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MSc Dissertation

Making People Work Longer – What is the Impact on the Medical Workforce?

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A dissertation submitted in partial fulfilment of the MSc in Operational Research.

This project is entirely the original work of May Kee Chow. Where material is obtained from published or unpublished works, this has been fully acknowledged by citation in the main text and inclusion in the list of references.

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Abstract

The current work examined the sociological impact of increasing the State Pension Age on the medical workforce in the United Kingdom. This project mainly focussed on Trained Hospital Doctors in England due to the extremely large data and time constraint. The government of the United Kingdom had carried forward the increment of the State Pension Age to 67 between year 2026 and 2028, which was earlier planned to be implemented between year 2034 and 2036. System dynamics modelling was chosen to be the most appropriate approach for this project. The project applied the qualitative and quantitative modelling. Qualitative modelling was done by constructing a causal loop diagram. Quantitative modelling consisted of two stages. The first stage was the development of retirement profile tool to calculate the retirement rate at each age group. Secondly, a system dynamics simulation model was developed using Vensim DSS to forecast the supply and demand of the English medical workforce up to year 2040 by generating plausible scenarios. Plausible scenarios were developed based on the retirement behavior of the medical workforce in response to the reformation of the State Pension age. The results showed the size of Trained Hospital Doctor workforce annually and evaluated the proposed reformation of the State Pension age.

Executive Summary

This project studied the sociological impact of increasing the State Pension age on the medical workforce in the United Kingdom. The government has intended to implement the changes due to longer life expectancy as well as managing the pension cost. It was considered to be time consuming and costly to train medical workforce. The British Medical Association later made a briefing paper on this report that concluded a total of approximately £250,000 was needed to train a medical doctor. Additional postgraduate training would sum up to a total of approximately £500,000 of training a consultant. A medical student would need at least 15 years of training in order to serve as a specialist legally. Therefore, it was believed to be vital to balance the supply and demand of the medical workforce to avoid any overspent.

This study was carried out by applying system dynamics approach. System dynamics has been applied widely in health and social care and the usage was still expanding. Improved system dynamics approach combined both qualitative and quantitative aspects to identify problem and study the comprehension of the structure of a problem (Brailsford and Hilton, 2001). It could relate different parts of complex system by problem solving approach of causal link and influence diagram. A causal loop diagram, used as a qualitative modelling was constructed to explain the behavior of the system. Quantitative modelling in this study consisted of two stages, which were the development of a retirement profile tool and application of Vensim DSS model developed by Centre for Workforce Intelligence.

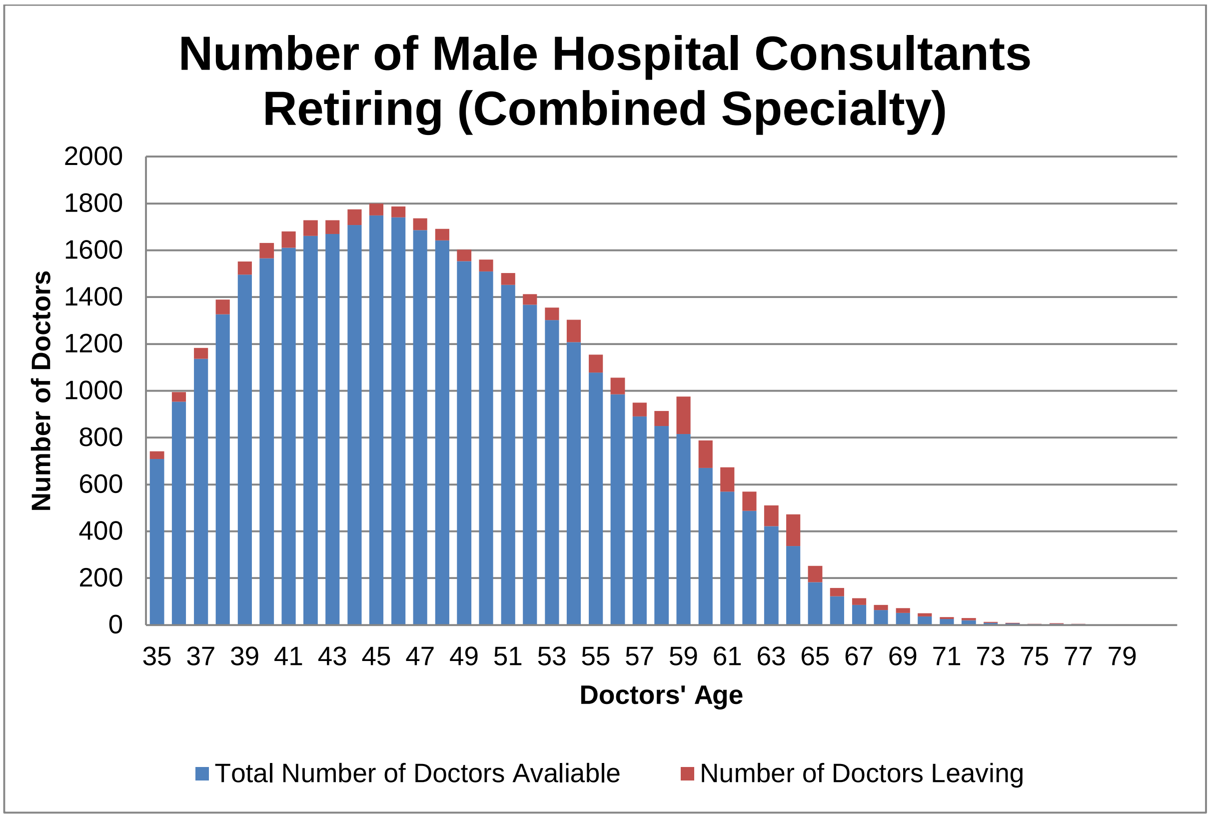
This project focussed mainly on hospital consultants due to extremely large workforce and time constraint. The retirement profile tool was developed to calculate the percentage of hospital consultants retiring at each age by accessing the number of hospital consultants leaving their profession at each age. As there were approximately 500,000 data records within those five years, only five specialty groups were applied in developing this retirement profile tool. These five specialty groups are the Accident and Emergency, Anaesthetics, Obstetrics and Gynaecology, Paediatrics and Psychiatry. They were chosen due to great interest and their large workforce structure.

This retirement profile tool would also aim to calculate the average retirement age and average participation rate. This retirement profile tool evaluated the retirement

behavior of hospital consultants and contributed in developing the system dynamics Vensim DSS model. This model forecast the size of medical workforce in the future. It is a simulation of the English medical training and career pathway system over a 30-year period. It forecast the supply and demand of the medical workforce up to year 2040. In this model, hospital consultants were calculated as Trained Hospital Doctors.

Based on the retirement behavior concluded, plausible 'What-if' scenarios were generated by considering possible situations in the future. Alteration of retirement rate and participation rate was done in the model to predict the impact of either hospital consultants retire early or later, working part time or full time. The model was then simulated and resulted in supply and demand of hospital consultant workforce.

The retirement rate increased as the age increased. Although the current State Pension age was 60 for women and 65 for men, some hospital consultants retire at the age of 55. There were some hospital consultants who retired before the age of 50, they however were considered as leaving the workforce due to other reasons. The table below showed the number of male hospital consultants retiring against the total number of hospital consultants available.



Female hospital consultants were recorded to retire earlier than men. Both retire between the ranges of 60 to 62. Hospital consultants from the Accident and Emergency specialty, Obstetrics and Gynaecology and Psychiatry were among the five specialties that have the earliest average retirement age. The average participation rate was recorded at 0.89, which indicated most of the hospital consultants work full time. The table below shows the average retirement age for each specialty according to gender.

Specialty	Average Retirement Age		
	Male	Female	Both
Accident and Emergency	60.38	59.8	60.09
Anaesthetics	61.45	61.37	61.41
Obstetrics and Gynaecology	61.87	58.97	60.42
Paediatrics	61.56	60.55	61.05
Psychiatry	61.23	59.97	60.60
Combined Specialty	61.30	60.13	60.71

A baseline condition was generated in the model as a comparison to the generated scenarios. This condition represented what would happen if the current trend of the hospital consultants remains up to year 2040. After running the simulation, the baseline showed serious oversupplying of Trained Hospital Doctors in the future. It is considered to be spending extra budget.

The supply of hospital consultants would increase compared to the baseline supply if THDs were to retire later or retire in line with the State Pension age. This could cause the oversupply of THDs and resulted in overspent on cost of paying and training medical doctors. However, the possibility of Trained Hospital Consultants retire later is very low and unlikely to happen.

The supply of hospital consultants would decrease compared to the baseline supply if THDs were to retire earlier than the average retirement age. If THDs aged over 55 chose to work part time, the supply would decrease as well. These scenarios are having a higher possibility to take place if compared to later retirement. These scenarios would reduce the current oversupply of THDs, therefore saving on the governments’ spending.

Another scenario was generated to explain the supply of the hospital consultants when older hospital consultants retire earlier to avoid being affected by the reformation but younger hospital consultants retire later after the changes to the State Pension age was implemented. This scenario was generated because older hospital consultants had been proven to have the intention to retire early but younger workforce could be persuaded to retire later.

There are both positive and negative impacts on the size of medical workforce when the State pension age is increased. More review and research should be done on the changes to the State Pension age in order to accomplish the intention of managing the State Pension.

Acknowledgement

I would like to express my greatest gratitude to my parents who gave me the opportunity to study at the University of Southampton. They were very supportive and encouraging during my study. I would like to thank my siblings for supporting me unconditionally. I would also like to thank Jun Jin Kong for giving me mental support and guided me throughout the whole duration of the project.

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The staff at the Centre for Workforce Intelligence, the sponsor organisation of the project were very helpful. They are Graham Willis, Head of Research and Development, Jack Turner, Lead Analyst, Andrew Woodward, Lead Modeller, and Anna Kosicka, Senior Analyst. I would like to thank them for mentoring me. They had done a great job in providing useful information and explanation throughout the whole duration of the project.

I would also like to thank my classmates who helped me in completing this project. They are Michelle Zhang, Anthony Registe, Aaditya Mehta and Steven Zheng. Lastly, I would like to express my gratitude to the Centre for Workforce Intelligence and the University of Southampton for providing me with the opportunity to work on this challenging project.

Glossary

A&E	Accident and Emergency
CCG	Clinical Commissioning Trust
CCT	Certificate of Completion of Training
CESR	Certificate of Eligibility for Specialist Registration
CfWI	Centre for Workforce Intelligence
GMC	General Medical Council
GP	General Practitioner
HENSE	Health Education National Strategic Exchange
MDSI	Medical and Dental Student Intake
NHS	National Health Service
O&G	Obstetrics and Gynaecology
PCT	Primary Care Trust
PSSRU	Personal Social Service Research Unit
THD	Trained Hospital Doctor
UK	United Kingdom

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1.0 Introduction

The age at which people retire has become a pressing issue as the current population was reported to have longer life expectancy. According to Office of National Statistics, the life expectancy at birth in England was 78.7 years for males and 82.6 years for females in the year 2009 to 2011. Over the past thirty years the life expectancy at birth had increased by four hours and six hours every day for females and males respectively. The chance of surviving from birth to age 85 had increased from 14% to 38% in year 2009 to 2011 compared to thirty years ago.

The government of the United Kingdom was considering how increasing the State Pension age could better reflect the impact in the future policy in terms of sociology and economy. Therefore, the government has decided to increase the State Pension Age to discourage long retirement period for workers as well as managing the cost of State Pension. The current State Pension Age was planned to increase to;

a) 66 between November 2018 and October 2020,
b) 67 between 2034 and 2036,
c) 68 between 2044 and 2046.

The legislation of Pension Act 2011 would bring forward the increment of State Pension age to 67 by eight years which is between 2026 and 2028. Further consideration of the increase of the State Pension would be reviewed every five years. This would also mean that the increment of State Pension age to 68 would be revised and perhaps, carried forward. Other than the changes made to the State Pension age, the Basic State Pension would also be demolished and replaced by a single-tier pension system.

Due to high costs and lengthy training involved with training medical workforce, it is critical to balance the supply of medical workforce with the demand of human population. This project would therefore study the sociological impact of such reformation of the State Pension on the English medical workforce.

1.1 Dissertation Structure

This dissertation consists of:

Chapter 1 explained the current issues in the UK.

Chapter 2 provided information on company's background, medical workforce in the UK, state pension system in the UK and NHS Pension Scheme.

Chapter 3 outlined aim and objectives for the project.

Chapter 4 reviewed past research on system dynamics approach and modeling.

Chapter 5 consisted of detailed explanation on how to adapt the approach and modelling into the project.

Chapter 6 analysed and interpreted the results. Graphs were drawn and explained.

Chapter 7 discussed the implication of results, research limitations and recommendations.

Chapter 8 concluded the aim of the project.

2.0 Background

2.1 Company Background

The project analysis work was done with the technical assistance from the Centre of Workforce Intelligence (CfWI). The CfWI is the national authority on workforce planning and development, providing advice and information to the health and social care system. This organisation aims to become the primary source of workforce intelligence for health and social care in England. Besides creating models, analysis and recommendations on medical training numbers the company provides effective advice to clients regarding the system on changes to future workforce requirements.

Workforce planning is an effective process to determine the supply and demand of services provided by professionals, ensuring the right people with the right skills in the right place at the right time (Centre for Workforce Intelligence, 2013). The main tool in completing this process is the robust workforce planning framework.

2.2 Medical Workforce Background

2.2.1 Registration for Medical Doctors

Graduate doctors have to register with the General Medical Council (GMC) to gain a license before working in any medical institution in the UK under the provisions of the Medical Act 1983, to ensure that quality work is delivered to the public (General Medical Council, 2013). The GMC was established with the aim to protect, promote and maintain the health and safety of the public by keeping high and proper standards in the practice of medicine. There are three types of registration for doctors that enable them to practice. Provisional registration is granted to those who have completed their medical education and enrolled into the first year of the foundation programme. This registration permit allows the newly qualified doctors to complete the general clinical training. Doctors who are registered provisionally can only work as junior house officers in hospitals or institutions where approval for pre-registration service is allowed. They obtain their full registration upon satisfactory completion in the first year of their postgraduate training. The specialist registration was introduced in the year of 1997. Any doctor who wishes to take up a specialist consultancy post must have his or her name included in the specialist register. The GP registration was made compulsory for doctors who worked in general practice in health service since 1 April 2006. These doctors must be fully registered in order to obtain GP registration.

2.2.2 Training to Become a Doctor

Undergraduate medical students in the UK have to study in accredited medical schools for at least five years to obtain their medical degree (General Medical Council, 2013). The GMC played an important role in granting the accreditation of the institutions. Medical schools have to meet the requirements and expectations set by GMC in order to obtain the license to issue medical degrees. Medical students enter a two-year foundation programme upon completion of their respective degrees.

Foundation schools managed the foundation training that comprised the medical schools, postgraduate deaneries and health care providers (The Foundation Programme, 2013). Medical students were known as Foundation House Officers (F1 or F2) depending on the year of the programme. This programme was designed to provide fresh graduates with general experiences on serving patients under strict supervision. Foundation House Officers had to take up a surgical post and a medical post for at least three months each in the first year to gain enough experience prior to full GMC registration. The F2 year usually consisted of four assorted three-month placements that give fresh graduates the opportunity to experience workloads in different specialties. These students would then need to choose an area in which to specialise for the future

Training for General Practitioner (GP) took up to three years while training for specialists would require a longer period (The National Recruitment Office for GP Training, 2013). Doctors trained under the GP training programme must complete eighteen-months of posts in a variety of hospital specialties (Specialty Registrar), followed by eighteen-months of training in general medicine (General Practice Specialty Registrar) before obtaining the rights to serve as GPs independently. These doctors would have to possess a Certificate of Completion of Training (CCT) before serving as GPs.

Two different training schemes, ‘run-through’ and ‘uncoupled’ training, were introduced to help equip junior doctors for specialty qualification (Modernising Medical Career, 2013). These training routes were usually undertaken based on the specialty criteria. Specialties such as Ophthalmology, Neurosurgery, Obstetrics and

Gynaecology and Paediatrics offered run-through training which allowed doctors to proceed to the next level automatically, provided that they satisfied professional competency. In uncoupled training, on the other hand, junior doctors need to undertake two or three years of core training before they reapply for higher specialty training in open competition. All specialty training programmes would lead to CCT which made each doctor qualified as a Specialist under the GMC. Doctors without CCT but wanting to practise as substantive, honorary or fixed term consultants could apply for specialty equivalent route. This route is an entry onto the Specialist Register with a Certificate of Eligibility for Specialist Registration (CESR). Figure 1 clearly shows the career structure for foundation and specialty training (Specialty Training, 2013).

