with a severe disability are predicted to get on with their lives without any care or support. On average, 500 men each year are predicted to report informal care as their main form of provision. This is less than the previous age group. In comparison to the previous age group, men with a severe disability are predicted to report the other two forms of care provision as well. Around 100 men are predicted to report on average each year that the local authority is their main form of care provision. 150 men are predicted to report that the private sector is their main form of care provision.

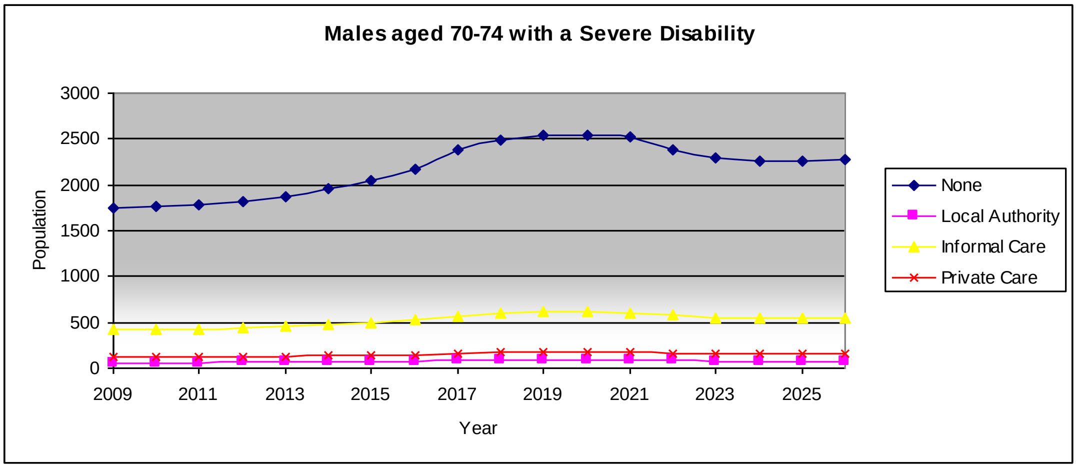

Figure A13.12: Care receipt for men aged 70-74 with severe disability

Disability projections for women aged 70-74

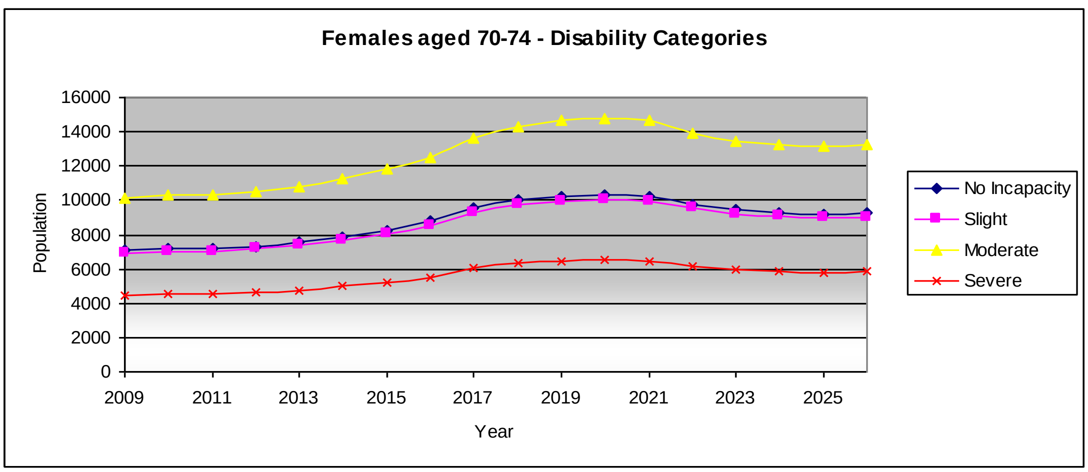

Figure A13.13: Women aged 70-74 by disability category

A very interesting result is that whilst in the total population for those aged 70-74 and the equivalent male population, the main disability group was those with a moderate disability, for the female population, the main disability group is no incapacity as shown in Figure A13.13. Over the eighteen year period there is predicted to be an increase of 30.20% in the number of women aged 70-74.

The number of elderly women over the period with no incapacity is estimated to be 7,100 in 2009. This is less than the increase in the male population. This is predicted to increase by 500 women in 2013, 2,900 women in 2018 and 2,100 women in 2026 in comparison to 2009.

The number of women with some level of disability is estimated to be 21,600 in 2009. This is considerably greater than the number of disabled people in the male population in the same age group. The number is slightly greater than the previous age group for women aged 65-69. The number of disabled people aged 70-74 is predicted to increase by 1,400 in 2013, 8,800 in 2018 and 6,500 in 2026 in comparison to 2009.

In 2009, there are estimated to be 6,900 women with a slight disability, 10,200 with a moderate disability and 4,500 with a severe disability. There are considerably more people with a moderate and severe disability in comparison to men in the same age group. The number of women with a slight disability is predicted to increase by 2,000 over the eighteen year period. This is very similar to the increase in the male population. The number of women with a moderate level of disability is predicted to increase by 3,100. Finally, women with a severe level of disability are predicted to increase by 1,400. This is much higher than the increase in the male population. There are no significant differences in comparison to the previous female age group.

Service rate projections for women aged 70-74

Women with no incapacity and a slight disability are predicted to receive no care or support based on the results of the General Household Survey. For women who are classified as having a moderate disability, the majority of them based on survey responses are predicted to have no care or support as their main form of care provision. On average, 100 women each year in the period are predicted to report informal care as their main provision type. This is considerably lower than women from the previous age group with the same level of disability.

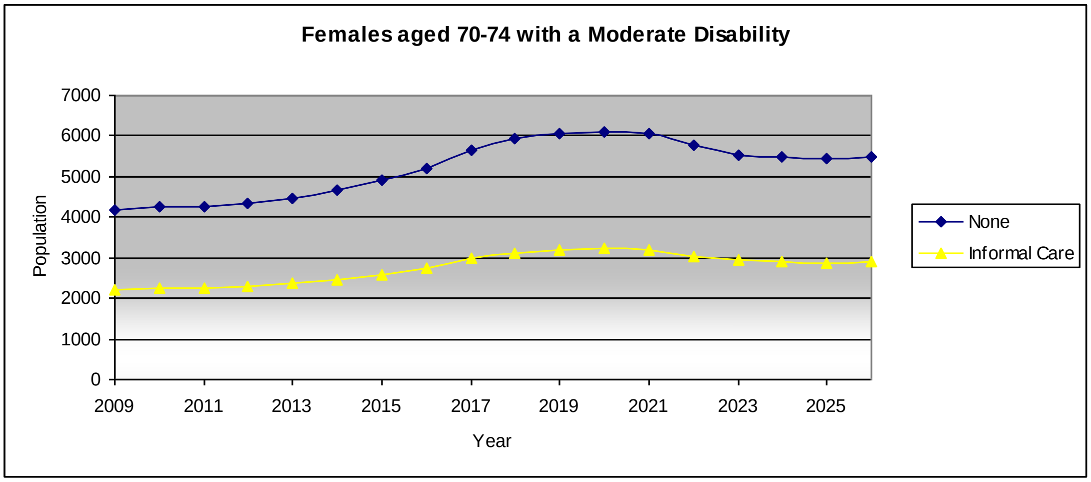

Figure A13.14: Care receipt for women aged 70-74 with moderate disability

Once again, the majority of women living in the household population with a severe disability are predicted to get on with their lives without any care or support as shown in Figure A13.15. On average, 2,200 women each year are predicted to report informal care as their main form of provision. This is significantly more than the number of men who are predicted to report informal care as the main source of care provision. Around 200 women are predicted to report 1on average each year that the local authority is their main form of care provision. 74 are predicted to report that the private sector is their main form of care provision.

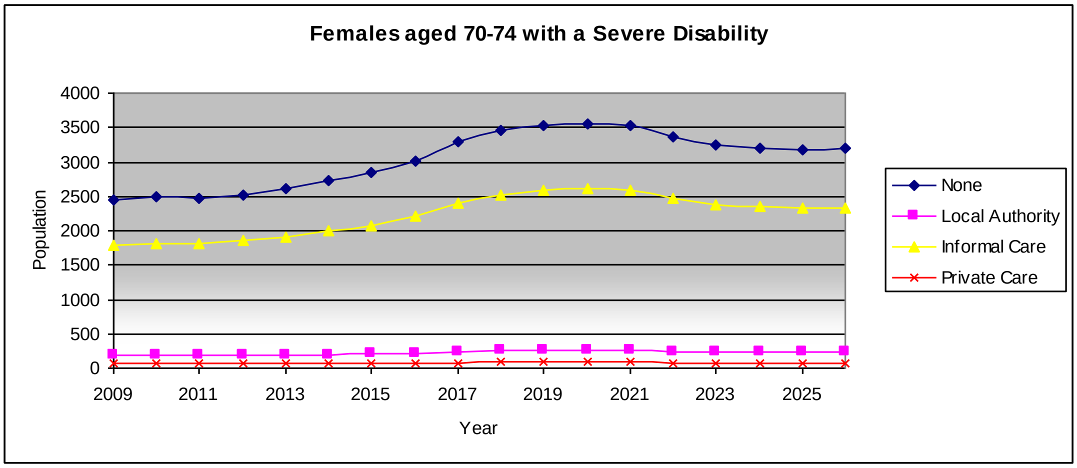

Figure A13.15: Care receipt for women aged 70-74 with severe disability

The next age group that will be explored are people who are aged 75-79.

Disability projections for all people aged 75-79

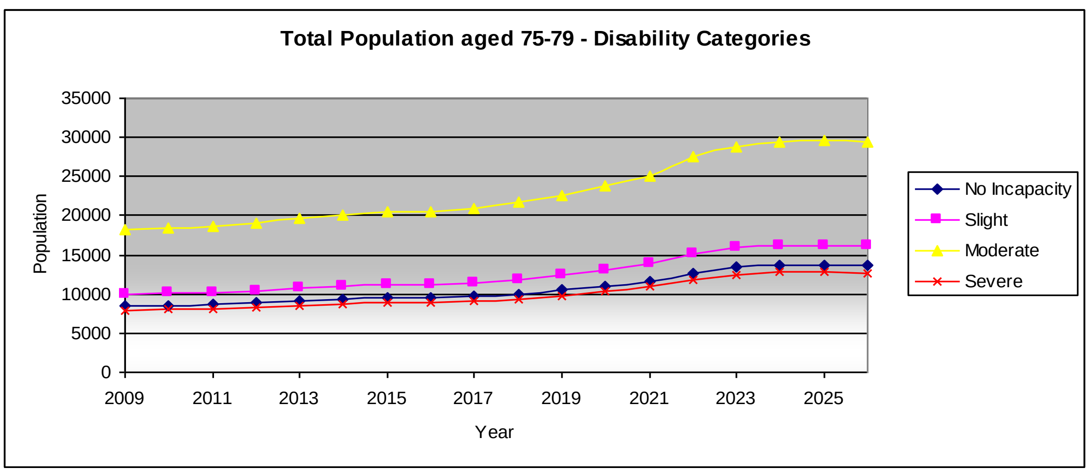

Figure A13.16: Total population aged 75-79 by disability category

Once again, those with a moderate disability are predicted to be the most populous disability category as shown in Figure A13.16. Over the eighteen year period there is predicted to be an increase of 61.39% in the number of people aged 75-79. This is considerably higher in comparison to the previous two age groups.

In 2009, there are estimated to be 8,400 people with no incapacity and this is likely to increase by 600 people in 2013, 1,600 people in 2018 and 5,200 in 2026 in comparison to 2009. There are significantly fewer people who have no incapacities in contrast to the previous age group.

The number of people with some level of disability is likely to be 36,100 people in 2009. In 2009, there are fewer people with a disability compared to those aged 70-74. This is likely to increase by 2,800 people in 2013, 6,900 people in 2018 and 22,100 in 2026 in comparison to 2009. The increase over the whole period is very noteworthy as it is greater by 10,200 people than is likely to be experienced in the previous age group. The increase in the next ten years is considerably greater than the previous age group. There are significant issues to be addressed in the next ten years.

In 2009, there are likely to be 10,000 people with a slight disability, 18,200 with a moderate disability and 7,900 with a severe disability. There are fewer people with a slight disability in comparison to the previous age group. Over the eighteen year period, the number of people with a slight disability is set to increase by 6,200. The number of people with a moderate level of disability is set to increase by 11,200. This is a very significant increase. Finally, those with a severe level of disability is set to increase by 4,800. The increase in the number of people with a severe disability is considerably higher than the previous two age groups. This is a very important point to note in the provision of long-term care.

Service rate projections for all people aged 75-79

Those with no incapacity receive no care or support based on the results of the General Household Survey. For those people who are classified as having a slight disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 90 people each year in the period are likely to report informal care as their main provision type.

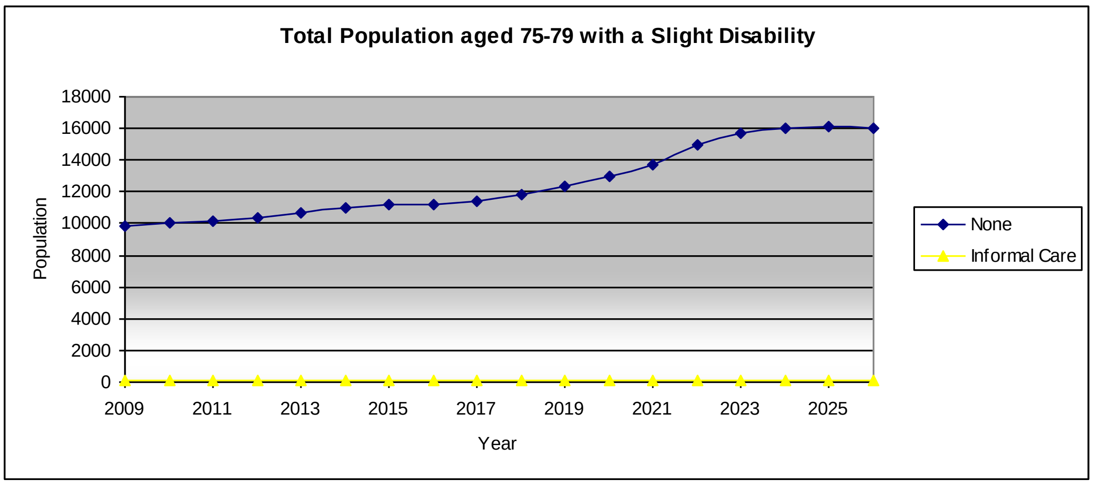

Figure A13.17 Care receipt for all people aged 75-79 with slight disability

As illustrated in Figure A13.18, for those people who are classified as having a moderate disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 600 people each year in the period are likely to report informal care as their main provision type.

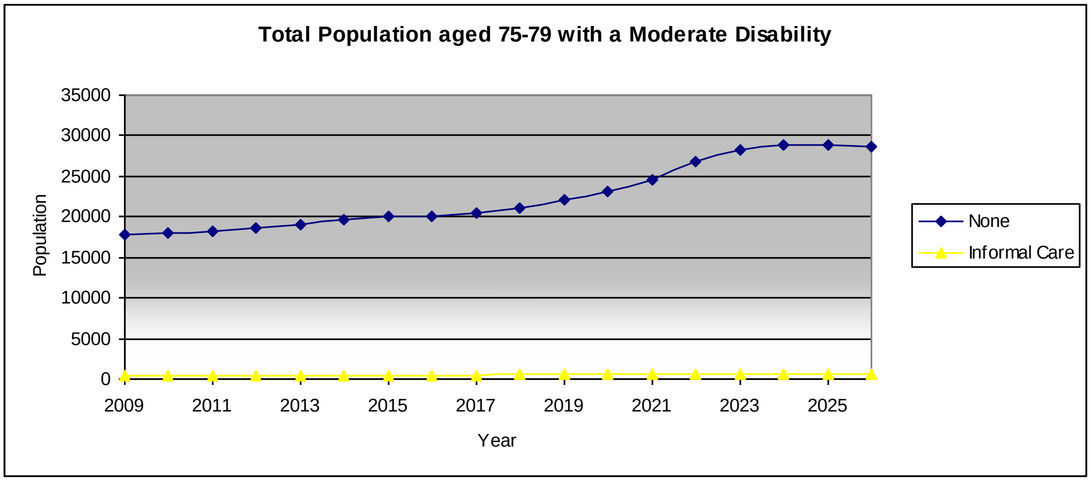

Figure A13.18: Care receipt for all people aged 75-79 with moderate disability

Once again, the majority of people living in the household population with a severe disability get on with their lives without any care or support as shown in Figure A13.19. On average, 2,400 people each year are likely to report informal care as their main form of provision. Around 600 people are expected to report on average each year that the local authority is their main form of care provision. 100 people are likely to report that the private sector is their main form of care provision.

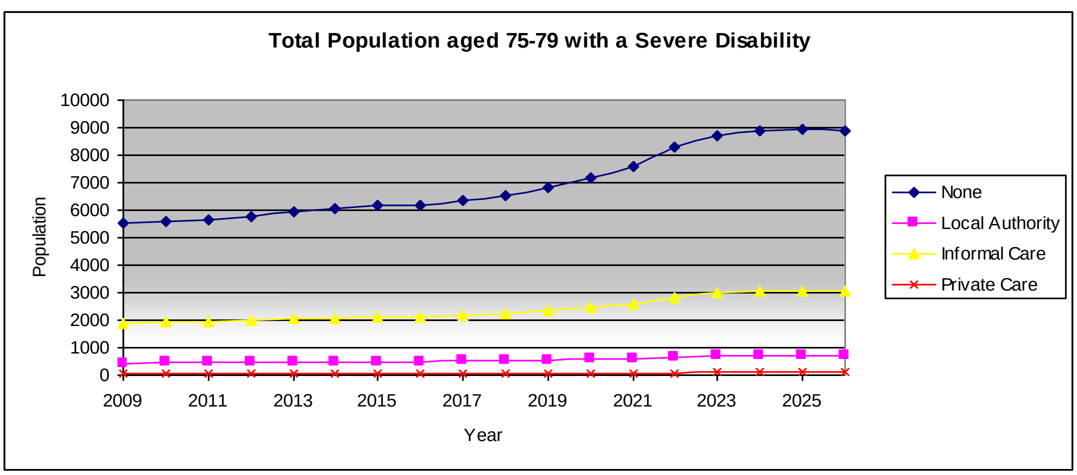

Figure A13.19: Care receipt for all people aged 75-79 with severe disability

A breakdown for the same age group by gender is now explored.

Disability projections for men aged 75-79

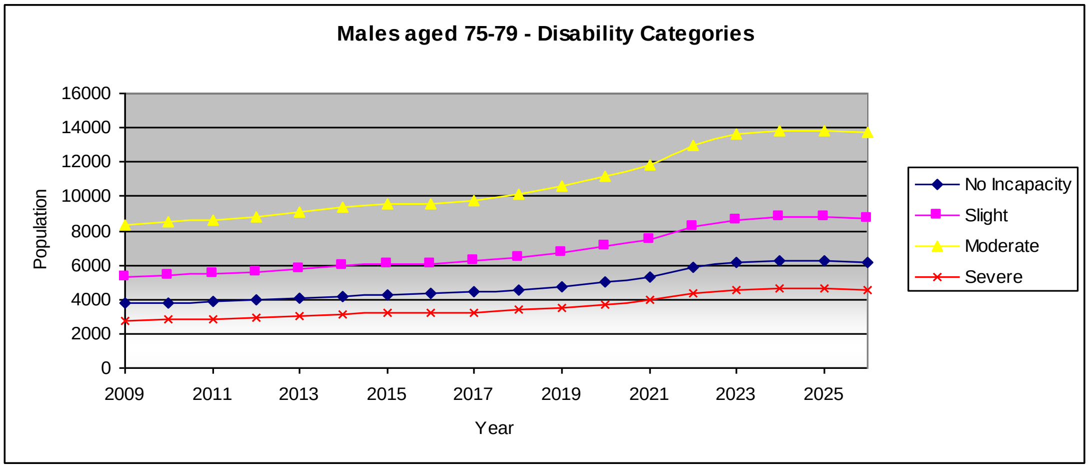

Figure A13.20: Men aged 75-79 by disability category

As shown in Figure A13.20, the moderate disability group is once again the main group. The no incapacity group is now the third highest group based on population numbers. Over the eighteen year period there is expected to be an increase of 65.36% in the number of men aged 75-79.

The number of elderly men over the period with no incapacity in 2009 is likely to be 3,700. This is considerably lower than the previous male age group. The number of men with no incapacity is likely to increase by 400 men in 2013, 800 men in 2018 and 2,200 men in 2026 in comparison to 2009. The increase over the whole period is similar to the change that is likely to be experienced in the previous age group.

The number of men with some level of disability in 2009 is likely to be 16,300 in 2009. This is likely to increase by 1,500 men in 2013, 3,600 men in 2018 and 10,700 men in 2026 in comparison to 2009. The increase over the whole period is about double the increase experienced in the previous age group.

In 2009, there are likely to be 5,300 men with a slight disability, 8,300 with a moderate disability and 2,800 with a severe disability. Over the eighteen year period, the number of men with a slight disability is set to increase by 3,300. The number of men with a moderate level of disability is set to increase by 5,400. This increase is considerably higher than the previous age group. Finally, those with a severe level of disability is expected to increase by 1,800. This is once again a greater increase than men aged 70-74.

Service rate projections for men aged 75-79

Those with no incapacity and are likely receive no care or support based on the results of the General Household Survey. For men who are classified as having a slight disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 100 men each year in the period are likely to report informal care as their main care provision type.

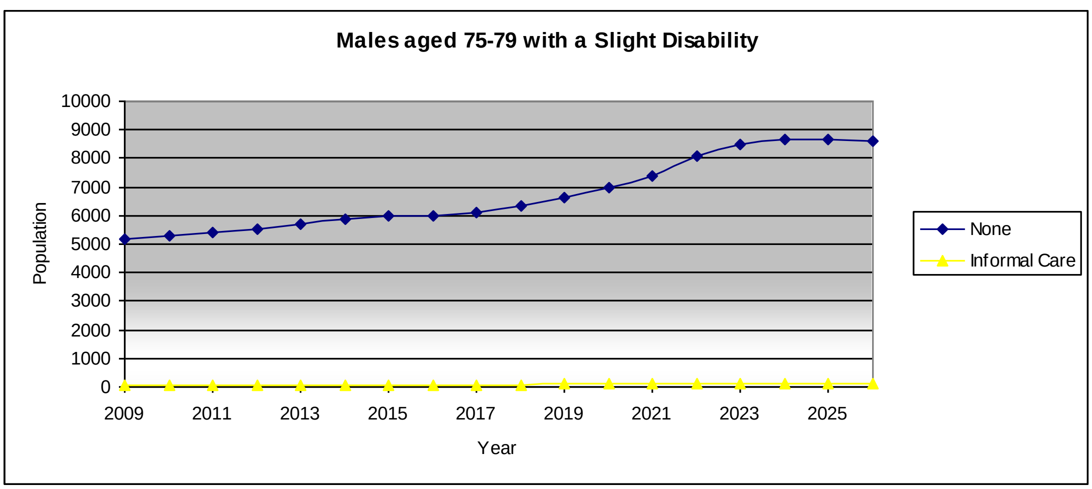

Figure A13.21: Care receipt for men aged 75-79 with slight disability

For men who are classified as having a moderate disability, the majority based on survey responses are likely to have no care or support as their main form of care provision. On average, 300 men each year in the period are likely to report informal care as their main care provision type.

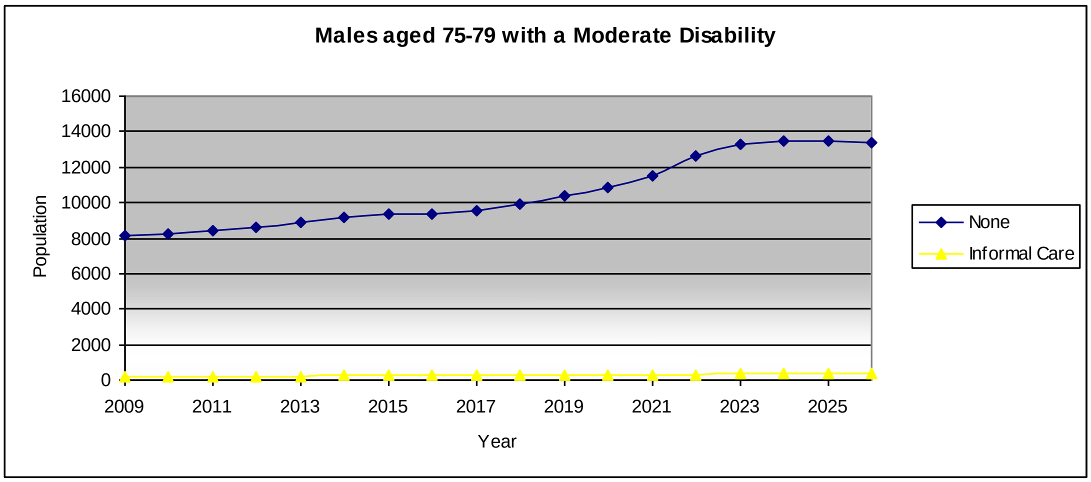

Figure A13.22: Care receipt for men aged 75-79 with moderate disability

Many men living in the household population with a severe disability get on with their lives without any care or support, as shown in Figure A13.23. On average, each year 900 men each year are likely to report informal care as their main form of provision. This is much less than the previous age group. Around 300 men are expected to report on average each year that the local authority is their main form of care provision. This is slightly higher than the previous age group. In line with the survey responses, no one is likely to report private care as their main source of care provision.

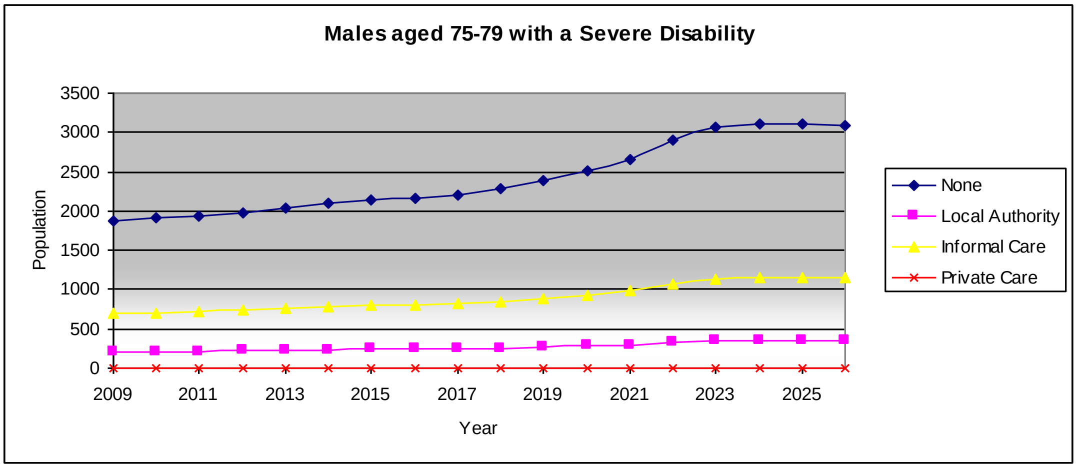

Figure A13.23: Care receipt for men aged 75-79 with severe disability

Disability projections for women aged 75-79

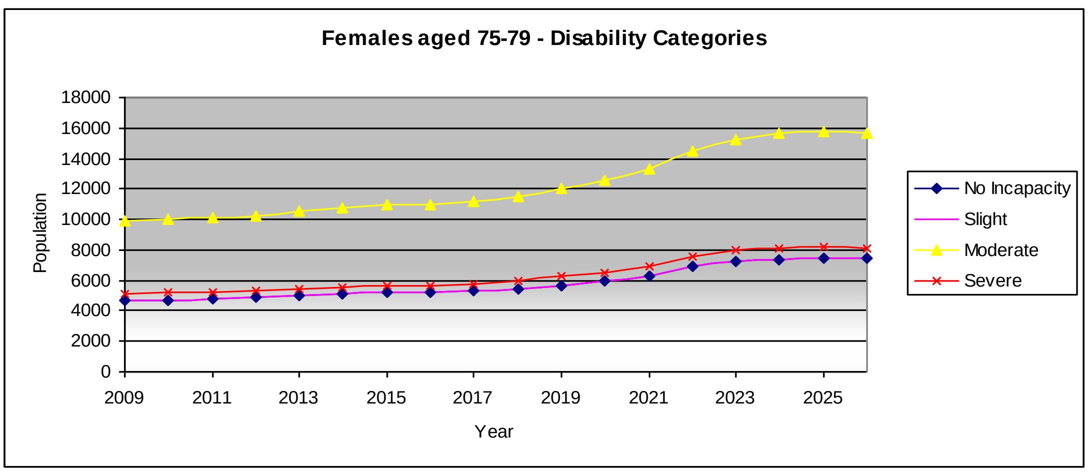

Figure A13.24: Women aged 75-79 by disability category

In comparison to the previous age group, those with a moderate disability are now the main disability category, as illustrated in Figure A13.24. Over the eighteen year period there is expected to be an increase of 58.13% in the number of women aged 75-79. Based on the survey results, the number of women with no incapacity and a slight disability are the same.

The number of elderly women over the period with no incapacity in 2009 is likely to be 4,700. In 2009, there are likely to be considerably fewer people with no incapacity in contrast to the preceding female age group. The number of women with no incapacity is likely to increase by 300 in 2013, 800 in 2018 and 2,700 in 2026 in comparison to 2009. The increase over the whole period is a slightly greater increase than the previous female age group. It is greater than the increase in the number of men aged 75-79 with no incapacity.

The number of women with some level of disability is likely to be 19,700 in 2009. There are likely to be 1,900 more people with a disability in the preceding age group. This is predicted to increase by 1,200 women in 2013, 3,200 women in 2018 and 11,500 women in 2026 in comparison to 2009. The increase over the whole period is considerably larger in comparison to women aged 70-74. The increase in the number of disabled people is greater for women aged 70-74 for the ten year projection. The increase is similar to the increase over the whole period for disabled men aged 75-79.

In 2009, there are likely to be 4,700 women with a slight disability, 9,900 with a moderate disability and 5,100 with a severe disability. The number of women with a slight or moderate disability is less than the women aged 70-74, but the number with a severe disability is greater. There are many more women with a severe disability in 2009 than men in the same age category. Over the eighteen year period, the number of women with a slight disability is set to increase by 2,700. The number of women with a moderate level of disability is set to increase by 5,700. Finally, those with a severe level of disability is likely to increase by 3,000. The increases in the number of women with a moderate or severe disability is greater in comparison to women aged 70-74. The increase in the number of women with a severe disability is greater than the number of men in the same age category.

Service rate projections for women aged 75-79

Those with no incapacity and a slight disability receive no care or support based on the results of the General Household Survey. For women who are classified as having a moderate disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 300 people on average each year in the period are expected to report informal care as their main care provision type.

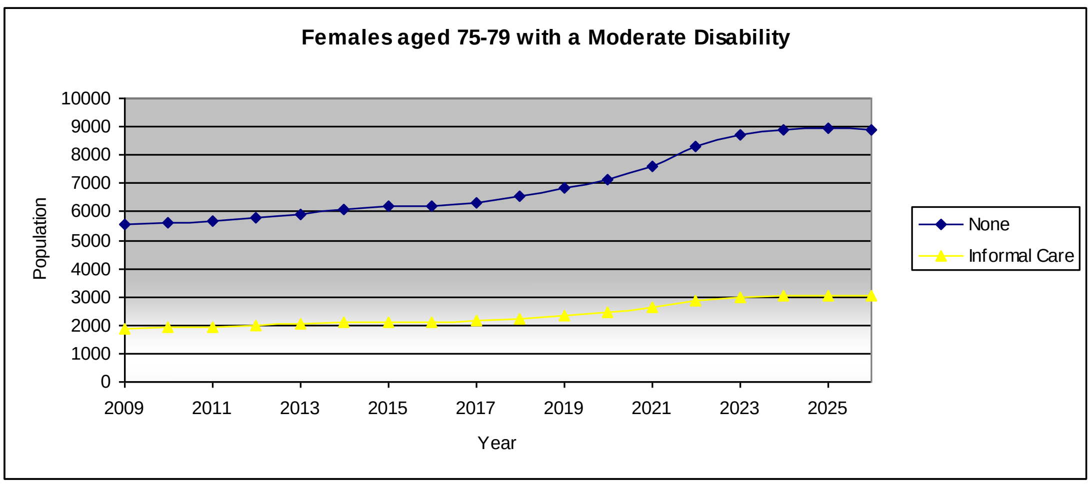

Figure A13.25: Care receipt for women aged 75-79 with moderate disability

Once again, the majority of women living in the household population with a severe disability will be able to get on with their lives without any care or support, as shown in Figure A13.26. On average, 1,500 women each year are likely to report informal care as their main form of provision. Around 300 women are expected to report on average each year that the local authority is their main form of care provision. 100 women are likely to report that the private sector is their main form of care provision.

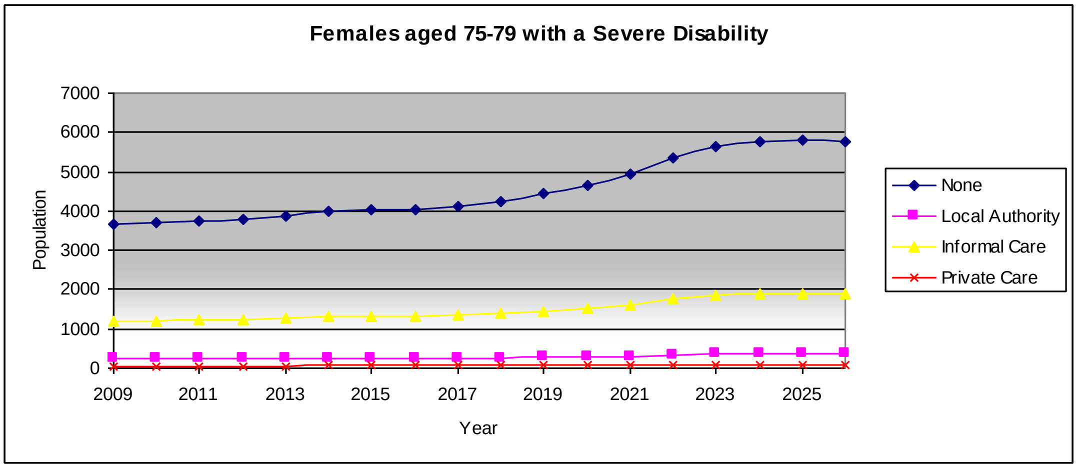

Figure A13.26: Care receipt for women aged 75-79 with severe disability

The next age group that will be explored are those who are aged 80-84.