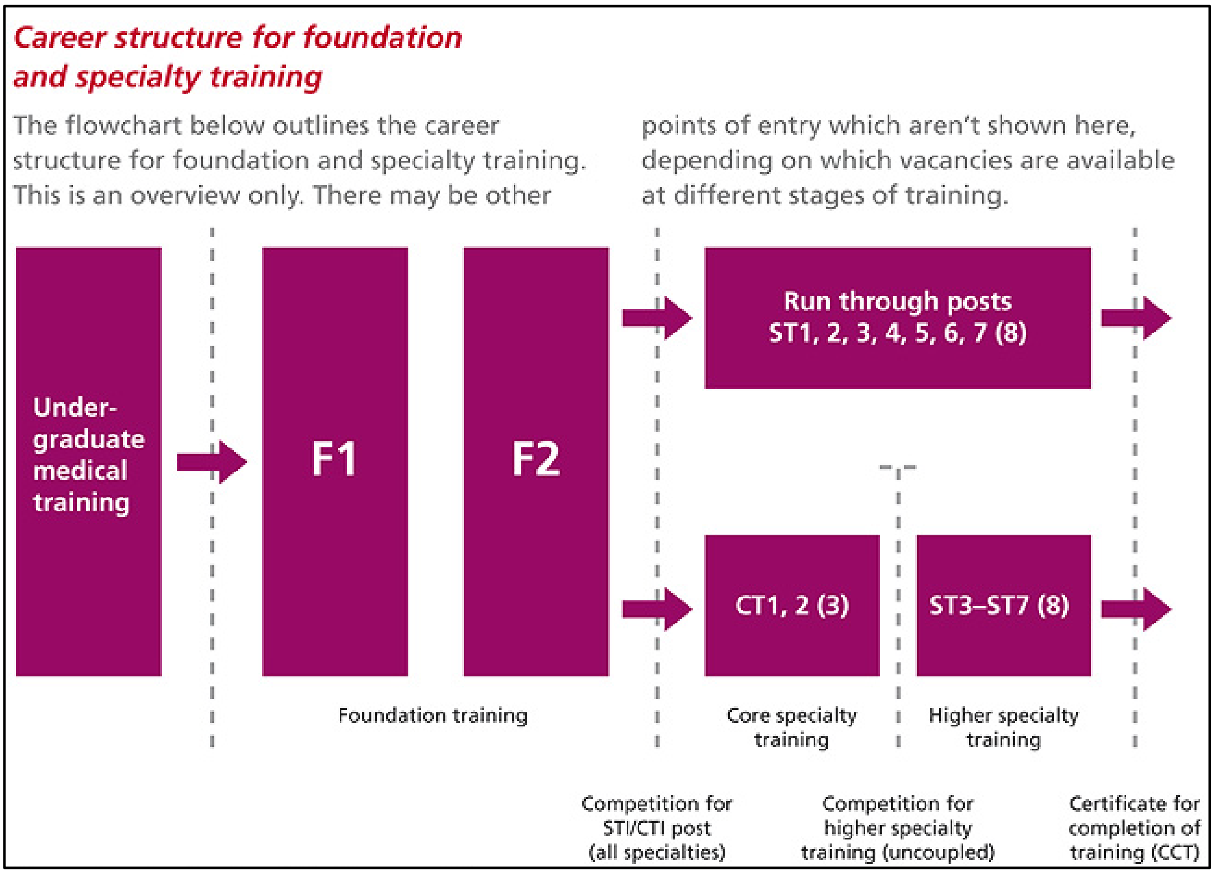

Figure 1 Career Structure for Foundation and Specialty Training (Medical Specialty Training (England), 2009)

Table 1 shows which specialties in 2013 are offering run-through training and which are offering core training followed by open competition.

Offer of run-through training in 2013 (Specialty training years are referred to as ST1, ST2, ST3, etc.)	**Offer with uncoupled training in 2013** (Core training followed by open competition to higher specialty training. Core training years are referred to as CT1, CT2, CT3, etc. and higher training years are referred to as ST3, ST4, etc.)
Obstetrics and Gynaecology	Anaesthesia
Ophthalmology	Core Medical Training, leading to competitive entry to medical specialties
Pediatrics and Child Health	Core Surgical Training, leading to competitive entry to medical specialties
General Practice	Emergency Medicine (three years of core training)
Public Health Medicine	Core Psychiatry Training (three years of core training), leading to competitive entry to psychiatry specialties.
Neurosurgery	Broad Based Training (two years of core training), leading to entry to ST3 medical specialty or enter the run-through training programme for GP or Paediatrics at ST2.
Histopathology	
Chemical Pathology	
Medical Microbiology/ Virology	
Clinical Radiology	
Academic Clinical Fellowship (ACF) Broad Based Training (two years of core training), leading to entry to the run-through training programme for GP or Paediatrics at ST2 or to ST3	

medical specialty or ST4 psychiatry specialty.	

Table 1 Training for Specialties in 2013 (Modernising Medical Career, 2013)

2.2.3 Financial Aspects

It is difficult to measure the exact cost of training to qualify as a CCT holder in the UK. One of the main reasons was the cost variation depending on the specialty (British Medical Association, 2013). However, the Personal Social Service Research Unit (PSSRU) has collected crucial evidence about unit costs within the UK health and social care sector. Lesley Curtis compiled a report of Unit Costs of Health and Social Care for year 2012 which estimated the cost of training the NHS doctors. In her report, the yearly wages, salary on costs, qualification costs, overhead costs, on-going training costs, and capital overhead costs for foundation house officers, registrar group, associate specialist and consultants respectively have been listed (Personal Social Service Research Unit, 2012).

The British Medical Association (BMA) later made a briefing paper on this report that concluded a total of approximately £250,000 was needed to train a medical doctor (British Medical Association, 2013). Additional postgraduate training would sum up to a total of approximately £500,000 of training a consultant. Table 2 showed the complete cost of training courses of doctors employed within the NHS, according to the level of specialty.

	Pre-registration			Post-graduate training	Totals	
	Tuition (£)	Living expenses/lost production costs (£)	Clinical placement (£)	Tuition and replacement costs (£)	Total investment (£)	Expected annual cost at 3.5% (£)
Foundation Officer 1	57,433	60,301	151,792	NA	269,527	20,189
Foundation Officer 2	57,433	60,301	151,792	24,637	294,164	22,458
Registrar Group	57,433	60,301	151,792	73,924	343,451	26,996
Associate Specialist	57,433	60,301	151,792	113,951	383,477	30,682
GP	57,433	60,301	151,792	228,962	498,489	41,272
Consultants	57,433	60,301	151,792	275,182	564,112	45,528

Table 2 Costs of Training of Doctors (British Medical Association, 2013)

The government spends heavily on doctor training courses every year. Therefore, it is vital to study the workforce planning on medical field for a better balancing of demand and supply of doctors in the future, with an attempt to maximise the efficiency of spending taxpayers' money.

2.3 State Pension System of the United Kingdom

2.3.1 Government Policy on State Pension

The UK government planned to design a simpler State Pension, in hoping that it would be fair for every citizen in the country (Department for Work and Pensions, 2013). The current State Pension system was complex and often caused confusion among the public in estimating their pension savings for their retirement period. This system sometimes raised inequality in certain work groups, especially for those who have scattered work histories and those who were self-employed.

Reformation of the State Pension system by introducing a single tier pension would help people to better understand their needs when saving for their retirement (Department for Work and Pensions, 2013). Single tier pension would eliminate the complexity and inequality of the current system. It would also ensure that the system remains fair between the generations. This reformation should reflect the increase in life span. The single tier pension would be put commence on 6 April 2016 and those reaching the State Pension age after the introduction date would be affected.

2.3.2 Reviewing the State Pension Age

The government aimed to increase the State Pension age in a regular and systematic basis to ensure that the State Pension system is easily manageable and economical in the long run (Department for Work and Pensions, 2013). This would help to balance the expected spending cost of increasing life expectancy between the generations.

The increase in life expectancy was the main reason in raising the State Pension age for retirement. It would be important to discourage a long retirement period for workers. Decision was planned to increase the State Pension age to 67 at an earlier rate. The UK government has announced the production of the first 5-year annual review in the next Parliament meeting to further discuss the matter to come with a better method in considering, should there be any changes in the State Pension age, in the coming years. This review would be based on the analytical research done by the Government Actuary’s Department.

2.3.3 Changes to the State Pension Age

There was a five-year difference in State Pension age between men and women ever since 1940. This inequality was then taken down by the virtue of Pension Act 1995, where the State Pension age for women would be increased to 65 by April 2020 (The Official Home of UK Legislation, 1995).

The government later proposed the raise in the State Pension age due to the growing number in pensioner population resulting from an increase in longevity and the falling birth rates (The Official Home of UK Legislation, 2007). Pension Act 2007 was then introduced to solve the retirement issue aroused from increasing life expectancy. The first increment, from 65 to 66, would be phased in between April 2024 and April 2026; the second increment, from 66 to 67, would be phased in between April 2034 and April 2036; and the third increment, from 67 to 68, between April 2044 and April 2046.

The date for the increase in State Pension age from 65 to 66 for both men and women was dragged earlier between the year of 2018 and 2020 under the newly passed Pension Act 2011 (The Official Home of UK Legislation, 2011). This Act also accelerated the process in increasing women's State Pension age to 65 by November 2018. The law now changed and brought forward the plan in further increasing the State Pension age to 67 in between 2026 to 2028. Further consideration of the increase of the State Pension age would be done on the basis of the forthcoming reviews every five years and would require approval by the Parliament. This would also mean that the increment of State Pension age to 68 would be revised and perhaps, carried forward.

2.3.4 State Pension Scheme of the United Kingdom

The current pension system in the UK was a three-tiered system (Blundell & Emmerson, 2007). The first tier consisted of the basic state pension and a significant level of means-tested benefits. The second tier, which was compulsory for all employees with a yearly wages above a certain amount, was made up of the State Earnings-Related Pension Scheme (SEPRS) and a large and continually growing level of private provision. Finally, the third tier consisted of other additional voluntarily contributions and other private insurances. The figure below showed the summary of the three-tier system.

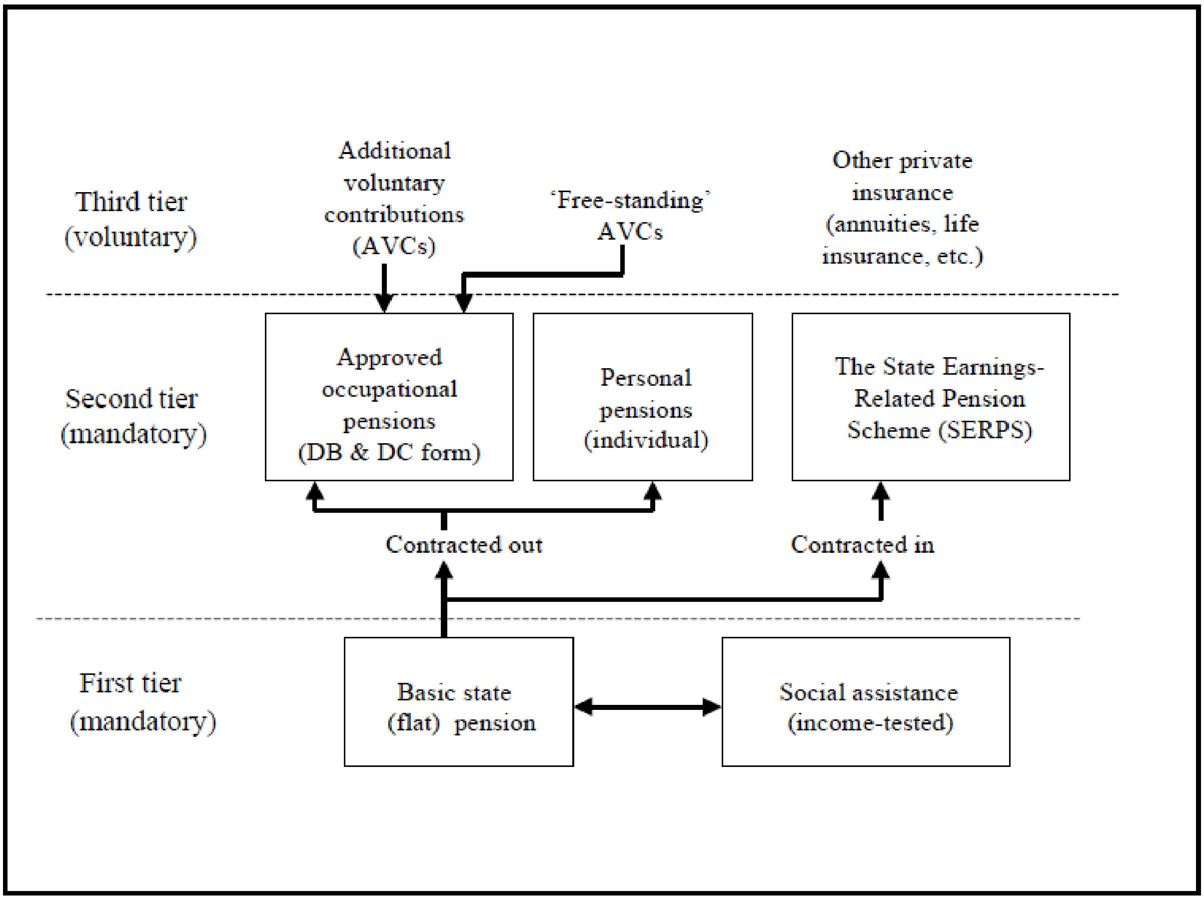

Figure 2 UK Pension System 1990 (Blundell & Emmerson, 2007)

The basic state pension is a flat rate contributory benefit payable to those who have reached the State Pension age and have made sufficient contributions throughout their working lives (Blundell & Emmerson, 2007). The maximum amount that a pensioner could get when he or she reached the State Pension age would be £110.15 weekly (GOV.UK, 2013). Some pensioners would get less than this amount because of fewer years of contributions to the National Insurance. One would need to contribute at least 30 years to obtain the full basic State Pension. However, those who had not contributed enough could always top up his or her State Pension by paying voluntary National Insurance contributions. Those unemployed could get their basic state pension too, provided that they care for children below 12 or someone disabled, or having spouses who covered their National Insurance contributions.

Some individuals might receive more than the basic state pension if they were eligible for the additional state pension (GOV.UK, 2013). The amount of additional state pension a pensioner could get would be based on his or her earnings. The additional state pension is made up of two schemes, the Second State Pension, which was introduced back in year 2002 and the State Earnings-Related Pension Scheme (SERPS) which started in year 1978 and ended in year 2002. Employees who earned over the lower earnings limit of £5668 yearly and those who claimed for Child benefit or Carer’s Credit had contributed towards their additional state pension through National Insurance contributions. Employees who earned below the lower earnings limit, unemployed or self-employed were not eligible to receive the additional state pension. An employee could choose to contract out if their employer run a contracted out pension scheme, which means not receiving any additional state pension or receiving a reduced amount of it.

2.3.5 Reformation of the State Pension

The Department of Work and Pension had conducted a survey on attitudes to pensions and the result showed 63 per cent of the respondents agreed that “sometimes pensions seem so complicated that I cannot really understand the best thing to do” (Macleod, et al., 2012). Only 21 per cent agreed that they knew “enough about pensions to decide with confidence how to save for retirement”. A number of responses to the consultation on state pension reform highlighted the complexity and uncertainty of the current state pension system.

The government of the UK had planned to reform the current pension system into a single tier pension system due to the complexity of the current pension system (Department for Work and Pensions, 2013). Those who reach the State Pension age after 6 April 2016 would be receiving the new single tier pension. The full rate of single-tier pension will be set above the basic level of means-tested support which is currently at £142.70 per week based on the Pension Credit Standard Minimum Guarantee.

An individual would need 35 qualifying years of National Insurance contributions in order to receive the full weekly rate of the single-tier pension (Departmen for Work and Pensions, 2013). Individuals not satisfying 35 years of contribution could also get a reduced amount of single tier pension, provided that they fulfil a minimum of 10 qualifying years of contributions. The existence of single-tier pension would eventually end the three most complex elements in the current system which includes:

a) the two-tier system of basic State Pension and State Second Pension, including the option to contract out of the State Second Pension
b) the Savings Credit element of Pension Credit
c) the ability to derive, inherit, or share a pension based on National Insurance contributions of a spouse or civil partner

A key objective of reform is to move to a simpler pension system that gives people clarity over what their state pension will be worth when they retire. This will ensure that people of working age have a solid foundation for saving.

2.4 The NHS Pension Scheme

The NHS Pension Scheme is one of the most well established and comprehensive scheme in the UK (NHS Careers, 2013). Staffs aged between 16 and 75 who directly employed by the NHS could join the NHS Pension Scheme (NHS Pensions, 2013). There are two sections of the NHS Pension Scheme. Members who joined the NHS before 1 April 2008 and have been making contributions towards their pension would be categorized in the 1995 Section (old contract) of the NHS Pension Scheme. Members in the 1995 Section. They could still enrol into the same section if they left their positions and returned to their profession within 5 years. On the other hand, members who joined the NHS on or after 1 April 2008 and had been paying for their pension were categorized in the 2008 Section (new contract) of the scheme. Members in the 1995 Section could move to the 2008 Section under the NHS Pension Choice Exercise.

2.4.1 1995 Section

The normal retirement age in the 1995 Section is 60 (NHS Pensions, 2013). Members in this section could claim their full pension once they have reached their 60th birthday. Nonetheless, there were some special cases recorded where members retire earlier (55 years old) and still obtain the full payment. These members included those who had special class status and Mental House Officers (MHOs). Selected groups of staff such as nurses, midwives, physiotherapists and health visitors who joined the scheme before 6 March 1995 had the privilege to obtain the special class status.

Members could choose to retire earlier than the normal retirement age. The earliest a NHS staff could retire was known as the minimum retirement age. The minimum retirement age was 50 for members who registered themselves in the scheme before 6 April 2006. On the contrary, those who joined the scheme on or after 6 April 2006 could only retire as early at the age of 55. Members who opted to retire before the normal retirement age would receive a reduced amount of pension. However, members who left their profession due to redundancy or poor health conditions would be paid immediately with full pension. Members could still continue their profession after the age of 60 and earn the extra benefits up to the age of 75, provided that they have not accumulated 45 years of membership.