Disability projections for all people aged 80-84

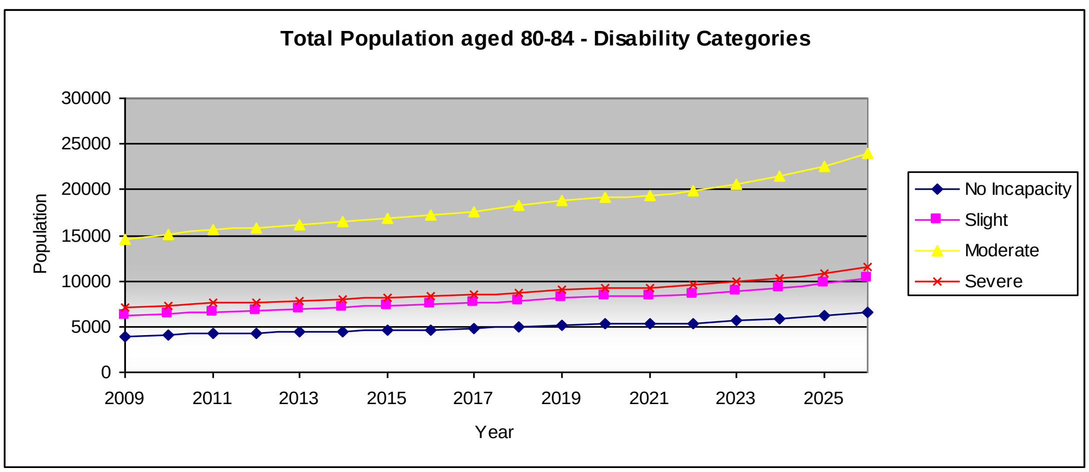

Figure A13.27: Total population aged 80-84 by disability category

The no incapacity disability group is the least populated group. The largest disability group by population size is once again those with a moderate disability. Over the eighteen year period there is expected to be an increase of 63.84% in the number of people aged 80-84, as shown in Figure A13.27. This is similar to the previous age group.

The number of elderly people over the period with no incapacity is expected to be 4,000 in 2009. This is likely to increase by 400 people in 2013, 1,000 people in 2018 and 2,600 in 2026 in comparison to 2009. The number of people with no incapacity is considerably fewer in comparison to those aged 75-79.

The number of people with some level of disability is likely to be 28,000 in 2009. There are considerably more disabled people in the proceeding age group in 2009. This is likely to increase by 3,000 in 2013, 7,000 in 2018 and 17,800 in 2026 in comparison to 2009. The majority of people aged 80-84 live with some sort of disability. The increase over the whole period is greater for those aged 75-79.

In 2009, there are likely to be 6,200 people with a slight disability, 14,600 with a moderate disability and 7,200 with a severe disability. There are considerably more people with a slight and moderate disability in the previous age group. Over the eighteen year period, the number of people with a slight disability is set to increase by 4,100 people. The number of people with a moderate level of disability is set to increase by 9,300. This is a very significant increase the number of people with a moderate disability. Finally, those with a severe level of disability is set to increase by 4,400. Whilst the increases are considerable over the eighteen year period, they are not as large as the previous age group.

Service rate projections for all people aged 80-84

Those with no incapacity and a slight disability are likely to receive no care or support based on the results of the General Household Survey. For people who are classified as having a moderate disability, the majority of them based on survey responses are likely to have no care or support as their main form of care provision. On average, 900 people each year in the period are likely to report informal care as their main provision type.

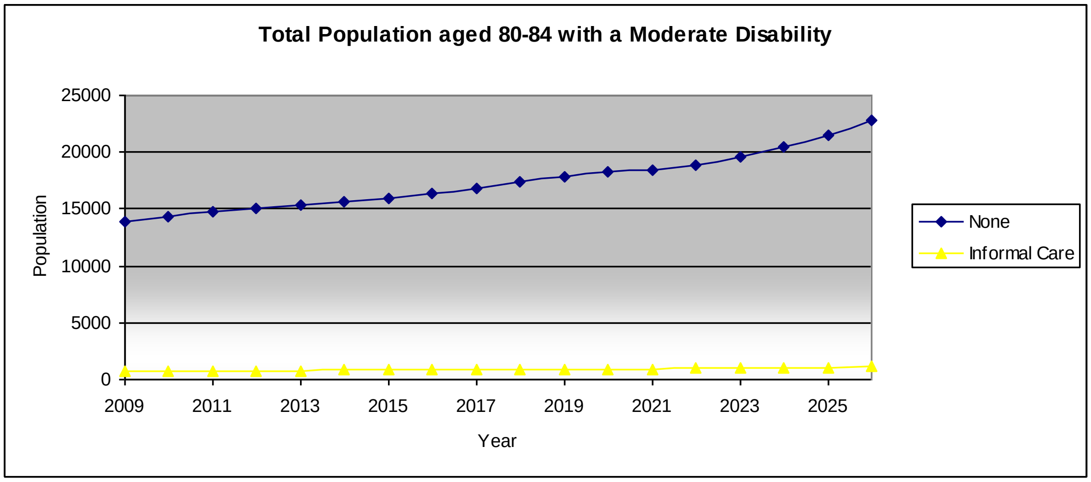

Figure A13.28: Care receipt for all people aged 80-84 with moderate disability

As illustrated in Figure A13.29, the majority of people living in the household population with a severe disability get on with their lives without any care or support. On average, 2,600 people each year are likely to report informal care as their main form of provision. Around 500 people are expected to report on average each year that the local authority is their main form of care provision. 300 people are likely to report that the private sector is their main form of care provision. This is a significant increase in comparison to the previous age group.

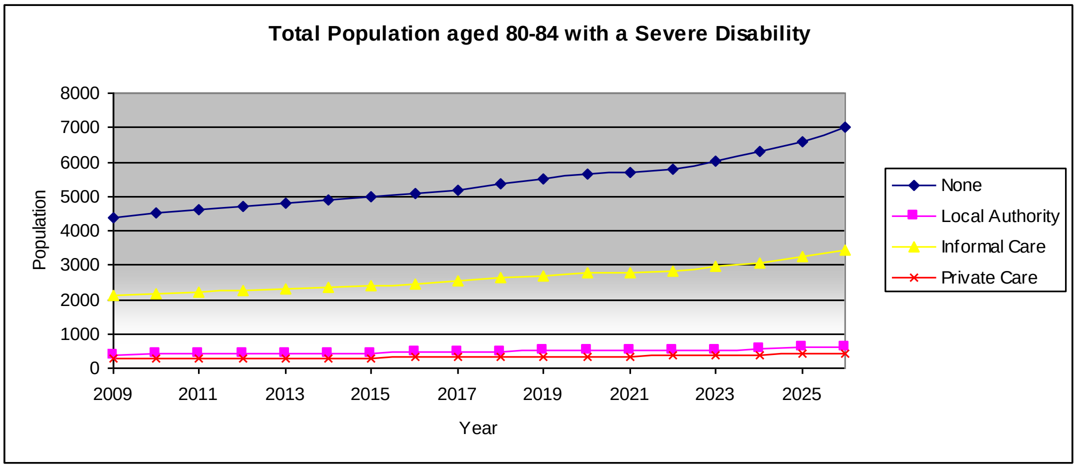

Figure A13.29: Care receipt for all people aged 80-84 with severe disability

A breakdown for the same age group by gender is now explored.

Disability projections for men aged 80-84

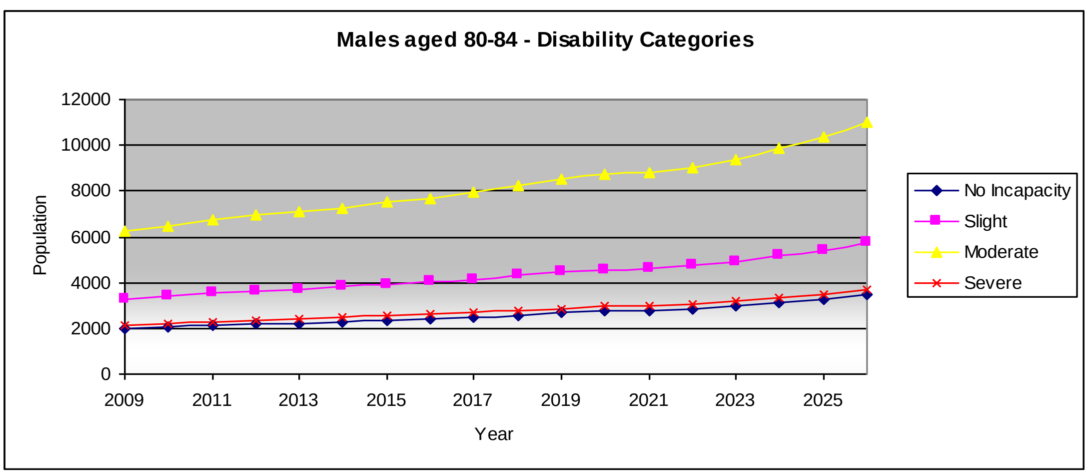

Figure A13.30: Men aged 80-84 by disability category

The moderate disability group is once again the main group. Over the eighteen year period there is expected to be an increase of 76.20% in the number of men aged 80-84.

The number of elderly men over the period with no incapacity in 2009 is likely to be 2,000. This is likely to increase by 300 in 2013, 600 in 2018 and 1,500 in 2026 in comparison to 2009. In contrast, there are more men with no incapacity aged 75-79 and this is expected to be the case throughout the whole period.

The number of men with some level of disability is expected to be 11,600 in 2009. There are likely to be more disabled men aged 75-79. The number of disabled men is likely to increase by 3,000 in 2013, 6,888 in 2018 and 8,900 in 2026 in comparison to 2009.

In 2009, there are likely to be 3,300 men with a slight disability, 6,200 with a moderate disability and 2,100 with a severe disability. These are less than the previous age group. Over the eighteen year period, the number of men with a slight disability is set to increase by 2,500. The number of men with a moderate level of disability is set to increase by 4,800. Finally, those with a severe level of disability are set to increase by 1,600.

Service rate projections for men aged 80-84

Those with no incapacity or no incapacity are likely to receive no care or support based on the results of the General Household Survey. For men who are classified as having a moderate disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 200 men each year in the period are likely to report informal care as their main care provision type.

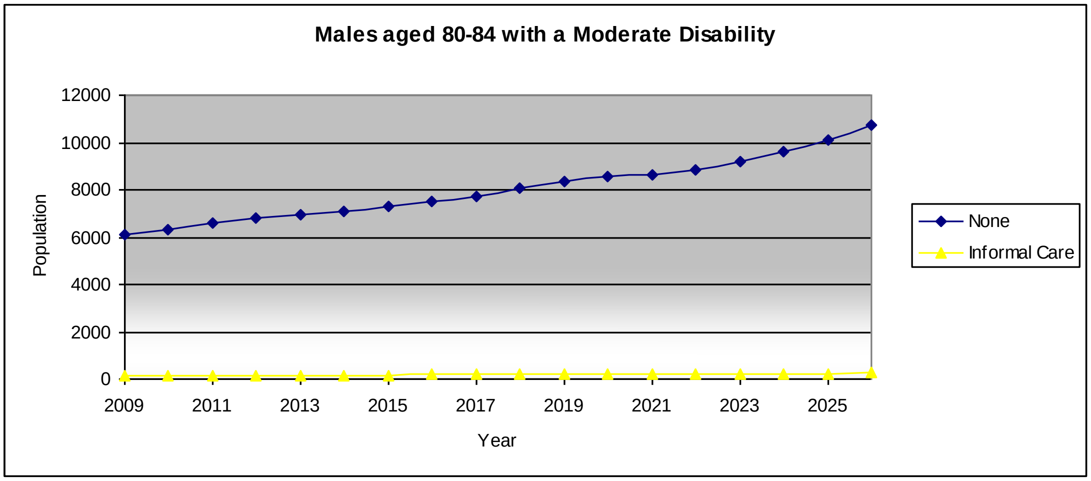

Figure A13.31: Care receipt for men aged 80-84 with moderate disability

Many men living in the household population with a severe disability get on with their lives without any care or support, as demonstrated in Figure A13.32. On average each year, 1,100 men are likely to report informal care as their main form of provision. Around 100 men are expected to report on average each year that the local authority is their main form of care provision. The same number of men is likely to report private care as their main source of care provision.

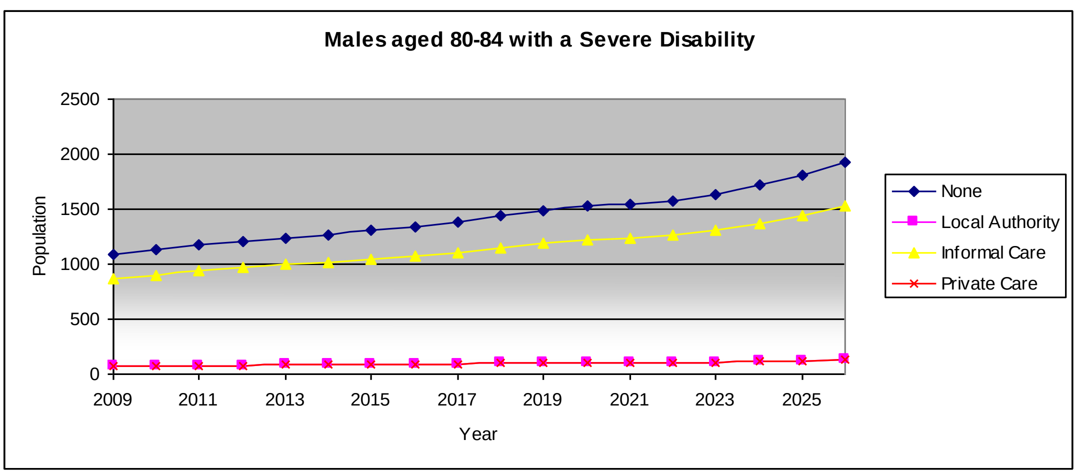

Figure A13.32: Care receipt for men aged 80-84 with severe disability

Disability projections for women aged 80-84

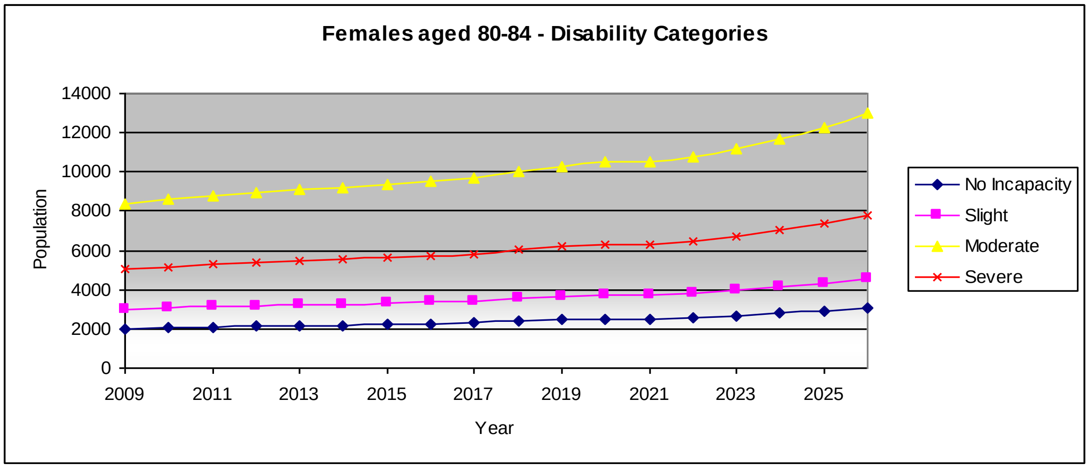

Figure A13.33: Women aged 80-84 by disability category

The moderate disability group is once again the main disability category. Over the eighteen year period there is expected to be an increase of 54.70% in the number of women aged 80-84.

The number of elderly women over the period with no incapacity in 2009 is likely to be 2,000. This is likely to increase by 200 women in 2013, 400 women in 2018 and 1,100 women in 2026 in comparison to 2009. These projections are very similar to men in the same age group. There are significantly more women with no incapacity in the preceding female age group.

The number of women with some level of disability is expected to be 16,400 in 2009. There are many more disabled women in contrast to men in the same group but less than the previous female age group. This is likely to increase by 1,400 in 2013, 3,200 in 2018 and 9,000 in 2026 in comparison to 2009.

In 2009, there are likely to be 3,000 women with a slight disability, 8,400 with a moderate disability and 5,000 with a severe disability. This is less than the numbers in previous age group. Whilst there are more men with a moderate disability in 2009, there are significantly more women with a severe disability. Over the eighteen year period, the number of people with a slight disability is set to increase by 1,600 people. The number of women with a moderate level of disability is set to increase by 4,600. Finally, those with a severe level of disability is set to increase by 2,800. The increases over the eighteen year period are less than those of the previous female age group. The increase in the number of women with a severe disability is greater than the number of men in the same age group.

Service rate projections for women aged 80-84

Those with no incapacity or a slight disability are likely to receive no care or support based on the results of the General Household Survey. For women who are classified as having a moderate disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 700 women on average each year in the period are likely to report informal care as their main provision care type.

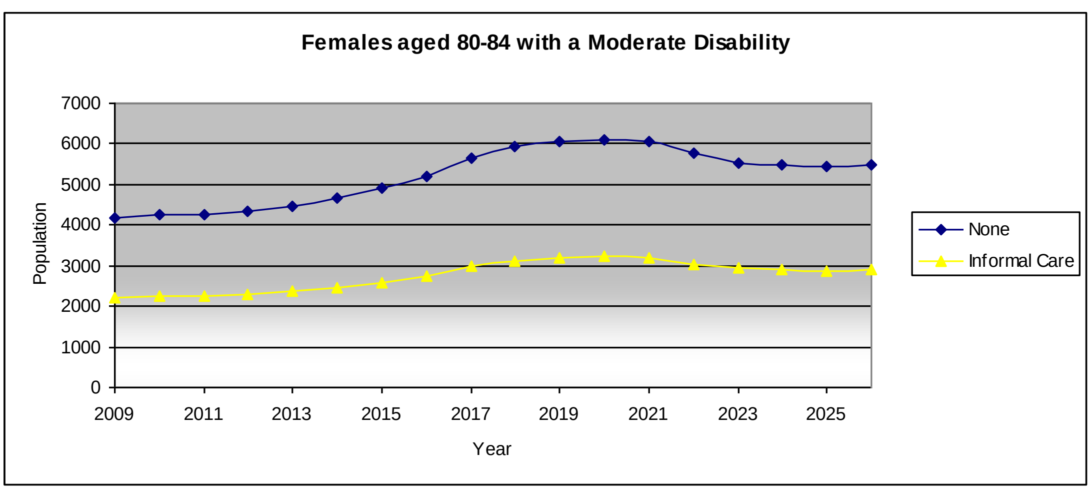

Figure A13.34: Care receipt for women aged 80-84 with moderate disability

Once again, the majority of women living in the household population with a severe disability will be able to get on with their lives without any care or support, as shown in Figure A13.35. On average, 1,500 women each year are likely to report informal care as their main form of provision. Around 400 women are expected to report on average each year that the local authority is their main form of care provision. 200 women are likely to report that the private sector is their main form of care provision.

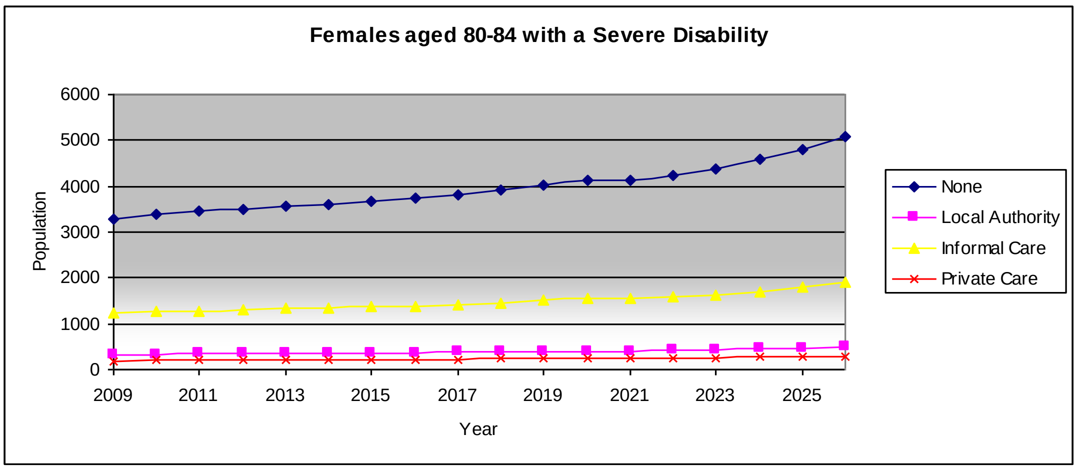

Figure A13.35: Care receipt for women aged 80-84 with severe disability

The final age group that will be explored are people aged 85 and over.

Disability projections for all people aged 85 and over

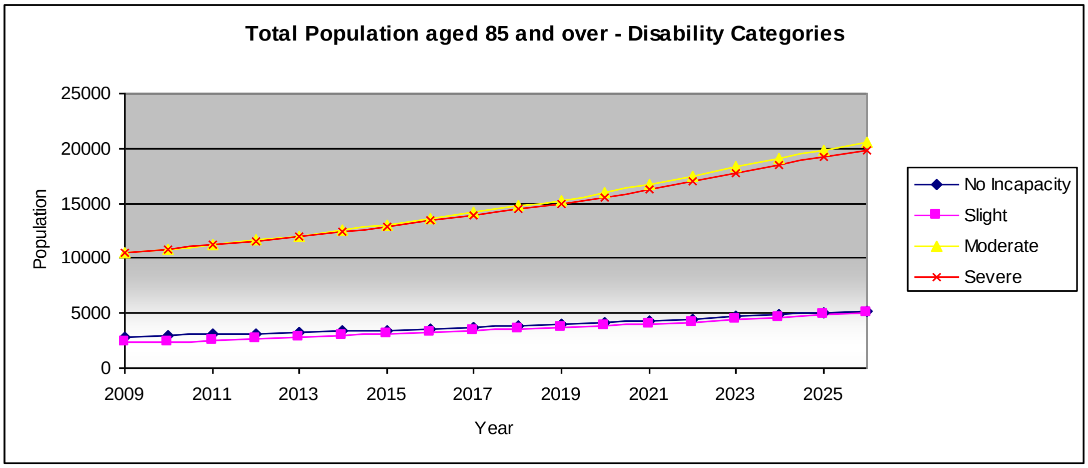

Figure A13.36: Total population aged ≥85 by disability category

As illustrated in Figure A13.36, the largest two disability categories are those with a moderate and severe disability. Over the eighteen year period, there is expected to be an increase of 92.93% in the number of people aged 85 and over.

The number of elderly people with no incapacity in 2009 is likely to be 2,900. This is likely to increase by 400 people in 2013, 1000 people in 2018 and 2,400 in 2026 in comparison to 2009. These results are very similar to those aged 80-84.

The number of people with some level of disability is likely to be 23,300 people in 2009. This is likely to increase by 3,500 people in 2013, 9,300 people in 2018 and 22,000 in 2026 in comparison to 2009. There are more disabled people in 2009 but the increase over the whole period is greater for those aged 85 and over.

In 2009, there are likely to be 2,300 people with a slight disability, 10,500 with a moderate disability and 10,600 with a severe disability. There are significantly more people with a severe disability than the previous age group. Over the whole period, the number of people with a slight disability is set to increase by 2,700. The number of people with a moderate level of disability is set to increase by 10,000. This is a very significant increase in the number of people with a moderate disability. Finally, those with a severe level of disability is set to increase by 9,300. The increase in the number of people with a severe disability is much greater for those aged 85 and over in contrast to those aged 80-84.

Service rate projections for all people aged 85 and over

Those with no incapacity and a slight disability are likely to receive no care or support based on the results of the General Household Survey. For those people who are classified as having a moderate disability, the majority of people based on survey responses are likely to have no care or support as their main form of care provision. On average, 700 people each year in the period are likely to report informal care as their main provision type. A further 100 people are likely to report the local authority as their main source of care provision.

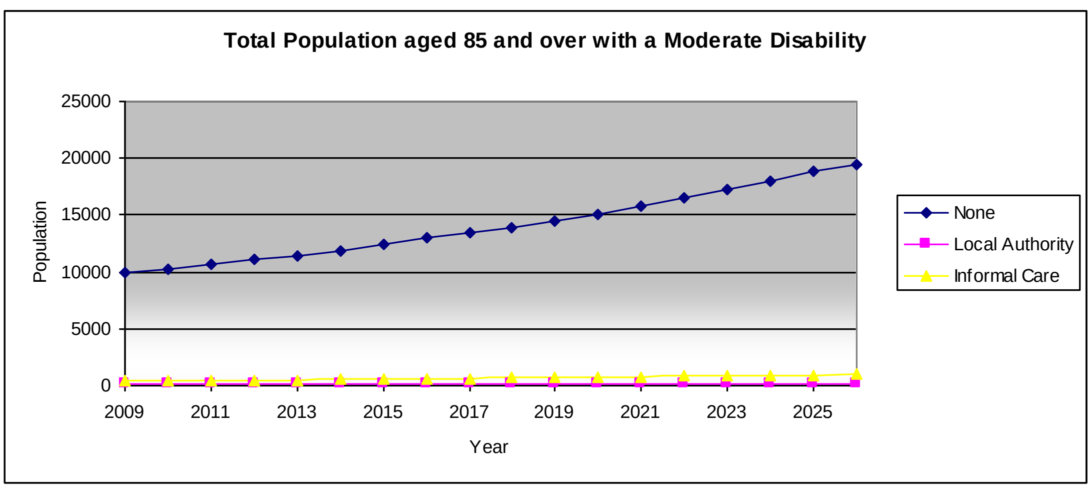

Figure A13.37: Care receipt for all people aged ≥85 with moderate disability

As demonstrated in Figure A13.38, once again, the majority of people living in the household population with a severe disability get on with their lives without any care or support. On average, 2,600 people each year are likely to report informal care as their main form of provision. Around 2,200 people are expected to report on average each year that the local authority is their main form of care provision. 1,400 people are likely to report that the private sector is their main form of care provision. This is a significant increase in comparison to the previous age group.

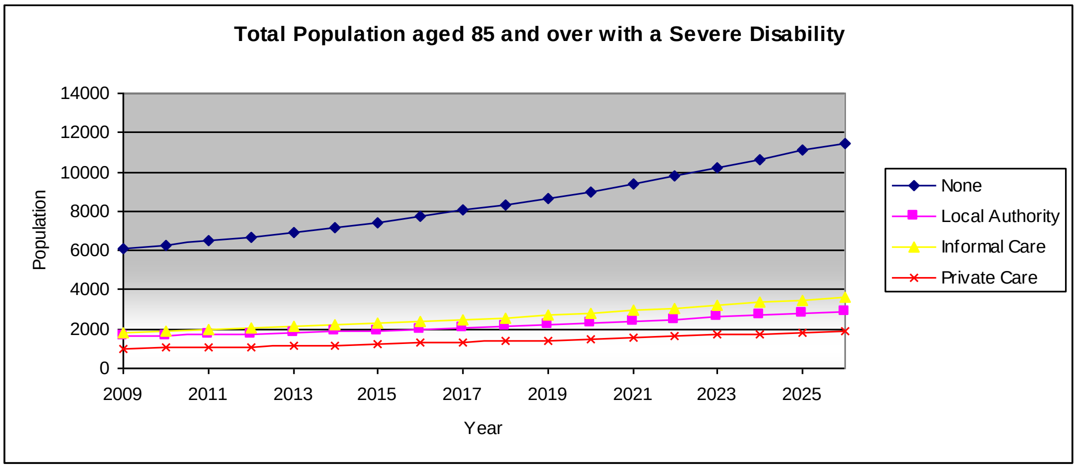

Figure A13.38: Care receipt for all people aged ≥85 with severe disability

A breakdown for the same age group by gender is now explored.

Disability projections for men aged 85 and over

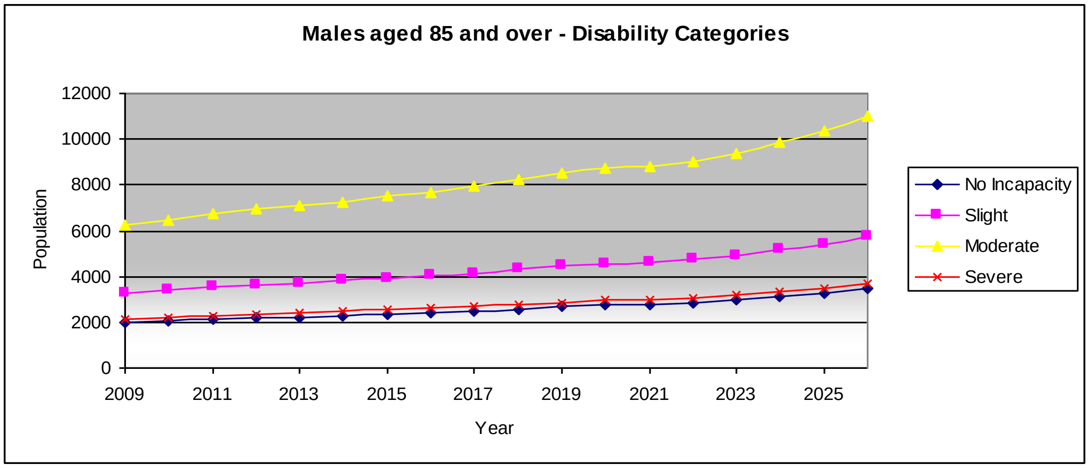

Figure A13.39: Men aged 85 and over by disability category

As shown in Figure A13.39, the moderate disability group is once again the main group. Over the eighteen year period there is expected to be an increase of 138.11% in the number of men aged 85 and over.

The number of elderly men over the period with no incapacity is likely to be 600 in 2009. This is likely to increase by 100 men in 2013, 400 men in 2018 and 900 men in 2026 in comparison to 2009. There are not many men with any disability for those aged 85 and over.

The number of men with some level of disability is likely to be 8,900 in 2009. This is likely to increase by 3,500 in 2013, 9,300 in 2018 and 12,200 in 2026 in comparison to 2009. The increases are greater than the previous male age group.

In 2009, there are likely to be 1,500 men with a slight disability, 4,200 with a moderate disability and 3,100 with a severe disability. It is projected that there are likely to be more men with a severe disability in comparison to the previous age group. Over the eighteen year period, the number of men with a slight disability is set to increase by 2,100. The number of men with a moderate level of disability is set to increase by 5,900. Finally, those with a severe level of disability are set to increase by 4,300. The increases in the number of men with a moderate and severe disability are much greater than the previous age group.

Service rate projections for men aged 85 and over

Those with no incapacity or a slight disability are likely to receive no care or support based on the results of the General Household Survey. For men who are classified as having a moderate disability, the majority of them based on survey responses are likely to have no care or support as their main form of care provision. On average, 700 men each year in the period are expected to report informal care as their main source of care provision.

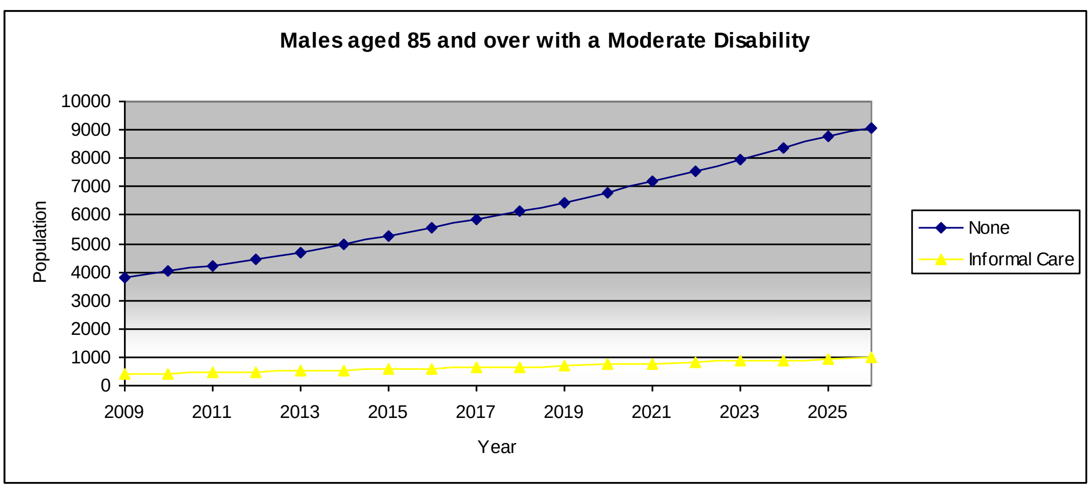

Figure A13.40: Care receipt for men aged ≥85 with moderate disability

As shown in Figure A13.41, many men living in the household population with a severe disability get on with their lives without any care or support. On average, each year 1,200 men are likely to report informal care as their main form of provision. Around 500 men are expected to report on average each year that the local authority is their main form of care provision. The same number of men is likely to report private care as their main source of care provision.

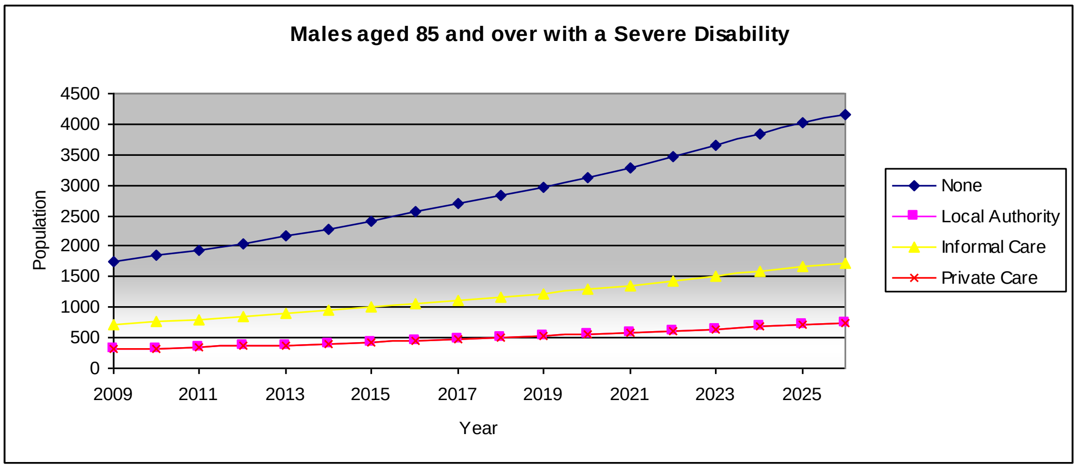

Figure A13.41: Care receipt for men aged ≥85 with severe disability

Disability projections for women aged 85 and over

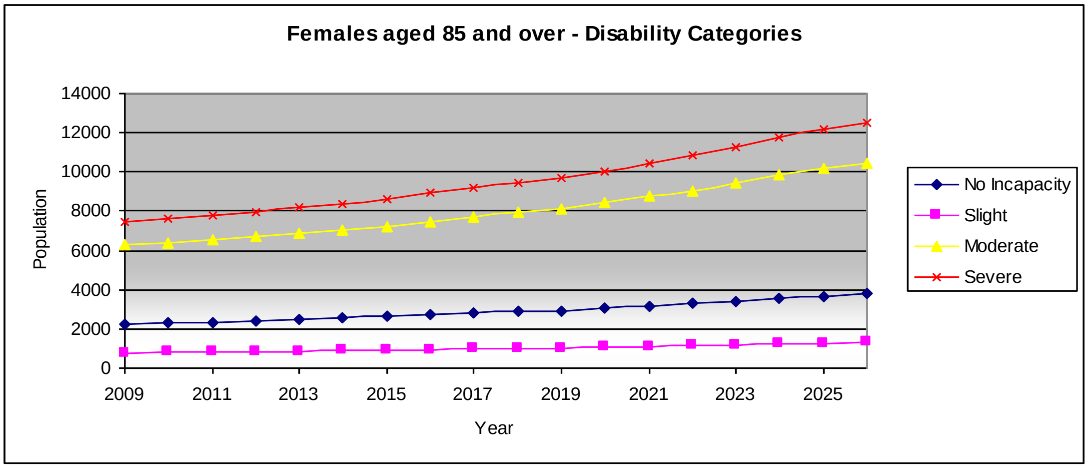

Figure A13.42: Women aged 85 and over by disability category

As shown in Figure A13.42, the severe disability group is now the most populous disability group. Over the eighteen year period, there is expected to be an increase of 67.46% in the number of women aged 85 and over.