Members could obtain both pension and a one-off payment upon retirement. There were two different pension calculations between ordinary NHS staffs and practitioners. For ordinary NHS staffs, their pension is formulated as follows:

$$\text{pensionable pay x pensionable membership x } \frac{1}{80} = \text{ pension per year}$$

Pensionable pay would be determined by the highest pay of the last three service years of the member while the pensionable membership represents the duration of memberships in the scheme. The retirement lump sum for NHS staffs would be three times their pension. For practitioners, their pension is formulated as follows:

$$\text{uprated earnings x } 1.4\% = \text{pension per year}$$

The retirement lump sum for practitioners would be three times their pension. The uprated earnings could be calculated by recording the pensionable earnings for each year of membership in the scheme and applied by a revaluation factor of 1.5%.

2.4.2 2008 Section

The normal retirement age in the 2008 Section is 65 (NHS Pensions, 2013). Members in this section could prefer to claim their pension or a lump sum at this age. Members could choose to retire and claim their benefits at any time between age 55 and 75. They could keep their profession if they wanted to claim their benefits. They could still continue working with a job with reduced participation rate, a lower grade job or a job with a lower amount of salary. Similar to members in the 1995 Section, those who retired before the age of 65 would receive a reduced pension because they were enjoying their pension longer than expected. Nevertheless, members who left their profession due to redundancy would be paid immediately with full pension, provided that they had at least two years of membership and reached the age of 55. Members who were severely ill would be given the privilege to an early retirement as well. They could still continue their profession after the age of 65 and earning extra benefits because the pension was claimed later than expected.

There are two different pension calculations between ordinary NHS staffs and practitioners. For ordinary NHS staffs, their pension is formulated as follows:

$$\text{reckonable pay x pensionable membership x } \frac{1}{60} = \text{ pension per year}$$

Reckonable pay would be determined by the annual average of the best pay of three consecutive years over the last ten service years before a member retire. The pensionable membership represents the duration of memberships in the scheme. For practitioners, their pension is formulated as follows:

$$\text{uprated earnings x } 1.87\% = \text{pension per year}$$

The uprated earnings could be calculated by recording the pensionable earnings for each year of membership in the scheme and applied by a revaluation factor of 1.5%. Members could choose to give up some amount of their pension to get a one off payment. Each pound given up from the yearly pension would contibute to £12 of the lump sum payment. The maximum a lump sum payment could be claimed is 4.28 times of the pension. Figure 3 clearly showed the difference of pension paid in both sections.

Feature or Benefit	NHS Staff		Practitioners		Practice and Approved Employer Staff	
Scheme section	1995 section	2008 section	1995 section	2008 section	1995 section	2008 section
Member contributions	5% - 13.3% depending on rate of pensionable pay		5% - 13.3% depending on amount of pensionable earnings		5% - 13.3% depending on rate of pensionable pay	
Pension	A pension worth 1/80th of final year's pensionable pay per year of membership	A pension worth 1/60th of reckonable pay per year of membership	A pension based on 1.4% of uprated earnings per year	A pension based on 1.87% of uprated earnings per year	A pension worth 1/80th of final year's pensionable pay per year of membership	A pension worth 1/60th of reckonable pay per year of membership
Retirement lump sum	3 x pension. Option to exchange part of pension for more cash up to 25% of capital value.	Option to exchange part of pension for cash at retirement, up to 25% of capital value. Some members may have a compulsory amount of lump sum	3 x pension. Option to exchange part of pension for more cash up to 25% of capital value.	Option to exchange part of pension for cash at retirement, up to 25% of capital value. Some members may have a compulsory amount of lump sum	3 x pension. Option to exchange part of pension for more cash up to 25% of capital value.	Option to exchange part of pension for cash at retirement, up to 25% of capital value. Some members may have a compulsory amount of lump sum

Table 3 NHS Pensions Scheme (NHS Pensions, 2013)

The NHS would be affected by the reformation of State Pension age, resulting in late retirement which was set to rise to the age of 68 over the next 30 years.

2.5 Early Retirement in Medical Workforce

The Public Service Pension Act 2013 linked the normal retirement age for public sector pensions to the State Pension age which would eventually rise to 68 by year 2046 (The Official Home of UK Legislation, 2013). Despite of having two sections for the NHS Pensions Scheme mentioned above, 2015 Section would be introduced to link the public sector normal retirement age to the State Pension age. This would indicate longer working hours in order to draw an unreduced pension. It is not necessary for doctors to retire in line with the State Pension age. However, doctors who retired before they reached the State Pension age would receive a reduced pension.

Despite of the reformation of the State Pension age implemented by the government, the rate of early retirement among hospital consultants had been growing for the past few years. More consultants opt for early retirement as dissatisfaction with the NHS grows (Jacques, 2011). Voluntary early retirements before the age of 60 had increased from 7.3% in year 2006 to 14% in year 2011. The high proportion of early retirement indicated the growing dissatisfaction among hospital consultants with the reformation made within the NHS. According to Ian Wilson, the deputy chairman of the British Medical Association's Consultants Committee, many hospital consultants would rather retire early before the changes to the public sector pensions officially implemented. He explained that hospital consultants retired early mainly because of long working hours and heavy workload caused by fall in numbers of junior doctors available.

A national survey of GP was conducted by the BMA in year 2011 (British Medical Association, 2011). The survey resulted in more than half of the respondents intended to retire early because of the NHS reforms. From the 13.3% of the 18,453 respondents, approximately two-thirds (67.5%) of them reported aging was the reason for their intention to retire early. The next common reasons given were the NHS reforms (53.8%), revalidation (36.3%) and changes to pension taxation (26.3%).

The survey also showed that many GPs were not satisfied with the reformation done to the NHS in England with a significant focus on commissioning. Primary Care Trusts (PCTs) which handled the GPs practices would be abolished and replaced by Clinical Commissioning Groups (CCGs), which also known as GPs Commissioning Consortia. Approximately two-thirds of the respondents did not believe that the GPs Commissioning Consortia would be effectively skilled and supported. A warning was then given by General Practitioners' leaders about 'workforce time bomb' due to the reformations made on the pensions and the NHS (British Medical Association, 2012).

The action taken to increase the State Pension age was intended to save government's spending on pensions. However, this action of wisdom was questioned when more doctors retiring early and working abroad (O'Dowd, 2010; Takata, et al., 2011). A recent article by Jacques (2013) stated that as much as 58% of the hospital consultants were considering leaving the NHS or early retirement over changes of the pension, based on the survey carried out by the Hospital Consultants and Specialists Association. In this survey, almost 75% of the respondents indicated that they doubted the proposal of the Review Body on Doctors' and Dentists' Remuneration (DDRB) on their pay would motivate them into better performance (Review Body on Doctors' and Dentists' Remuneration, 2012).

3.0 Aims and Objectives

This project aims to study the sociological impact of increasing the State Pension age on the medical workforce up to the year of 2040. The impact would identify the size of the medical workforce annually so that the conclusion for the proposed State Pension age would be evaluated. Several objectives were outlined in order to achieve the project aim:

- To study the background of the medical workforce training
- To investigate the State Pension system in the UK including a detailed NHS Pension Scheme
- To review the usage of different approaches in simulating problems
- To further review the usage of modeling tools including various softwares
- To draw a methodology on how to execute the simulation and modeling
- To draw a Retirement Profile Tool to calculate the retirement rate at each age group
- To predict the supply and demand of the medical workforce up to 2040 by tabulating and analyzing the collected data
- To generate plausible scenarios for case study
- To recommend the company in medical workforce planning by providing a baseline forecast of the medical workforce supply
- To relate the retirement behaviour with the size of the medical workforce in the future by interpreting the result and drawing valid discussion

This project would mainly focus only hospital consultants in England due to the extremely large data and incomplete data collected for the medical workforce in the UK. Secondly, this project would investigate the potential impact on the service delivery of hospital consultants.

4.0 Literature Review

The following chapter presented a detailed review on the past research done on the application of system dynamics approach simulation in similar areas for the current project. This review began with an overview of the applications of different approaches simulation in healthcare. This is followed by a detailed review on system dynamics approach simulation, the execution of the approach and then proceeded to the discussion of benefits and limitations of the approach. The impact of increasing State Pension age on the medical workforce in England would be evaluated by the size and age structure of the English medical workforce in the future. Therefore, review on local as well as oversea medical workforce planning should be studied to compare the similarities and looked for the compatibility to the current project. This was then followed by a brief research on the factors that influenced retirement behaviors, which was then compared to the suggested State Pension age scenarios by manipulating different policies and conditions.

4.1 Application of Different Approaches in Health and Social Care

There were many different approaches applied to tabulate and simulate collected data to review the outcome of behavioural studies. Other than applying system dynamics modelling into medical workforce planning, some other countries had tried different types of approach into modelling future workforce.

Lavieri and Puterman (2009) developed a linear programming hierarchical planning model to optimise the nursing workforce in British Columbia. Attrition rates and age dynamics were the important variables in this model. Linear programming was chosen for this model because of its flexibility in scenario testing.

Starkiene et al. (2005) applied computer spreadsheet simulation into modelling the Lithuanian family physicians. This model involved three demand scenarios and three supply scenarios. Different rates of retirement, migration and withdrawal from training were considered in creating demand scenarios. One of the supply scenarios was determined using the Delphi method, which was adapted by CfWI in getting a panel of experts to estimate parameters.

Takata et al. (2011) concluded the intention of Japanese government to increase the medical student intake would bring to a significant doctors surplus in the future in their model. Although the current shortage for medical doctors worried the Japanese government, this situation would not worsen as the population would decrease in the future. The method used for this model was computer simulation. Two scenarios were simulated for comparison. The first scenario showed what happened if the current medical student quota was maintained whereas the other showed simulated the situation where the quota was increased by 50%.

Jacoby et el. (1998) applied a discrete actuarial supply model in examining the current supply of Obstetrics and Gynaecology workforce in the United States and plan future supply under different outlines.

There were three scenarios tested where percentage of females enrolling into Obstetrics and Gynaecology specialty were set at 55%, 65% and 75%. A graph was then projected from year 1997 to year 2020 to observe the growth of female workforce in Obstetrics and Gynaecology and descriptive statistics were generated using STATA software. This model resulted in slow to no growth in workforce of Obstetrics and Gynaecology to female population ratios in the future.

Another model was built to model the cost effectiveness of Anaesthesia workforce in America by Glance (2000). The purpose of this study was to judge the incremental cost effectiveness of Anaesthesia workforce staffing scenarios by adopting the decision analysis technique. Five varied staffing scenarios for anaesthesia care were introduced, ranging from physician-intensive to nurse-intensive practise settings. Patients were categorised into high, intermediate and low risk. These scenarios distributed those patients to certified nurse anaesthetists, a physician working alone, an anaesthesia care team or a combination of these anaesthesia care providers.

A decision tree was then constructed to analyse the discrepancy in incremental cost effectiveness of those scenarios from the aspect of the payer. There were two major limitations for this model. Firstly, there was no reliable data on the outcomes of combined anaesthesia skills to set as a baseline for the decision analysis. The limitation on the outcomes to survive or die was also one of the weaknesses in this model. Such application although was comprehensive, it had led to many arguable conclusions due to many uncertainties.

Different problems could be modelled using varied approaches. However, research need to be done to find the appropriate method to model each problem.

4.2 What is System Dynamics Approach?

Brailsford and Hilton (2001) described system dynamics as a simulation that models a series of stocks and flows where the state changes continuously. Each item in system dynamics is viewed as a continuous quantity. These items would flow through stocks which are fixed with certain rates of inflow and outflow. The system was created by Professor Jay Forrester from the Massachusetts Institute of Technology, in his work on "industrial dynamics" (Forrester, 1968).

Centre for Workforce Intelligence (2012) explained system dynamics as a modeling technique for studying and managing complicated feedback systems. System Dynamics approach was usually applied to a work frame system over a period of time to evaluate a specific subject in order to test for a behavioural outcome. It is a simulation method that allows behavior of complicated systems to be reviewed and simulated over a period of time.

In Wu et al. (2013) model, system dynamics was firstly explained to describe the scenario and determine the stock or flows. Secondly, mathematical models would be developed and lastly, computer simulations were carried out. Ishikawa et al. (2013) on the other hand described system dynamics as;

'It addresses the flow of people, processes, materials and information by exposing a tenet of all complex systems - feedback loops.'

Lane (2000) suggested that system dynamics has three characteristics. The first characteristic was the concept of information feedback loops, which involve collecting possible influential variables that might make changes to the system. Secondly, the computer simulation considered the behavioural consequences over time for the hypothesized causal network. The last characteristic is the need to interact with mental models.

According to Motawa and Banfill (2011), system dynamics modeling comprised of five steps:

i. The definition of the problem,
ii. The generation of a dynamic hypothesis or theory about the root of the problem,
iii. The generation of a simulation model to evaluate the dynamic hypothesis,
iv. The experimentation of the model output to accomplish the purpose,
v. The formation and evaluation of policies for improvement.

System dynamics approach was reported to be an analytical modeling methodology (Brailsford and Hilton, 2001). System dynamics could combine qualitative and quantitative aspects to identify problem and improving comprehension of the structure of a problem. It could relate different parts of complex system by problem solving approach of causal link and influence diagram. System dynamics has been applied widely in vast fields of study due to its flexibility of the process, as well as its capability of conjoining both qualitative and quantitative pathways.

4.3 Application of System Dynamics in Healthcare

4.3.1 Qualitative Analysis System Dynamics

Wolstenholme (1993) had succeeded in applying the qualitative system dynamics approach into community care. The government intended to reduce the public spending on social services by handing over the duty of home care for the elderly to the regional social services department with limited money allocation under the Community Care Act. Wolstenholme, however, proved that this decision would actually increase the social service costs. Wolstenholme applied system dynamics and arranged several consultations with the politicians and health care planners in pursuance of revealing the adverse effects that might cause waiting lists for community care to increase.

Coyle (1984) considered the qualitative method in studying the problem of short-stay psychiatric patients. Coyle implemented three concept of influence link to aid him in constructing his diagrammatic model. These three concepts included a physical flow, controls applied by system managers and a behavioural response. Behavioural response represented the force of nature whereby managers have only indirect control. One of the examples given in Coyle's work was the issue of duration of treatment on the deferment before a patient returned for further treatment.

4.3.2 STELLA

Townshend and Turner (2000) made a model for screening for *Chlamydia,* a sexually transmitted disease, using system dynamics approach modelling. *Chlamydia* was reported to be the one of the main reasons for infertility in the UK. A model of a population was constructed using STELLA, which was layered by age and by risk group using subscripted arrays (also known as *ithink*). System dynamics was chosen for this model due to its ability to handle large populations. System dynamics could also provide feedback effects caused by re-infection of treated individuals and update the model with the latest population who were infected with *Chlamydia*.

A model created by Brailsford et al. (2004) demonstrated the advantage of applying system dynamics in modelling a large complicated system. This model also proved how useful the qualitative and quantitative aspects of the system dynamics approach in solving this project. This project focused on the delivery of emergency care, which involved a population of over 600,000 inhabitants in the city of Nottingham, England. A group of stakeholders participated in the drawing of a conceptual map of the emergency health care system in Nottingham. This map was then used as the ground for the quantitative computer model using STELLA. STELLA was very useful in investigating different scenarios as well as serving as a medium for addressing and tackling discussion and comments.

Lane et al. (2000) also constructed a model using *ithink* on how the number of hospital beds affects waiting time in the A&E department. This study proved that the major impact brought by the reduction in number of hospital beds was mainly on elective admissions, instead of the delay in the A&E department. This study also explained the importance of developing a 'dynamic hypothesis' that would help to explain the behaviour of a system. In this model, causal loop diagram was applied to show how other external factors influence the waiting time in the A&E department.

Barber and López-Valcárcel (2010) described the objective of system dynamics model as to interpret how the structure of a system explains its behaviour. This interpretation could generate groundwork for discovery where necessary actions could improve the system. System dynamics models were considered as typical time-step simulations, which take a number of simulation steps along the time axis. System dynamics modelling enabled us to investigate different objectives, examined the causal links, factor uncertainties and various scenarios (Ishikawa et al., 2013).

4.3.3 Pascal Programming

A full system dynamics model which combined the qualitative and quantitative modelling was applied by Bronkhurst et al. (1991). Their model was created using *Pascal* programming software that concentrated on the supply and demand for the dental health care system in the Netherlands. The team succeeded in transforming the previous model with only 20 state variables into a complex model of 400 state variables. The entire model was linked by three parts that were the population model, submodels displaying the demand side of the Dutch dental health care system and lastly, the supply side of the system.

4.4 Application of System Dynamics in Workforce Planning in Health and Social Care

The planning of the supply and demand of workforce in health care was considered a deserted issue, where arguments have been carried out for decades with no resolutions (Bloor et al., 2003). Workforce planning policies were designed with the assumption that existing health care delivery systems are economical and productive. Ordinary workforce planning systems usually neglected the diversity in practice and the opportunity in altering productivity, mixed skills and substitution. Health care policy planners therefore realised the importance to manage the workforce in order to be more effective to the system requirements.

Taylor (2005) had described the effective people resourcing as ‘Securing the services of the right people, in the right place, at the right time’. This was indeed important for an effective human resource management in health care sector. Barber and López-Valcárcel (2010) explained that the responsibility of planning human health resources included the identification of the right number of doctors with the correct specialties for the suitable place at the appropriate time.

4.4.1 Modelling Software

4.4.1.1 Powersim Studio

Due to the shortage of medical doctors in Spain few years ago, Barber and López-Valcárcel (2010) had applied system dynamics into forecasting the need for medical specialists in the country. Similar to the model designed by Vanderby et al. (2013), this model created a supply and demand simulation model that comprised of demographic, education and labour market variables.

Quoted by Barber and López-Valcárcel (2010),

‘The challenge of dynamically adjusting the supply and demand of doctors involves making the right decisions at the right time about the number of slots for training, about retention and retirement of doctors in practise, and in regard to medical immigration; ensuring a reasonable composition of specialties and a balanced geographical distribution; and setting the right working conditions and compensation schedules.’

Barber and López-Valcárcel (2010) developed two types of diagrams in applying the qualitative aspect, which are the causal loop diagram and the stock and flow diagram. Their causal loop diagram indicates how the variables such as immigration, separation, emigration and recruiting influence the number of workforce. On the contrary, in their stock and flow diagram, the stocks or levels characterised the states of the system whereas the flows represented the rates of change of levels.

Delphi method was also applied in this model to identify the participation rate of specialists in Spain. Parameters such as the quantity of medical students, compulsory retirement age, number of physicians available for each specialty, and immigration rate by specialty were identified for quantitative modelling. This simulation model for 43 medical specialties, separately for men and women was developed using Powersim Studio 2005. Scenarios of ‘what-if’ were generated as comparison to the baseline which assumed that all the manageable parameters would remain as at present values. Other than proving the growth in deficit of medical specialists in the future, this model also resulted in significant differences in the trends of providers supply by varied specialty.

4.4.1.2 Stella

Another model was developed in Asia by Ishikawa et al. (2013) to forecast the absolute and relative shortfall of physicians in Japan using the system dynamics approach. Causal loop diagram was again applied here to determine the relationships and interactions of the feedback loops. Two physicians supply simulation model were then developed using STELLA® version 8.1.1.The first model was the total number of clinical physicians whereas the latter was number of Obstetrics and Gynaecology physicians. The specialty of Obstetrics and Gynaecology was particularly focused due to the serious shortage in this workforce.

4.4.1.3 Vensim

Centre for Workforce Intelligence (2013) introduced robust workforce planning as a new approach in outlining a workforce that satisfy conditions required. Workforce modelling was the third stage in robust workforce planning and contributed the most to this project. Workforce models involved a lot of data. These data should be obtained from assured sources to assess the data quality. CfWI used system dynamics modelling in developing a model that calculated the demand and supply of the workforce. System dynamics approach was chosen because it was considered the most relevant to the current complex system with responses and can be expanded or modified easily in order to address to additional issues. The usage of system dynamics modelling in the Medical and Dental Student Intakes (MDSI) model would be discussed in further detail in next chapter.

The last part of this robust workforce planning was to investigate the impact of possible policy decisions and demonstrate the results. Various scenarios generated were tested with the developed model. These scenarios would be compared to a baseline, an original unchanged condition, of what might happen if the current trend continues. CfWI had also applied these four building blocks successfully in predicting and planning the future English pharmacist workforce. The CfWI adopted this framework as it implemented an understandable and logical separation of the key factors and Delphi process described above was well utilised to quantify them.

Vanderby et al. (2013) modelled the future of the Canadian cardiac surgery workforce using system dynamics. Canada’s ageing population would conceivably lead to an increase in demand for health care providers and in the end, a rise in retirement age was planned and this might affect many practitioners who are currently in training. The model was developed to simulate the workforce within a single specialty at a national level. This model included both demand and supply components. The demand part was established based on statistical composition of the population while the supply part combined both currently practising surgeons and cardiac students in training. The 'What-if' scenarios generated were explored in the model to explain possible situations in the future.

Their model too included both qualitative and quantitative aspects of system dynamics modelling. A causal loop diagram was developed to include feedback loops that demonstrated the relationship between the provider supply and population demand factor. Such diagram was a good platform to conceptualise the system as well as determining parameters and feedback loops which would be quantitatively expressed within the model.

This model was created quantitatively using Vensim Professional32 Version 5.2a and contained five modules that were linked to each other. Retirement or departure factor were inserted into the cardiac surgeon workforce that simulated surgeons as they become older. Variables such as enrolment rates, student population, graduation proportion, surgeon population and surgeon departure rates were also included to model the system. The results resembled the population of surgeons as they age over time and the flow of cardiac students in training into becoming cardiac surgeons.

Responding to the fall of birth rates and a single-payer health care system, the Paediatrics workforce in Taiwan might be over supplied. Wu et al. (2013) therefore applied system dynamics into forming their model to predict the future supply and demand for the Paediatrics workforce. Their modelling process was divided into three stages. Qualitative aspect was practised in their first model while the rest applied the quantitative modelling.

Wu et al. (2013) exemplified the outlines and variables that influenced the flow of the Paediatrics workforce by providing causal loop and stock and flow diagram in their first model. The second model was the population model and needs for Paediatricians which included both birth rate and mortality rate from different population subgroups. The flow rate to each population subgroups based on their respective mortality rate would estimate the subsequent demand for Paediatricians.

The third model basically explained the flow of Paediatricians between four career stages: residents in a Paediatric residency program; subspecialty fellows in a subspecialty program; hospital staffs; and primary care Paediatricians. Hospital staffs could no longer remain in the hospital when they reach the age of 65 (retirement). However, they could continue their profession as primary Paediatricians in local hospitals. Therefore, retirement factor was considered in this model. For example, the number of hospital staffs was evaluated with;

$$\text{Integral [Join hospital rate} - \text{Departure rate} - \text{Retire rate]}$$

The last two models were simulated using Vensim PLE software, version 5.11A which resulted in differences between demand for and supply of Paediatricians. System dynamics modelling was chosen for this simulation as different policies could be examined as well as appropriate measure could be taken in a timely manner.

In these simulation models, the retirement, deaths and movement speciality rates were assumed to remain constant for the retirement factor. System dynamics modelling was chosen to project this forecast because it allowed the inclusion of the movement of a physician factor into the model. However, the difficulty to obtain data was considered as a limitation in this study.

5.0 Methodology

This chapter presents the methodology applied in this project. This project involved a huge population of medical workforce in England which mainly considered the retirement factor to model the future workforce. Models developed by Vanderby et al. (2013), Barber and López-Valcárcel (2010) and Wu et al. (2013) were very similar to this current project in terms of workforce structure and objectives. Therefore, system dynamics was chosen for this project. As discussed in the literature review, system dynamics is comprised of qualitative modelling and quantitative modelling. This chapter will begin with the qualitative modelling which explained the behaviour of this model using a causal loop diagram.

The quantitative modelling of the current work would comprise of the formation of retirement profile tool and modification of the system dynamics model developed by CfWI using Vensim DSS. Due to time constraints and the extremely large workforce to be considered, the subject to be tested in this methodology would be hospital consultants instead of the whole medical workforce including general practitioners. Moreover, it takes a longer time and higher cost to train a hospital consultant. Therefore, it is vital to evaluate how the hospital consultant manpower will be affected in the future.

5.1 Qualitative Modelling

System dynamics approach, as mentioned in the literature review, was reported to be an analytical modeling methodology (Brailsford and Hilton, 2001). System dynamics could combine qualitative and quantitative aspects to identify problem and improving comprehension of the structure of a problem. It could relate different parts of complex system by problem solving approach of causal link and influence diagram. A causal loop diagram was therefore constructed to explain the model.

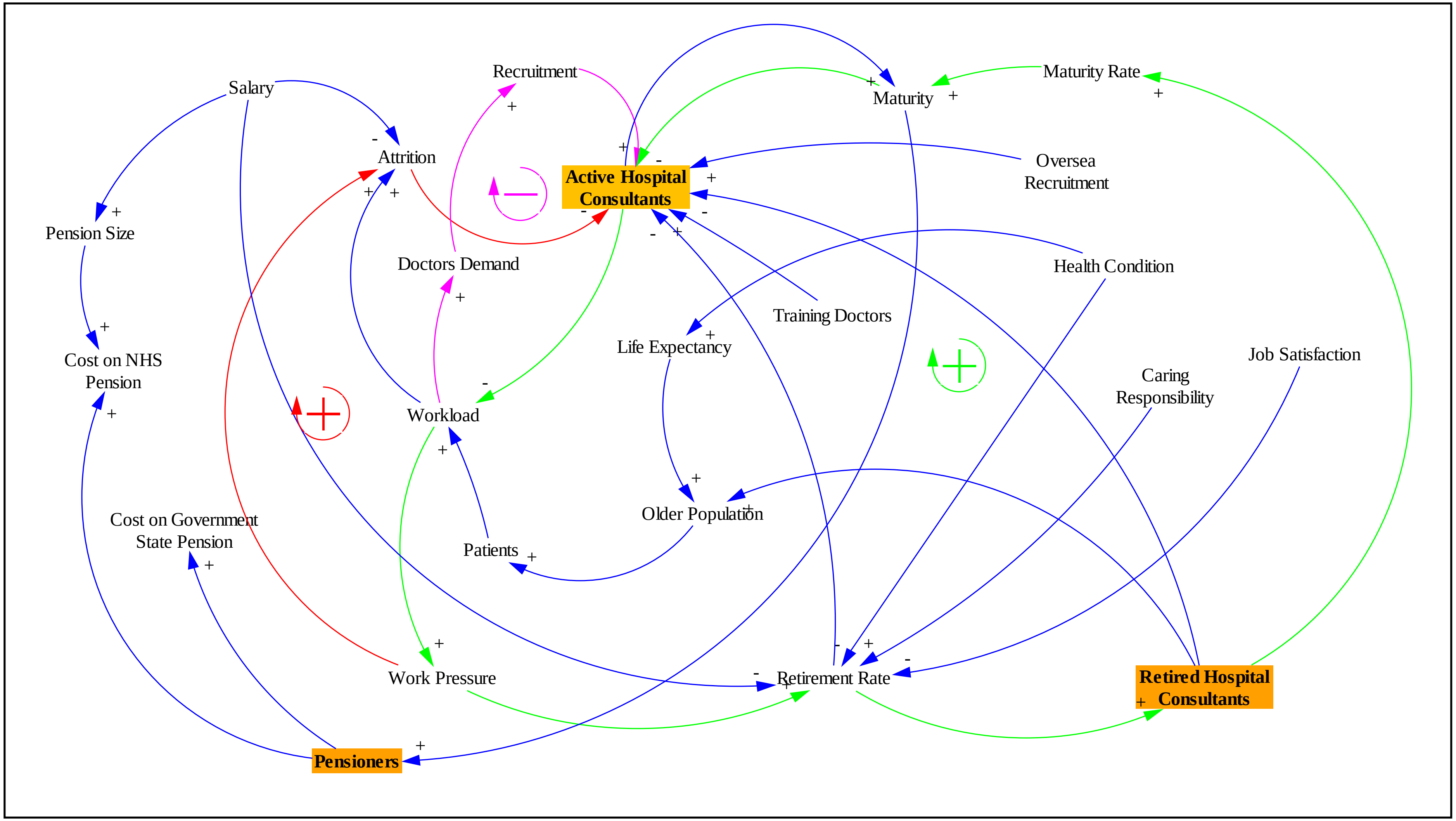

Figure 3 Causal Loop Diagram

A causal loop diagram is a part of system dynamics qualitative modelling which is applied to analyse the complicated relationship within a dynamics system (Sapiri et al., 2010). A causal loop is determined in which the chain effects of a cause are traced, through a set of variables, and back to the original cause. A causal loop is formed when a set of variables are connected to each other with arrow headed lines. The positive sign on each arrow head indicates the affecting and target variables change in the same direction while the negative sign indicates the opposite direction.

There are two types of causal loop. Reinforcing loop (+) contains even number of negative relationship which produced the same result as the initial assumption in the loop while balancing loop (-) contains odd number of negative relationship where the result contradicts with the initial assumption.

The causal loop diagram above showed the relationships between three different stocks and how other variables affected them in the model. The three different stocks mentioned above consisted of:

a) Active hospital consultants – hospital consultants working under the NHS
b) Retired hospital consultants – retired hospital consultants that retire before or at the compulsory State Pension age
c) Pensioners – retired hospital consultants that reach maturity and are receiving pension

This study focused on the sociological impact of increasing the State Pension age on the hospital consultants. This causal loop diagram will explain how retirement among hospital consultants affects the size of the medical workforce and that will conclude the effectiveness of reformation of the State Pension age.

Active hospital consultants represents the headcount of hospital consultants in the country. Factors influencing this stock include recruitment (regional or overseas), attrition, existing training doctors, maturity and retirement rate. Maturity rate and maturity level symbolise the rate of hospital consultants reaching the retirement age and become pensioners. Therefore, increase in maturity will result in decrease in active hospital consultants.

There are three important causal loops discovered in the diagram above. The first loop is represented by purple coloured arrows which explains the increase of workload will result in higher demand for hospital consultants. More recruitment will increase the size of active hospital consultants and therefore reducing the workload. This is a balancing loop.

Red coloured arrows represent a reinforcing loop. The growth in hospital consultant workforce will reduce the workload and work pressure. Hence, there will be less attrition which indicates the hospital consultant workforce will continue to grow. The second reinforcing loop is represented by green coloured arrows that connected active hospital consultants, workload, work pressure, retirement rate, retired hospital consultants, maturity rate, and maturity. As the workforce decrease in size, heavy workload and high level of pressure will cause higher retirement rate. This will result in more retired hospital consultants, increasing maturity and finally reduced size of active hospital consultants.

Salary acts as an important factor that influence the attrition and retirement rate of hospital consultants. High salary will attract hospital consultants to continue working. However, some hospital consultants will choose to retire early when they have earned enough money. Therefore, further research can be done by studying the relationship between salary and attrition which will affect the size of hospital consultants.

Assuming that retirement rate will decrease when the State Pension Age increases, the maturity level will be reduced and result in lower cost spent on government State Pension and NHS Pension.

5.2 Quantitative Modelling

5.2.1 Retirement Profile Tool

The age at which doctors would actually stop working was difficult to foresee (British Medical Association, 2013). Comprehensive data on retirement from the NHS is not available, making it difficult to establish existing retirement patterns or to model future behaviour. The approach of creating a retirement profile tool was to calculate the percentage of doctors retiring at each age by accessing the number of doctors leaving their profession at each age. This retirement profile tool would also aim to calculate the average retirement age and average participation rate.

The Centre for Workforce Intelligence had previously created its own retirement profile tool using Microsoft Excel by calculating the net number of doctors (joiners and leavers) at each age. The result obtained from this original tool was used to develop the system dynamics model using Vensim DSS. This new retirement profile tool was created using Microsoft Excel with the aim of improving the original tool by considering only the leavers at each age. Both tools would be compared in the discussion of this dissertation.

5.2.1.1 Data Description and Data Pre-processing

The database for the registered medical workforce was obtained by the Health and Social Care Information Centre (HSCIC) which contains the information for registered NHS staff from year 2008 to year 2012. The database consisted of highly confidential information of each staff including:

i. registered GMC (General Medical Council) number,
ii. unique ID (Identification Number),
iii. SHA (Strategic Health Authority) code for respective organisation and name,
iv. occupation code,
v. specialty group,
vi. specialty,
vii. gender,
viii. grade,
ix. age in years, and
x. full time equivalent (FTE) which is the participation rate (Health and Social Care Information Centre, 2010).

As there were approximately 500,000 data records within those five years, only five specialty groups were applied in developing this retirement profile tool. These five specialty groups are the Accident and Emergency (A&E), Anaesthetics, Obstetrics and Gynaecology (O&G), Paediatrics and Psychiatry. They were chosen due to high interest and their huge workforce structure. For example, the Anaesthetics and Paediatric workforce were chosen mainly because of their massive manpower in

England. In September 2012, there was a total of 12,432 and 8,223 staff in the Anaesthetics and Paediatrics workforce respectively (Health and Social Care Information Centre, 2013).

On the other hand, the Psychiatry workforce was selected due to its higher attrition rate and lower retirement age. The Psychiatry workforce was considered to be the specialty with significant number of premature retirements. Kendell and Pearce (1997) carried out a survey on consultant psychiatrists whom retired prematurely. Heavy workload and high level of mental pressure were the main reasons that lead to early retirement of these respondents.

There were four stages of data pre-processing before analysis was carried out. Firstly, duplicated inputs in the database were deleted. Secondly, the database was rearranged in increasing GMC number order and a large number of inputs were found to be missing GMC numbers in the year 2010, 2011 and 2012. These inputs were reassigned with their respective GMC number, where they were sorted out according to their unique ID using Excel Spreadsheet Commands.

After that, inputs of hospital consultants whose age were below 35 and above 80 were deleted from the dataset as they were considered outliers. Finally, the last stage of data pre-processing would be the exclusion of hospital consultants whom were not considered retiring and the method would be explained in 5.2.1.3.

5.2.1.2 Methods and Techniques

The dataset was sorted according to different specialties and genders using pivot tables from the Ms. Excel Spreadsheet. Pivot table consists of:

a) GMC number in increasing value in the row label
b) Age in years in increasing value in the column label
c) Number of inputs in different age group (years) was collected for each row and column accordingly

The purpose of creating these pivot tables was to assess the retirement age for each hospital consultant. For each GMC number, the last working age was recorded, to show at what age did the respective hospital consultant retired.

Another pivot table was then drawn to collect the number of hospital consultants leaving at each age. The result from this pivot table was applied to calculate the retirement percentage at each age. Retirement percentage of each age was formulated as below:

$$\frac{\text{Number of hospital consultants retiring at each age}}{\text{Total number of hospital consultants at each age}} \text{ x } 100\%$$

The total number of hospital consultants at each age was assessed by calculating the number of working hospital consultants at each age from year 2008 to year 2011. Graphs of retirement age in percentage by each specialty, gender, combined specialty and combined gender were plotted against the hospital consultants' age. Stacked bar charts were also created to compare the number of hospital consultants leaving at each age with the total number of hospital consultants at each age.