The number of elderly women over the period with no incapacity is likely to be 2,300 in 2009. This is predicted to increase by 200 women in 2013, 600 women in 2018 and 1,500 women in 2026 in comparison to 2009. There are actually more women in 2009 with no incapacity in contrast to the previous age group. The rates of increase are greater for women aged 85 and over. There are many more women with no incapacity when compared to men in the same age category.

The number of women with some level of disability is expected to be 14,500 in 2009. This is much greater than the number of men with a disability in the same age group. This is likely to increase by 1,400 in 2013, 3,900 in 2018 and 10,000 in 2026 in comparison to 2009. There are more disabled women aged 80-84 in 2009 but the anticipated change over the whole period is greater for women aged 85 and over.

In 2009, there are likely to be 800 women with a slight disability, 6,300 with a moderate disability and 7,500 with a severe disability. The number of women with a severe disability is considerably higher than the previous age group and the number of men in the same age group. There are also significantly more women with a moderate disability than men in the same age group in 2009. Over the eighteen year period, the number of women with a slight disability is predicted to increase by 500. The number of women with a moderate level of disability is predicted to increase by 4,200. Finally, those with a severe level of disability is predicted to increase by 5,000. In comparison to men in the same age group, the rates of increase are considerably less for the moderate disability category but are higher for those with a severe disability.

Service rate projections for women aged 85 and over

Women with no incapacity or a slight disability are likely to receive no care or support based on the results of the General Household Survey. For women who are classified as having a moderate disability, the majority based on survey responses are likely to have no care or support as their main form of care provision. On average, 100 women on average each year in the period are likely to report local authority care as their main care provision type.

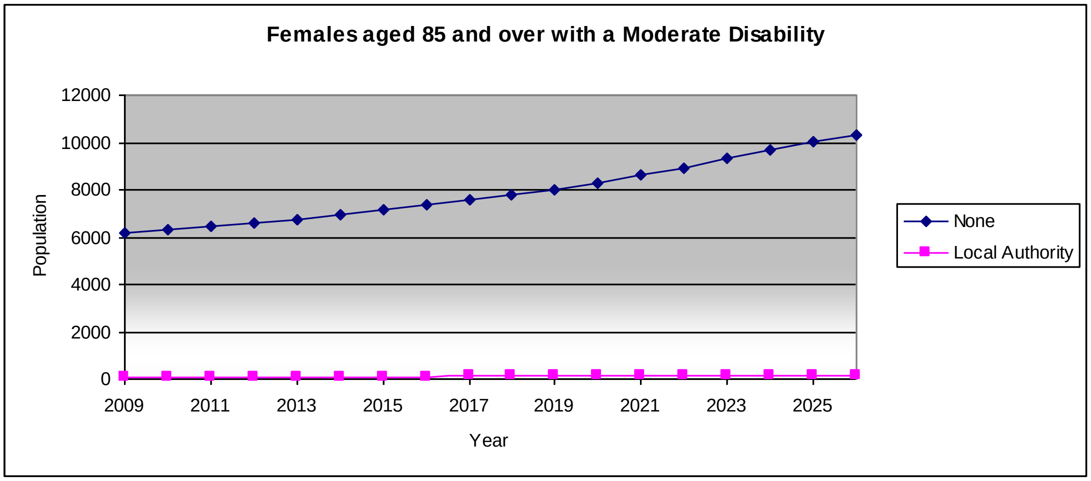

Figure A13.43: Care receipt for women aged ≥85 with moderate disability

As demonstrated in Figure A13.44, once again, the majority of women living in the household population with a severe disability will be able to get on with their lives without any care or support. On average, each 1,400 women each year are likely to report informal care as their main form of provision. Around 1,700 women are expected to report on average each year that the local authority is their main form of care provision. 900 women are likely to report that the private sector is their main form of care provision.

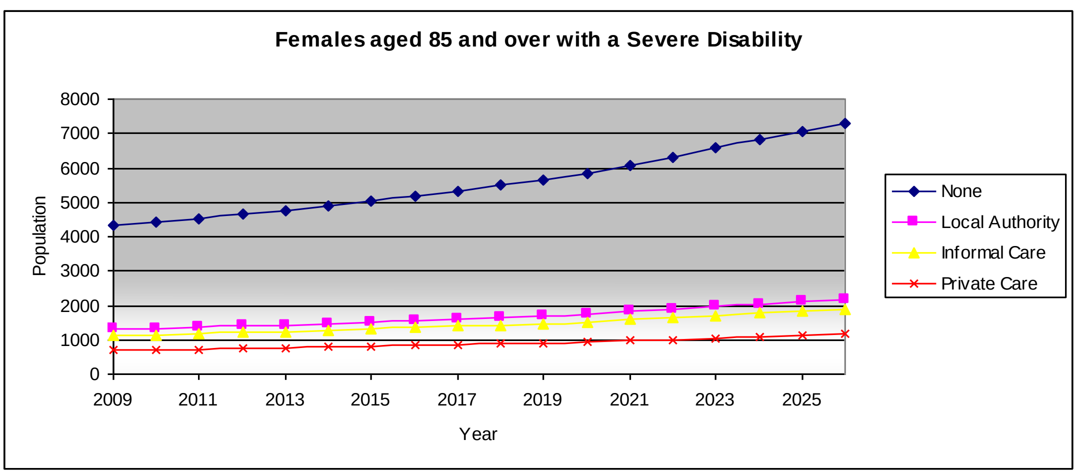

Figure A13.44: Care receipt for women aged ≥85 with severe disability

Appendix A14 Service Rate Projections by Gender

Total male population service rate projections

Elderly men who are classified as having no incapacity receive no care or support based on the results of the General Household Survey as shown in Figure A14.1.

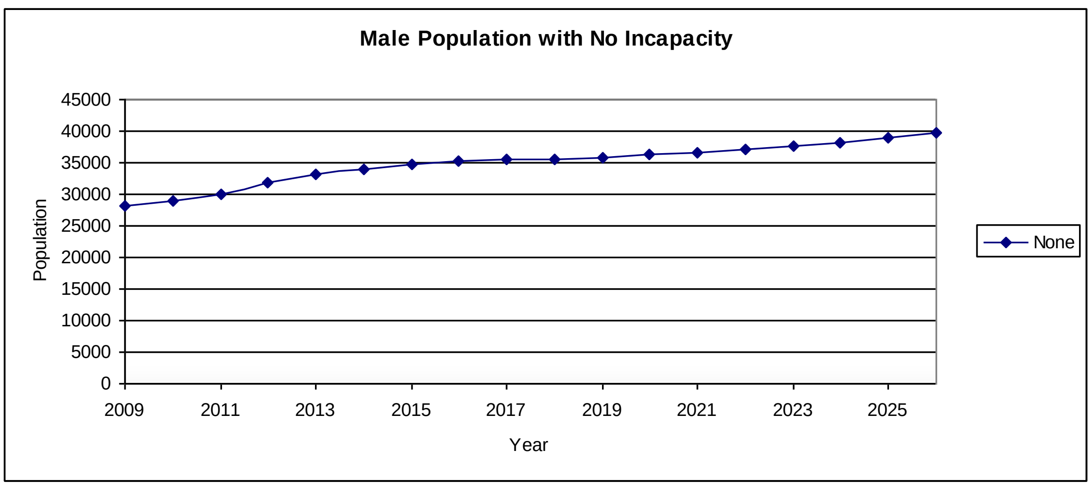

Figure A14.1: Care receipt for all men with no incapacity

The majority of elderly men who are classified as having a slight disability are predicted to receive no care or support as shown in Figure A4.2. A small number of people are predicted to report informal care as their main care provision.

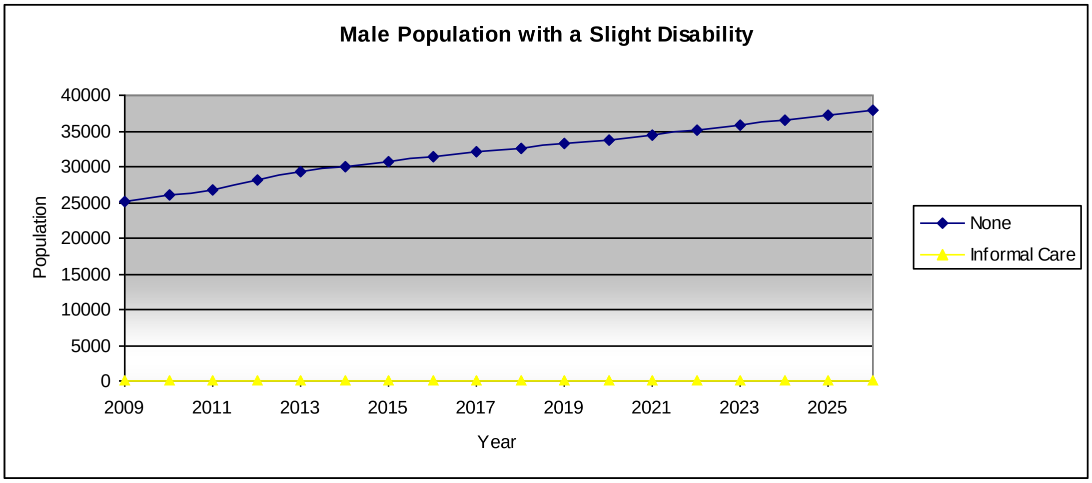

Figure A14.2: Care receipt for all men with slight disability

Once again, the majority of men who are classified as having a moderate disability receive no care or support as shown in Figure A14.3. A small number of people are predicted to report informal care as their main care provision.

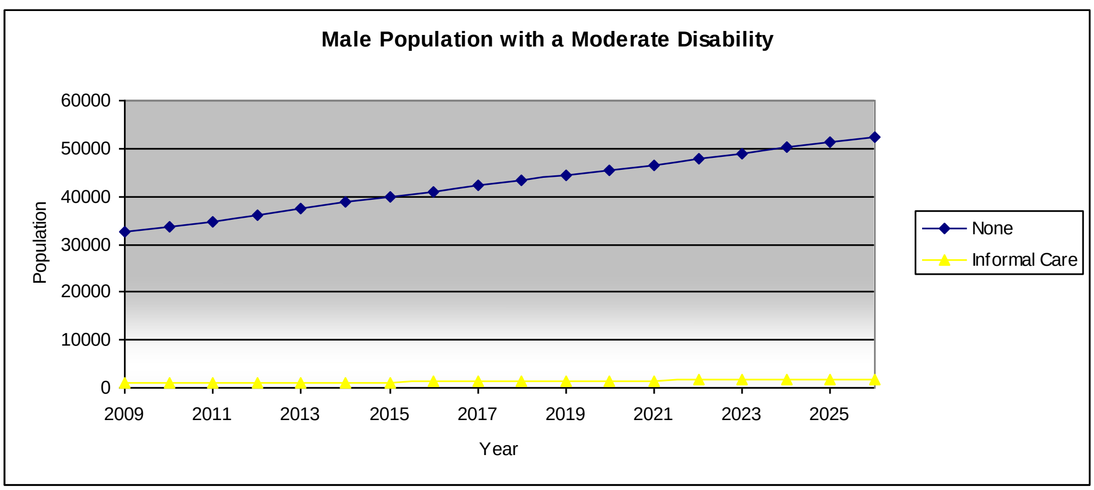

Figure A14.3: Care receipt for all men with moderate disability

As demonstrated in Figure A14.4, the majority of elderly men who are predicted to have a severe disability report are expected to receive no care or support. On average each year

10,500 people are predicted to receive no care or support. On average each year 900 people are predicted to receive local authority care as their main source of care provision. On average each year 4,900 people are predicted to receive informal care as their main source of care provision. Finally, on average each year 700 people are predicted to receive private care as their main source of care provision.

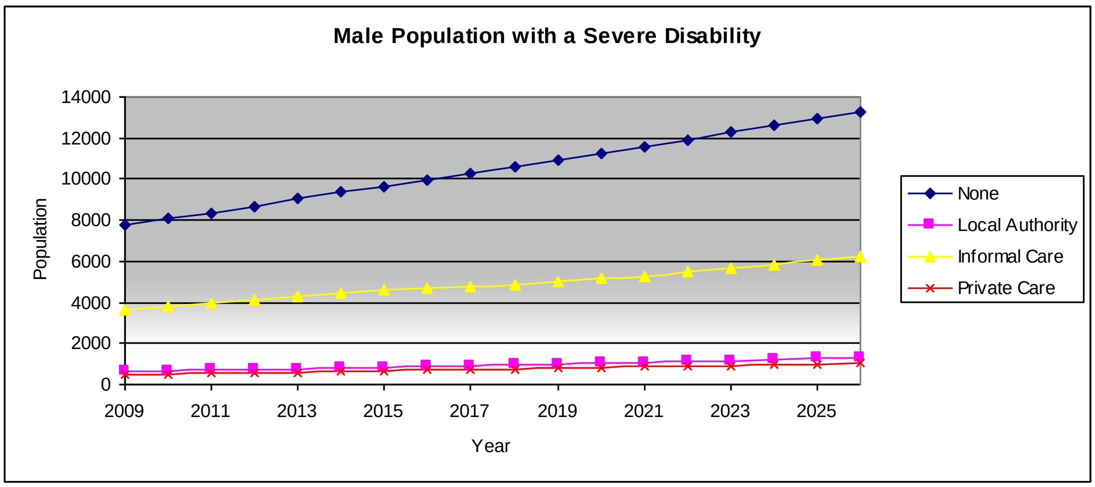

Figure A14.4: Care receipt for all men with severe disability

Total female population service rate projections

Elderly women who are classified as having no incapacity receive no care or support based on the results of the General Household Survey as shown in Figure A14.5.

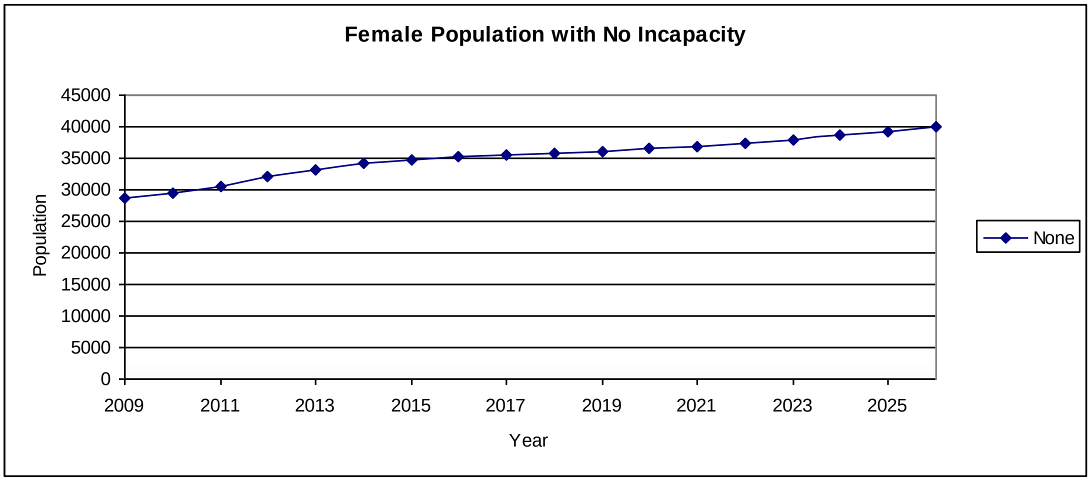

Figure A14.5: Care receipt for all women with no incapacity

Elderly women who are classified as having a slight disability receive no care or support as shown in Figure A14.6.

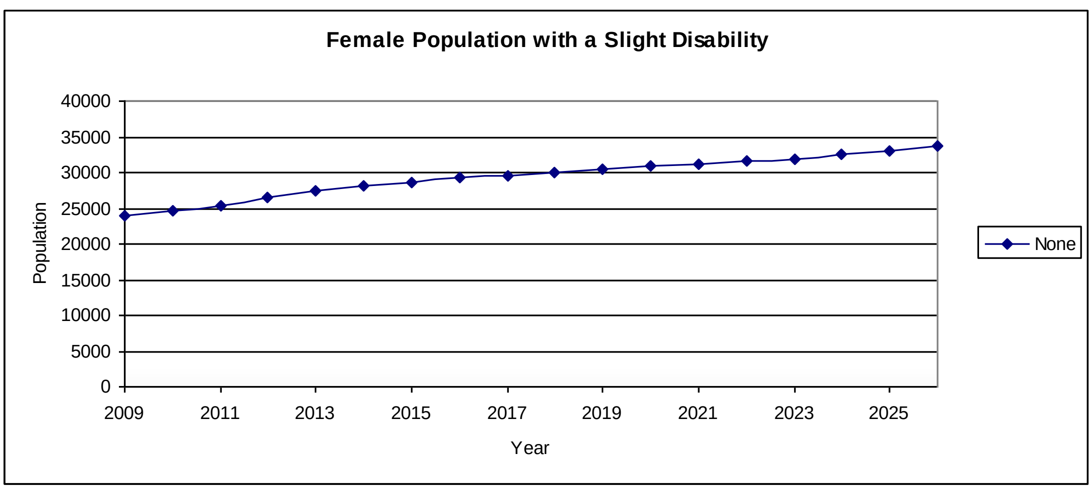

Figure A14.6: Care receipt for all women with slight disability

Once again, the majority of elderly women who are classified as having a moderate disability receive no care or support as illustrated in Figure A14.7. A small number of people are predicted to report informal care or local authority care as their main care provision.

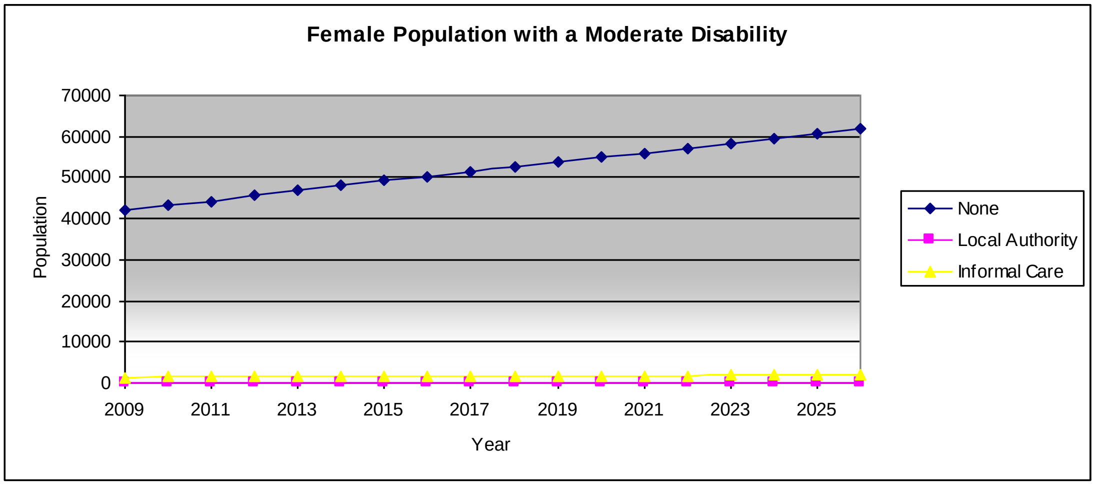

Figure A14.7: Care receipt for all women with moderate disability

As illustrated in Figure A14.8, the majority of elderly women who are predicted to have a severe disability report are expected to receive no care or support. On average each year 19,300 women are predicted to receive no care or support. On average each year 2,600 women are predicted to receive local authority care as their main source of care provision. On average each year 7,600 women are predicted to receive informal care as their main source of care provision. Finally, on average each year 1,300 women are predicted to receive private care as their main source of care provision.

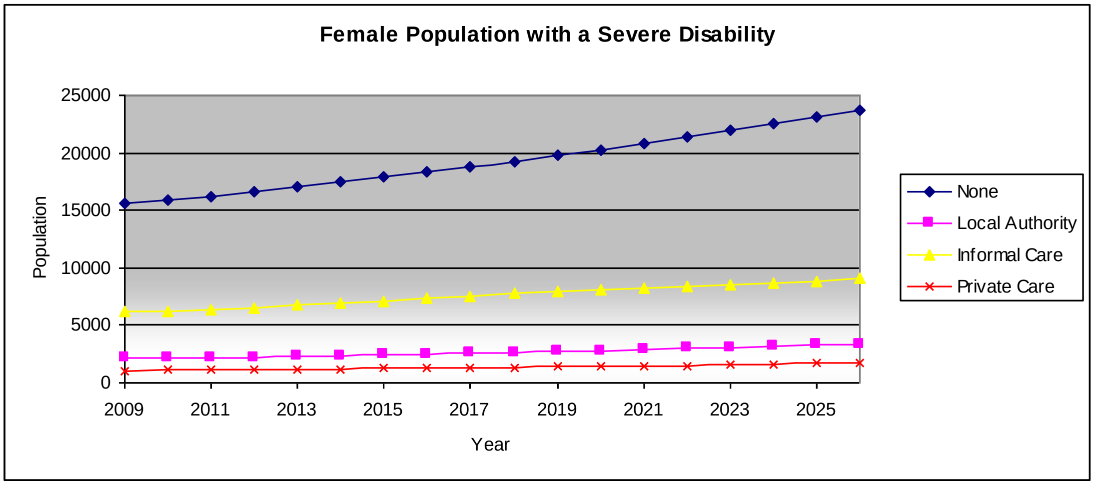

Figure A14.8: Care receipt for all women with severe disability

Appendix A15 Scenario 2 Results by Gender

Percentage Change	Age Group	Disability Category	Population in 2009	Population Change by Year		
				2013	2018	2026
0%	65-69	Moderate	6,500	1,800	1,000	2,100
1%	65-69	Moderate	6,800	1,900	1,100	2,200
2%	65-69	Moderate	7,100	1,900	1,100	2,300
0%	65-69	Severe	2,300	600	400	700
1%	65-69	Severe	2,000	500	300	600
2%	65-69	Severe	1,700	500	300	500
0%	70-74	Moderate	8,400	600	3,600	2,600
1%	70-74	Moderate	8,600	600	3,700	2,700
2%	70-74	Moderate	8,900	600	3,800	2,800
0%	70-74	Severe	2,300	200	1,000	700
1%	70-74	Severe	2,100	200	900	600
2%	70-74	Severe	1,800	100	800	600
0%	75-79	Moderate	8,300	800	1,800	5,400
1%	75-79	Moderate	8,500	800	1,900	5,600
2%	75-79	Moderate	8,700	800	1,900	5,700
0%	75-79	Severe	2,800	300	600	1,800
1%	75-79	Severe	2,600	200	600	1,700
2%	75-79	Severe	2,400	200	500	1,500
0%	80-84	Moderate	6,200	900	2,000	4,800
1%	80-84	Moderate	6,400	900	2,000	4,900
2%	80-84	Moderate	6,500	900	2,100	5,000
0%	80-84	Severe	2,100	300	700	1,600
1%	80-84	Severe	2,000	300	600	1,500
2%	80-84	Severe	1,800	300	600	1,400
0%	85+	Moderate	4,200	1,000	2,600	5,800
1%	85+	Moderate	4,300	1,000	2,700	5,900
2%	85+	Moderate	4,400	1,000	2,700	6,100
0%	85+	Severe	3,100	700	1,900	4,300
1%	85+	Severe	3,000	700	1,800	4,100
2%	85+	Severe	2,900	700	1,800	4,000

Table A15.1: Scenario 2 Hampshire Male Population split by moderate and severe disability

Percentage Change	Age Group	Disability Category	Population in 2009	Population Change by Year		
				2013	2018	2026
0%	65-69	Moderate	9,100	2,400	1,700	2,800
1%	65-69	Moderate	9,400	2,500	1,700	2,900
2%	65-69	Moderate	9,700	2,600	1,800	3,000
0%	70-74	Moderate	10,200	600	4,200	3,100
1%	70-74	Moderate	10,500	700	4,300	3,200
2%	70-74	Moderate	10,700	700	4,400	3,200
0%	75-79	Moderate	9,900	600	1,600	5,700
1%	75-79	Moderate	10,100	600	1,700	5,900
2%	75-79	Moderate	10,400	700	1,700	6,000
0%	80-84	Moderate	8,400	700	1,600	4,600
1%	80-84	Moderate	8,600	700	1,700	4,700
2%	80-84	Moderate	8,700	700	1,700	4,800
0%	85+	Moderate	6,300	600	1,700	4,200
1%	85+	Moderate	6,400	600	1,700	4,300
2%	85+	Moderate	6,600	600	1,800	4,400
0%	65-69	Severe	2,700	700	500	800
1%	65-69	Severe	2,400	600	400	700
2%	65-69	Severe	2,100	600	400	600
0%	70-74	Severe	4,500	300	1,800	1,400
1%	70-74	Severe	4,200	300	1,700	1,300
2%	70-74	Severe	3,900	200	1,600	1,200
0%	75-79	Severe	5,100	300	800	3,000
1%	75-79	Severe	4,900	300	800	2,800
2%	75-79	Severe	4,700	300	800	2,700
0%	80-84	Severe	5,000	400	1,000	2,800
1%	80-84	Severe	4,800	400	900	2,700
2%	80-84	Severe	4,700	400	900	2,500
0%	85+	Severe	7,500	700	2,000	5,000
1%	85+	Severe	7,300	700	1,900	4,900
2%	85+	Severe	7,100	700	1,900	4,800

Table A15.2: Scenario 2 Hampshire Female Population split by moderate and severe disability

Appendix A16 Local Authority Care Projections by Gender

The following are results broken down by gender.

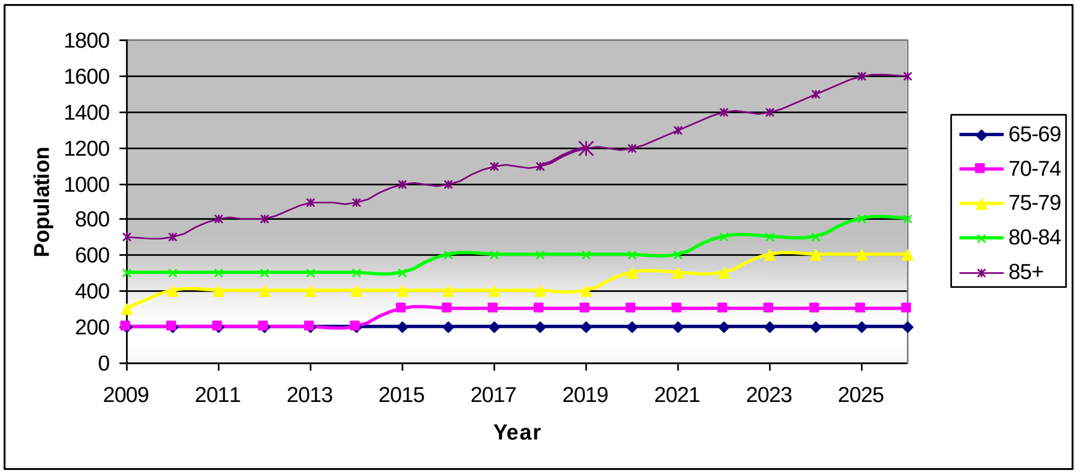

Figure A16.1: Hampshire local authority care projections (men)

Over the whole period, the number of men receiving formal care services in the home and community is predicted to increase by 1,600. This is equivalent to an 84% increase. This is greater than the increase in the total population. It is predicted that in 2013, the number of men is predicted to increase by 300 and in 2018 years by 700. These results are now explored by age group.

For people aged 65-69, the projected increase in absolute numbers is predicted to increase by a very small number over the projection period. For people aged 70-74, the increase over the projection period is once again very small, with an increase of only 100 men.

For people aged 75-79, the increase is greater, over the projection period the number of men is predicted to increase by 300 men. In percentage terms, this equates to a predicted increase of 33% in 2013, 33% in ten 2018 and 100% over the whole period. This is greater than the predicted increase in the total population.

For people aged 80-84, the increase is once greater than the previous group, over the projection period the number of men is predicted to increase by 300 men. In percentage terms, this equates to a predicted increase of 0% in 2013, 20% in 2018 and 60% over the whole period.

The greatest changes in both absolute and percentage terms are predicted to be experienced by people ages 85 and over. Over the projection period the number of men is predicted to increase by 900. In percentage terms, this equates to a predicted increase of 29% in 2013, 57% in 2018 and 129% over the whole period. This is considerably greater than the predicted increase in the total population.

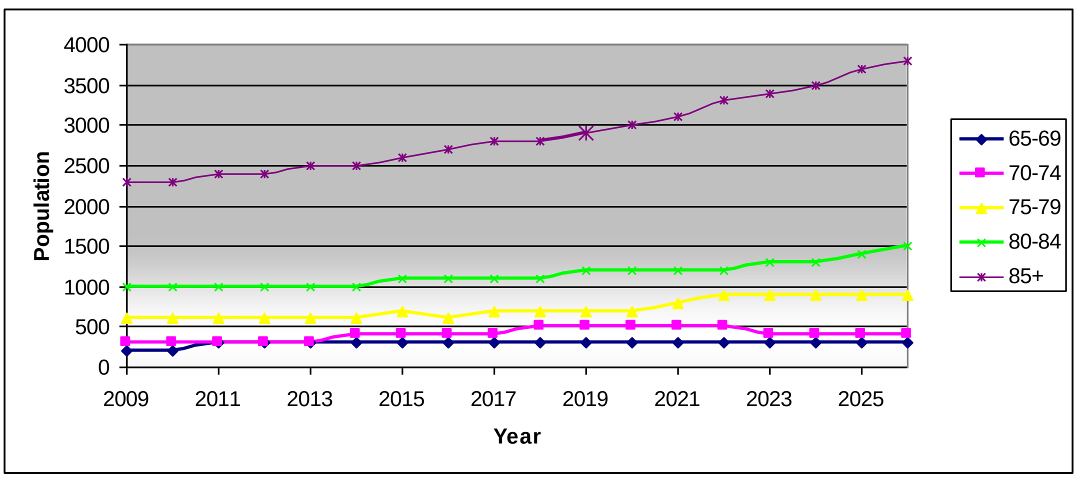

Figure A16.2: Hampshire local authority care projections (women)

Over the whole period, the number of women receiving formal care services in the home and community is predicted to increase by 2,500. This is equivalent to a 57% increase. The increase is greater in absolute terms in comparison to the male population but is less in percentage terms. It is predicted that in 2013, the number of women is predicted to increase by 300 women and in 2018 by 1000. These results are now explored by age group.

For people aged 65-69, the projected increase in absolute numbers is predicted to increase by only 100 women over the projection period. For people aged 70-74, the increase over the projection period is once again very small, with an increase of only 100 women. This is the same as the changes predicted in the male population.

For people aged 75-79, the increase is greater, over the projection period the number of women is predicted to increase by 300. This is the same as the changes predicted in the male population. However, there are differences in percentage terms, this equates to a predicted increase of 0% in 2013, 17% in 2018 and 50% over the whole period. This is less than the predicted increase in the total population and much less than the change in the male population over the whole period.

For people aged 80-84, the increase is once again greater than the previous group, over the projection period the number of women is predicted to increase by 500. In percentage terms, this equates to a predicted increase of 0% in 2013, 10% in 2018 and 50% over the whole period.

The greatest changes in both absolute and percentage terms are predicted to be experienced by people ages 85 and over. Over the projection period the number of women is predicted to increase by 1,500. This is considerably larger than the increase in the number of men. In percentage terms, this equates to a predicted increase of 9% in 2013, 22% in 2013 and 65% over the whole period. The percentage increases are less than the predicted increase in male population.

It has been shown that in both absolute and percentage terms there are differences between the genders within each age group both in the short- and long-term. The Local Authority will need to take this account when planning future services as it is quite likely that the services require by the two genders could differ. The gender differences can be explored at the district level in the cell-based model.

Appendix A17 Hybrid Results

The predicted results of hybrid model experiments are discussed in this section.

Experiment one: Impact on performance with no feedback in 2010

The first experiment explores the impact of natural increases in call arrivals on performance.

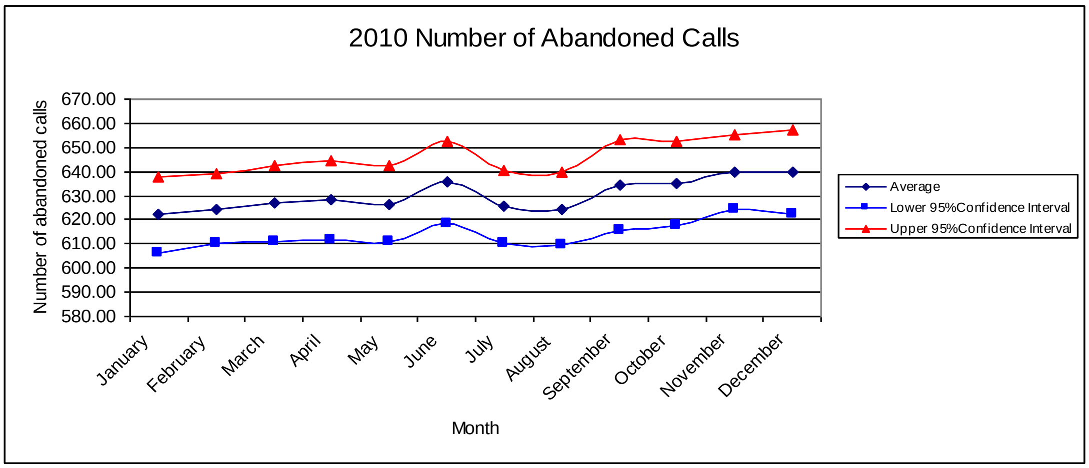

Figure A17.1: Abandoned calls, 2010

There is likely to be no significant change in the number of abandoned calls over the twelve month period. This is demonstrated in Figure A17.1 which illustrates only small month on month changes. The average number of abandoned calls is expected to increase by 2.87% over the twelve month period. There are on average 630 abandoned calls each month.

There is no noteworthy alteration to the staff utilisations for either agents or advisors. The reason for this occurrence is that the call arrivals are very similar for each month.

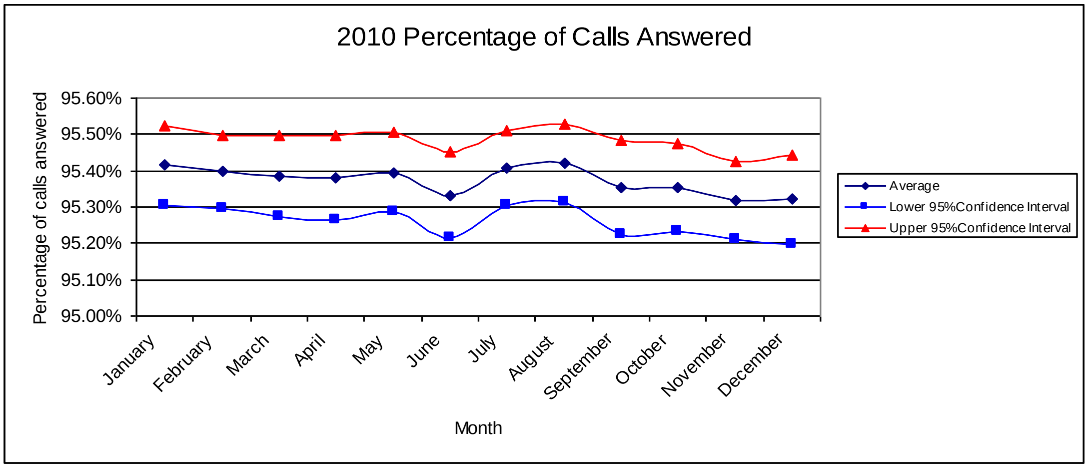

Figure A17.2: Calls answered, 2010

The percentage of calls answered only decreased by 0.09% over the period. Figure A17.2 illustrates a decline in percentage of calls answered over the year but there are some months which could in fact experience an increase in performance. Changes in this type of performance are very small. The 95% confidence interval did not change considerably over the year. The required performance levels are achieved.

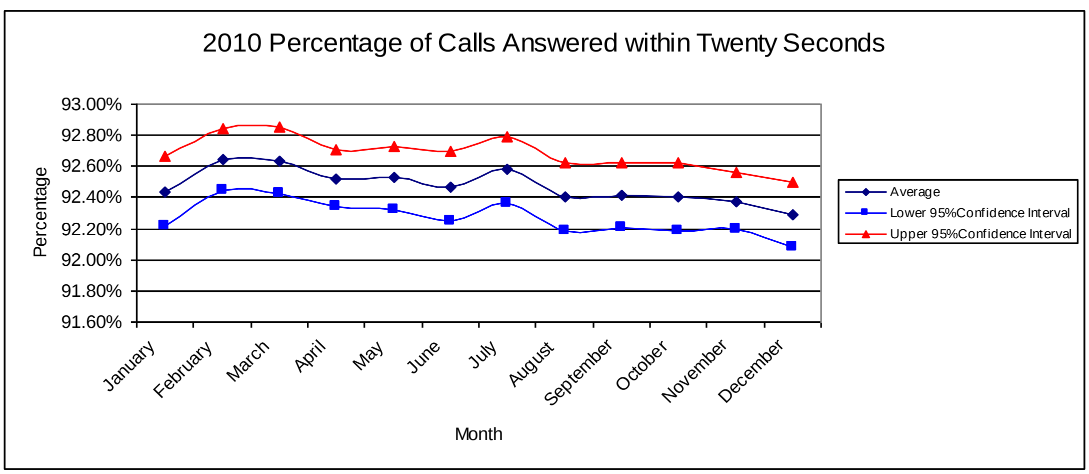

Figure A17.3: Calls answered in 20 sec, 2010

The percentage of calls answered within 20 seconds only decreased by 0.15% over the period which is shown in Figure A17.3. The 95% confidence interval did not change considerably either. The required performance target was achieved for each month.

Over the twelve month period no staff intervention was required as all the performance criteria were met.

The impact of feedback created by abandoned calls is now explored in 2010. Firstly, the impact of 2% of abandoned calls calling back is explored.

Experiment two: Impact on performance with 2% feedback in 2010

There is no significant difference between experiments one and two. The reason for this occurrence is that only thirteen additional calls are being added each month to the original number of call arrivals.

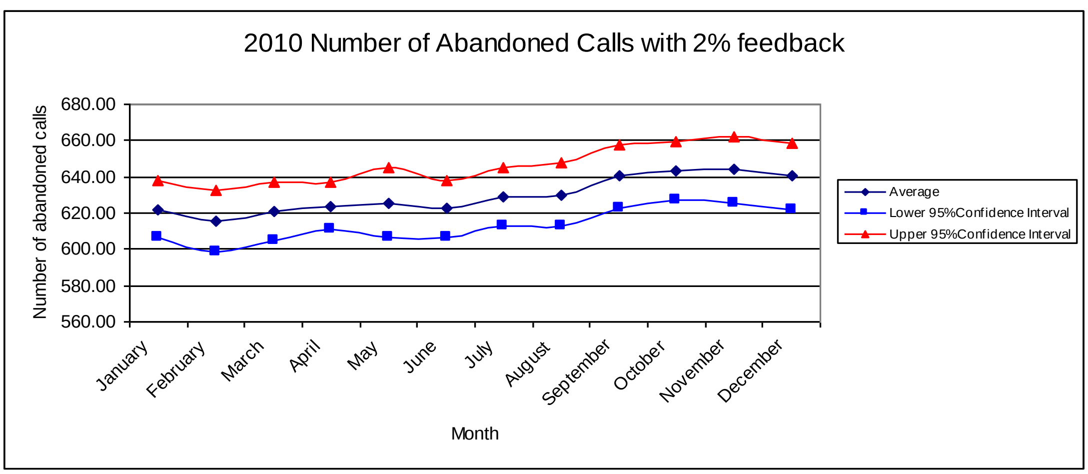

Figure A17.4: Abandoned calls, 2% feedback, 2010

The number of abandoned calls is predicted to increase by 2.92% over the twelve month period. There are on average 630 abandoned calls each month which is the same as experiment one. The trends illustrated in Figure A17.4 are very similar to that of experiment one (Figure A17.1). There is a small gradual increase in the number of abandoned calls over the year.

Once again there is no considerable alteration to the staff utilisations for either agents or advisors.

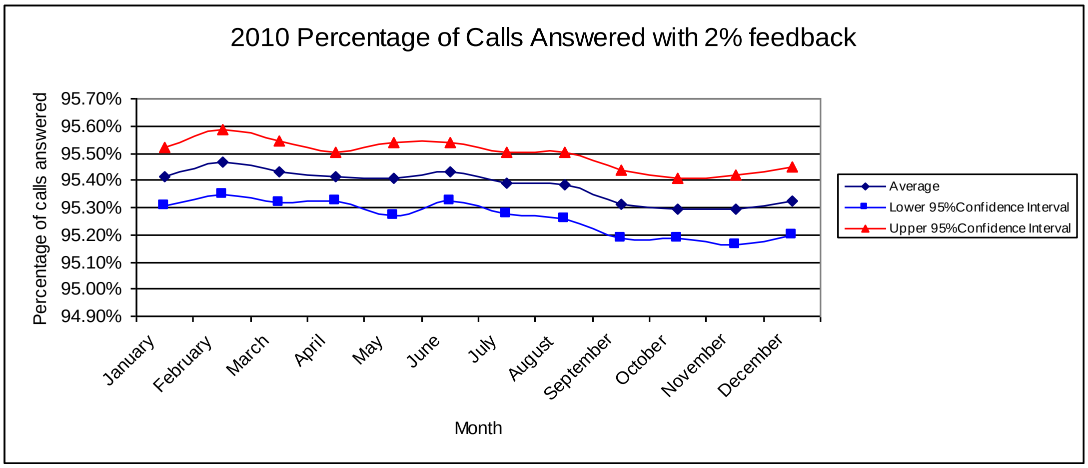

Figure A17.5: Calls answered, 2% feedback, 2010

The percentage of calls answered once again only decreased by 0.09% over the period as illustrated in Figure A17.5. The 95% confidence interval did not change considerably. The required performance levels were once again achieved.

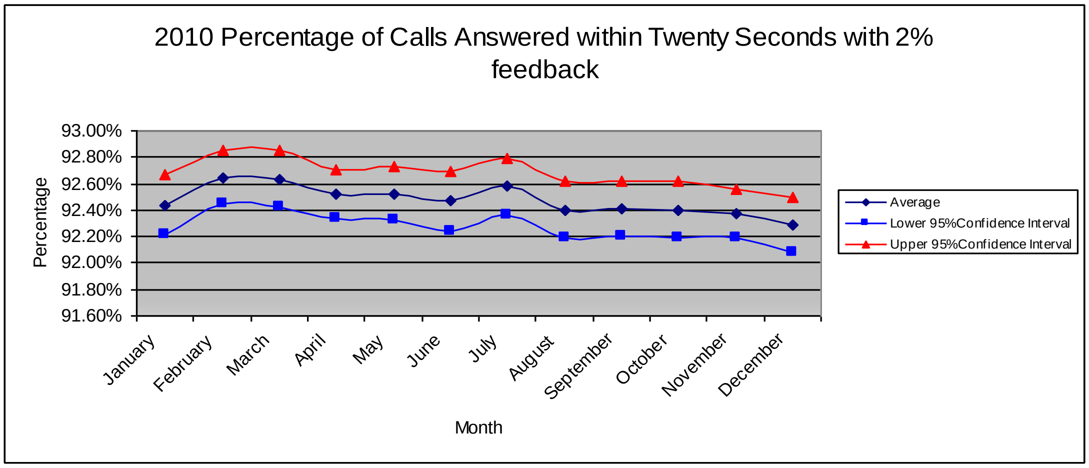

Figure A17.6: Calls answered in 20 sec, 2% feedback, 2010

The percentage of calls answered within 20 seconds only decreased by 0.13% over the period as illustrated in Figure 10. The 95% confidence interval did not change considerably. The required performance target was achieved for each month.

Over the twelve month period no staff intervention was required as all the performance criteria were met as in experiment one. Setting the feedback at two percent does not have any significant impact upon performance in 2010.

Experiment three: Impact on performance with 5% feedback in 2010

There is once again no significant difference between experiments one, two and three. The reason for this occurrence is that only on average 32 additional calls are being added each month to original number of call arrivals. As these additional calls are spread over the month there is an insignificant difference in the number of call arrivals in all three experiments. The impact of performance only becomes more evident when the number of abandoned calls is much greater than it currently is. This impact of feedback is greater for the experiments that have been carried out for 2015 and 2020.

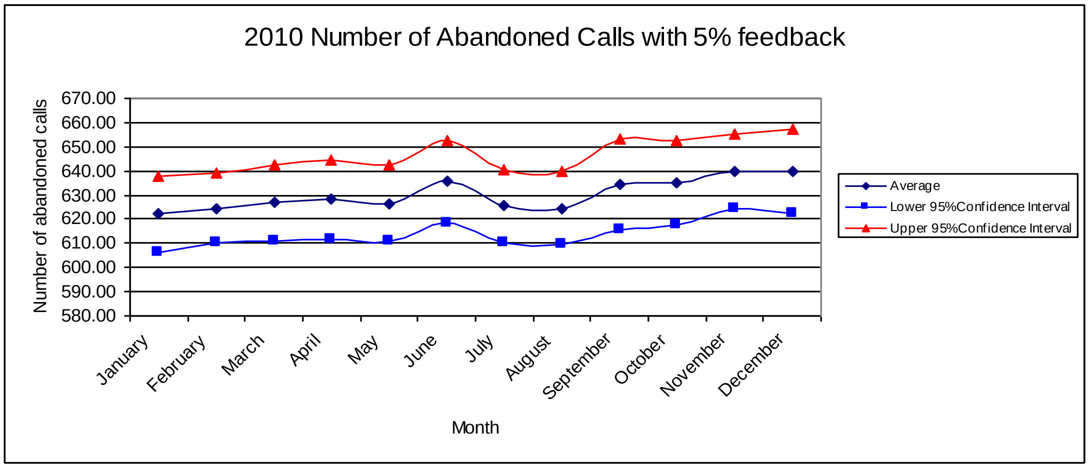

Figure A17.7: Abandoned calls, 5% feedback, 2010

The number of abandoned calls is expected to increase by 3.44% over the twelve month period. There are on average 634 abandoned calls each month. This is only slightly higher than the average number of abandoned calls for experiments one and two. Figure A17.7 exhibits a gradual increase in the number of abandoned calls over the year.

Once again there are no significant changes to the staff utilisations for either agents or advisors.

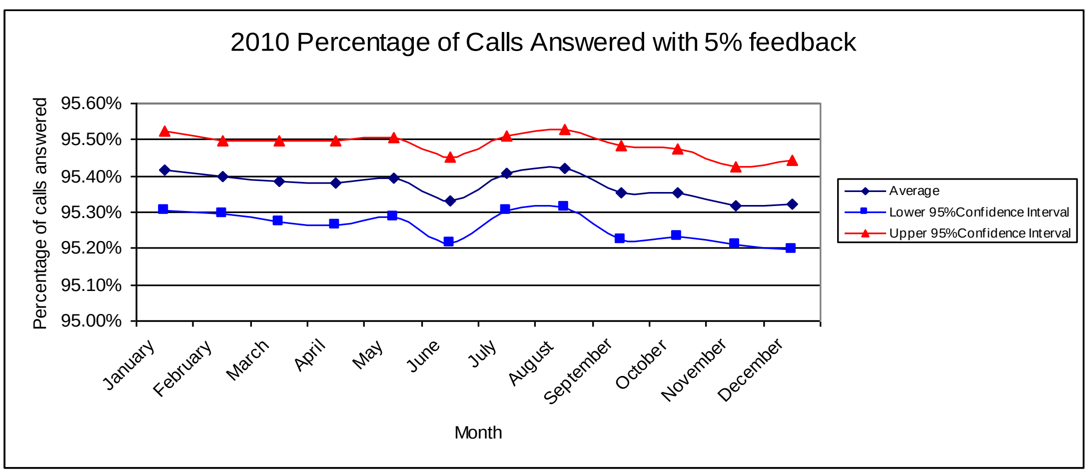

Figure A17.8: Calls answered, 5% feedback, 2010

The percentage of calls answered once again only decreased by a small percentage (0.11) over the twelve month period as displayed in Figure A17.8. The 95% confidence interval did not change considerably. The 95% target was once again achieved like the previous two experiments.

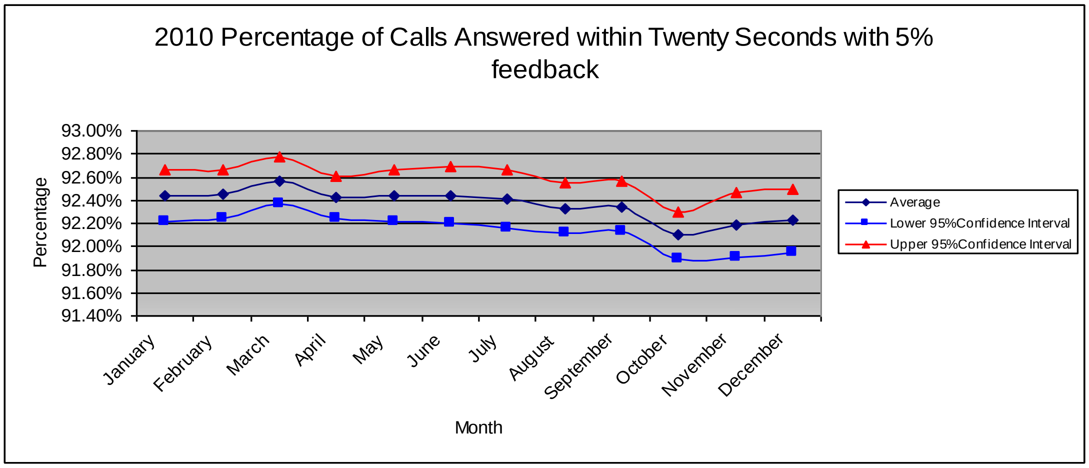

Figure A17.9: Calls answered in 20 seconds, 5% feedback, 2010

Figure A17.9 illustrates a steady decline in the measure. The percentage of calls answered within 20 seconds only decreased by 0.22% over the period. This is an extremely minute amount. The 95% confidence interval did not change considerably. The 80% target was as expected achieved when 5% feedback from abandoned calls was established in the system.

Over the twelve month period no staff intervention was required as all the performance criteria were met as in experiment one. Introducing feedback at a five percent level did not cause any noteworthy changes to the performance levels of the system.

Experiment four: Impact on performance with 10% feedback in 2010

As expected, there is once again no significant difference between experiments one, two, three and four. The reason for this occurrence is that only on average 65% additional calls are being added each month to the original number of call arrivals for the final experiment of 2010. As these additional calls are spread over the month there is an insignificant difference in the number of call arrivals.

The same trends are shown in Figures A17.10, A17.11 and A17.12 in comparison to the previous three experiments.

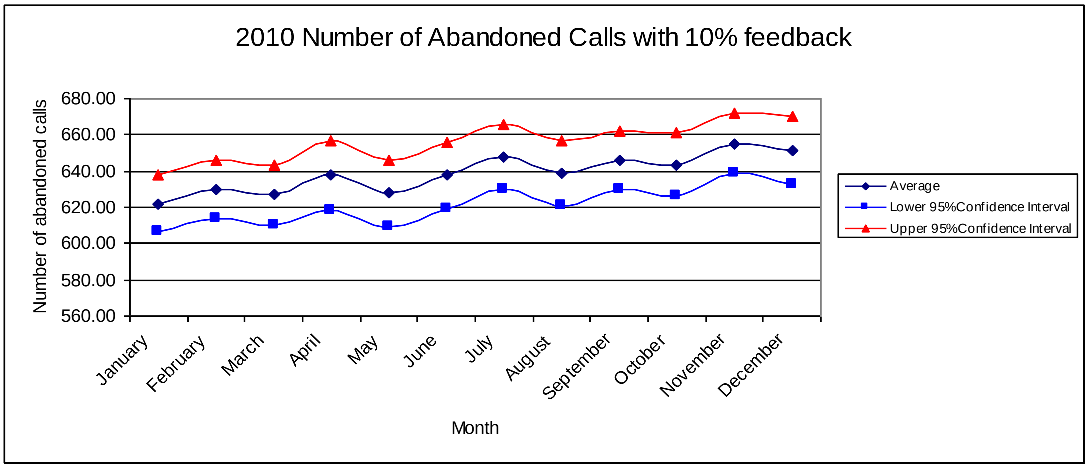

Figure A17.10: Abandoned calls, 10% feedback, 2010

The number of abandoned calls is expected to increase by 4.72% over the twelve month period. There are on average 639 abandoned calls each month.

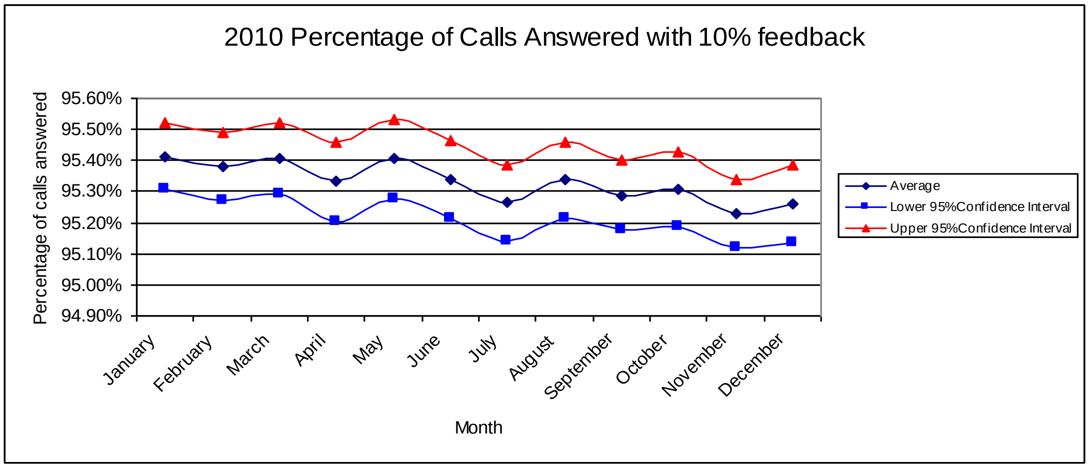

Figure A17.11: Calls answered, 10% feedback, 2010

The percentage of calls answered once again only decreased by 0.15% over the period. The 95% confidence interval did not change considerably. The 95% target was once again achieved like the previous three experiments.

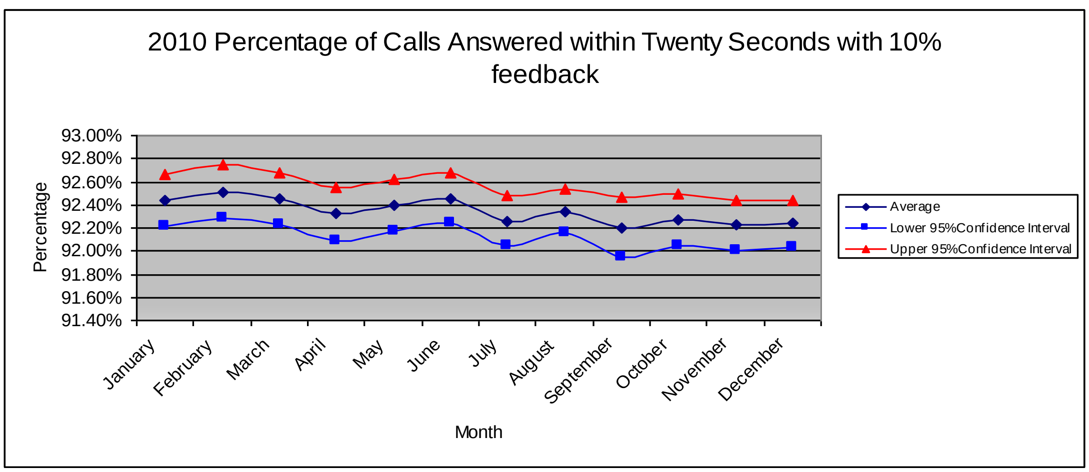

Figure A17.12: Calls answered in 20 sec, 10% feedback, 2010

The percentage of calls answered within 20 seconds only decreased by 0.20% over the period. The 95% confidence interval did not change considerably. The 80% target was as expected achieved when 10% feedback from abandoned calls was introduced into the system.

Once again over the twelve month period no staff intervention was required as all the performance criteria were met as in experiment one.

Over the four experiments in 2010 changes in performance are likely to be due to natural changes in the population. The introduction of feedback into system is likely to have no considerable effect on either of the two key performance measures. The number of abandoned calls does not increase by any noteworthy amount. As the call centre takes social service related calls, it is important that no call is missed as a person's welfare could be at stake.

The next set of results are for 2015, and this time staffing interventions are required to return performance back to acceptable levels. As previously discussed, two types of staffing intervention are carried out.

In comparison to 2010, there were originally 13,607 calls per month on average. In 2015 this increases 14,467 calls on average per month. This equates to a 6.23% increase in the average call arrivals per month. In 2010 there were on average 1,223 more Children's type calls than Adults' service calls. There is a significant reduction in the difference in 2015: there are now only 475 more Children's type calls than Adults' service calls.

Experiment five: Impact on performance with no feedback in 2015

The fifth experiment explores the impact of natural increases in call arrivals on performance in 2015. The contact centre conditions are kept exactly the same as the 2010. Call arrivals is the only variable that is changed.

The same trends are shown in Figures A17.13, A17.14 and A17.15 in comparison to the previous set of experiments.

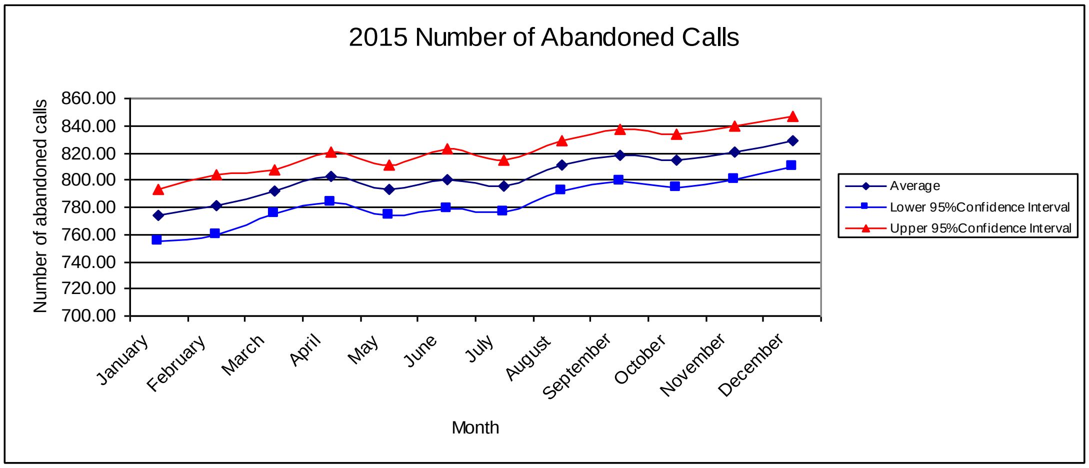

Figure A17.13: Abandoned calls, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.03%. The number of abandoned calls in December 2015 is likely to be 29.46% more than in December 2010. This is a noteworthy increase in the number of abandoned calls. It is important that critical social care calls are not missed as people's welfare needs are at stake. In December 2015 over the forty replications the 85% confidence interval is 810 to 847. There are on average 803 abandoned calls each month.

There is no noteworthy alteration to the staff utilisations for either agents or advisors. The reason for this occurrence is that the call arrivals are very similar for each month. This is same result as experiment one in 2010 where no feedback is introduced into the system.

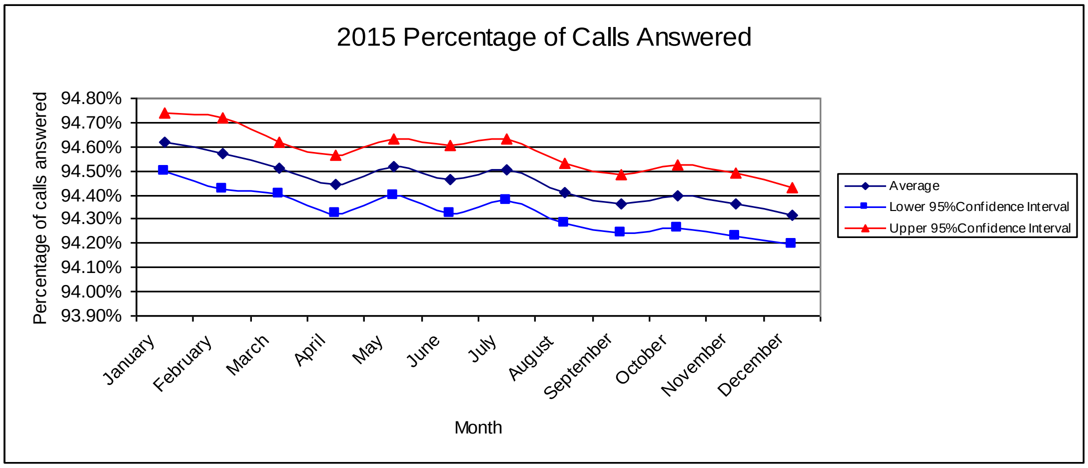

Figure A17.14: Calls answered, 2015

The percentage of calls answered in January 2015 is 94.62%. This is less than the required 95% so further experiments will be carried out to calculate the number of additional agents and advisors to meet the required performance criteria.

The percentage of calls answered decreased by 0.31% over the twelve month period.

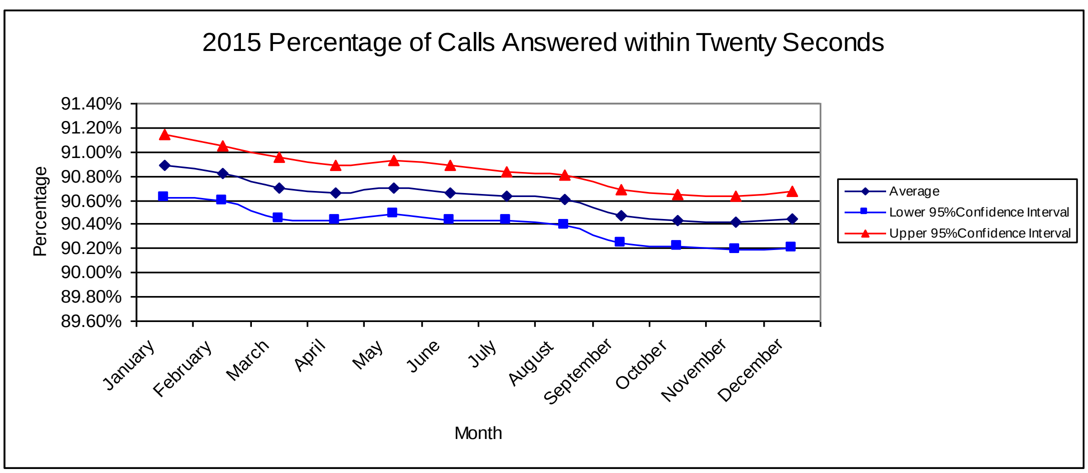

Figure A17.15: Calls answered in 20 sec, 2015

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.44% over the period.

The impact of feedback created by abandoned calls is now explored in 2015. Firstly, the impact of 2% of abandoned calls calling back is explored.

Experiment six: Impact on performance with 2% feedback in 2015

The sixth experiment explores the impact on performance when 2% of abandoned calls call back from the previous month.

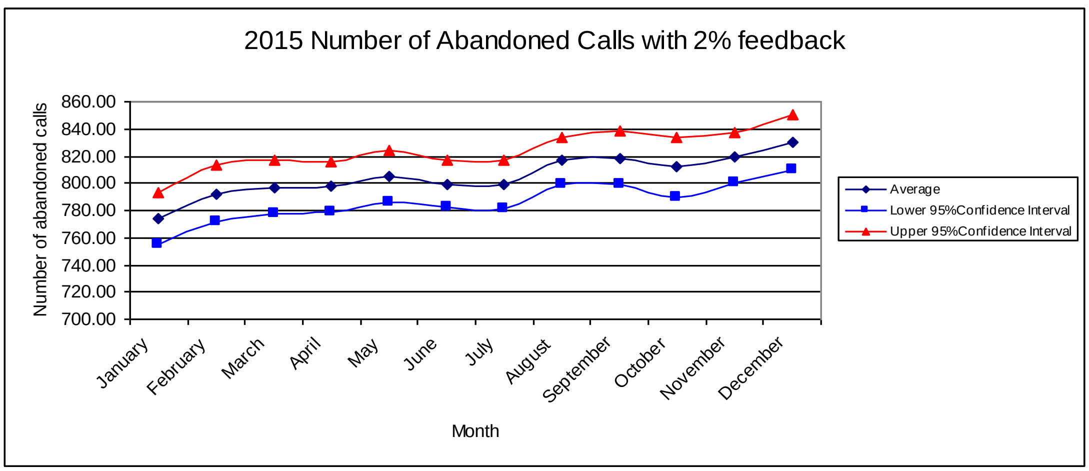

Figure A17.16: Abandoned calls, 2% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.26%. This is only slightly different in comparison to experiment one for 2015. There are on average 805 abandoned calls each month.

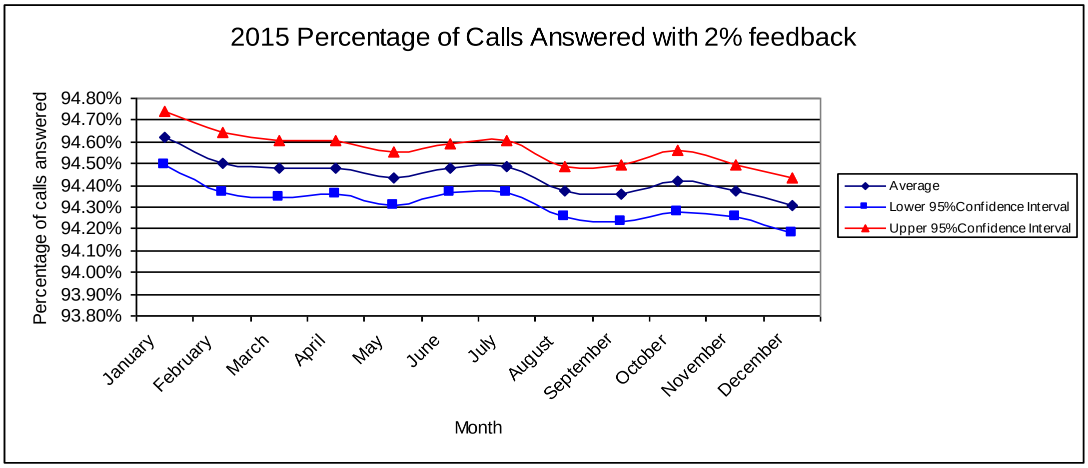

Figure A17.17: Calls answered, 2% feedback, 2015

Once again as expected, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with 2% feedback.

The percentage of calls answered decreased by 0.31% over the twelve month period. This is a particularly small change.

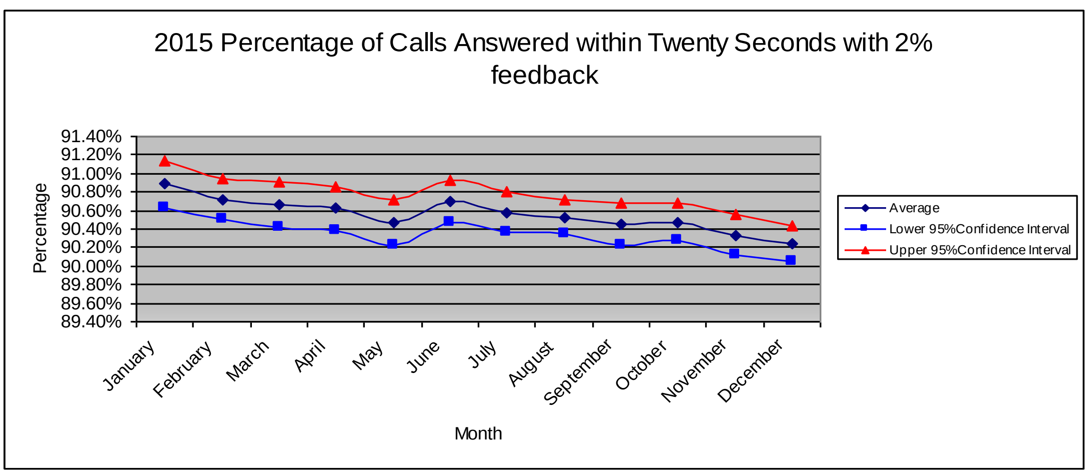

Figure A17.18: Calls answered in 20 sec, 2% feedback, 2015

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.64% over the period.

Experiment seven: Impact on performance with 5% feedback in 2015

The seventh experiment explores the impact on performance when 5% of abandoned calls call back from the previous month.