The average retirement age were then calculated to approximate when hospital consultants from each specialty chose to retire. Average retirement age for each gender by specialty were then calculated by the following formula:

$$\frac{\sum_{i=55}^{80} \text{Age in Years}(i) \text{ x } N\text{umber of hospital consultants retiring at } i}{\sum_{i=55}^{80} N\text{umber of hospital consultants retiring at } i}$$

Other than formulating the retirement percentage, calculations for the average participation rate for hospital consultants aged above 55 were made to determine how much the older medical workforce contributed their life to work. Participation rate is equivalent to the full time equivalent (FTE) divided by the headcount (HC). A frequency histogram was created to display the frequency of full time equivalent working. This step was vital for scenario generation which would be discussed in the next chapter.

5.2.1.3 Assumptions

A number of assumptions were drawn based on certain particular features and limitations on the available data. As explained in the background, a medical student would need to be trained for at least fifteen years to practice as a hospital consultant. Some students might need longer training and some could complete their training quicker than other students. Therefore, for the purpose of accuracy, it was assumed that an individual could only serve as a hospital consultant at the age of 35. Hospital consultants aged above 80 were not considered due to the small number and the potential that the data was anomalous. This assumption was based on common practice in this research field (Centre for Workforce Intelligence, 2013). There exist several irregular cases where octogenarians were still serving as hospital consultants. However, they were excluded from the dataset to focus on the more common retirement ages.

The likelihood of retirement was computed according to each age of hospital consultants. Some hospital consultants were not taken into consideration in calculating the rate of retirement at each age. There were three cases of hospital consultants whom were excluded from the dataset:

Hospital consultants who still worked in year 2012

a) Hospital consultants who started working in year 2012
b) Hospital consultants who left and returned to work in year 2012
c) These hospital consultants were excluded because they were not considered as retiring from their profession. Since this is a retirement profile tool, the only subjects focused on were permanent leavers, which were hospital consultants whom left on or before year 2011.

Members of the NHS Pension Scheme whom were registered before April 2008 (Section 1995) could retire at any time from the age of 50 provided that they had at least two years pensionable service (NHS Pension Scheme, 2013). On the other hand, staffs that joined the scheme beyond April 2008 (Section 2008) could only take voluntary early retirement and retire at any time from the age of 55.

The number of hospital consultants who took the voluntary early retirement in year 2011 increased drastically compared to year 2010 (Jacques, 2011). Voluntary early retirement before the age of 60 has increased by 72% in year 2011. Therefore, to increase the accuracy of the analysis, hospital consultants were assumed to start retiring at the age of 55 in the calculation of the average retirement age. The same assumption was applied to calculate the average participation rate to observe how the older workforce participated in their work as they aged. These assumptions would then contribute to the projection of system dynamics modelling which will be discussed next.

Another important assumption for this model was the representation of the retirement rate by the percentage of hospital consultants leaving at each age. There was no significant proof that those hospital consultants who left their profession were actually retiring. As the data was only available up to year 2012, hospital consultants who were considered retiring in the model might actually rejoin the workforce in the future. Moreover, hospital consultants could also change their profession or work in private sector. Therefore, throughout the model, it was assumed that hospital consultants who left their profession were actually retiring from the NHS.

5.2.2 Vensim DSS Modelling

As described in the literature review, the CfWI applied the newly developed robust workforce planning framework to the medical workforce to advise the Health Education National Strategic Exchange (HENSE) review group regarding the future medical and dental student intakes (MDSI). This methodology would mainly focus on the third stage of the robust workforce planning framework, which was the workforce modelling. A report was drawn by the company outlining several objectives for this model;

a) Calculate the supply and demand for the medical workforces from now through to 2040,
b) Segment the workforce by age and gender,
c) Represent the training pipeline from entering university through to delivering service as fully qualified doctors,
d) Represent the complex career paths for doctors following qualification,
e) Integrate with large datasets from a variety of NHS and other official data sources,
f) Use the data from the Delphi workshops that define the attributes of the four scenarios,
g) Enable policy analysis to be carried out to determine the impact of different policies on the different scenarios,
h) Execute rapidly and produce outputs that can be readily analysed,
i) Be fully tested and documented, with an audit trail for all assumptions,
j) Allow the sensitivity of the input assumptions to be determined.

(Centre for Workforce Intelligence, 2013)

As suggested by Brailsford and Hilton (2001), system dynamics was a simulation which models a series of stocks and flows where the state changes continuously. The medical workforce was represented by stocks and they were subdivided by age, gender and country of origin. Changes such as migration, length of training and retirement age could be modelled easily by using this approach. Other than the ability to interpret the behaviour of a system over time, system dynamics approach could also perform complex processes and merge with complex datasets. These were the major reason of CfWI choosing system dynamics as their modelling approach (Centre for Workforce Intelligence, 2013).

5.2.2.1 Model Development Process

The development of the process is comprised of four stages (Centre for Workforce Intelligence, 2013). Firstly, model specification was meant to define clearly the purpose of constructing this model. The appropriate approach for this model development was also selected in the specification stage. Secondly, a map that illustrated the relevant processes of the training and career pathways were constructed to enable stakeholders to provide their opinions and comments. Consensus was then achieved for further development of the quantitative model.

The model was then thoroughly documented and tested to ensure it was suitable for simulation. This stage was very important to eliminate any errors or inaccuracies for correct implementation of the model. Finally, when the model was proved to be efficient, policy analysis would be carried out.

5.2.2.2 Model Technical Description

Despite several system dynamics software options, the CfWI preferred Vensim DSS for the projection of the future medical workforce supply (Centre for Workforce Intelligence, 2013). This software could handle the complication of flows of medical and dental training, including sub-categorisation. Vensim DSS modelling also had the advantage of managing different factors that influence the modelling supply such as the ageing of the workforce. On top of that, this software could be simulated rapidly to produce findings within a short period.

Microsoft Excel was used as a platform to tabulate data and it is used as a user interface to the system dynamics model (Centre for Workforce Intelligence, 2013). This interface enables non-system dynamics analysts to understand and adapt the model easily and carry out policy analysis. All data could be referenced and would be included with a complete data audit trail. The medical demand calculations were also implemented in the Excel spreadsheet.

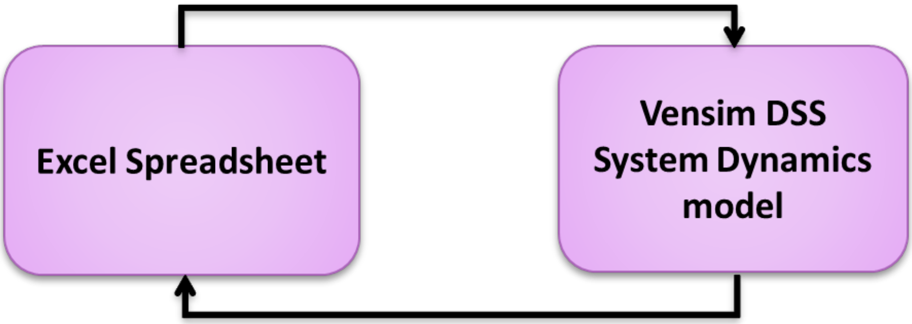

Figure 4 MDSI Medical Model Architecture (Centre for Workforce Intelligence, 2013)

The figure illustrated above explained the two key structures of the medical and dental student intakes (MDSI) model which comprised of the Microsoft Excel spreadsheet and the Vensim DSS model. The spreadsheet basically carried out the calculation for the demand part and contained all input data that were applied into the Vensim DSS model for supply calculation. All the variables and inputs were described in the spreadsheet. Creation or modification of policies could be made using the spreadsheet.

The Vensim DSS model read input data from the spreadsheet, analysed and calculated the training pipeline and resulted in the size of the workforce over a period of 30 years. These results would be shown and represented graphically by demand and supply in the spreadsheet whereby comparison between both demand and supply could be done.

The supply component of this model was a simulation of the medical training and career pathway system over a 30-year period. The system starts with the enrolment into medical school and ends with GPs or THDs. The CfWI applied the stock and flow diagram to briefly represent the system of the medical workforce. Each stock represented the number of headcounts in each career stage while flows indicated the flow rates of subjects in and out of the stocks. The figure below shows the stock and flow diagram of the MDSI medical model.

The spreadsheet carried out the calculation for the demand part and contained all input data that were applied into the Vensim DSS model for supply calculation. All the variables and inputs were described in the spreadsheet. New and modified policies could be used in the spreadsheet.

The Vensim DSS model read input data from the spreadsheet, analysed and calculated the training pipeline and resulted in the size of the workforce over a period of 30 years. These results would be shown and represented graphically by demand and supply in the spreadsheet whereby comparison between both demand and supply could be done.

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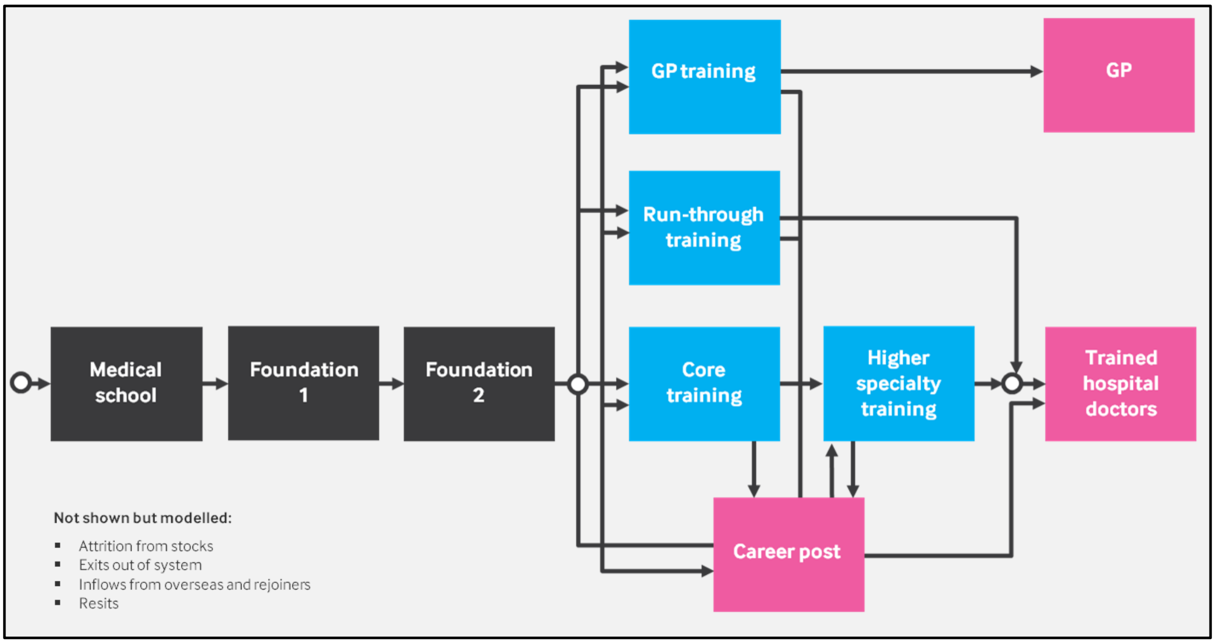


Figure 5 Stock and flow diagram of the MDSI medical model (Centre for Workforce Intelligence, 2013)

The model was then further constructed quantitatively using Vensim DSS which is a visual modelling tool that allows documentation, simulation, analysis, and optimization of dynamics systems. Variables that influenced the stocks were added and connected as causal connections. Mathematical equations were included to each causal connection by using equation editor. These variables included attrition from each stock, retreat from stock, inflows from overseas, workforce rejoiners, etc. Each variable was calculated at increments of time which was represented as Δt. A basic calculation of the GP workforce in the system over time could be formulated as being the number of GPs at time $(t - \Delta t)$ plus changes due to those joining the workforce from the English system, those joining from outside the English system and attrition during Δt which is as follows:

$$\mathrm{GP(t)} = \mathrm{GP}(\mathrm{t} - \Delta t) + \text{Join GP workforce}(\Delta t) + \text{Rejoiners from outside English system}(\Delta t) - \text{Attrition}(\Delta t)$$

Furthermore, each stock and flow in the supply model was subdivided by age and gender to enable variables like attrition and participation rates to be thoroughly considered according to age and gender. These considerations were then applied to model the medical training and career pathway system using Vensim DSS.

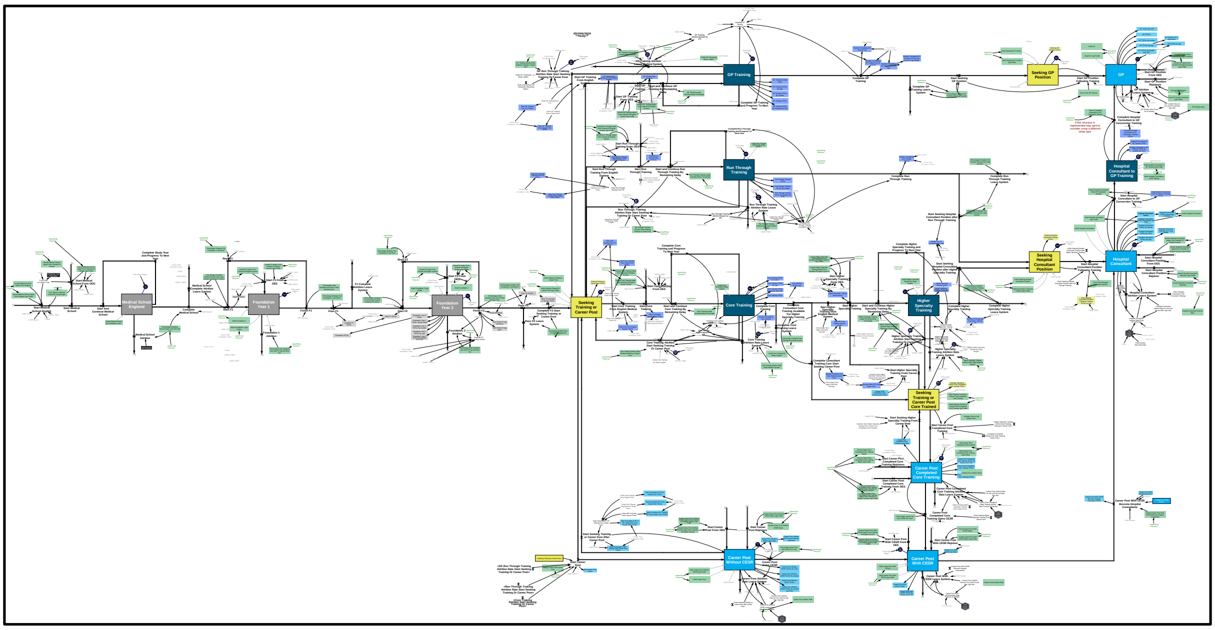


Figure 6 System Dynamics model of the medical training and career pathway system (Centre for Workforce Intelligence, 2013)

Figure 6 showed the detailed stock and flow diagram from the Vensim system dynamics model. The figure clearly showed the complexity of the stocks and flows in the full model. The model consisted of 14 separate influence diagrams, 997 different variables and the model was initialized with 903,525 items of data. Despite its complexity, the simulation of this model would only require thirty seconds using Vensim DSS. Different policies and scenarios could be generated by modifying the parameters in the model such as participation rate, average retirement age and attrition rate which were earlier determined using the Delphi method.

The demand component of this model projected the future demand for GPs and Trained Hospital Doctors (THDs). The future demand was calculated based on the current demand for service, the percentage of the current demand, future population projections, changes in levels of need, changes in productivity and changes in service delivery.

The development of this model could illustrate the model structure diagrammatically and effectively explain the behaviour of the system. Simulation of policies and scenarios could be done in a short time, proving the efficiency of this model to project the future medical workforce up to year 2040. The model constructed was also flexible and manageable for further research, should there be one.