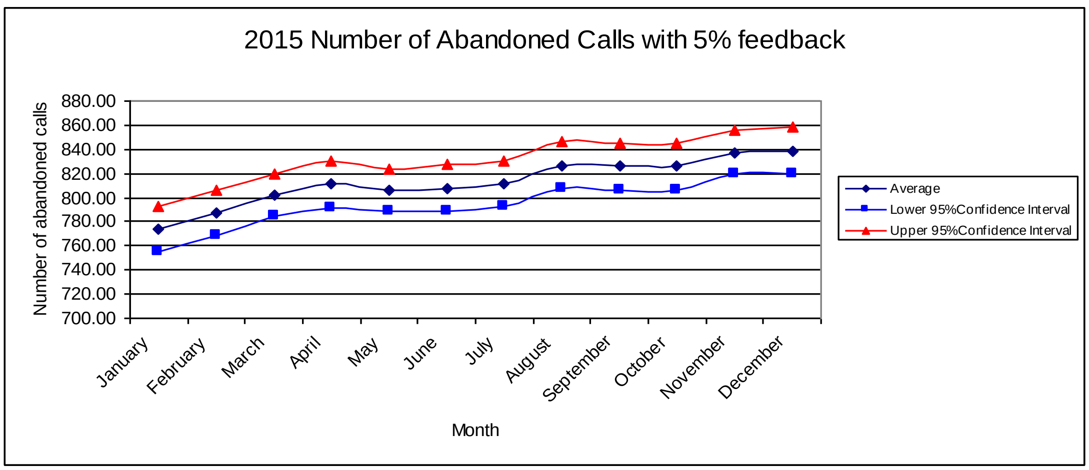

Figure A17.19: Abandoned calls, 5% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 8.37%. There are on average 813 abandoned calls each month. This is no noteworthy change in the number of abandoned calls in comparison to the previous two experiments.

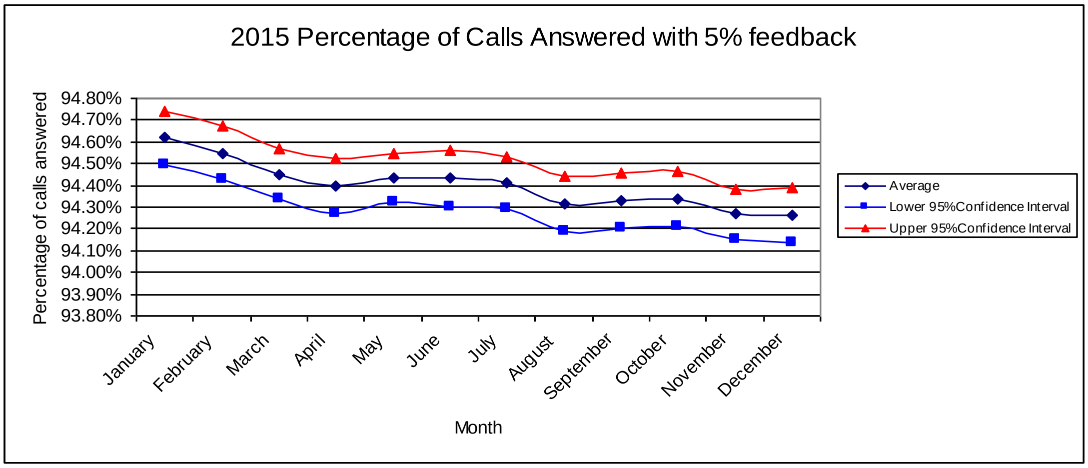

Figure A17.20: Calls answered, 5% feedback, 2015

Once again as expected, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with 5% feedback.

The percentage of calls answered decreased by 0.36% over the twelve month period.

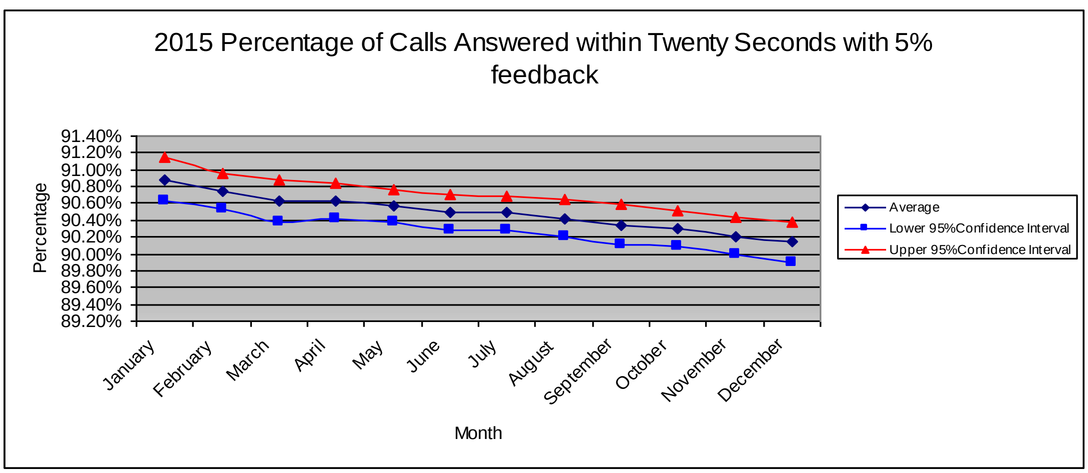

Figure A17.21: Calls answered in 20 sec, 5% feedback, 2015

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.74% over the period.

Experiment eight: Impact on performance with10% feedback in 2015

The eighth experiment explores the impact on performance when 10% of abandoned calls call back from the previous month.

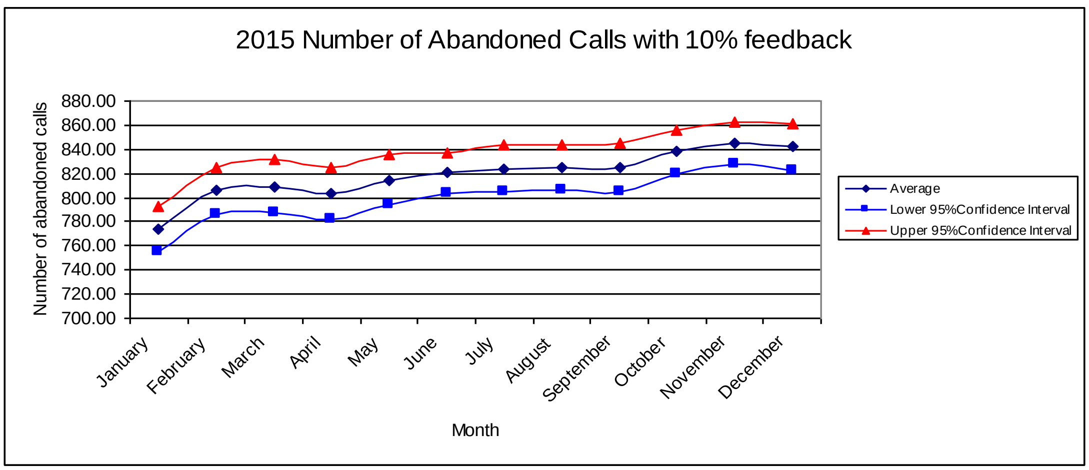

Figure A17.22: Abandoned calls, 10% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 8.78%. There are on average 819 abandoned calls each month. This is no noteworthy change in the number of abandoned calls in comparison to the previous three experiments.

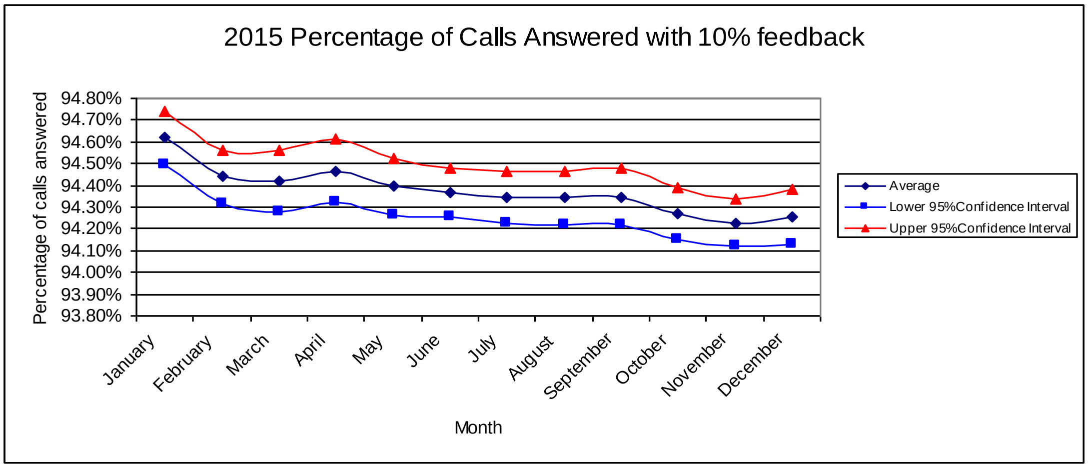

Figure A17.23: Calls answered, 10% feedback, 2015

Once again as expected, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with 10% feedback.

The percentage of calls answered decreased by 0.36% over the twelve month period.

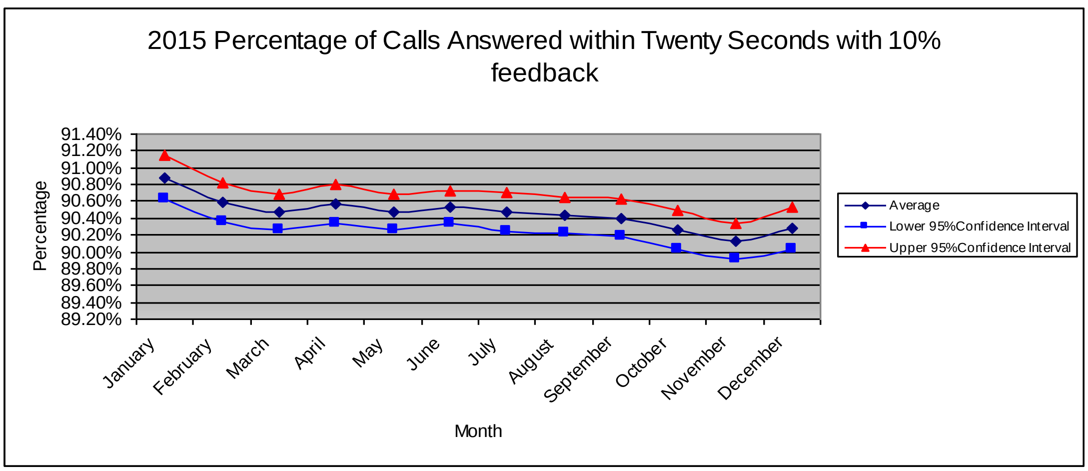

Figure A17.24: Calls answered in 20 sec, 10% feedback, 2015

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.60% over the period. This is in fact slightly less than experiment three for 2015.

The impact of feedback does not change the performance of the system in any significant way. There are slight changes in the number of abandoned calls.

An intervention is required as the percentage of calls answered is less than 95% for all four experiments for 2015.

The first intervention is to increase the number of agents until the percentage of calls is greater than 95%. With an increase of one agent this criteria is satisfied.

Experiment nine: Impact on performance with no feedback and one additional agent in 2015

The ninth experiment explores the impact of natural increases in call arrivals on performance with one additional agent.

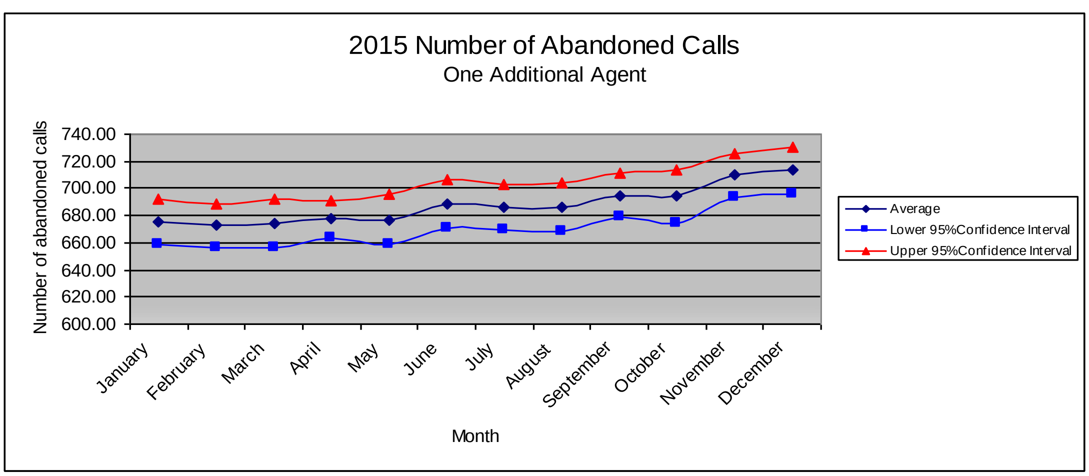

Figure A17.25: Abandoned calls, 1 extra agent, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 5.59%. Before the staff intervention, the average number of abandoned calls is 803. This is reduced to 688 due to there being an additional agent. This will help improve performance and decrease the chance of a serious social service call not being attended to due to performance issues.

In 2010 there were on average 630 abandoned calls each month. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of staff also impacts upon the utilisation of agents and advisors. Under the initial conditions the agents' utilisation is 78.51%. With the introduction of an additional agent, the utilisation changes slightly to 76.66%. There is a slight decrease in the utilisation of advisors as a result of increase in the number of agents. Utilisation falls from 72.50% to 71.13%.

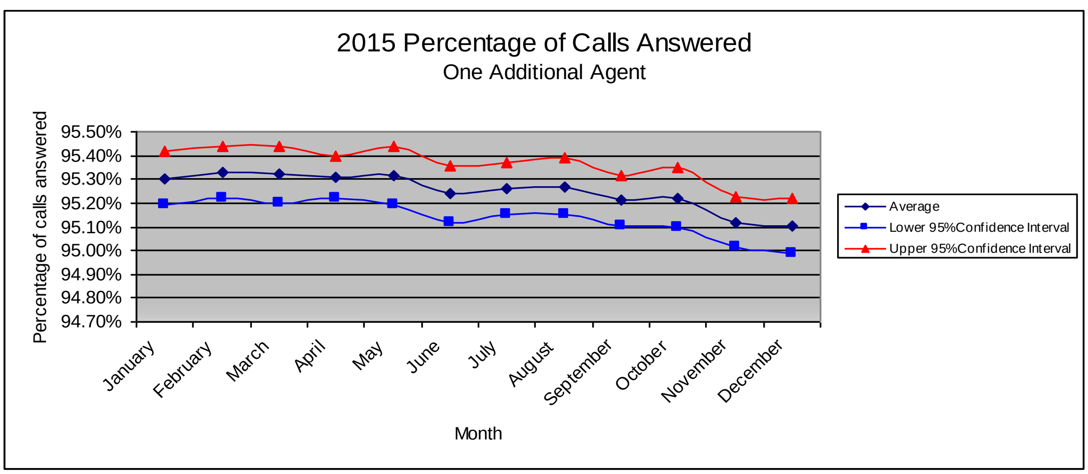

Figure A17.26: Calls answered, 1 extra agent, 2015

The addition of one agent returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when no feedback was introduced into the system. The percentage of calls answered is likely to decrease by 0.20% over the twelve month period. This is slightly less reduction under the initial conditions. There is not much change in this performance target over the twelve month period.

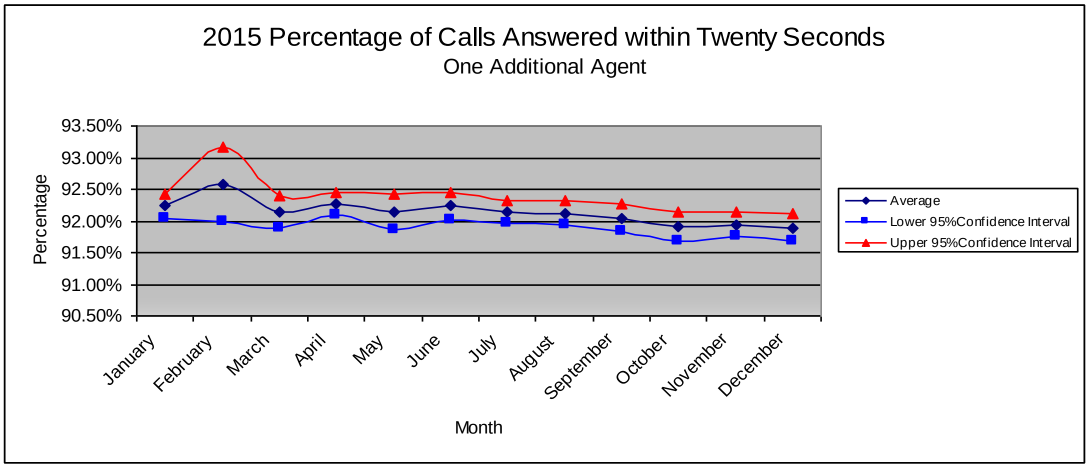

Figure A17.27: Calls answered in 20 sec, 1 extra agent, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.62% to 92.14%. The performance target is now very similar to the 2010 average when no feedback was introduced into the system. This will help increase customer satisfaction. The percentage of calls answered within 20 seconds only decreased by 0.34% over the period. This is slightly less reduction under the initial conditions.

As a result of the increase of one agent, the required performance measures are met.

Experiment ten: Impact on performance with 2% feedback and one additional agent in 2015

The next experiment simulated the impact of having one additional agent in 2015 and explores the impact on performance when 2% of abandoned calls call back from the previous month.

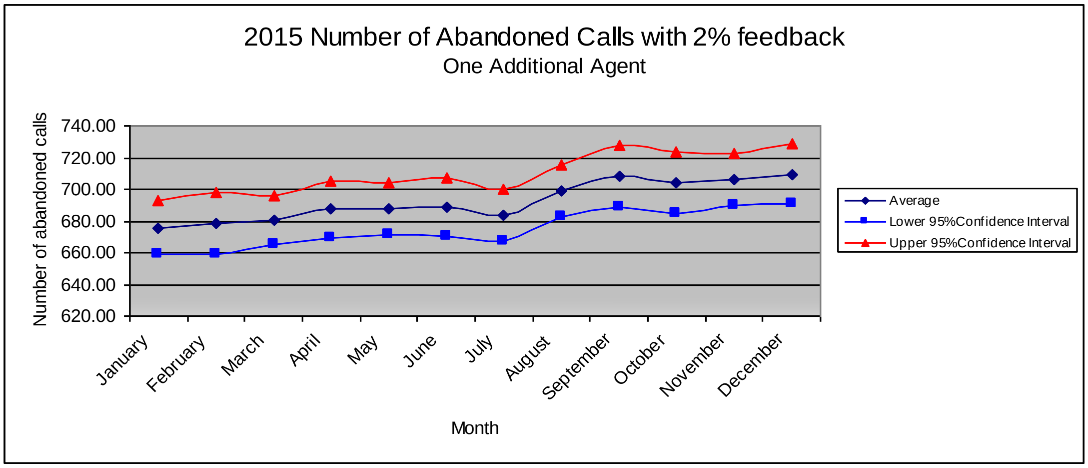

Figure A17.28: Abandoned calls, 1 extra agent, 2% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 4.99%. This is less than the experiment when no feedback is introduced. Before the staff intervention the average number of abandoned calls is 805. This is reduced to 694 on average per month due to there being an additional agent.

In 2010 there were on average 630 abandoned calls each month when 2% was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of staff also impacts upon the utilisation of agents and advisors. Under the initial conditions, the agent's utilisation is 78.52%. With the introduction of an additional agent and two percent feedback, the utilisation changes slightly to 76.71%. There is a slight decrease in the utilisation of advisors as a result of increase in the number of agents. Utilisation falls from 72.55%to 71.15%.

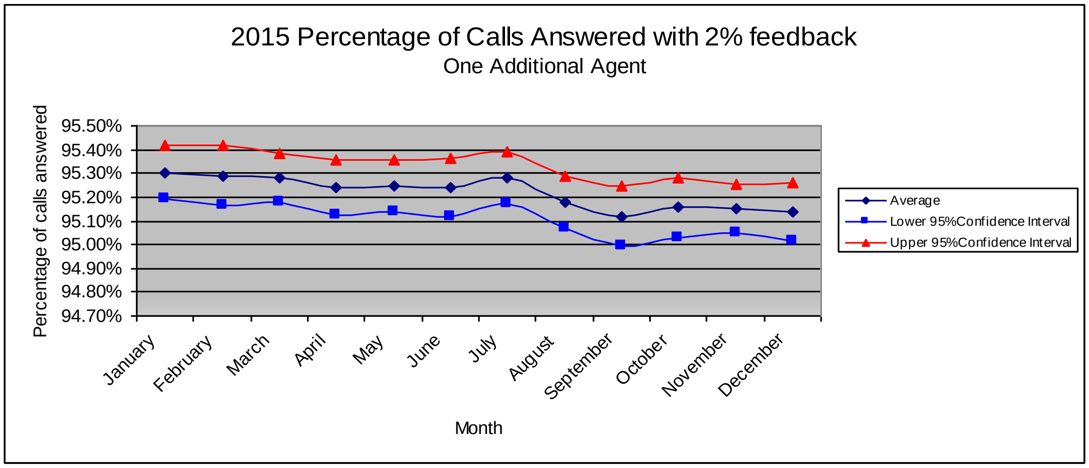

Figure A17.29: Calls answered, 1 extra agent, 2% feedback, 2015

The addition of one agent returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when 2% feedback was introduced into the system. The percentage of calls answered decreased by 0.17% over the twelve month period.

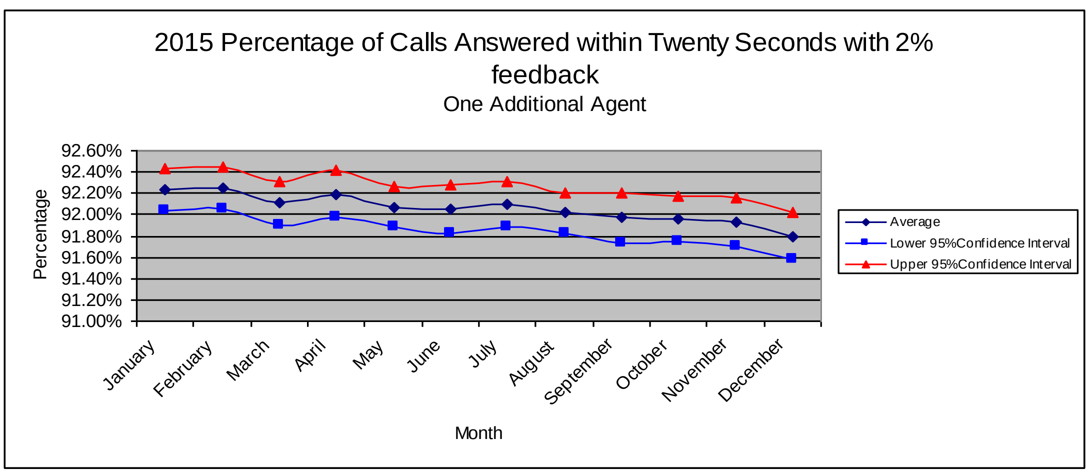

Figure A17.30: Calls answered in 20 sec, 1 extra agent, 2% feedback, 2015

Like the previous experiment there is an increase in the average percentage of calls answered within 20 seconds per month from 90.56% to 92.96%. The performance target is now very similar to the 2010 average when two percent feedback was introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.44% over the period.

Like the previous experiment, the real impact of the staff intervention is once again seen with a significant reduction in the number of abandoned calls. For instance, a like-for-like comparison of December 2015 results in a decrease of 14.58% in the number of abandoned calls.

Experiment eleven: Impact on performance with 5% and one additional agent feedback in 2015

The next experiment simulated the impact of having one additional agent in 2015 and explores the impact on performance when 5% of abandoned calls call back from the previous month.

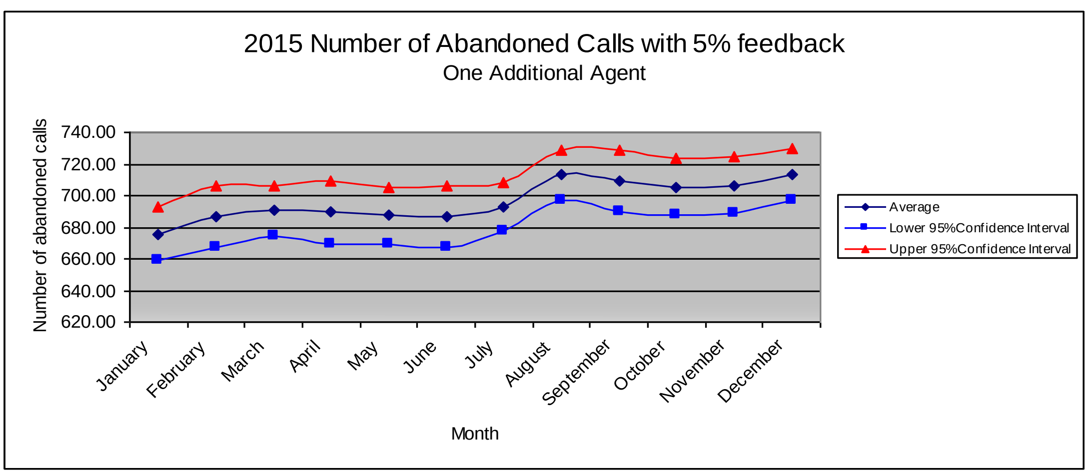

Figure A17.31: Abandoned calls, 1 extra agent, 5% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 5.56%. This is slightly more than the experiment where 2% feedback is introduced. Before the staff intervention, the average number of abandoned calls is 813. This is reduced to 696 on average per month due to there being an additional agent.

In 2010 with 5% feedback there were on average 634 abandoned calls each month. The staffing intervention reduces the average number of calls per month but there are nearly 70 more abandoned calls per month in 2015 in comparison to 2010.

An increase in the number of agents also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 78.69%. With the introduction of an additional agent and 2% feedback, the utilisation changes slightly to 76.78%. There is a slight decrease in the utilisation of advisors as a result of increase in the number of agents. Utilisation falls from 72.64% to 71.21%.

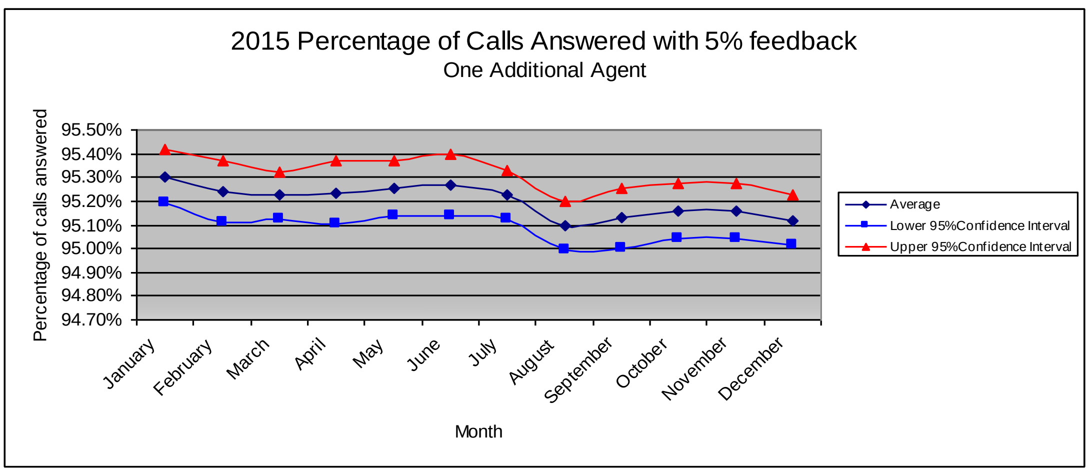

Figure A17.32: Calls answered, 1 extra agent, 5% feedback, 2015

The addition of one extra agent returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when 5%

feedback was introduced into the system. The percentage of calls answered decreased by 0.18% over the twelve month period.

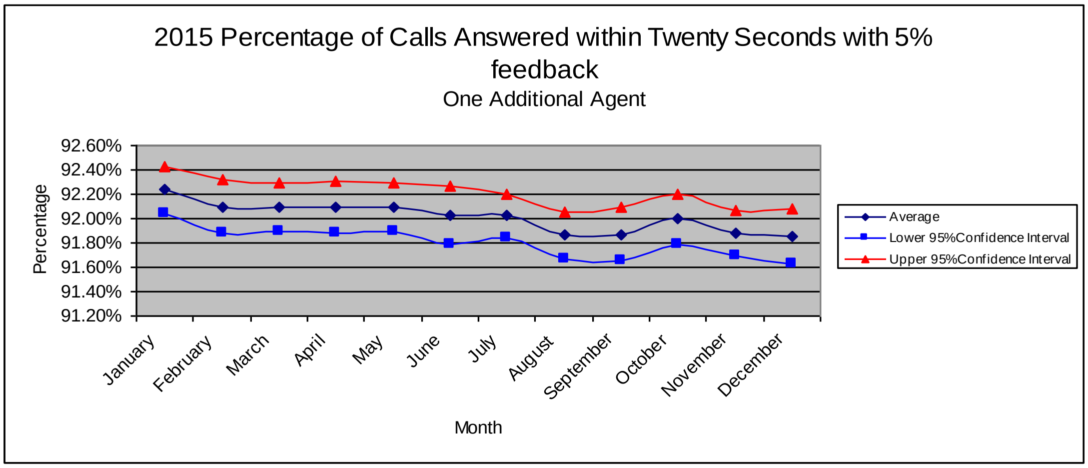

Figure A17.33: Calls answered in 20 sec, 1 extra agent, 5% feedback, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.49% to 92.01%. The performance target is now very similar to the 2010 average when five percent feedback was introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.38% over the period.

Like the previous two experiments the significant impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For instance, a like-for-like comparison of December 2015 results in a decrease of 14.93% in the number of abandoned calls.

Experiment twelve: Impact on performance with `0% feedback and one additional agent in 2015

The next experiment explored the impact of having one additional agent in 2015 and explores the impact on performance when 10% of abandoned calls were allowed to call back from the previous month.

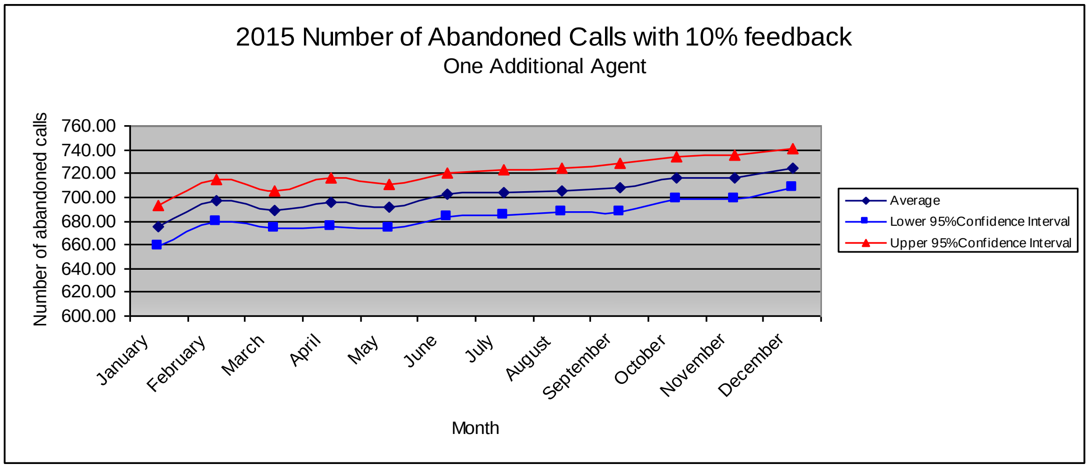

Figure A17.34: Abandoned calls, 1 extra agent, 10% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.23%. This is slightly less than the original staffing configuration with 10% feedback. Before the staff intervention the average number of abandoned calls is 819. This is reduced to 702 on average per month due to there being an additional agent.

In 2010 with 10% feedback there were on average 639 abandoned calls each month. The staffing intervention reduces the average number of calls per month but there are nearly 70 more abandoned calls per month in 2015 in comparison to 2010.

An increase in the number of agents also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 78.73%. With the introduction of an additional agent and two percent feedback, the utilisation changes slightly to 76.86%. There is a slight decrease in the utilisation of advisors as a result of an increase in the number of agents. Utilisation falls from 72.77% to 71.30%. The utilisation results for all four experiments where the number of agents are increased in 2015 are very similar.

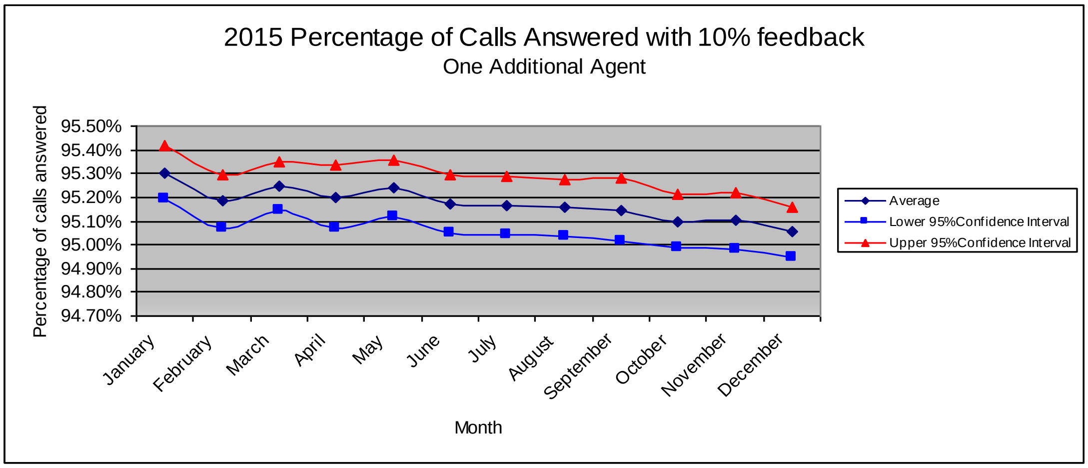

Figure A17.35: Calls answered, 1 extra agent, 10% feedback, 2015

The addition of one extra agent returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when 5% feedback was introduced into the system. The percentage of calls answered decreased by 0.25% over the twelve month period.

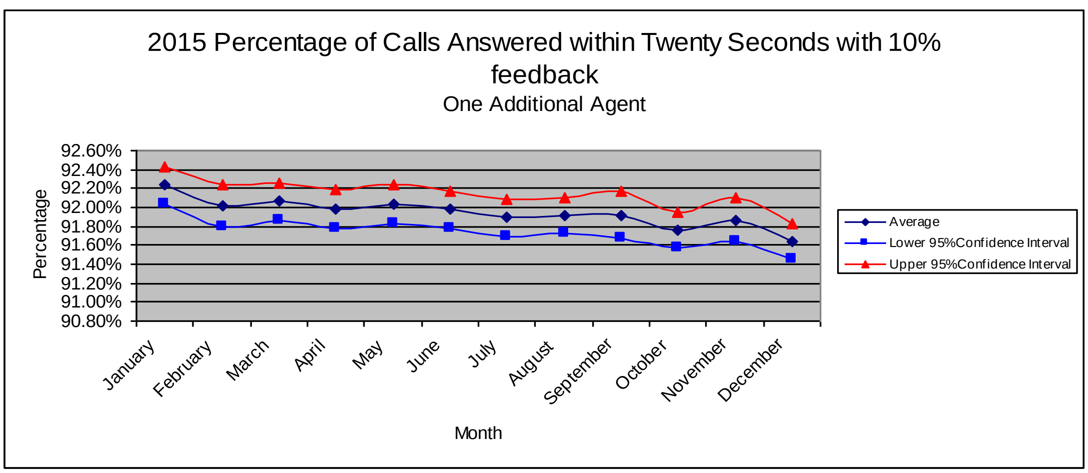

Figure A17.36: Calls answered in 20 secs, 1 extra agent, 10% feedback, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.46% to 91.94%. The performance target is now very similar to the 2010 average when five percent feedback was introduced into the system. The percentage of calls answered within 20 seconds decreased by 0.60%over the period.

Like the others experiment with an agent staffing intervention the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 13.90% in the number of abandoned calls.

The second intervention explored for 2015 is to increase the number of advisors until the percentage of calls is greater than 95%. With an increase of one advisor this criteria is satisfied. Thus, an increase of one member of staff can return the contact centre performance back to acceptable levels.

Intervention: Increase the number of advisors by one

Experiment thirteen: Impact on performance with no feedback and one additional advisor in 2015

The first experiment simulated the impact of having one additional advisor in 2015 and the impact upon performance is investigated.

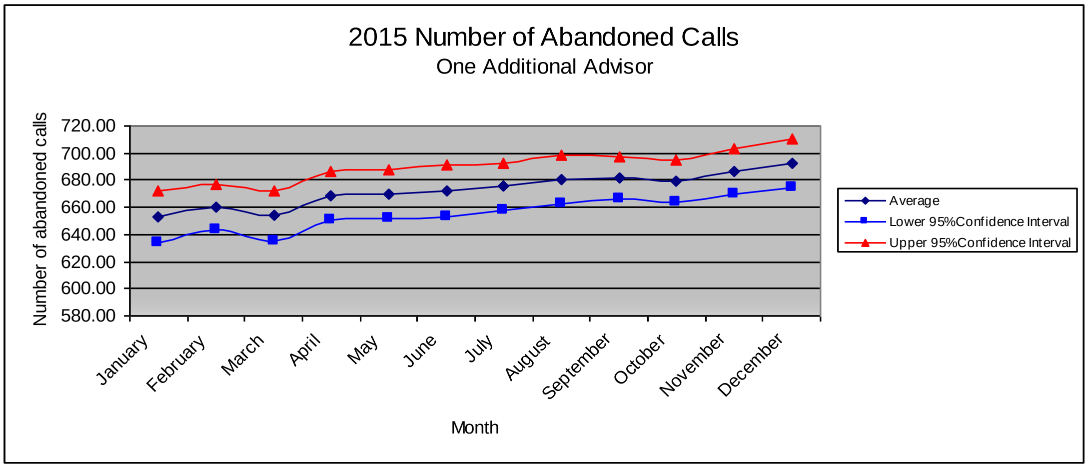

Figure A17.37: Abandoned calls, 1 extra advisor, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 6.03%. This is slightly less than the original staffing configuration. Before the staff intervention the average number of abandoned calls is 803. This is reduced to 673 on average per month due to there being an additional advisor. This is slightly less than the agent's intervention.

In 2010 there were on average 630 abandoned calls each month. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels. The increase in the advisors only has a slightly better improvement on performance in comparison to agent intervention.

An increase in the number of advisors also impacts upon the utilisation of agents and advisors. Under the initial conditions the advisor's utilisation is 72.50%. With the introduction of an additional agent and two percent feedback, the utilisation changes slightly to 70.83%. This is very similar to the advisors utilisation for the agent's intervention. There is a slight decrease in the utilisation of agents as a result of increase in the number of advisors. Utilisation falls from 78.51% to 77.12%. Once again we get a very similar result to previous agents' intervention.

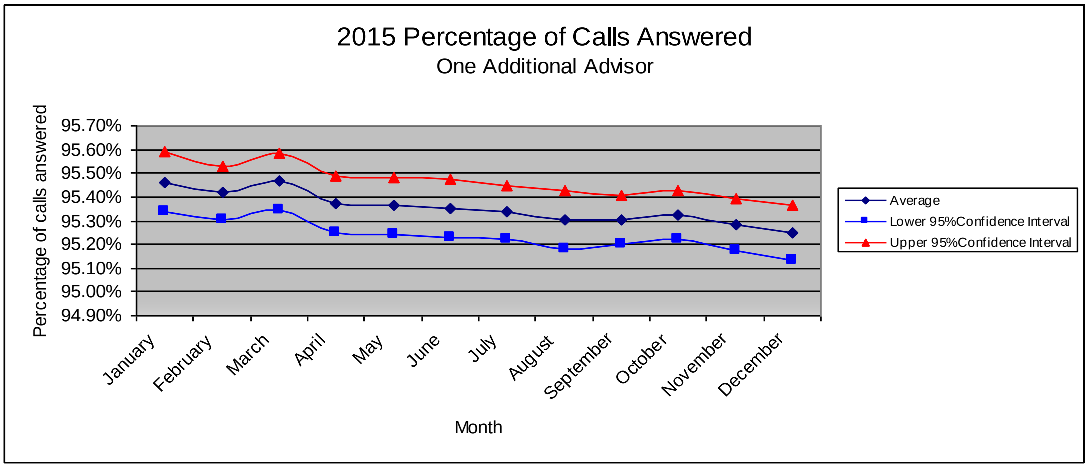

Figure A17.38: Calls answered, 1 extra advisor, 2015

The addition of one advisor returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when no feedback was introduced into the system. This is a very similar result to the agent's intervention in 2015. The percentage of calls answered decreased by 0.21% over the twelve month period.

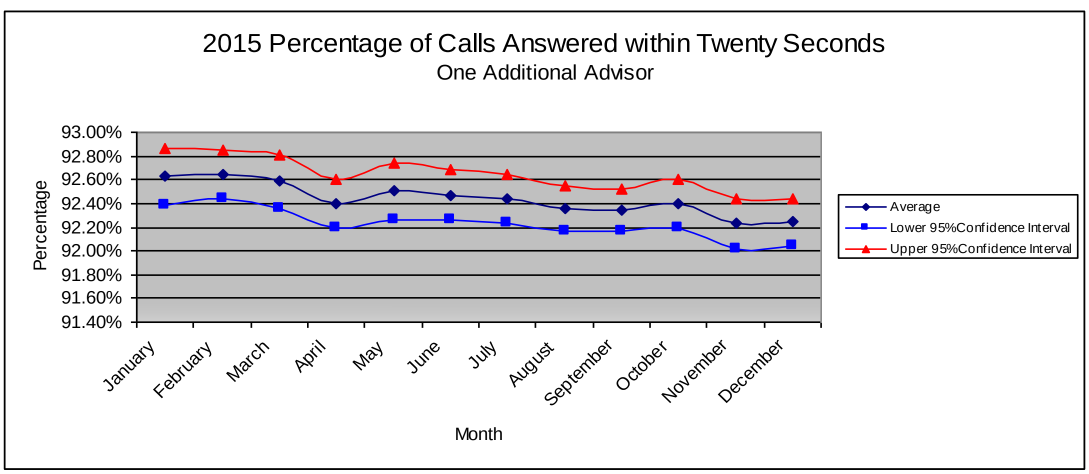

Figure A17.39: Calls answered in 20 sec, 1 extra advisor, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.62% to 92.44 %. The performance target is now very similar to the 2010 average when no feedback was introduced into the system and only slightly higher than the result of agent's intervention where no feedback from abandoned calls is introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.38% over the period.

Like the other experiment with a staffing intervention the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 16.43% in the number of abandoned calls.

Experiment fourteen: Impact on performance with 2% feedback and one additional advisor in 2015

The next experiment simulates the impact of having one additional advisor in 2015 and explores the impact on performance when 2% of abandoned calls call back from the previous month.

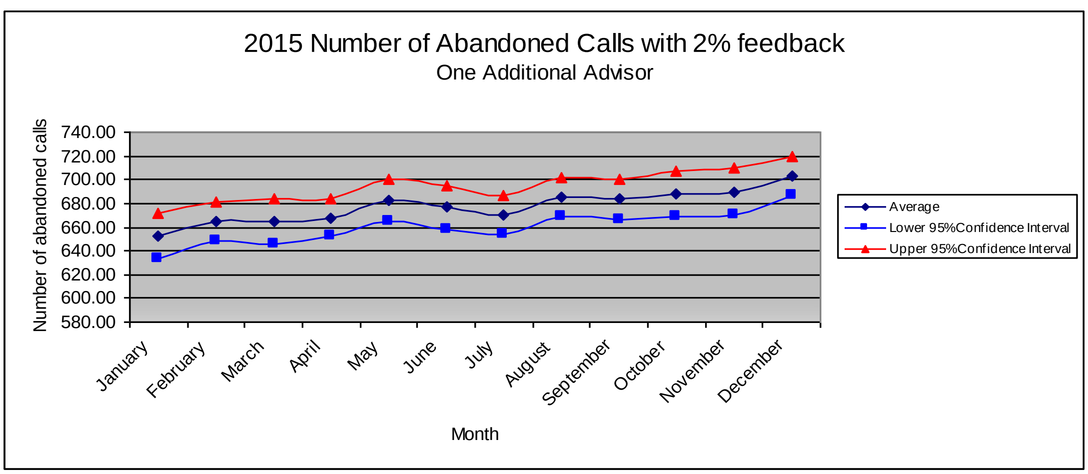

Figure A17.40: Abandoned calls, 1 extra advisor, 2% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.66%. This is slightly more than the original staffing configuration with 2% feedback. Before the staff intervention the average number of abandoned calls is 805. This is reduced to 677 on average per month due to there being an additional advisor. This is slightly less than the agent's intervention.

In 2010 there were on average 630 abandoned calls each month when 2% feedback was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of advisors also impacts upon the utilisation of agent and advisors. Under the initial conditions the average advisor's utilisation is 72.55%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 70.88%. There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 78.52% to 77.15%.

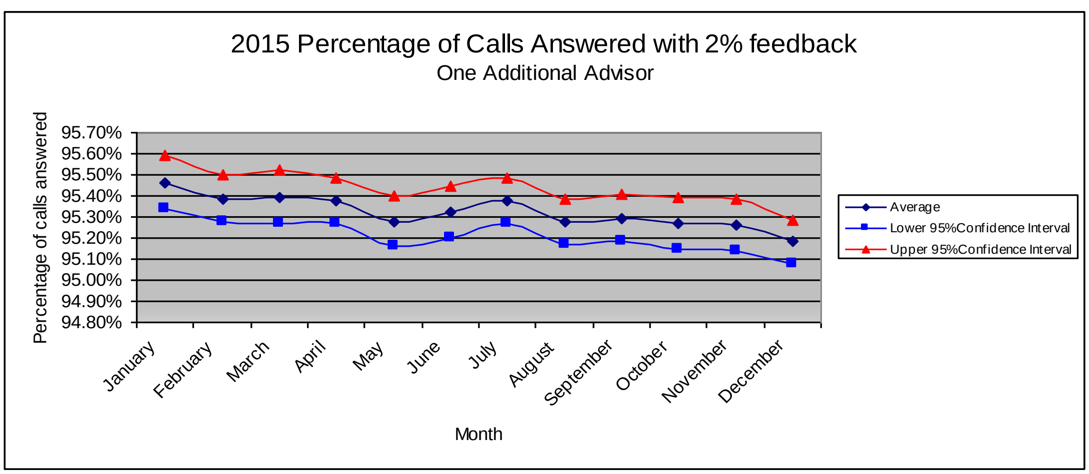

Figure A17.41: Calls answered, 1 extra advisor, 2% feedback, 2015

The addition of one advisor returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when two percent feedback was introduced into the system. The percentage of calls answered decreased by 0.28% over the twelve month period.

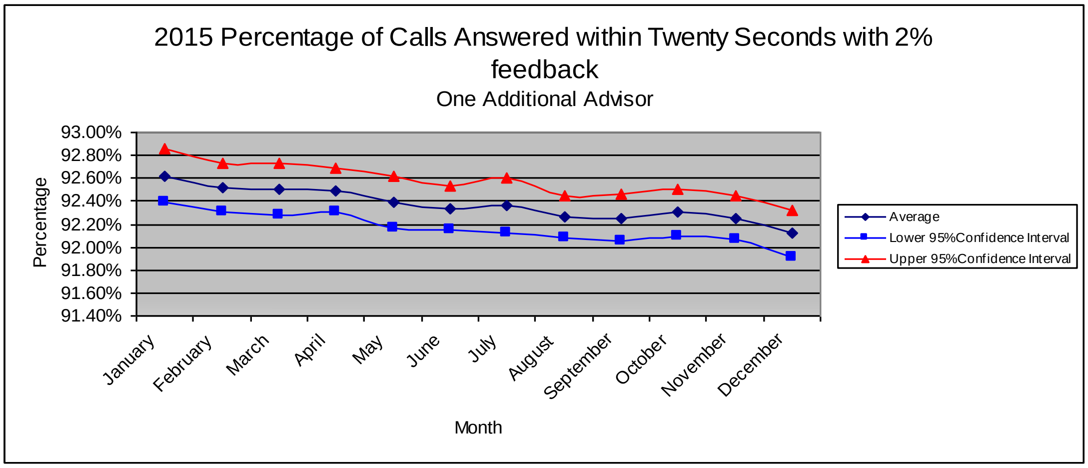

Figure A17.42: Calls answered in 20 sec, 1 extra advisor, 2% feedback, 2015

Like the previous experiment there is an increase in the average percentage of calls answered within 20 seconds per month from 90.56% to 92.37%. The performance target is now very similar to the 2010 average when two percent feedback was introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.50% over the period.

Like the other experiment with a staffing intervention, the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 15.30% in the number of abandoned calls.

Experiment fifteen: Impact on performance with 5% and one additional advisor feedback in 2015

The next experiment simulated the impact of having one additional advisor in 2015 and explores the impact on performance when 5% of abandoned calls call back from the previous month.

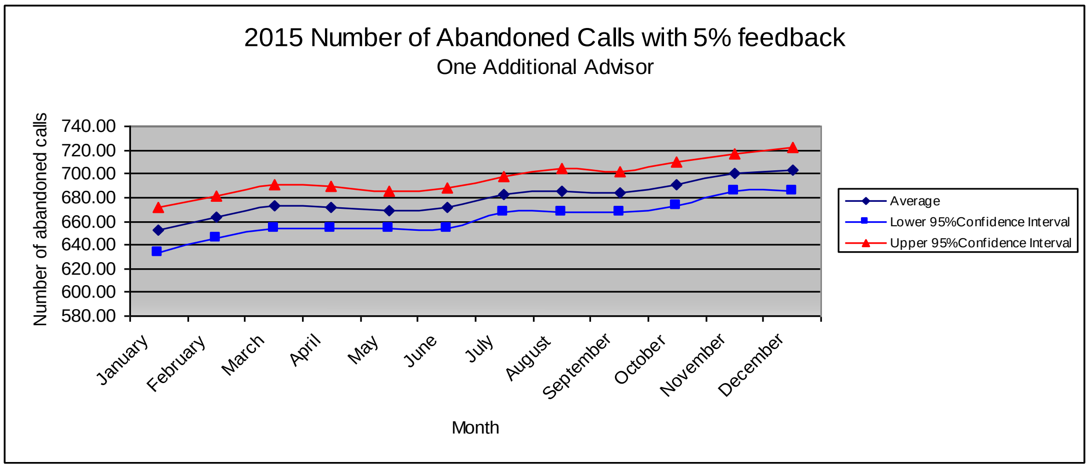

Figure A17.43: Abandoned calls, 1 extra advisor, 5% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.81%. Before the staffing intervention the average number of abandoned calls is 813. This is reduced to 679 on average per month due to there being an additional advisor. This is slightly less than the agent's intervention.

In 2010 there were on average 634 abandoned calls each month when 5% feedback was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of advisors also impacts upon the utilisation of agent and advisors. Under the initial conditions the average advisor's utilisation is 72.64%. With the introduction of an additional agent and two percent feedback, the utilisation changes to

70.92%. There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 78.69% to 77.17%.

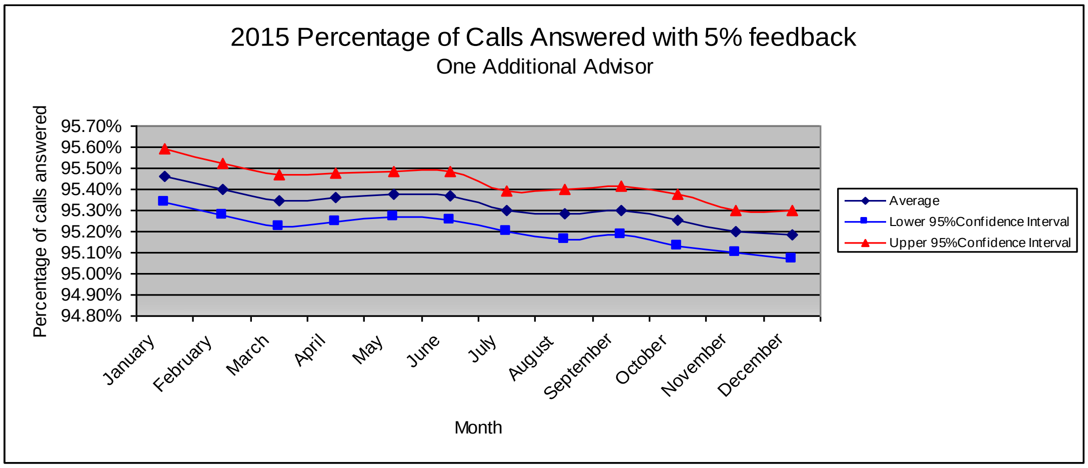

Figure A17.44: Calls answered, 1 extra advisor, 5% feedback, 2015

The addition of one additional advisor returns the system back to acceptable levels over the twelve month period. The percentage of calls answered decreased by 0.28% over the twelve month period. This is the same decrease experienced in the previous experiment.

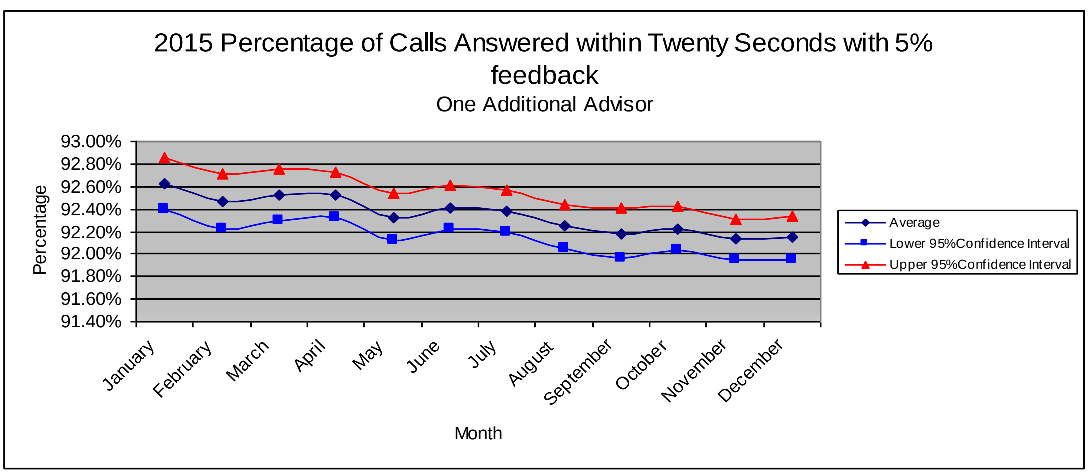

Figure A17.45: Calls answered in 20 sec, 1 extra advisor, 5% feedback, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.49% to 92.35%. The performance target is now very similar to the 2010 average when 5% feedback was introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.48% over the period.

Like the other experiment with a staffing intervention, the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 15.99% in the number of abandoned calls.

Experiment sixteen: Impact on performance with 10% feedback and one additional advisor in 2015

The final experiment of 2015 simulated the impact of having one additional advisor and explores the impact on performance when 10% of abandoned calls call back from the previous month.

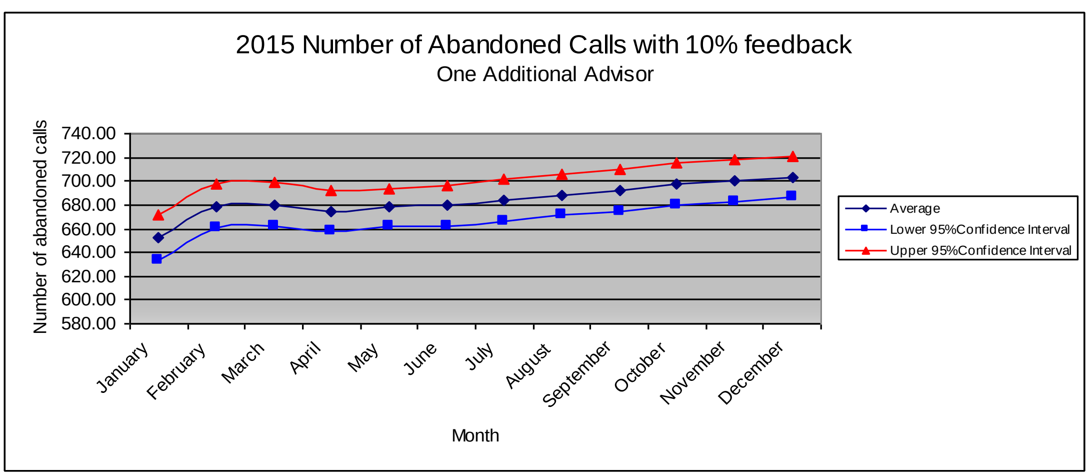

Figure A17.46: Abandoned calls, 1 extra advisor, 10% feedback, 2015

Over the twelve month period in 2015, the number of abandoned calls increases by 7.81% which is the same result as the previous experiment. Before the staffing intervention the average number of abandoned calls is 819. This is reduced to 684 on average per month due to there being an additional agent.

In 2010 there were on average 639 abandoned calls each month when 10% feedback was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of advisors also impacts upon the utilisation of agents and advisors. Under the initial conditions the average advisor's utilisation is 72.77%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 70.99%. There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 78.73% to 77.28%.

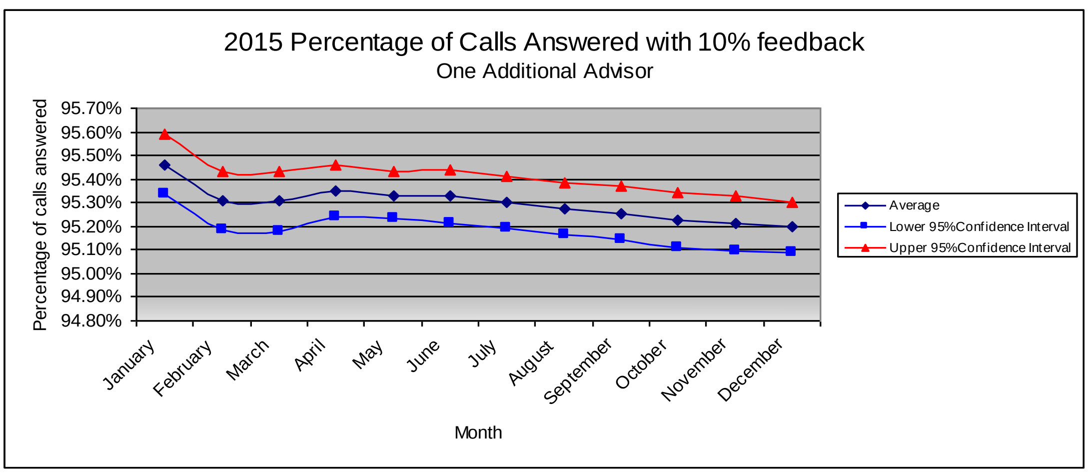

Figure A17.47: Calls answered, 1 extra advisor, 10% feedback, 2015

The addition of one extra agent returns the system back to acceptable levels over the twelve month period. The performance target is now very similar to the 2010 average when 5%

feedback was introduced into the system. The percentage of calls answered decreased by 0.27% over the twelve month period.

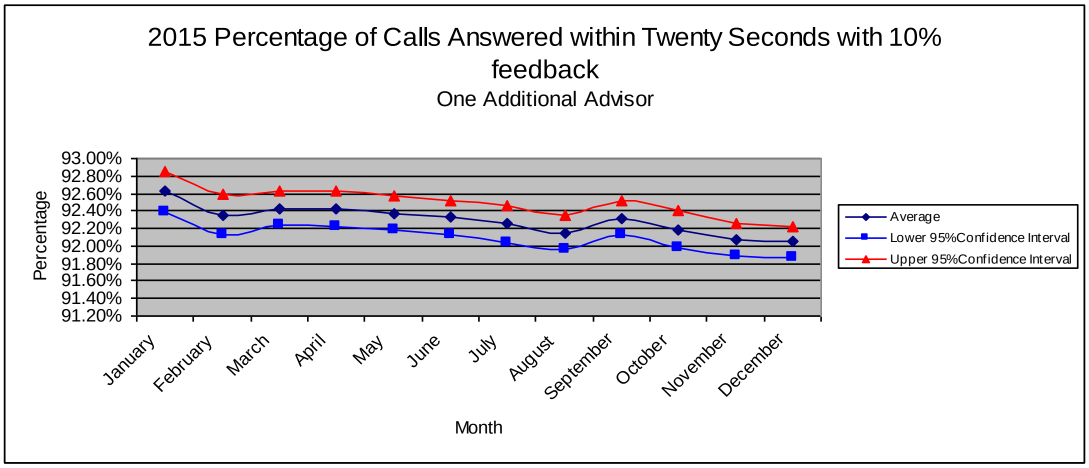

Figure A17.48: Calls answered in 20 sec, 1 extra advisor, 10% feedback, 2015

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 90.46% to 92.30%. The performance target is now very similar to the 2010 average when 5% feedback was introduced into the system. The percentage of calls answered within 20 seconds only decreased by 0.58% over the period.

Like the others experiment with a staffing intervention the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 16.51% in the number of abandoned calls.

The final set of experiments is for 2020 and, like the experiments for 2015, staffing interventions are required to return performance back to acceptable levels. This time, though, the staffing interventions require more than one additional member of staff to reach acceptable performance levels.

In comparison to 2010, there were originally 13,607 calls per month on average. In 2020 this increases to 15,693 calls on average per month. This equates to a 15.03% increase in the average call arrivals per month. In 2010 there were on average 1,223 more Children's type calls than Adult Service calls. There are now more Adult Service type calls than Children's Service calls in 2020. There are in fact on average 291 more Adult Service calls on average each month. There is likely to be a 29.07% increase in the number of calls to do with Adult Services and a 3.86% increase in the calls for Children's Services.

Experiment seventeen: Impact on performance with no feedback in 2020

The seventeenth experiment explores the impact of natural increases in call arrivals on performance in 2020. The contact centre conditions are kept exactly the same as for 2010. Call arrivals is the only variable that is changed.

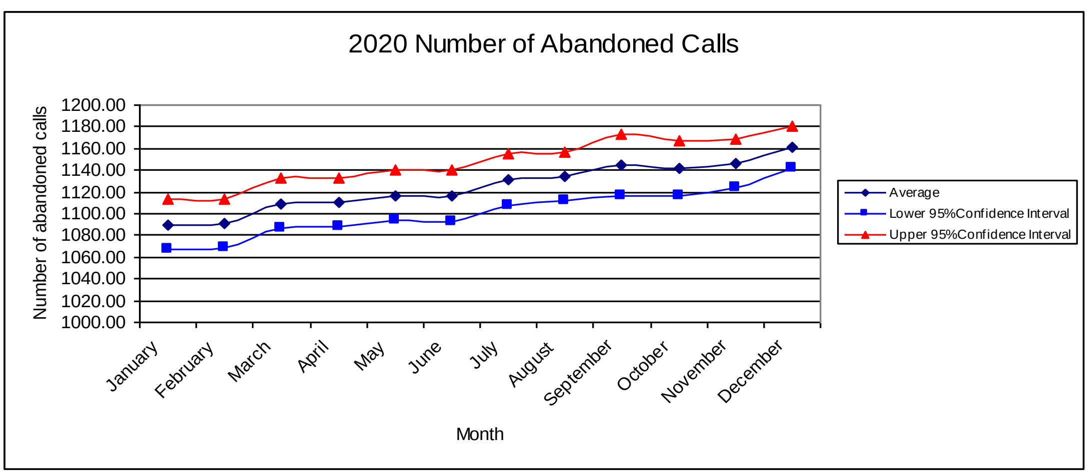

Figure A17.49: Abandoned calls, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 6.52%. The number of abandoned calls in December 2020 is likely to be 81.45% more than in December 2010. It is 40.16% more than in December 2015. There are significant increases over the ten year period. In December 2020 over the forty replications the 95% confidence interval is 1141 to 1181.

There is no noteworthy alteration to the staff utilisations for either agents or advisors. The reason for this occurrence is that the call arrivals are very similar for each month. This is the same result for 2010 and 2015 where the simulations are run with no feedback.

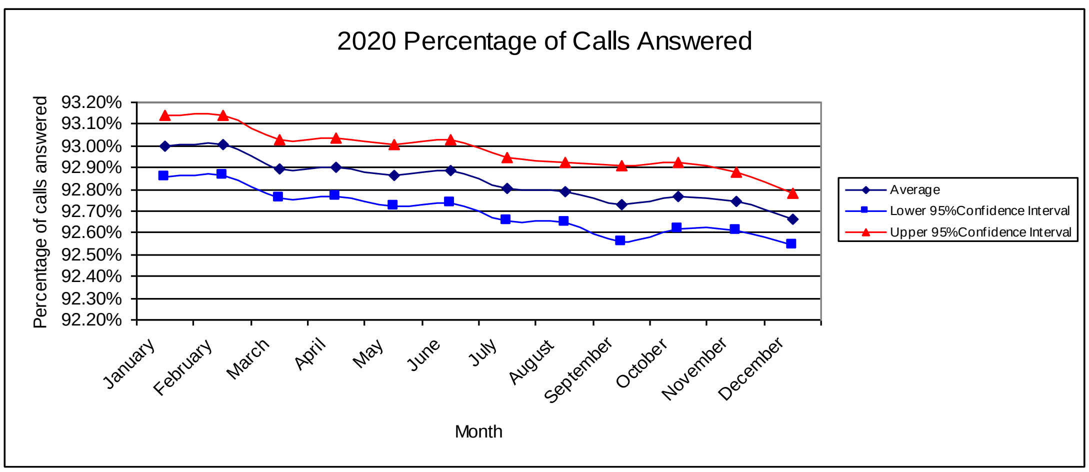

Figure A17.50: Calls answered, 2020

The percentage of calls answered in January 2020 is 93.00%. This is less than the required 95% percent target so further experiments will be carried out to calculate the number of additional agents and advisors to meet the required performance criteria. The results of intervention are explored after the effects of feedback are investigated before any staffing intervention takes place.

The percentage of calls answered decreased by 0.34% over the twelve month period due to natural increases in the population.

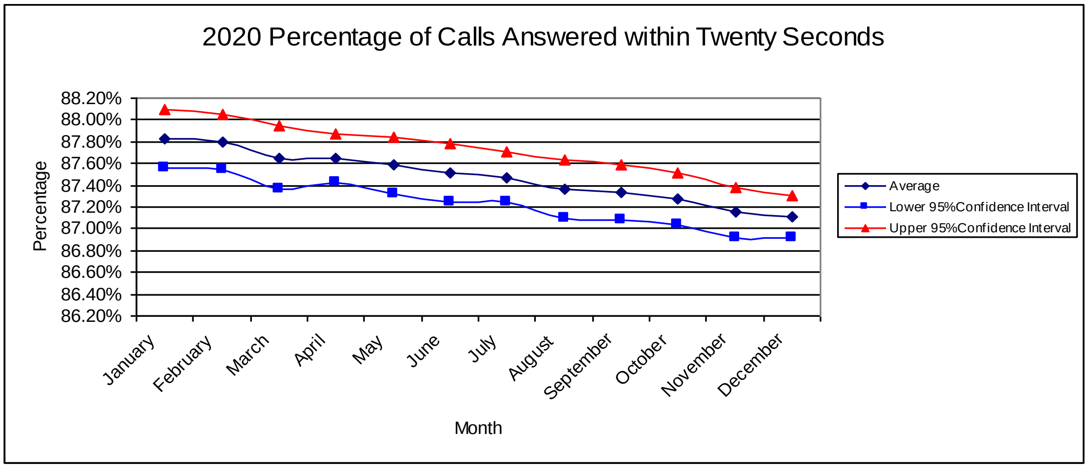

Figure A17.51: Calls answered in 20 sec, 2020

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.72% over the period.

The impact of feedback created by abandoned calls is now explored in 2020. Firstly, the impact of 2% of abandoned calls calling back is explored.

Experiment eighteen: Impact on performance with two percent feedback in 2020

The second experiment in 2020 explores the impact on performance when 2% of abandoned calls call back from the previous month.

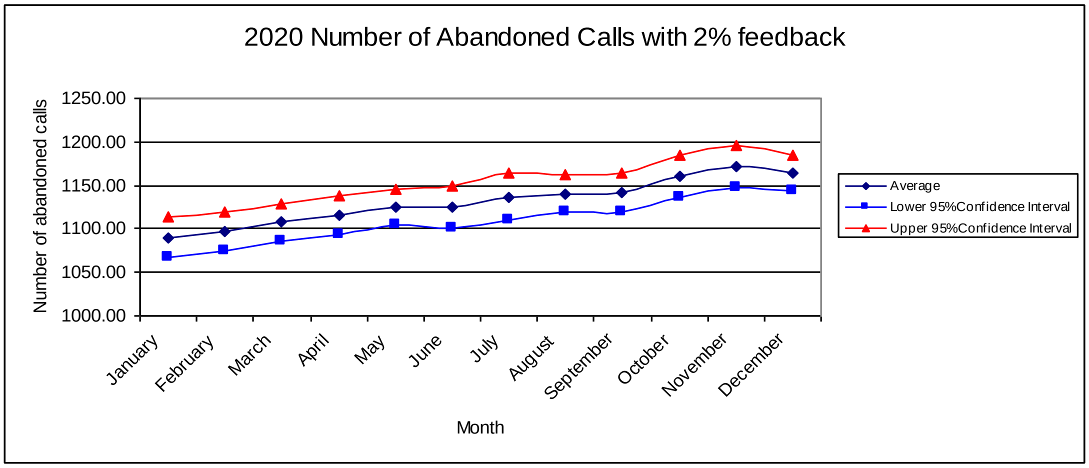

Figure A17.52: Abandoned calls, 2% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls is likely to increase by 6.78%. This is only slightly higher in comparison to experiment one for 2020 with 2% feedback.