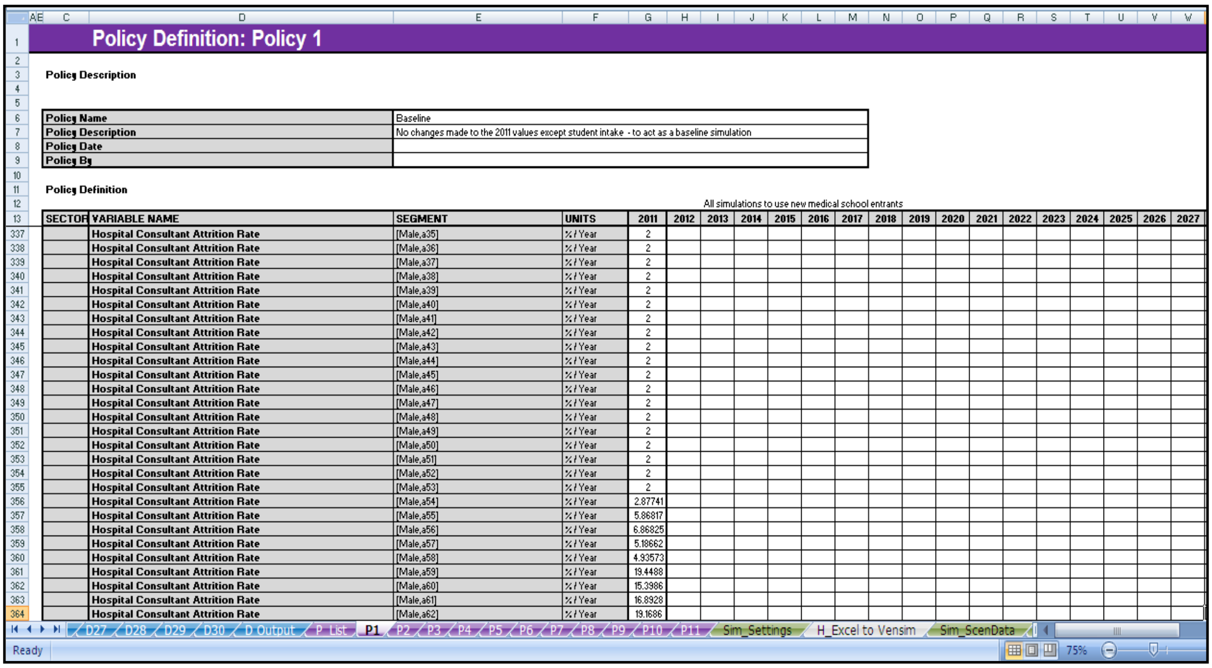
5.2.2.3 Model Application

Due to time constraints, the MDSI system dynamics model created by CfWI modellers would be adapted to project the impact of the changing State Pension age on the medical workforce. This model would only focus on hospital consultants due to extremely large workforce. The MDSI model referred THDs as the combination of hospital consultants and a smaller number of CESR qualified doctors. However, THDs and hospital consultants were numerically the same. Therefore, it was assumed that THDs were equal to hospital consultants.

The initial idea was to replace the attrition rates in the Vensim DSS model with the retirement percentages from the new retirement profile tool. However, this could not be done as the attrition rates from the model considered both leavers and joiners of the workforce. Each stock in the model took into account new joiners and joiners from outside the system as explained above. Replacing the attrition rates with the new retirement rates that only considered leavers would be inappropriate as the model would produce inaccurate results. Nonetheless, the new retirement profile tool was useful in the generation of scenarios in the Vensim DSS model. Results from the tool would inform the level of alteration for parameters in different policies such as attrition rate and participation rate.

Plausible ‘what-if’ scenarios would be generated by considering possible situations in the future. Vanderby et al. (2013) and Barber and López-Valcárcel (2010) had proved scenario generation to be very useful in planning future medical workforce. Reviews of previous research and results obtained from the retirement profile tool were the main source for generating scenarios in this project. When a plausible scenario was created, a policy in the model would be adjusted according to different variables to generate the scenario.

The two main parameters that would be altered in this model were the attrition rate and participation rate, according to gender and age. Retirement age shift was done to analyse the impact of hospital consultants working longer on average. Figure 7 shows the policy tabs (P1 – P11) from the spreadsheet of this MDSI model where parameters could be altered.



Policy Definition: Policy 1

Policy Description

Policy Name	Baseline
Policy Description	No changes made to the 2011 values except student intake - to act as a baseline simulation
Policy Date	
Policy By	

Policy Definition

All simulations to use new medical school entrants

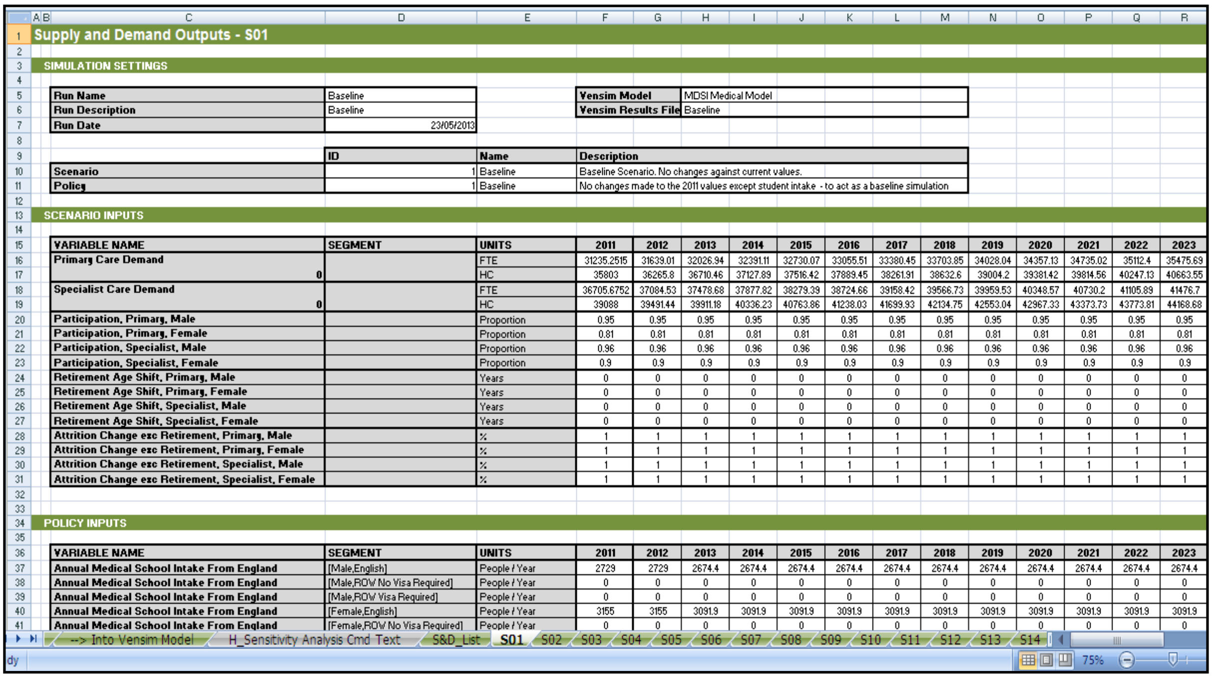
	SECTOR	VARIABLE NAME	SEGMENT	UNITS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
337		Hospital Consultant Attrition Rate	[Male,a35]	% / Year	2																
338		Hospital Consultant Attrition Rate	[Male,a36]	% / Year	2																
339		Hospital Consultant Attrition Rate	[Male,a37]	% / Year	2																
340		Hospital Consultant Attrition Rate	[Male,a38]	% / Year	2																
341		Hospital Consultant Attrition Rate	[Male,a39]	% / Year	2																
342		Hospital Consultant Attrition Rate	[Male,a40]	% / Year	2																
343		Hospital Consultant Attrition Rate	[Male,a41]	% / Year	2																
344		Hospital Consultant Attrition Rate	[Male,a42]	% / Year	2																
345		Hospital Consultant Attrition Rate	[Male,a43]	% / Year	2																
346		Hospital Consultant Attrition Rate	[Male,a44]	% / Year	2																
347		Hospital Consultant Attrition Rate	[Male,a45]	% / Year	2																
348		Hospital Consultant Attrition Rate	[Male,a46]	% / Year	2																
349		Hospital Consultant Attrition Rate	[Male,a47]	% / Year	2																
350		Hospital Consultant Attrition Rate	[Male,a48]	% / Year	2																
351		Hospital Consultant Attrition Rate	[Male,a49]	% / Year	2																
352		Hospital Consultant Attrition Rate	[Male,a50]	% / Year	2																
353		Hospital Consultant Attrition Rate	[Male,a51]	% / Year	2																
354		Hospital Consultant Attrition Rate	[Male,a52]	% / Year	2																
355		Hospital Consultant Attrition Rate	[Male,a53]	% / Year	2																
356		Hospital Consultant Attrition Rate	[Male,a54]	% / Year	2.87741																
357		Hospital Consultant Attrition Rate	[Male,a55]	% / Year	5.86817																
358		Hospital Consultant Attrition Rate	[Male,a56]	% / Year	6.86825																
359		Hospital Consultant Attrition Rate	[Male,a57]	% / Year	5.18662																
360		Hospital Consultant Attrition Rate	[Male,a58]	% / Year	4.93573																
361		Hospital Consultant Attrition Rate	[Male,a59]	% / Year	19.4488																
362		Hospital Consultant Attrition Rate	[Male,a60]	% / Year	15.3986																
363		Hospital Consultant Attrition Rate	[Male,a61]	% / Year	16.8928																
364		Hospital Consultant Attrition Rate	[Male,a62]	% / Year	19.1686																

D27 D28 D29 D30 D Output P List P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 Sim_Settings H_Excel to Vensim Sim_ScenData

Ready

Figure 7 Policy tabs in the Excel Spreadsheet of the MDSI model

Different policies could be selected to be simulated in a simulation settings tab. Each simulation of the model could only simulate one policy to create one scenario. The model was simulated over a period of 30 years, analysing the selected policies. The results of simulation were then displayed in the scenario tabs which were shown in the figure below.



Supply and Demand Outputs - S01

SIMULATION SETTINGS

Run Name	Baseline	Vensim Model	MDSI Medical Model
Run Description	Baseline	Vensim Results File	Baseline
Run Date	23/05/2013		

	ID	Name	Description
Scenario	1	Baseline	Baseline Scenario. No changes against current values.
Policy	1	Baseline	No changes made to the 2011 values except student intake - to act as a baseline simulation

SCENARIO INPUTS

VARIABLE NAME	SEGMENT	UNITS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Primary Care Demand		FTE	31235.2515	31639.01	32026.94	32391.11	32730.07	33055.51	33380.45	33703.85	34028.04	34357.13	34735.02	35112.4	35475.69
0		HC	35803	36265.8	36710.46	37127.89	37516.42	37889.45	38261.91	38632.6	39004.2	39381.42	39814.56	40247.13	40663.55
Specialist Care Demand		FTE	36705.6752	37084.53	37478.68	37877.82	38279.39	38724.66	39158.42	39566.73	39959.53	40348.57	40730.2	41105.89	41476.7
0		HC	39088	39491.44	39911.18	40336.23	40763.86	41238.03	41699.93	42134.75	42553.04	42967.33	43373.73	43773.81	44168.68
Participation, Primary, Male		Proportion	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Participation, Primary, Female		Proportion	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Participation, Specialist, Male		Proportion	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Participation, Specialist, Female		Proportion	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Retirement Age Shift, Primary, Male		Years	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Age Shift, Primary, Female		Years	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Age Shift, Specialist, Male		Years	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Age Shift, Specialist, Female		Years	0	0	0	0	0	0	0	0	0	0	0	0	0
Attrition Change exc Retirement, Primary, Male		%	1	1	1	1	1	1	1	1	1	1	1	1	1
Attrition Change exc Retirement, Primary, Female		%	1	1	1	1	1	1	1	1	1	1	1	1	1
Attrition Change exc Retirement, Specialist, Male		%	1	1	1	1	1	1	1	1	1	1	1	1	1
Attrition Change exc Retirement, Specialist, Female		%	1	1	1	1	1	1	1	1	1	1	1	1	1

POLICY INPUTS

VARIABLE NAME	SEGMENT	UNITS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Annual Medical School Intake From England	[Male,English]	People / Year	2729	2729	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4	2674.4
Annual Medical School Intake From England	[Male,ROW No Visa Required]	People / Year	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Medical School Intake From England	[Male,ROW Visa Required]	People / Year	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Medical School Intake From England	[Female,English]	People / Year	3155	3155	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9	3091.9
Annual Medical School Intake From England	[Female,ROW No Visa Required]	People / Year	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8 Scenario tabs in the Excel Spreadsheet of the MDSI model

As explained in the literature review, many of the medical doctors had the intention to retire early regardless of the reformation made to the State Pension age. Therefore, scenarios would also be generated based on the research done on the retirement behaviour of medical doctors.

6.0 Results

This chapter will begin with the findings obtained from the retirement profile tool. This retirement profile tool will then be compared to the original retirement profile tool created by CfWI. Plausible scenarios would be generated based on research and logical assumptions. Different policies would be analysed to provide answers to those scenarios generated.

6.1 Retirement Rate among Hospital Consultants

Retirement Percentages among hospital consultants from the age of 35 up to 80 will be shown by specialty and gender. Stacked bar charts will be presented as well for clearer version of the number of hospital consultants leaving against total number of hospital consultants serving at these ages.

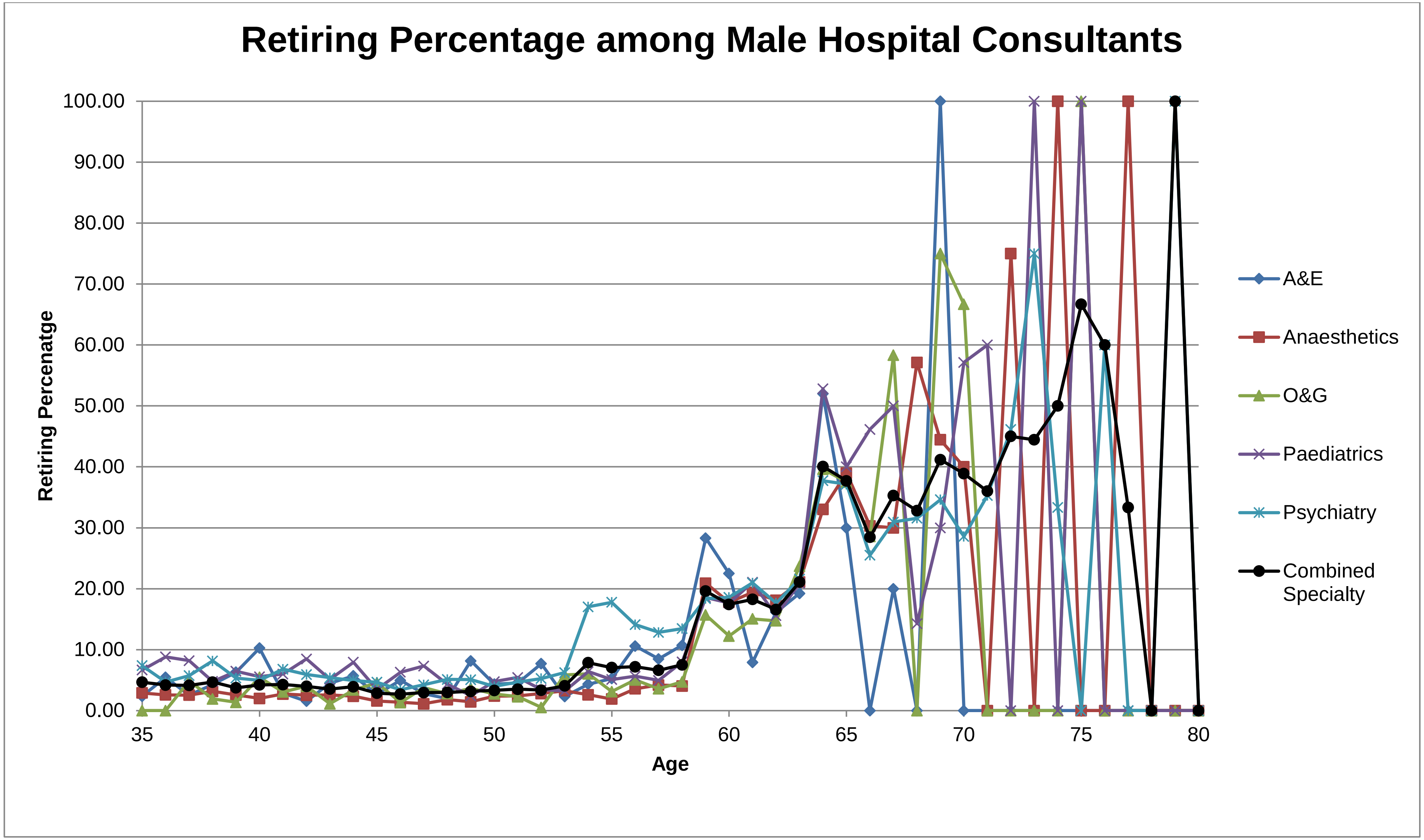


Figure 9 Retirement Percentage among Male Hospital Consultants

Figure 9 showed graph of the retirement percentage from the age of 35 to 80 for male hospital consultants by specialty. It could be seen that as the age increased, the retirement percentage increased as well for these five specialties. The retirement percentage of combined specialties for male hospital consultants was also included in the graph. Significant increment of retirement percentage was observed roughly from the age of 58. There exist some noises for younger workforce who aged less than 55. However, the retirement percentage for these young male hospital consultants varied between 0% and 10%, which was really low to be considered as retiree. It was very unlikely for hospital consultants to retire so young provided that they could only claim their pensions when they reach the normal pension age.

The existing noise for the young workforce might be due to unplanned attrition from their profession. Personal issues such as caring responsibilities, health illness, or changing of profession were among the reasons that lead to attrition. Although members from the NHS Pension Scheme could get their pensions earlier by retiring under voluntary early retirement, as explained in the assumption from the model, hospital consultants were assumed to start retiring only after the age of 55.

From the graph, the peak of 100% retirement percentage was first formed at the age of 69 for the male hospital consultants from A&E, followed by Paediatricians at the age of 73, Anaestheticians at the age of 74, Obstetricians and Gynaecologists at the age of 75, and lastly Psychiatrists at the age of 79. These peaks showed that 100% of the working male hospital consultants, working at these particular ages, were already retired. These peaks did not indicate that most male hospital consultants would choose to retire at these resulted ages. That explained the unusual extreme values at 0% for some of the ages between 70 and 80. There were two clarifications for retirement rate at 0% as follows:

a) there were doctors working at that particular age but none of them retired,
b) there were no doctors working at that particular age.

Further explanation could be made by observing the comparison of number of male hospital consultants leaving at each age with the total number of male hospital consultants at each age for the five combined specialties in the stacked bar chart shown below.