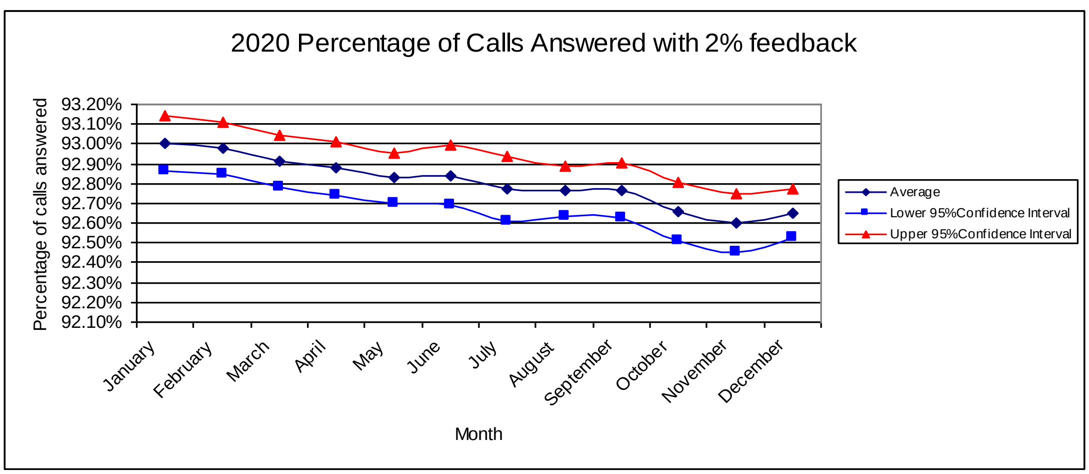

Figure A17.53: Calls answered, 2% feedback, 2020

Once again as expected, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with two percent feedback.

The percentage of calls answered decreased by 0.35% over the twelve month period. This is a particularly small change.

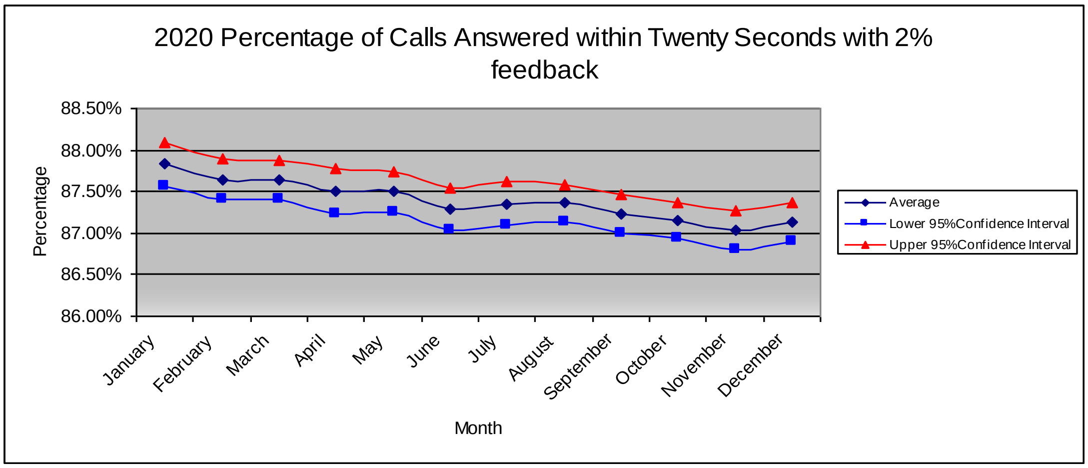

Figure A17.54: Calls answered in 20 sec, 2% feedback, 2020

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 0.70% over the period.

Experiment nineteen: Impact on performance with five percent feedback in 2020

The nineteenth experiment explores the impact on performance when 5% of abandoned calls call back from the previous month.

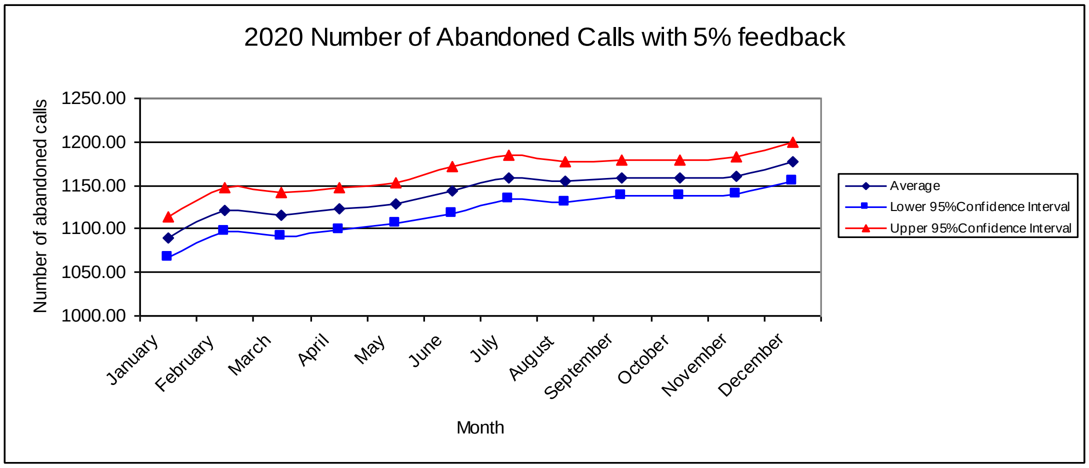

Figure A17.55: Abandoned calls, 5% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 8.00%. This is a significant rise the in the number of abandoned calls.

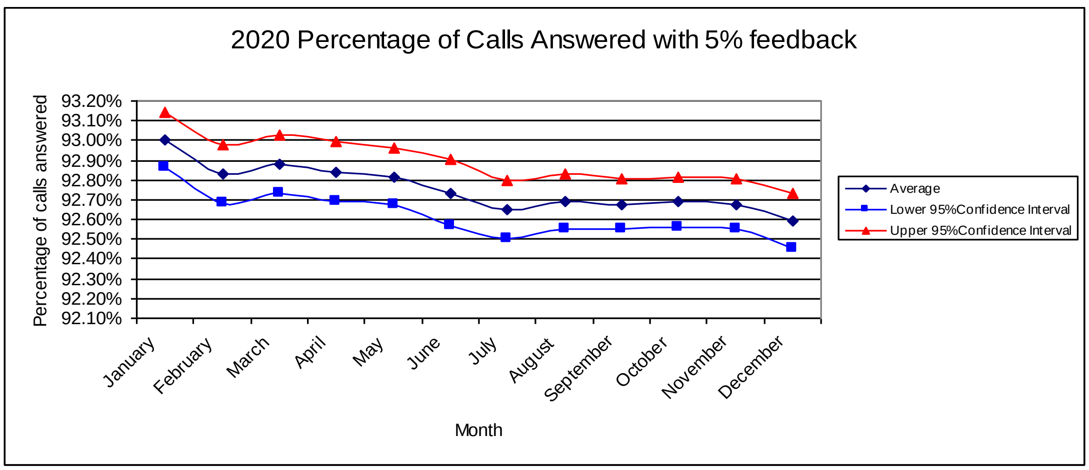

Figure A17.56: Calls answered, 5% feedback, 2020

Once again like the two previous experiments, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with five percent feedback for 2020.

The percentage of calls answered decreased by 0.41% over the twelve month period.

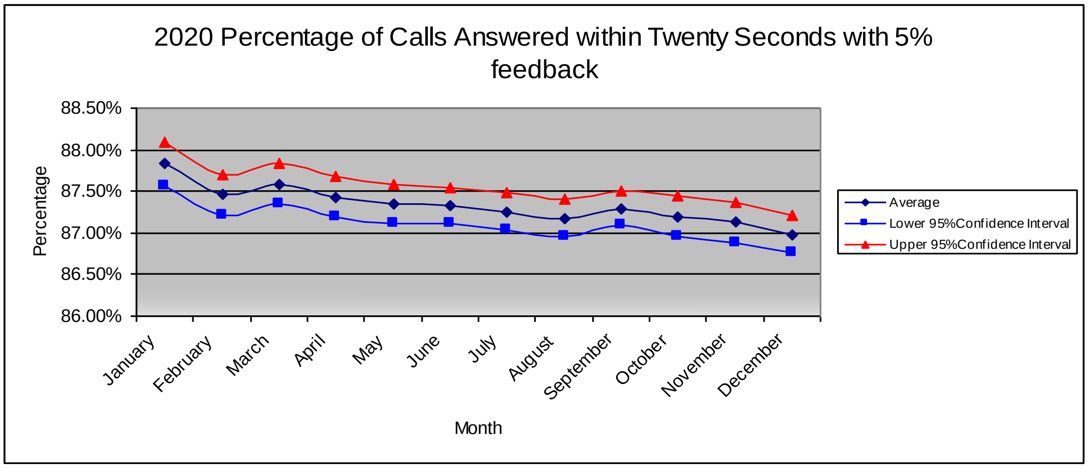

Figure A17.57: Calls answered in 20 sec, 5% feedback, 2020

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period in 2020. The percentage of calls answered within 20 seconds only decreased by 0.84% over the period.

Experiment twenty: Impact on performance with 10% feedback in 2020

The fourth and final experiment without any staffing intervention in 2020 explores the impact on performance when 10% of abandoned calls call back from the previous month.

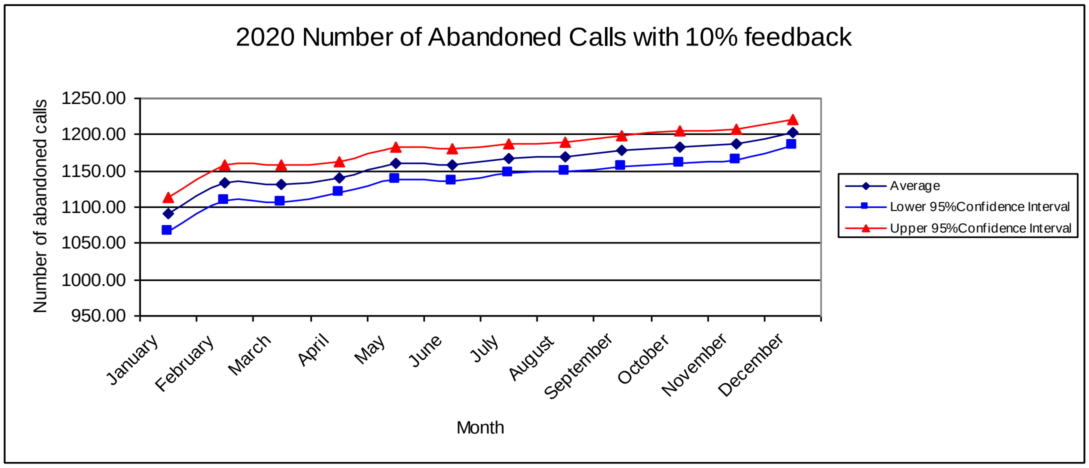

Figure A17.58: Abandoned calls, 10% feedback, 2020

Over the twelve month period in 2015, the number of abandoned calls increases by 10.36%. There are on average 1158 abandoned calls each month. This is 81.2% higher than the number of abandoned calls in 2010. This is a very noteworthy increase over the decade.

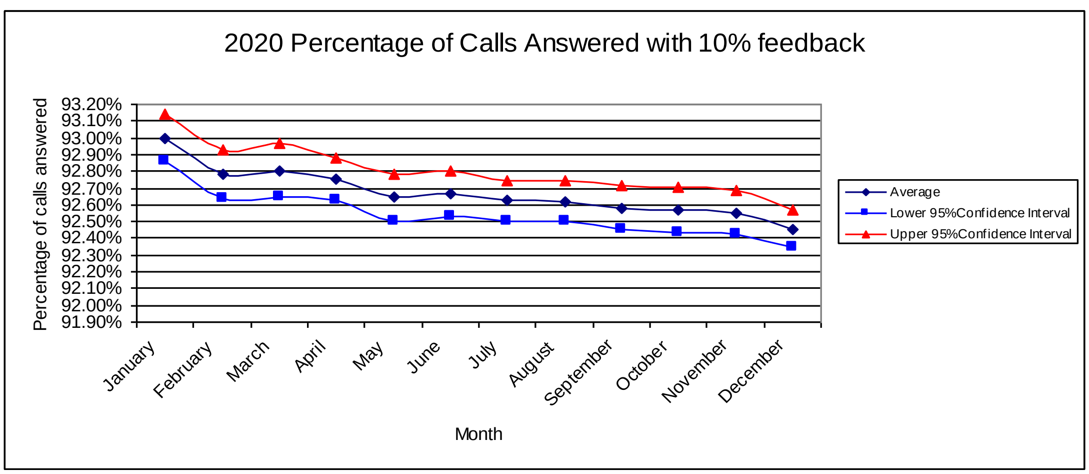

Figure A17.59: Calls answered, 10% feedback, 2020

Once again as expected, the percentage of calls answered over the year fails to meet the required performance levels. Thus, a staffing reconfiguration will be investigated with 5% feedback.

The percentage of calls answered decreased by 0.54% over the twelve month period.

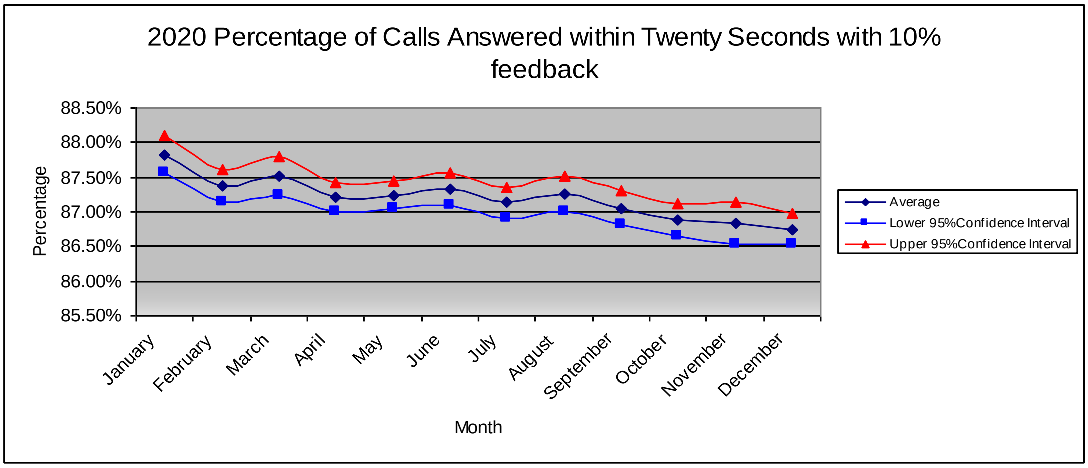

Figure A17.60: Calls answered in 20 sec, 10% feedback, 2020

The percentage of calls answered within 20 seconds met the required criteria over the twelve month period. The percentage of calls answered within 20 seconds only decreased by 1.08% over the period.

An intervention is required as the percentage of calls answered is less than 95% for all four experiments for 2020.

The first intervention is to increase the number of agents until the percentage of calls is greater than 95%. Unlike 2015, more than one additional agent is needed.

Intervention: Increase the number of agents by one

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	93.82%	93.95%	94.08%

Table A17.1: 2020 One additional agent intervention

As the percentage of calls answered is still under the 95% threshold, the number of agents was increased by two.

Intervention: Increase the number of agents by two

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	93.98%	94.11%	94.24%

Table A17.2: 2020 Two additional agents intervention

As the percentage of calls answered is still under the 95% threshold, the number of agents was increased by three. With an increase of three agents this criteria is satisfied.

Intervention: Increase the number of agents by three

Experiment twenty-one: Impact on performance with no feedback and three additional agents in 2020

The twenty-first experiment explores the impact of natural increases in call arrivals on performance with three additional agents.

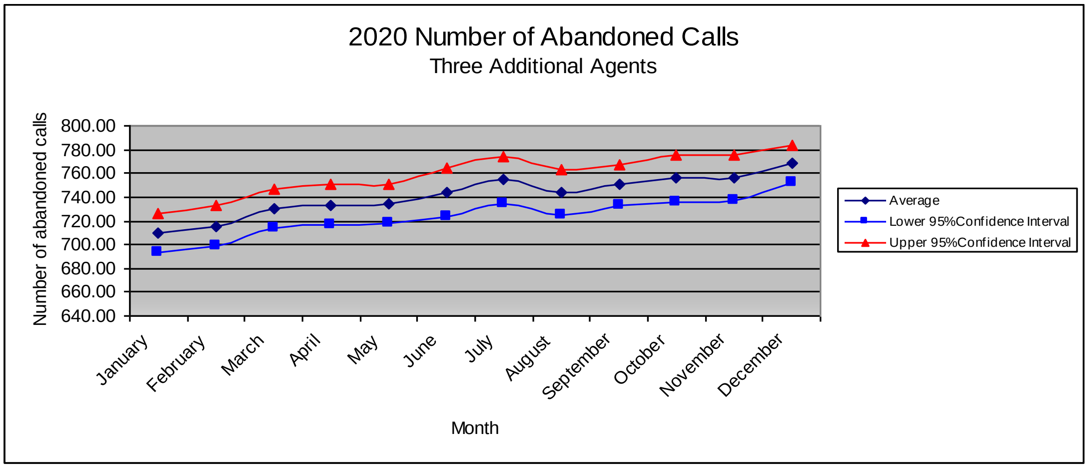

Figure A17.61: Abandoned calls, 3 extra agents, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 8.23%. This is in fact a higher percentage increase than before the staffing intervention but in terms of the actual number of abandoned calls, it is considerably lower due to three additional staff being able to take calls. Before the staff intervention the average number of abandoned calls is 1125. This is reduced to 742 due to there being additional agents handling calls. This is a substantial reduction in the number of abandoned calls.

In 2010 there were on average 630 abandoned calls each month. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels but not as much as the agent intervention resulted in 2015.

An increase in the number of staff also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 81.84%. With the introduction of additional agents, the utilisation changes to 76.55%. There is a significant decrease in the utilisation of advisors as a result of an increase in the number of agents. Utilisation falls from 75.89% to 71.87%.

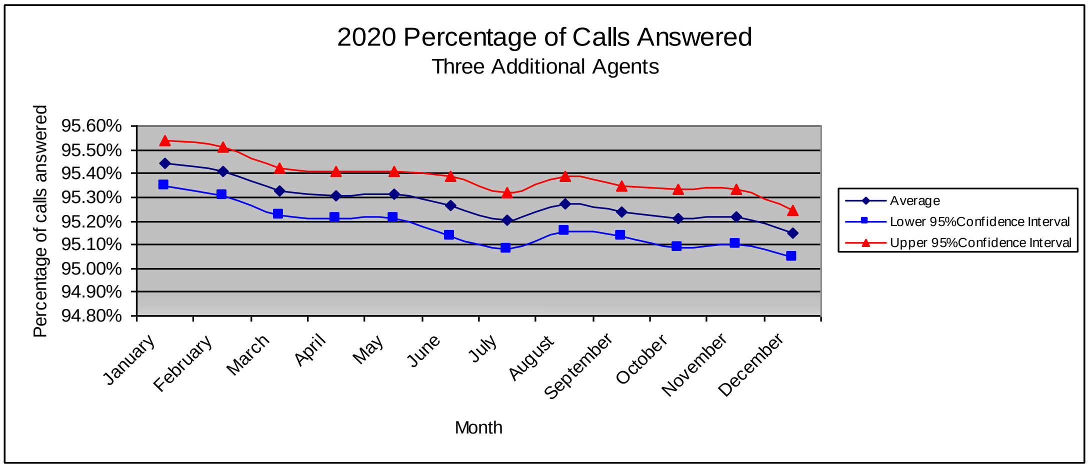

Figure A17.62: Calls answered, 3 extra agents, 2020

The addition of one agent returns the system back to acceptable levels over the twelve month period. The percentage of calls answered decreased by 0.30% over the twelve month period.

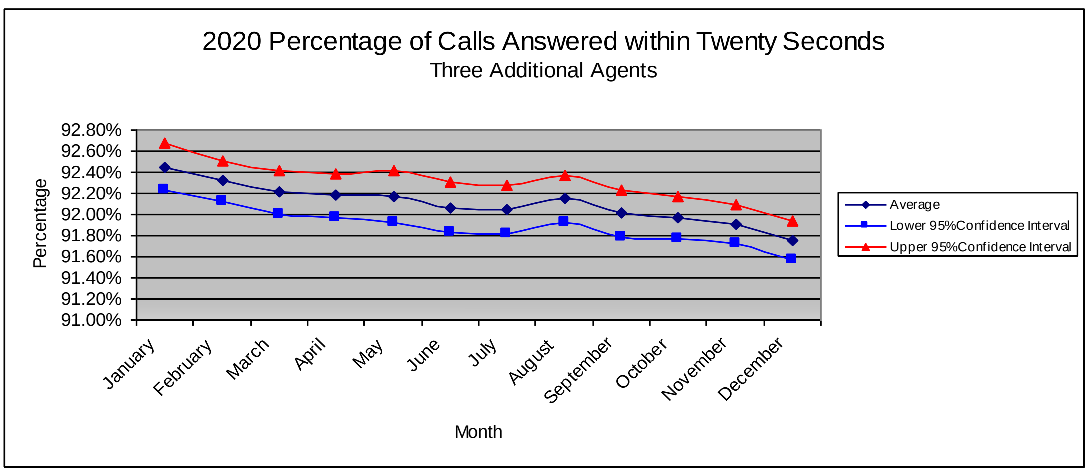

Figure A17.63: Calls answered in 20 sec, 3 extra agents, 2020

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 87.48% to 92.10%. This is now very similar to the results experienced in 2010 and 2015. The percentage of calls answered within 20 seconds only decreased by 0.69% over the period. This is a slightly lower reduction under the initial conditions.

As a result of the increase of three agents, the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 33.85% in the number of abandoned calls.

Experiment twenty-two: Impact on performance with 2% feedback and three additional agents in 2020

The next experiment simulated the impact of having three additional agents in 2020 and explores the impact on performance when 2% of abandoned calls call back from the previous month.

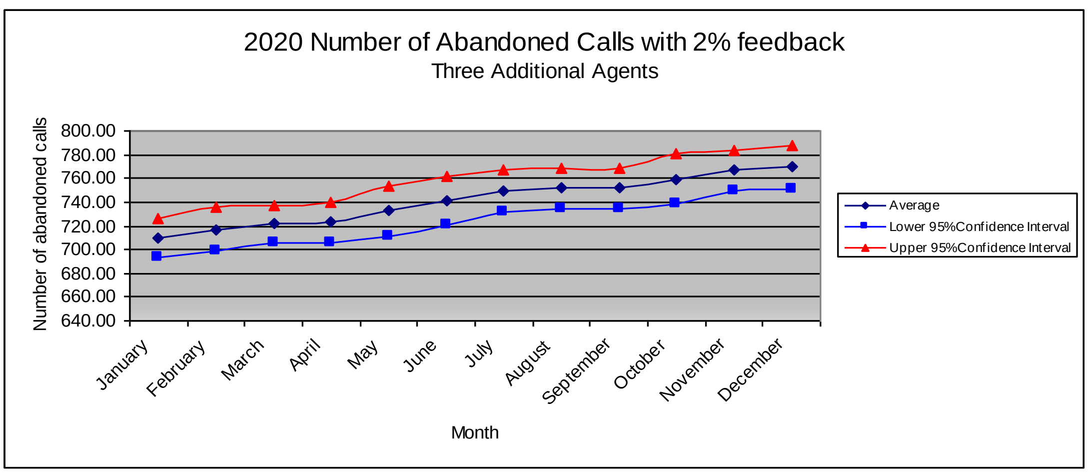

Figure A17.64: Abandoned calls, 3 extra agents, 2% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 8.41%. Before the staff intervention the average number of abandoned calls is 1131. This is reduced to 741 on average per month due to there being three additional agents. This is a sizeable reduction in the number of abandoned calls.

In 2010 there were on average 630 abandoned calls each month when 2% feedback was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels.

An increase in the number of staff also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 81.85%. With the introduction of an additional agent and two percent feedback, the utilisation changes slightly to 76.61%. There is also a significant decrease in the utilisation of advisors as a result of an increase in the number of agents. Utilisation falls from 75.96% to 71.87%.

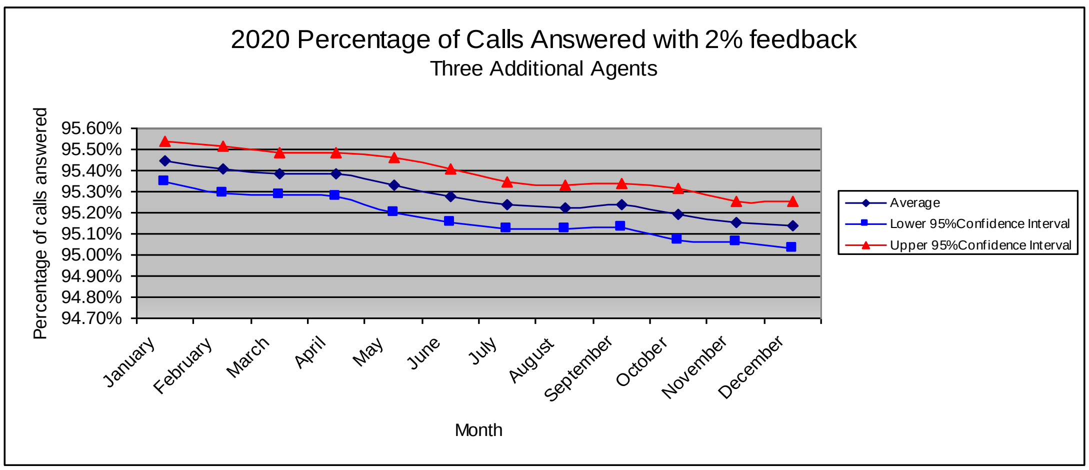

Figure A17.65: Calls answered, 3 extra agents, 2% feedback, 2020

The addition of one agent returns the system back to acceptable levels over the twelve month period. The percentage of calls answered decreased by 0.30% over the twelve month period.

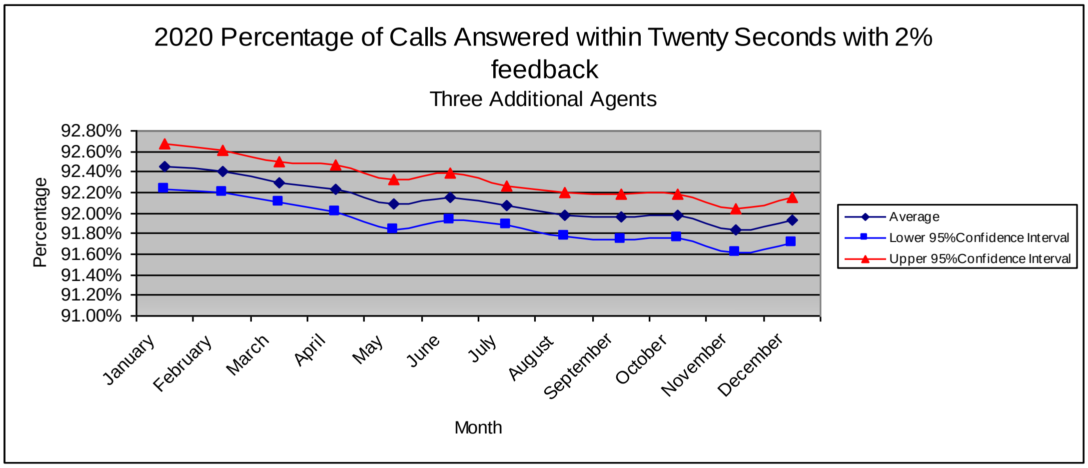

Figure A17.66 Calls answered in 20 sec, 3 extra agents, 2% feedback, 2020

Like the previous experiment there is an increase in the average percentage of calls answered within 20 seconds per month from 87.39% to 92.12%. The percentage of calls answered within 20 seconds only decreased by 0.52% over the period. These results are very similar to the previous experiment.

Like experiments one and two the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For instance, a like-for-like comparison of December 2015 results in a decrease of 33.93% in the number of abandoned calls.

Experiment twenty-three: Impact on performance with five percent feedback and three additional agents in 2020

The next experiment explored the impact of having three additional agents in 2020 and explores the impact on performance when five percent of abandoned calls call back from the previous month.

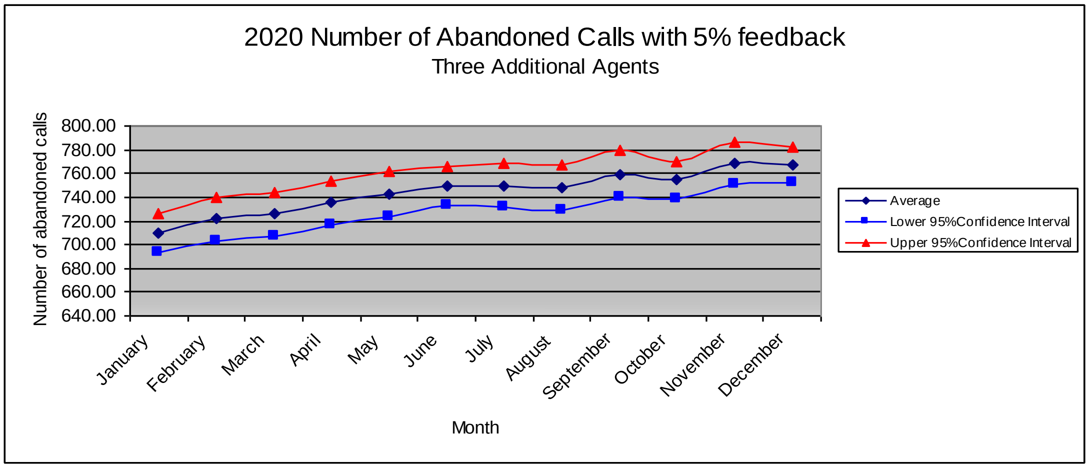

Figure A17.67: Abandoned calls, 3 extra agents, 5% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 8.17%. Before the staff intervention the average number of abandoned calls is 1141. This is reduced to 744 on average per month due to there being an additional three agents. This is a considerable reduction in the number of abandoned calls.

In 2010 there were on average six hundred and thirty-four abandoned calls each month when two percent feedback was introduced into the system. The staffing intervention aided in returning the number of abandoned calls closer to the acceptable 2010 levels but not as much as the previous two experiments.

An increase in the number of agents also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 81.96%. With the introduction of three additional agents and two percent feedback, the utilisation changes slightly to 76.68%. There is a slight decrease in the utilisation of advisors as a result of increase in the number of agents. Utilisation falls from 76.05% to 71.95%.

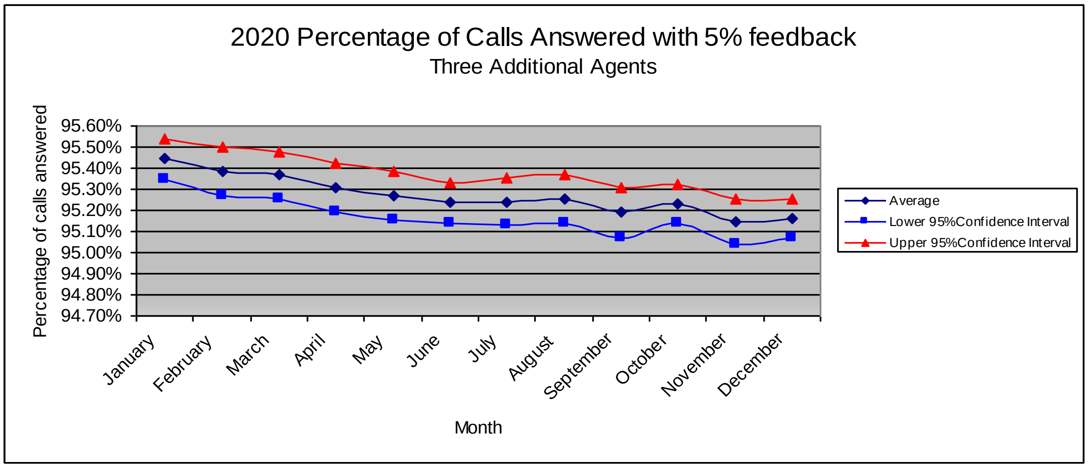

Figure A17.68: Calls answered, 3 extra agents, 5% feedback, 2020

The addition of three additional agents returns the system back to acceptable levels over the twelve month period. The percentage of calls answered decreased by 0.28% over the twelve month period.

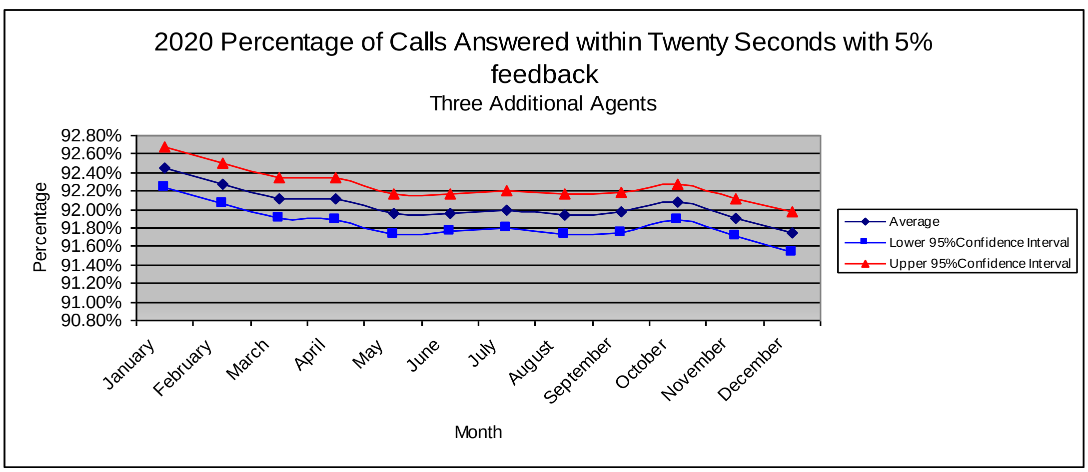

Figure A17.69: Calls answered in 20 sec, 3 extra agents, 5% feedback, 2020

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 87.33% to 92.05%. The percentage of calls answered within 20 seconds only decreased by 0.70% over the period.

Like the previous three experiments the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For instance, a like-for-like comparison of December 2015 results in a decrease of 34.75% in the number of abandoned calls.

Experiment twenty-four: Impact on performance with ten percent feedback and three additional agents in 2020

The final agent intervention experiment simulated the impact of having three additional agents in 2020 and explores the impact on performance when ten percent of abandoned calls are allowed to call back from the previous month.

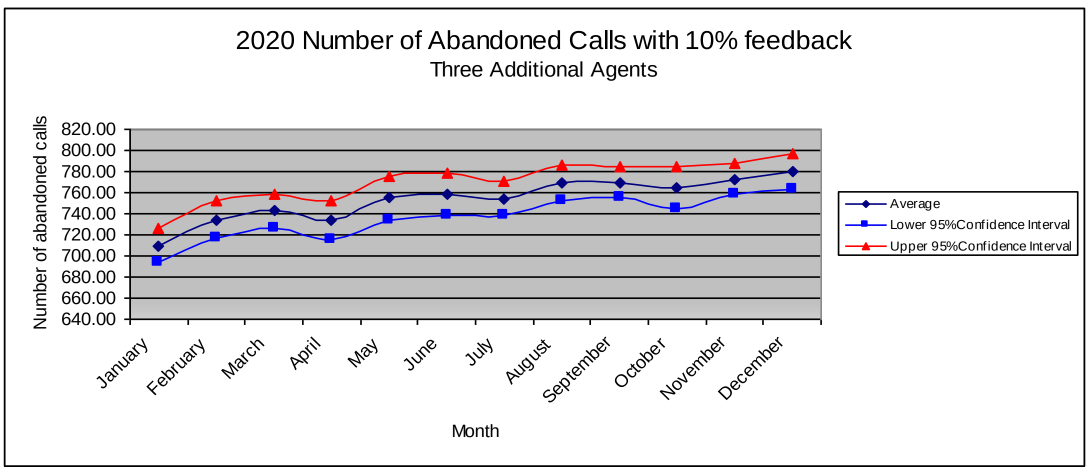

Figure A17.70: Abandoned calls, 3 extra agents, 10% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls increases by 9.88%. Before the staff intervention the average number of abandoned calls is 1158. This is reduced to 754 on average per month due to there being an additional three agents.
In 2010 there were on average six hundred and thirty-four abandoned calls each month when two percent feedback was introduced into the system. The staffing intervention aided

in returning the number of abandoned calls closer to the acceptable 2010 levels but not as much as the previous two agent intervention experiments of 2020.

An increase in the number of agents also impacts upon the utilisation of agents and advisors. Under the initial conditions the agent's utilisation is 82.11%. With the introduction of an additional three agents and ten percent feedback, the utilisation changes to 76.75%. There is a slight decrease in the utilisation of advisors as a result of an increase in the number of agents. Utilisation falls from 76.20% to 72.07%. The utilisation results for all four experiments where the number of agents are increased in 2020 are very similar.

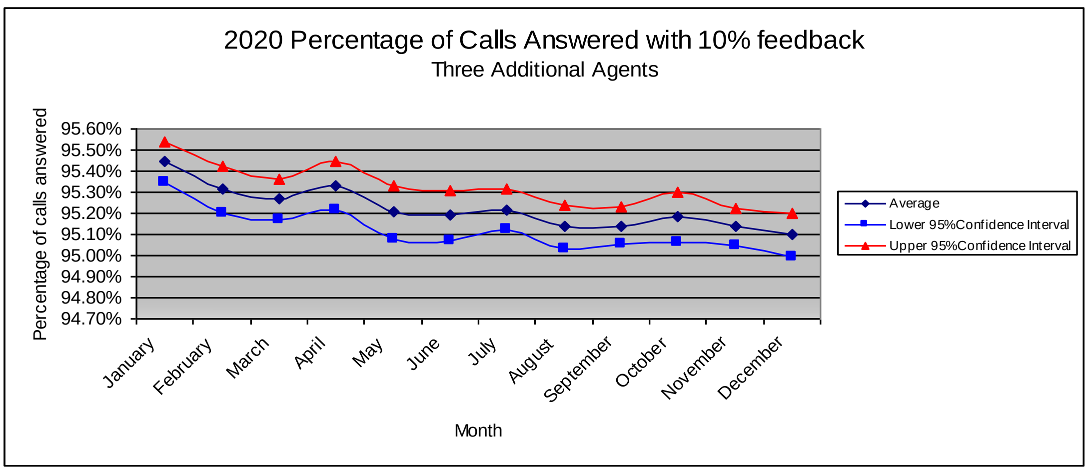

Figure A17.71: Calls answered, 3 extra agents, 10% feedback, 2020

The addition of three extra agents returns the system back to acceptable levels over the twelve month period. The percentage of calls answered decreased by 0.54% over the twelve month period.

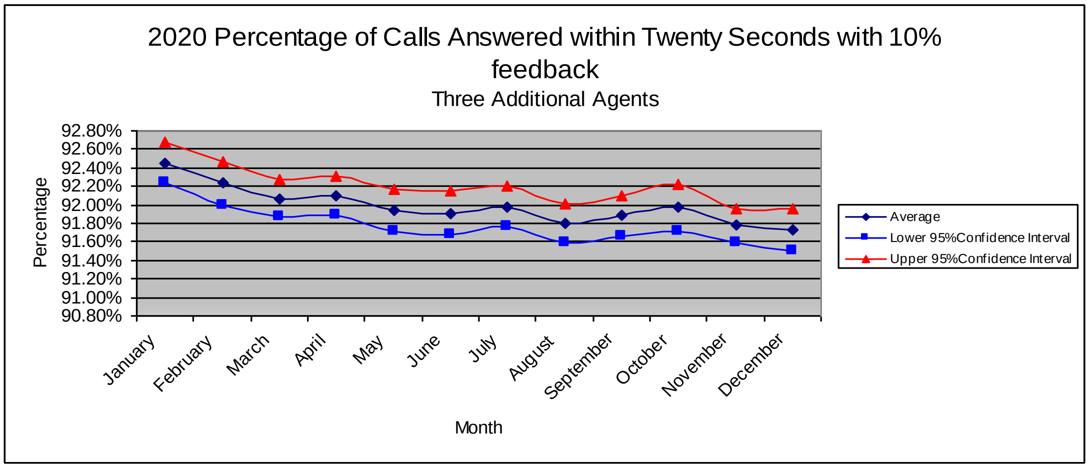

Figure A17.72: Calls answered in 20 sec, 3 extra agents, 10% feedback, 2020

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 87.20% to 91.99%. The percentage of calls answered within 20 seconds only decreased by 0.72% over the period.

Like the other experiments with a staffing intervention the required performance measures are met but the real impact of the staff intervention is seen with a significant reduction in the number of abandoned calls. For example, a like-for-like comparison of December 2015 results in a decrease of 35.16% in the number of abandoned calls.

The results of the four agent interventions for 2010 are very similar to each to other. The second intervention explored for 2020 is to once again increase the number of advisors until the percentage of calls is greater than 95%. This produces some very interesting results which are now discussed. The next set of experiments now follow very different trends to the previous set of experiments.

Intervention: Increase the number of advisors by one

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	94.02%	94.18%	94.33%

Table A17.3: 2020 One additional advisor intervention

As the percentage of calls answered is still under the ninety-five percent threshold, the number of agents was increased by two.

Intervention: Increase the number of advisors by two

The average percentage of calls answered in January 2020 meets the required ninety-five percent criteria and only an additional two advisors are required whereas three agents were required in the previous experiment. An interesting result occurs after a few months in each experiment. The criteria fails after a few months and a further advisor is required to once again meet the prerequisite target.

For experiment one, where no feedback from abandoned calls is introduced, the number of advisors needs to be increased by a further advisor in April 2020. As shown in Table A17.4, the required target is not met by 0.02%.

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	94.86%	94.98%	95.10%

Table A17.4: April 2020 Failure

Intervention: Increase the number of advisors by three in April 2020

Experiment twenty-five: Impact on performance with no feedback and two/three additional advisors in 2020

The first experiment simulated the impact of having additional advisors in 2020 and the impact upon performance is investigated.

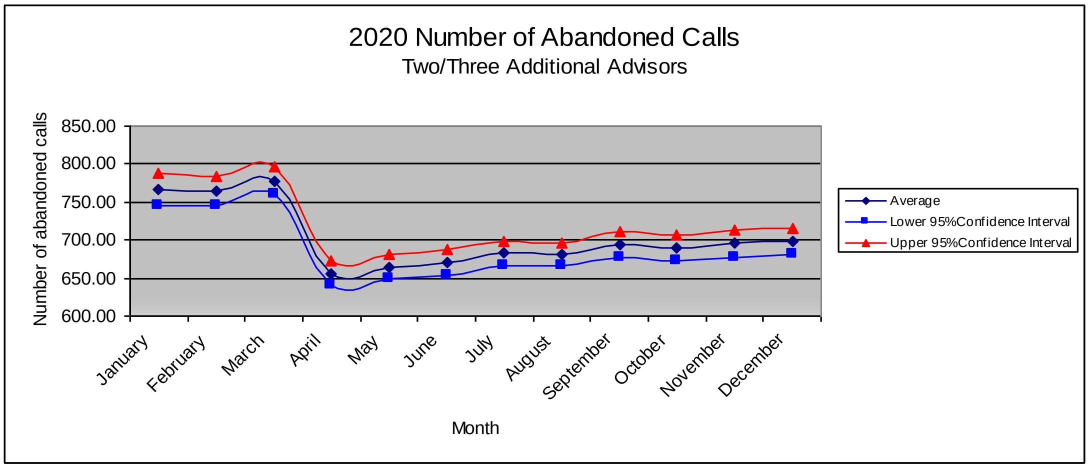

Figure A17.73: Abandoned calls, 2-3 extra advisors, 2020

Over the twelve month period in 2020, the number of abandoned calls decreases by 8.91%. This is the first experiment where an intervention causes a reduction in the number of abandoned calls over the twelve month period. The reason for this occurrence is that two interventions occur during the year. There are two additional advisors during the first two months which causes an initial reduction in the number of abandoned calls and aids the system in returning to acceptable performance levels. The additional advisor which was added in April causes a further reduction in the number of abandoned calls. So whilst the number of abandoned calls falls throughout the twelve month period, there are increases over the period January to March and April to December.

Before the staff intervention the average number of abandoned calls is 1125. This is reduced to 704 on average per month due to there being additional advisors. A like-for-like comparison of December 2015 results in a decrease of 39.88% in the number of abandoned calls.

An increase in the number of advisors also impacts upon the utilisation of agent and advisors. Under the initial conditions the advisor's utilisation is 75.89%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 71.37%. As there were two interventions, two further comparisons are made.

The advisor's utilisation on average from January to March was 75.61 and after the initial intervention the utilisation falls to 72.47. During the next part of the year the average utilisation was 75.98. Due to the second intervention, utilisation falls to 71.23 on average. This is slightly less than utilisation with two additional advisors. The real impact of the increase of the number of advisors is seen with the reduction in the number of abandoned calls.

As a result of the additional advisors, there are also changes in the utilisation rates of the agents. There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 81.84% to 78.33%. There is not much impact of the utilisation of agents due to the change in the number of advisors. The same effect can be seen before and after the second intervention.

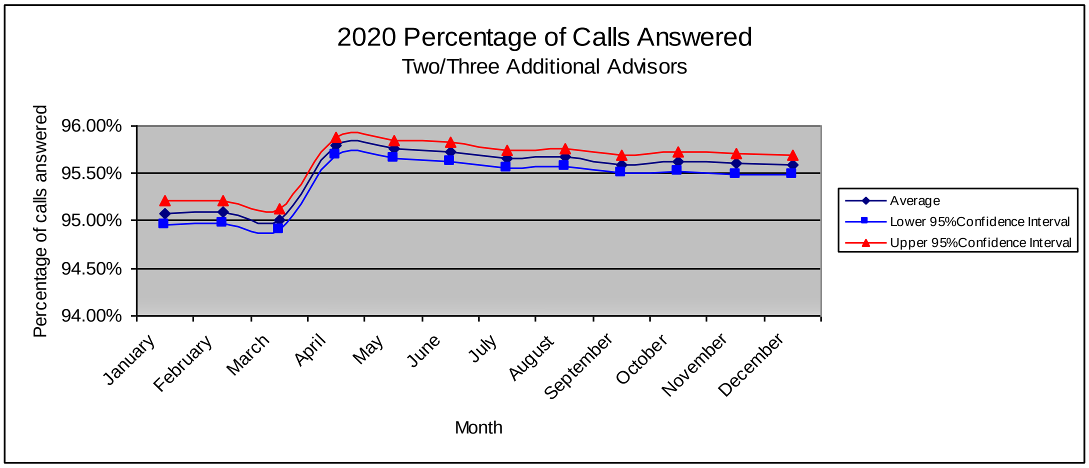

Figure A17.74: Calls answered, 2-3 extra advisors, 2020

The addition of three advisors returns the system back to acceptable levels over the twelve month period. The percentage of calls answered increased by 0.51% over the twelve month period. This again is a different result compared to all the previous results. The reason for the increase in the percentage of calls answered throughout the year is due to there being two interventions as opposed to one. There is a decrease in the percentage of calls answered over the periods January to March and April to December.

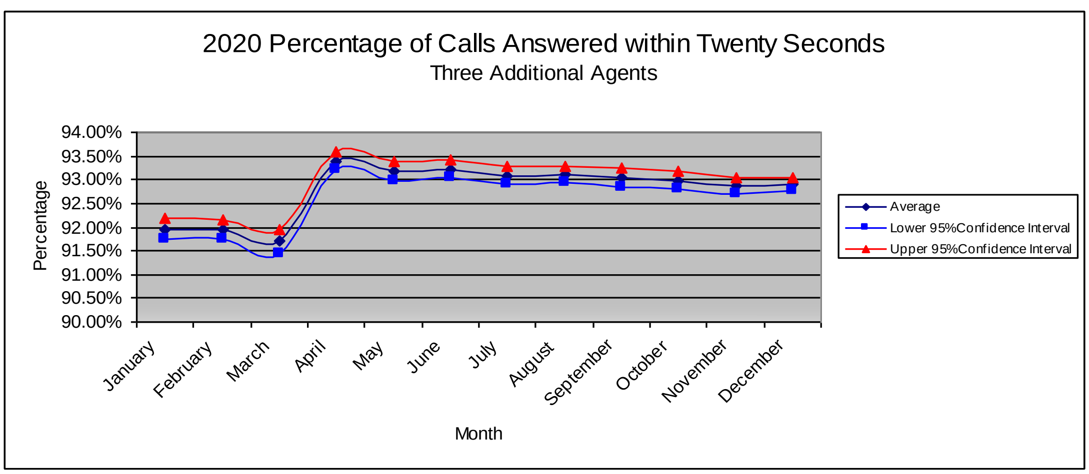

Figure A17.75: Calls answered in 20 sec, 2-3 extra advisors, 2020

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 87.20% to 92.79%. This is a very similar result to the intervention of three additional agents. The percentage of calls answered within 20 seconds only increased by 0.94% over the period. This again is a different result compared to all the previous results. The reason for the increase in the percentage of calls answered within 20 seconds throughout the year is due to there being two interventions as opposed to one. There is a decrease in the percentage of calls answered within 20 seconds over the periods January to March and April to December.

Experiment twenty-six: Impact on performance with two percent feedback and two/ three additional advisors in 2020

The next experiment simulated the impact of having additional advisors in 2020 and explores the impact on performance when two percent of abandoned calls call back from the previous month.

Two additional advisors are required to achieve acceptable performance levels.

Intervention: Increase the number of advisors by two

For experiment two the number of advisors needs to be increased by a further advisor in April 2020. As shown in Table A17.5, the required target is not met by 0.04%.

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	94.84%	94.96%	95.08%

Table A17.5: April 2020 Failure with 2% feedback

Intervention: Increase the number of advisors by three in April 2020

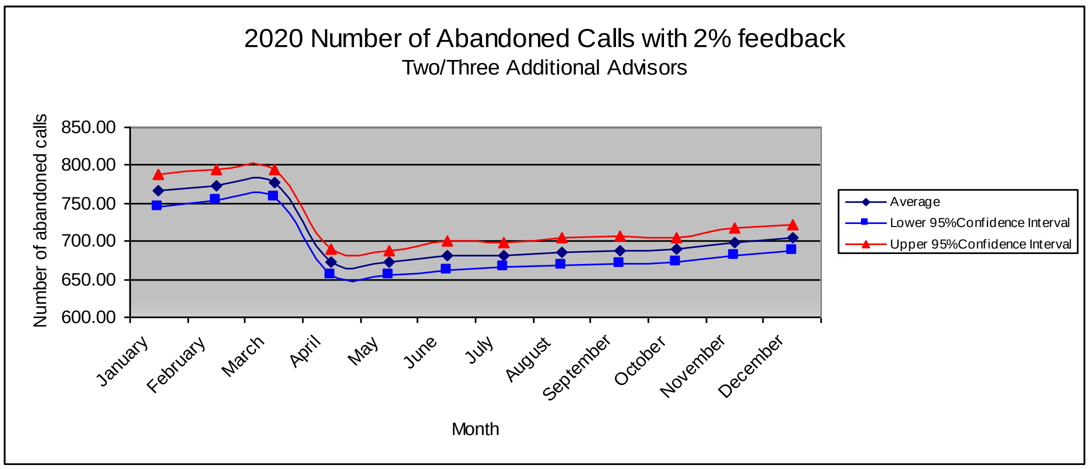

Figure A17.76: Abandoned calls, 2-3 extra advisors, 2% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls decreases by 8.00%. This is same result experienced in the previous experiment.

Before the staff intervention the average number of abandoned calls is 1131. This is reduced to 708 on average per month due to there being additional advisors. A like-for-like comparison of December 2015 results in a decrease of 39.43% in the number of abandoned calls. These are very similar results to the previous experiment.

Under the initial conditions the advisor's utilisation is 75.96%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 71.39%.

The advisors utilisation on average from January to March was 75.61 and after the initial intervention the utilisation falls to 72.28. During the next part of the year the average utilisation was 76.08. Due to the second intervention, utilisation falls to 71.10 on average.

As a result of the additional advisors, there are also changes in the utilisation rates of the agents.

There is a slight decrease in the utilisation of agents as a result of increase in the number of advisors. Utilisation falls from 81.85% to 78.13%. There is not much impact of the utilisation of agents due to the change in the number of advisors. The same effect can be seen before and after the second intervention.

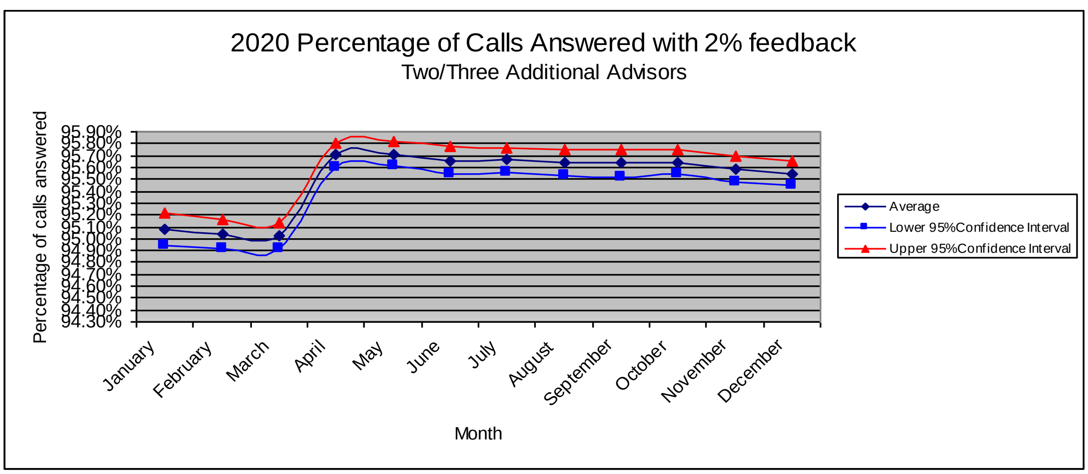

Figure A17.77: Calls answered, 2-3 extra advisors, 2% feedback, 2020

The addition of additional advisors returns the system back to acceptable levels over the twelve month period. The percentage of calls answered increase by 0.47% over the twelve month period.

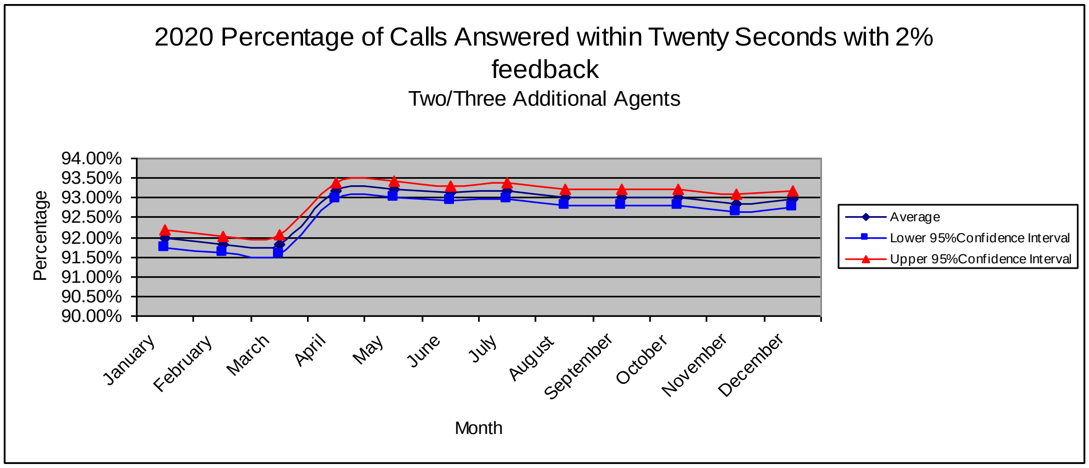

Figure A17.78: Calls answered in 20 sec, 2-3 extra advisors, 2% feedback, 2020

Like the previous experiment there is an increase in the average percentage of calls answered within 20 seconds per month from 87.39% to 92.76%. The percentage of calls answered within 20 seconds increases by 1.01% over the period.

Experiment twenty-seven: Impact on performance with five percent and two/three additional advisors feedback in 2020

The next experiment simulated the impact of having additional advisors in 2020 and explores the impact on performance when five percent of abandoned calls call back from the previous month.

Two additional advisors are required to achieve acceptable performance levels.

Intervention: Increase the number of advisors by two

For experiment two the number of advisors needs to be increased by a further advisor in February 2020. As shown in Table A17.6, the required target is not met by 0.04%

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	94.86%	94.96%	95.07%

Table A17.6: February 2020 Failure with 5% feedback

Intervention: Increase the number of advisors by three in February 2020

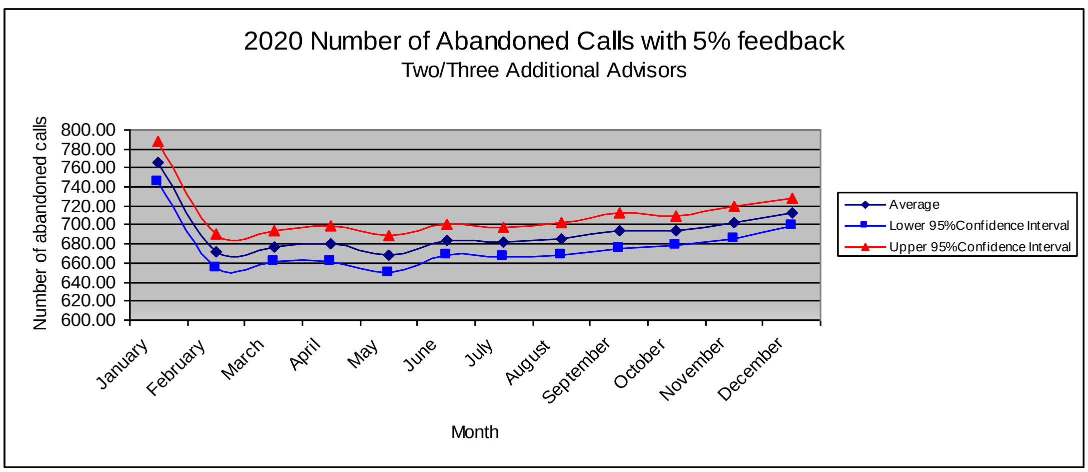

Figure A17.796: Abandoned calls, 2-3 extra advisors, 5% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls decreases by 6.86%. This is same result experienced in the previous experiment.

Before the staff intervention the average number of abandoned calls is 1141. This is reduced to 694 on average per month due to there being additional advisors. A like-for-like comparison of December 2015 results in a decrease of 39.34% in the number of abandoned calls. These are very similar results to the previous two experiments.

Under the initial conditions the advisor's utilisation is 76.05%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 71.19%.

The advisors utilisation on average from January to March was 75.72 and after the initial intervention the utilisation falls to 71.31. During the next part of the year the average utilisation was 76.16. Due to the second intervention, utilisation falls to 71.15 on average.

As a result of the additional advisors, there are also changes in the utilisation rates of the agents.

There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 81.96% to 78.19%. There is not much impact of the utilisation of agents due to the change in the number of advisors. The same effect can be seen before and after the second intervention.

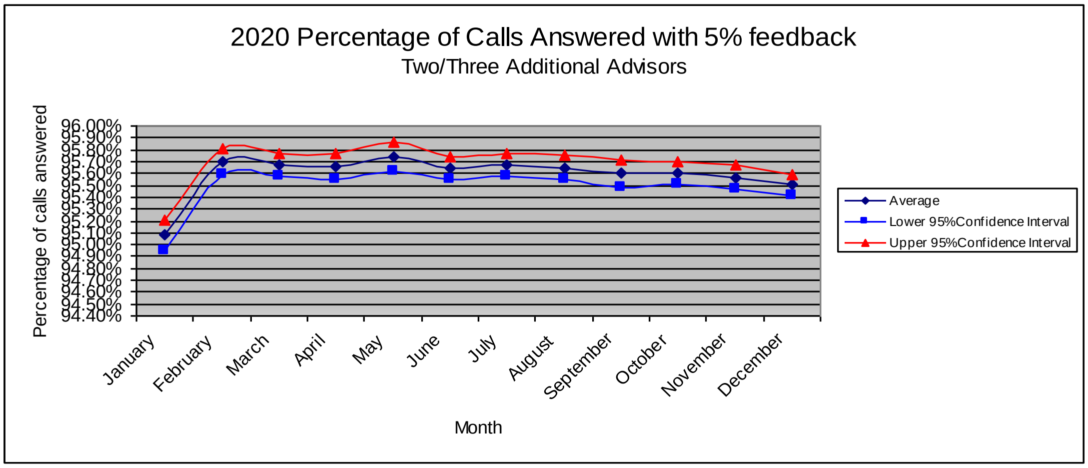

Figure A17.80: Calls answered, 2-3 extra advisors, 5% feedback, 2020

The addition of three additional advisors returns the system back to acceptable levels over the twelve month period. The percentage of calls answered increased by 0.42% over the twelve month period.

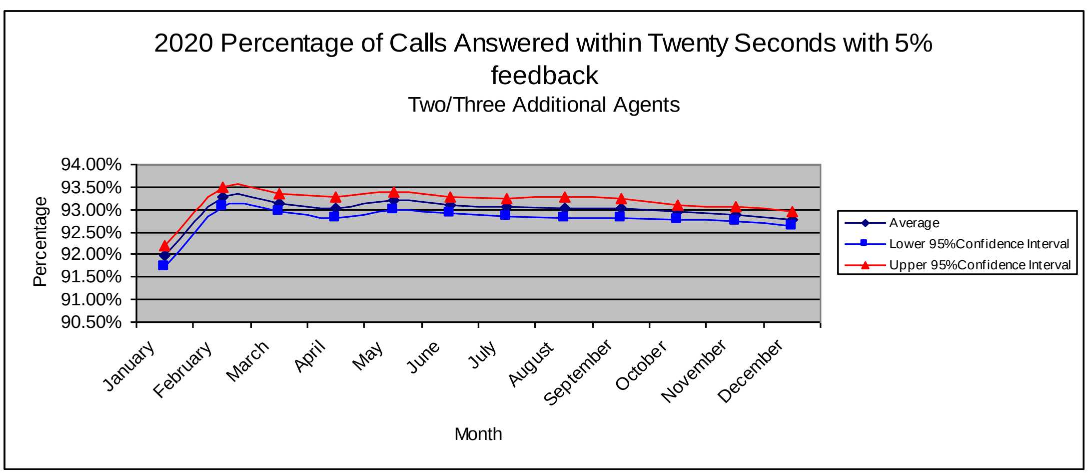

Figure A17.81: Calls answered in 20 sec, 2-3 extra advisors, 5% feedback, 2020

As a result of the increase in the number of advisors there is an increase in the average percentage of calls answered within 20 seconds per month from 87.33% to 92.96%. The percentage of calls answered within 20 seconds increases by 0.82% over the period.

Experiment twenty-eight: Impact on performance with ten percent feedback and two/ three additional advisors in 2020

The next experiment simulated the impact of having additional advisors in 2020 and explores the impact on performance when ten percent of abandoned calls call back from the previous month.

Two additional advisors are required to achieve acceptable performance levels.

Intervention: Increase the number of advisors by two

For experiment two the number of advisors needs to be increased by a further advisor in March 2020. As shown in Table A17.7, the required target is not met by 0.08%.

	Lower 95% Range	Average	Upper 95% Range
Percentage of Calls Answered	94.81%	94.92%	95.04%

Table A17.7: March 2020 Failure with 10% feedback

Intervention: Increase the number of advisors by three in March 2020

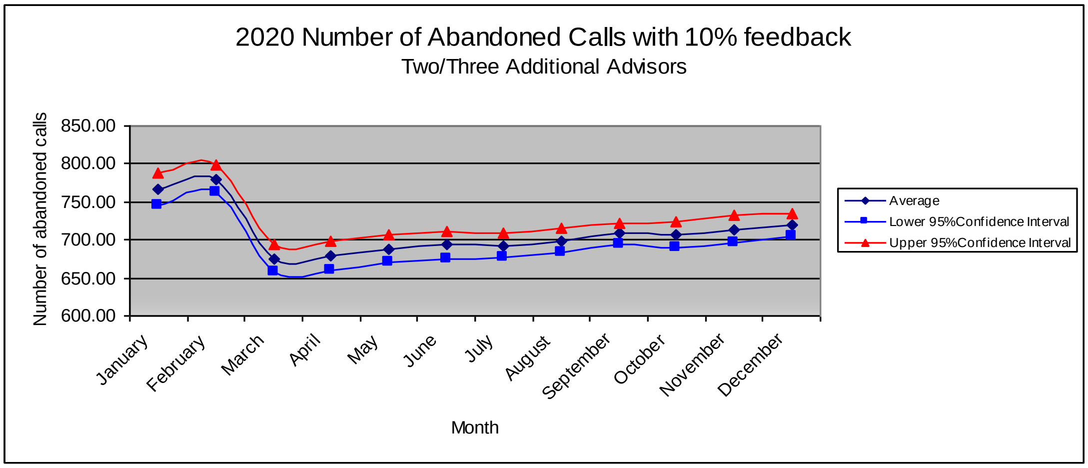

Figure A17.82: Abandoned calls, 2-3 extra advisors, 10% feedback, 2020

Over the twelve month period in 2020, the number of abandoned calls decreases by 6.12%. This is same result experienced in the previous experiment.

Before the staff intervention the average number of abandoned calls is 1158. This is reduced to 710 on average per month due to there being additional advisors. A like-for-like comparison of December 2015 results in a decrease of 40.23% in the number of abandoned calls. These are very similar results to the previous three experiments.

Under the initial conditions the advisor's utilisation is 76.20%. With the introduction of an additional agent and two percent feedback, the utilisation changes to 71.43%.

The advisors utilisation on average from January to March was 75.80 and after the initial intervention the utilisation falls to 71.88. During the next part of the year the average utilisation was 76.34. Due to the second intervention, utilisation falls to 71.28 on average.

As a result of the additional advisors, there are also changes in the utilisation rates of the agents.

There is a slight decrease in the utilisation of agents as a result of an increase in the number of advisors. Utilisation falls from 82.11% to 78.34%. There is not much impact of the utilisation of agents due to the change in the number of advisors. The same effect can be seen before and after the second intervention.

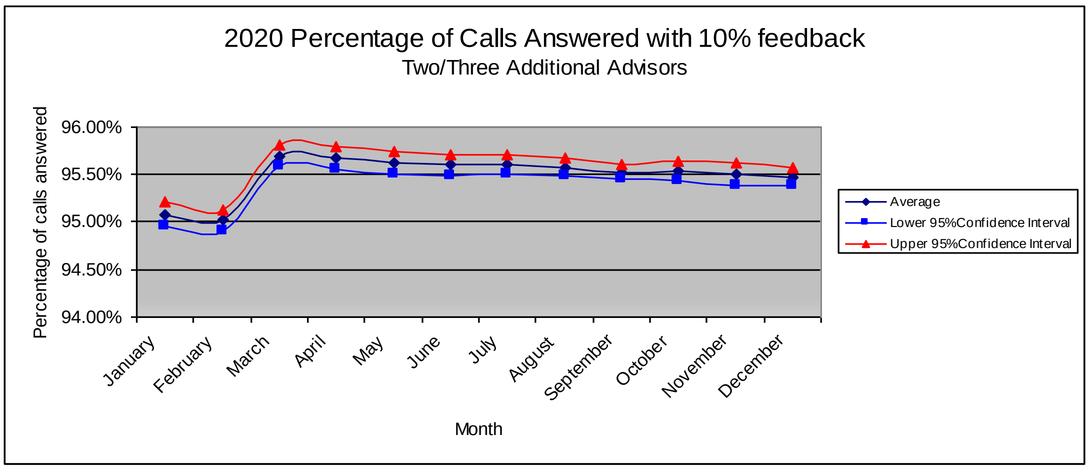

Figure A17.837: Calls answered, 2-3 extra advisors, 10% feedback, 2020

The addition of three extra agents returns the system back to acceptable levels over the twelve month period. The percentage of calls answered increased by 0.40% over the twelve month period.

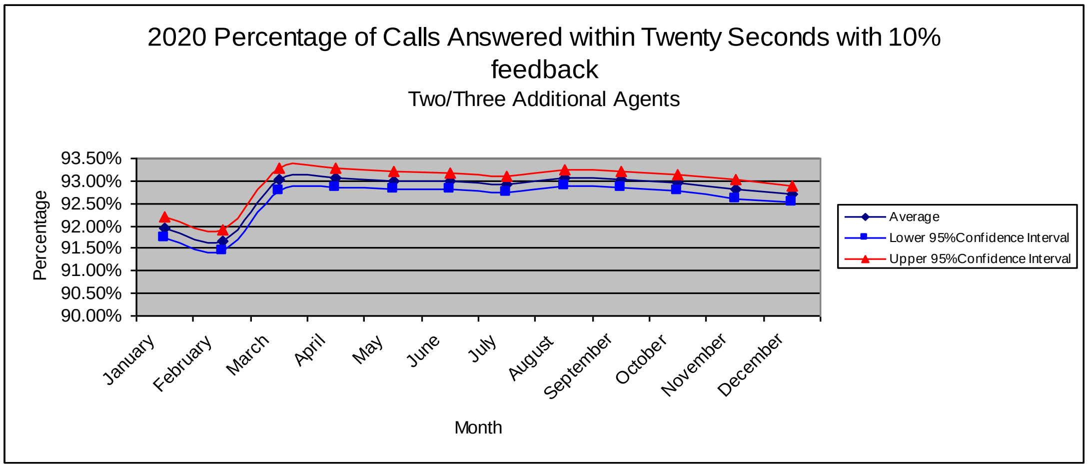

Figure A17.84: Calls answered in 20 sec, 2-3 extra advisors, 10% feedback, 2020

As a result of the increase in the number of agents there is an increase in the average percentage of calls answered within 20 seconds per month from 87.20% to 92.77%. This is very similar to the results of 2010 with ten percent feedback. The addition of three extra advisors returns the system back to acceptable levels over the twelve month period. The percentage of calls answered within 20 seconds increases by 0.74% over the period.