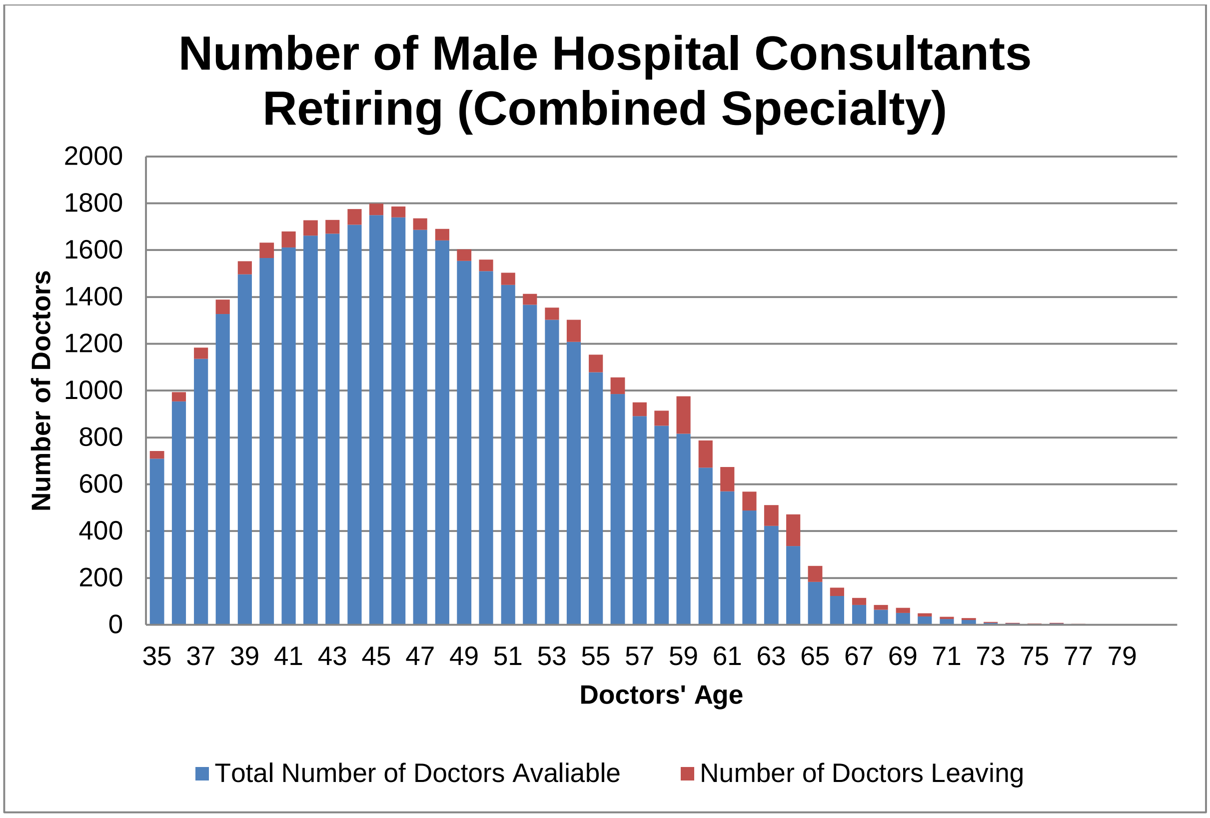


Figure 10 Number of Male Hospital Consultants Retiring (Combined Specialty)

Figure 10 clearly showed more headcounts in younger workforce (age 35-54) compared to the older workforce. The graph skewed to the left and indicated huge number of working young hospital consultants appearing at the age of 45. From the age of 45, the total number of working hospital consultants showed a downward trend as the age increased. A drastic fall of total number of working hospital consultants could be observed between the age of 59 and 60 and between the age of 64 and 65. At these ages, there were a significant number of hospital consultants retiring from their profession.

The workforce became significantly small beyond the age of 65 (less than 200 headcounts). Although there were still hospital consultants working at their 70s, they were an extremely small number who was almost negligible. That explained the unusual extreme values at 0% in previous graph for some of the ages between 70 and 80 which indicated zero headcounts of male hospital consultants. A small amount of male hospital consultants could be seen leaving their profession before the age of 59. However, these young leavers would only be considered as withdrawing themselves from the workforce due to personal reasons. Beyond the age of 59, the number of hospital consultants retiring was very significant.

The total headcount of available male hospital consultants increases from the age of 35 up to 40. Larger workforce could be seen when the male hospital consultants were in their 40s with the peak at the age of 45. These explained the completion of medical training where hospital consultants could only start practising from the age of 35. The trend indicated male hospital consultants retired gradually in their 50s. Most of them chose to stop working between the ages of 59 and 65.

This stacked bar chart showed a general trend of male hospital consultants from the five specialties. Stacked bar charts were also created for each specialty. All five specialties exhibited almost similar trends with the results using combined specialty. Therefore, only one specialty which exhibited a rather unique trend was discussed below as a comparison. Stacked bar charts of other specialties were included in the appendix.

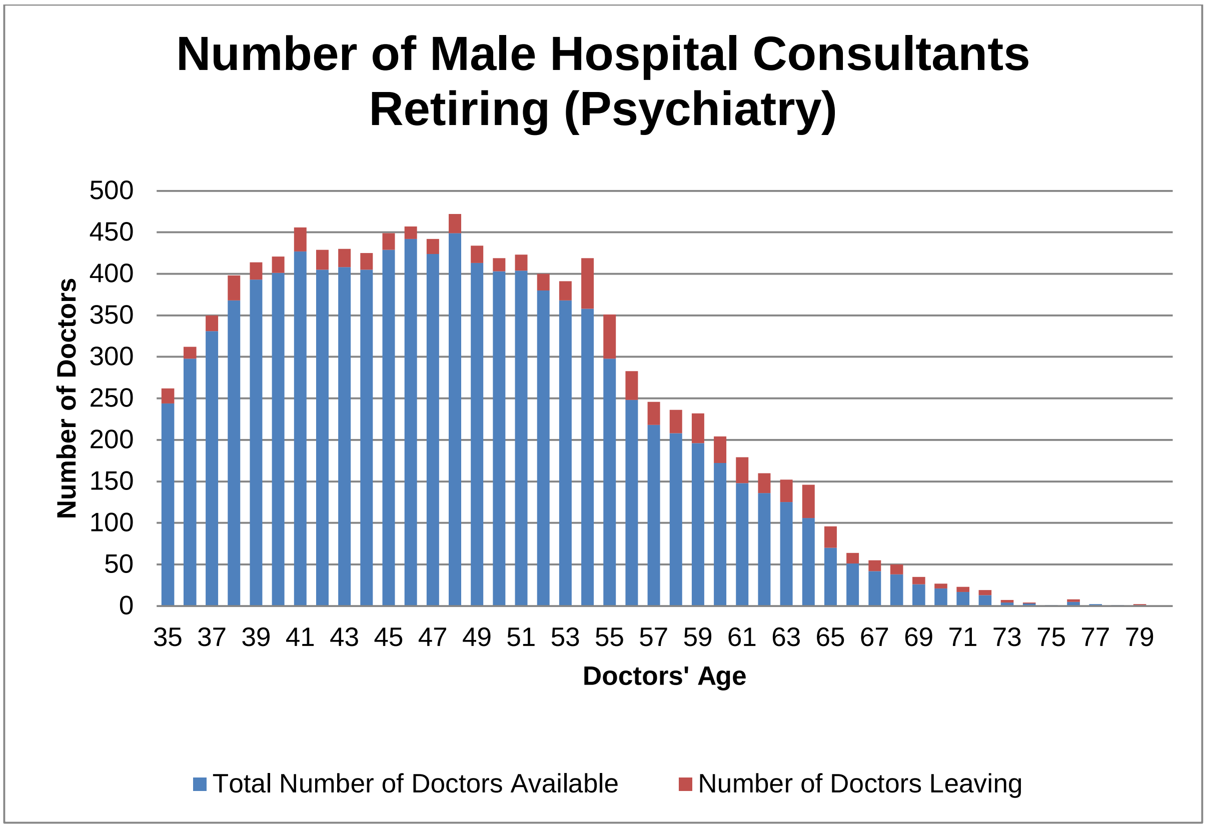


Figure 11 Number of Male Hospital Consultants Retiring (Psychiatry)

Figure 11 showed the graph of the number of male Psychiatrists retiring and total number of available male Psychiatrists. As shown, similar trend could be seen in this bar chart compared to the one that combined all specialties where the trend went upward from the age of 35, remained stable between ages of 40 to 50, and plummeted as the age increased. The significant downward trend from the age of 54 signified lesser male hospital consultants were working as the age increased.

A small number of young male Psychiatrists could be seen leaving before the normal retirement age. However, as explained above, they were considered as leaving the workforce due to other reasons. The number of male Psychiatrists retiring rocketed at the age of 54, indicating most of them started retiring beyond this age. This observation showed that male Psychiatrists retired much earlier compared to the general trend where other hospital consultants left few years later at the age of 59. Male hospital consultants from other specialties retired approximately at the age of 59. This was proven when a significant number of male hospital consultants retiring from each specialty could be observed in respective stacked bar chart.

The retirement behaviour varied between men and women especially in the medical field. The current State Pension age for women is 60 which is five years earlier than the men. The next figure displayed the graph of the retirement percentage from the age of 35 to 80 for female hospital consultants by specialty.

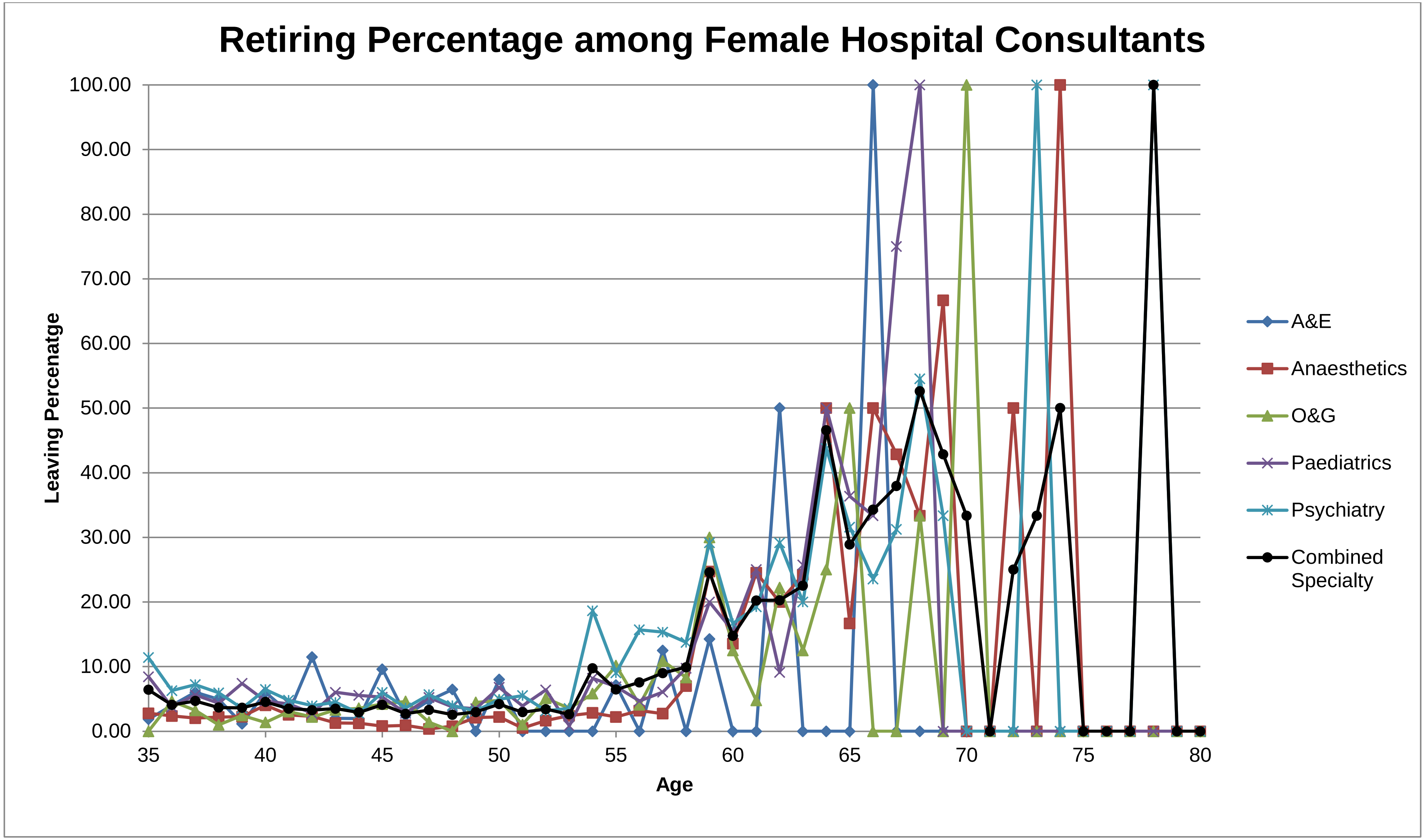


Figure 12 Retiring Percentage among Female Hospital Consultants

Figure 12 showed the graph of the retirement percentage from the age of 35 to 80 for female hospital consultants by specialty. It could be seen that as the age increased, the retirement percentage increased as well for these five specialties with an obvious earlier increment compared to the retirement percentage for males. The retirement percentage of combined specialties for female hospital consultants was also included in the graph. Significant increment of retirement percentage was observed roughly from the age of 54, which was four years earlier than that of males. There exist some noises for younger workforce who aged less than 54. However, the retirement percentage for these young male hospital consultants varied between 0% and 10%, which was really low to be considered as retiree. It was very unlikely for hospital consultants to retire so young provided that they could only claim their pensions when they reach the normal pension age.

The noise found on the graph lines of young female workforce existed due to the attrition from their profession. Personal issues such as caring responsibilities, health illness, or changing of profession were among the reasons that lead to attrition. Compared to males, female hospital consultants had higher probability of attrition due to maternity leave. Part of them would continue their profession after they have given birth. However, some might prefer to work as full time homemaker when they had children. Although members from the NHS Pension Scheme could get their pensions earlier by retiring under voluntary early retirement, as explained in the assumption from the model, hospital consultants were assumed to start retiring only after the age of 55 as long as they were concerned about their financial aspects.

From the graph, the peak of 100% retirement percentage was first formed at the age of 66 for the male hospital consultants from A&E, followed by Paediatricians at the age of 68, Obstetricians and Gynaecologists at the age of 70, Psychiatrists at the age of 73, and lastly Anaestheticians at the age of 74. The same discussion were drawn here as that of the male hospital consultants. These peaks showed that, 100% of the working female hospital consultants at these particular ages, were already retired.

Further explanation could be made by observing the comparison of number of female hospital consultants leaving at each age with the total number of female hospital consultants at each age in Figure 13.

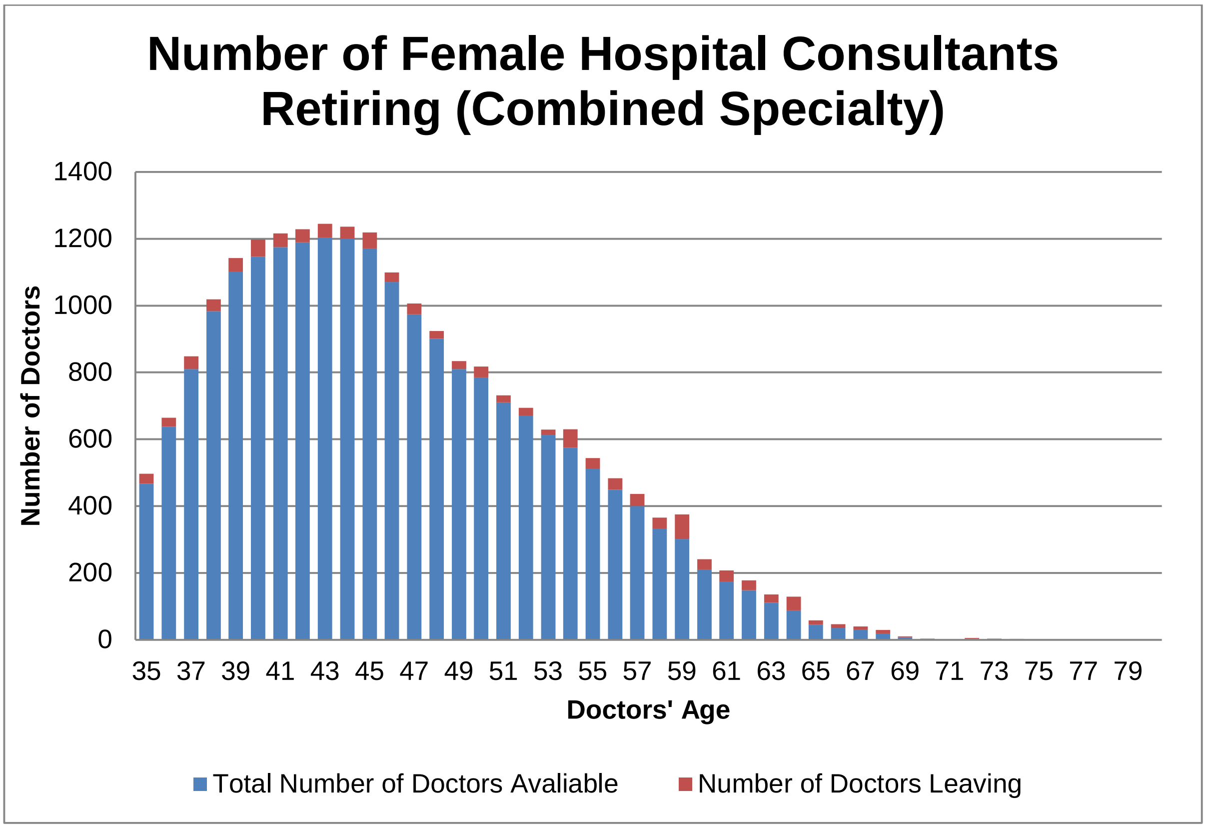


Figure 13 Number of Female Hospital Consultants Retiring (Combined Specialty)

The female hospital consultant workforce shown above was smaller than the male hospital consultant workforce. Similar to the male workforce, the graph skewed to the left indicating huge number of working young hospital consultants with the mode appearing at the age of 43. From the age of 43, the total number of working hospital consultants showed a downward trend as the age increased. The workforce became significantly small beyond the age of 60 (less than 200 headcounts). Septuagenarian female hospital consultants were made up of extremely small workforce or almost negligible. That as well explained the rare extreme values at 0% in previous figure for some of the ages between 70 and 80 indicated zero headcounts of female hospital consultants.

A small amount of female hospital consultants could be seen leaving their profession before the age of 54. However, these young leavers would only be considered as withdrawing themselves from the workforce due to personal reasons. The number of hospital consultants retiring became significant beyond the age of 54.

The total headcounts of available female hospital consultants shot up from the age of 35 up to 40, remained stable between the ages of 40 to 45, lastly decreased to zero as the age increased. There were female hospital consultants retiring at each age but this number of retirement was significant starting from the age 54. From figures 12 and 13, it could be concluded that female hospital consultants retired earlier than male hospital consultants.

Similar to the opposite gender, one specialty which exhibited a rather unique trend was discussed below as a comparison. Stacked bar charts of other specialties were included in the appendix.

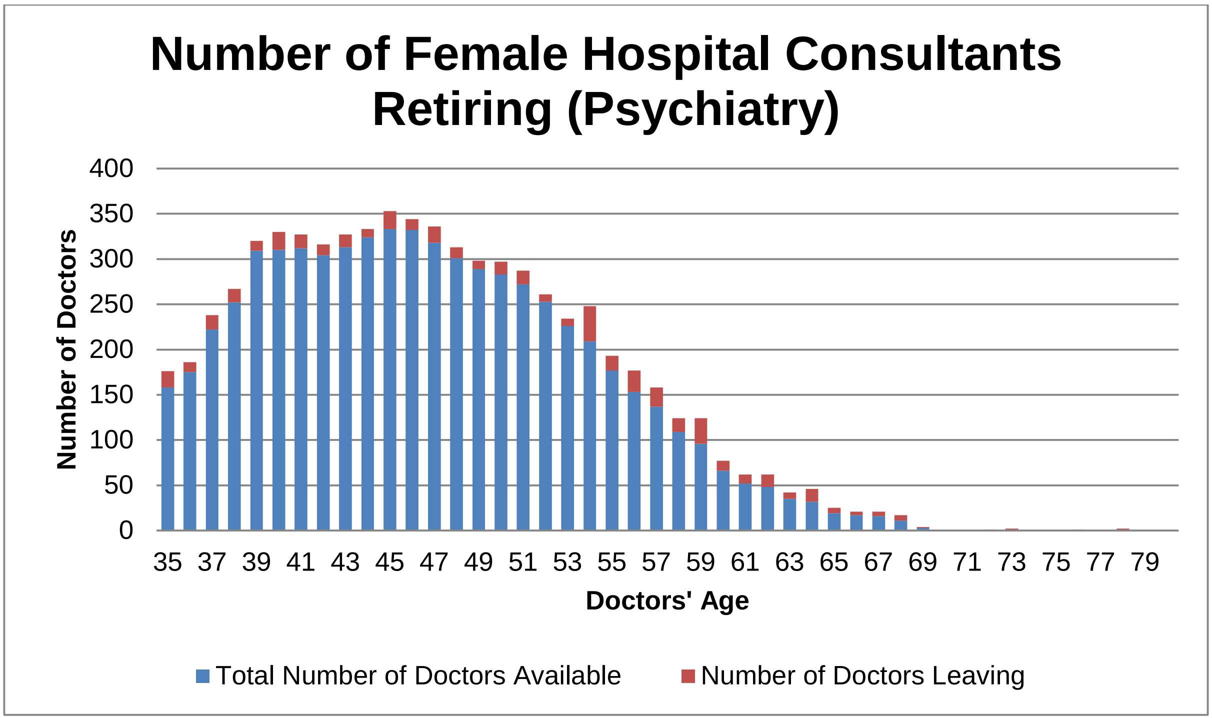


Figure 14 Number of Female Hospital Consultants Retiring (Psychiatry)

Figure 14 showed the graph of the number of female Psychiatrists retiring and total number of available female Psychiatrists. The female Psychiatrist workforce had most headcount at the age of 45. The significant downward trend from the age of 54 signified lesser female hospital consultants were working as the age increased.

The number of female Psychiatrists retiring rocketed at the age of 54, indicating most of them started retiring beyond this age. Although the retirement was recorded from the young workforce, as mentioned, they were considered as leaving the workforce due to other reasons. The number of female Psychiatrists retiring at the age of 54 was significantly more compared to the general trend, indicating more female Psychiatrists retire at the age of 54 compared to other specialties.

This retirement profile tool has proven that most hospital consultants retire earlier than the normal retirement age. Premature retirement among female hospital consultants was very significant compared to male hospital consultants. The Psychiatrists workforce had the most premature retirement compared to other four specialties which was probably due to high level of work stress. Although some hospital consultants retire before the age of 50, they however were considered as leaving the workforce due to other reasons.

6.2 Comparison between Retirement Profile Tool

Results obtained from the original retirement profile tool created by CfWI were applied into Vensim DSS model as attrition rates. These attrition rates took into account new joiners or joiners from outside the NHS system. However, these joiners were neglected in the new retirement profile tool where only leavers were considered for the calculation of retirement rates. These attrition rates and retirement rates were compared by specialty and gender. Only one comparison would be made for each gender. Results for other comparison were included in the appendix.

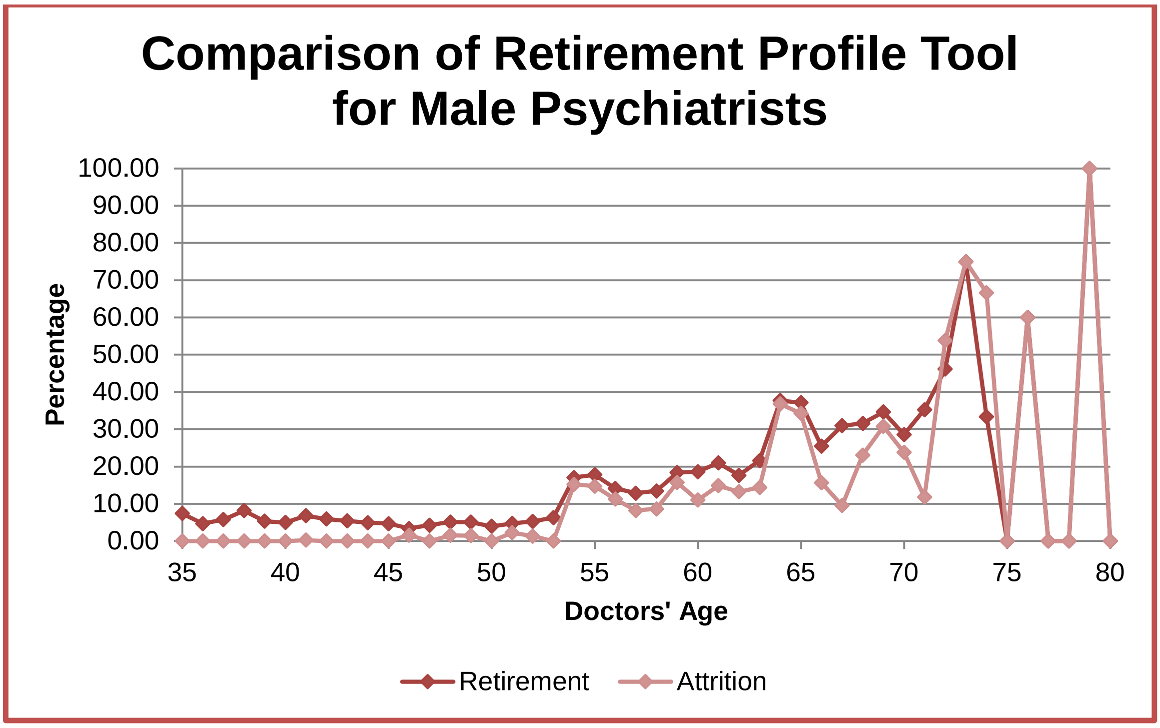


Figure 15 Comparison of Retirement Profile Tool for Male Psychiatrists

Figure 15 compared the retirement rates and attrition rates mentioned for male Psychiatrists. There was gap between retirement rates and attrition rates. This gap appeared across the ages but was significant beyond the age of 55. Between the age of 35 and 55, the difference between both rates indicated a small number of retirements from the workforce. Beyond the age of 55, the gap indicated addition of joiners into the old workforce. The comparison of retirement and attrition rates was displayed for the female Psychiatrists as shown below.

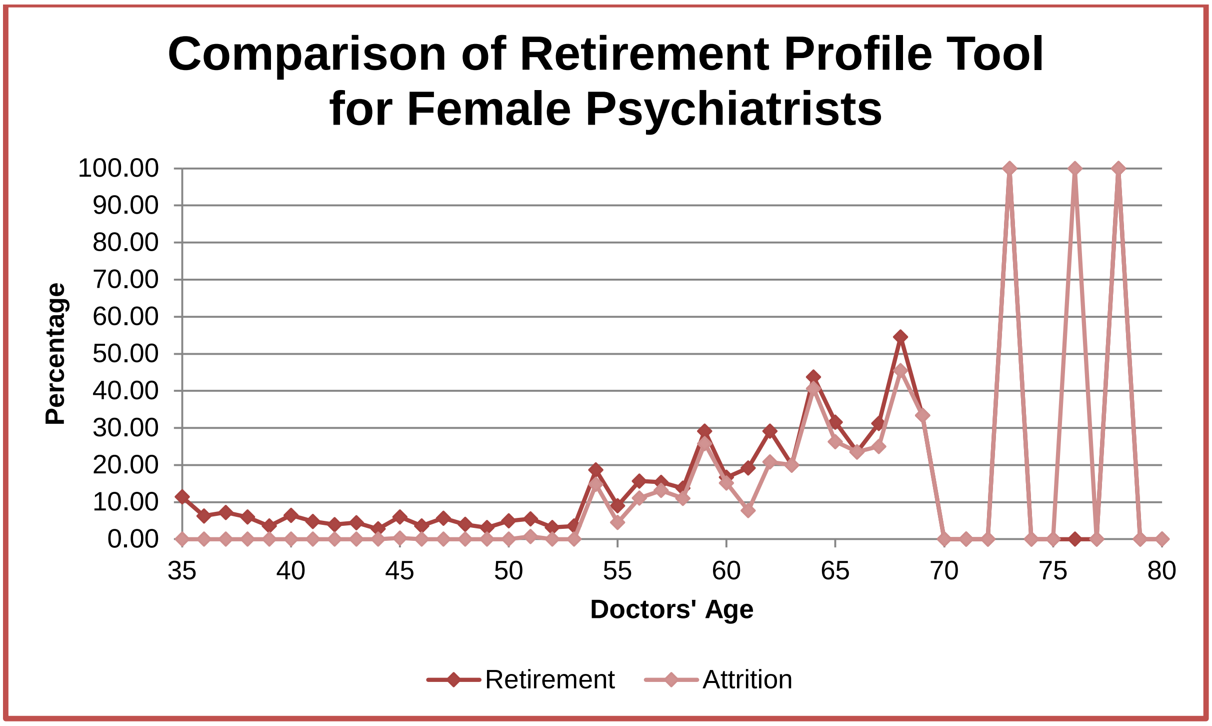


Figure 16 Comparison of Retirement Profile Tool for Female Psychiatrists

Figure 16 compared the retirement rates and attrition rates mentioned for female Psychiatrists. This gap appeared across the ages but was significant beyond the age of 53. Between the age of 35 and 53, the difference between both rates indicated a small number of retirements from the workforce. Beyond the age of 53, the gap indicated addition of joiners into the old workforce.

6.3 Average Retirement Age

As explained in the methodology, the average retirement age were assessed for each specialty by gender. The table below showed the results of average retirement age calculated from the retirement profile tool.

Specialty	Average Retirement Age		
	Male	Female	Both
Accident and Emergency	60.38	59.8	60.09
Anaesthetics	61.45	61.37	61.41
Obstetrics and Gynaecology	61.87	58.97	60.42
Paediatrics	61.56	60.55	61.05
Psychiatry	61.23	59.97	60.60
Combined Specialty	61.30	60.13	60.71

Table 4 Average Retirement Age

The overall workforce retired roughly between the ages of 60 to 62. The Anaesthetics workforce retired the latest while the A&E workforce retired the earliest. Male hospital consultants from these five specialties were seen to have higher average retirement age compared to females. The average retirement age for men was 61.3. Accident and Emergency hospital consultants retired the earliest at the age of 60.38, followed by Psychiatrists, Anaesthetists, Paediatricians and lastly Obstetricians and Gynaecologists. On the other hand, the average retirement age for women was 60.13, slightly earlier than men with Obstetricians and Gynaecologists retiring the earliest at the age of 58.97, followed by A&E hospital consultants, Psychiatrists, Paediatricians and lastly Anaesthetists. Graphs of average retirement age by specialty and gender were compared to the State Pension age over a period of 30 years which were shown as below. The current average retirement age for each specialty was remained up to year 2040 while the State Pension age increased based on reformation.

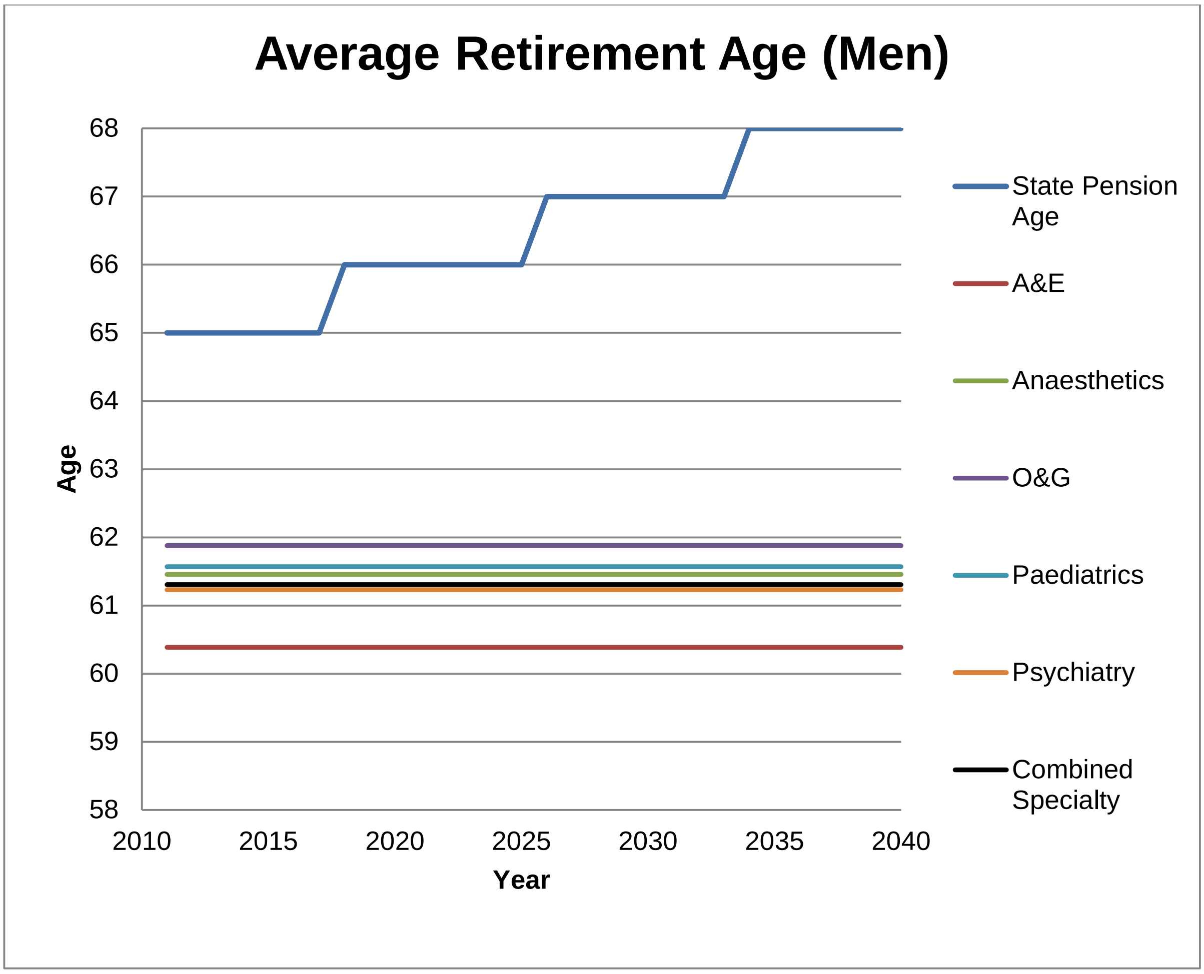


Figure 17 Average Retirement Age (Men)

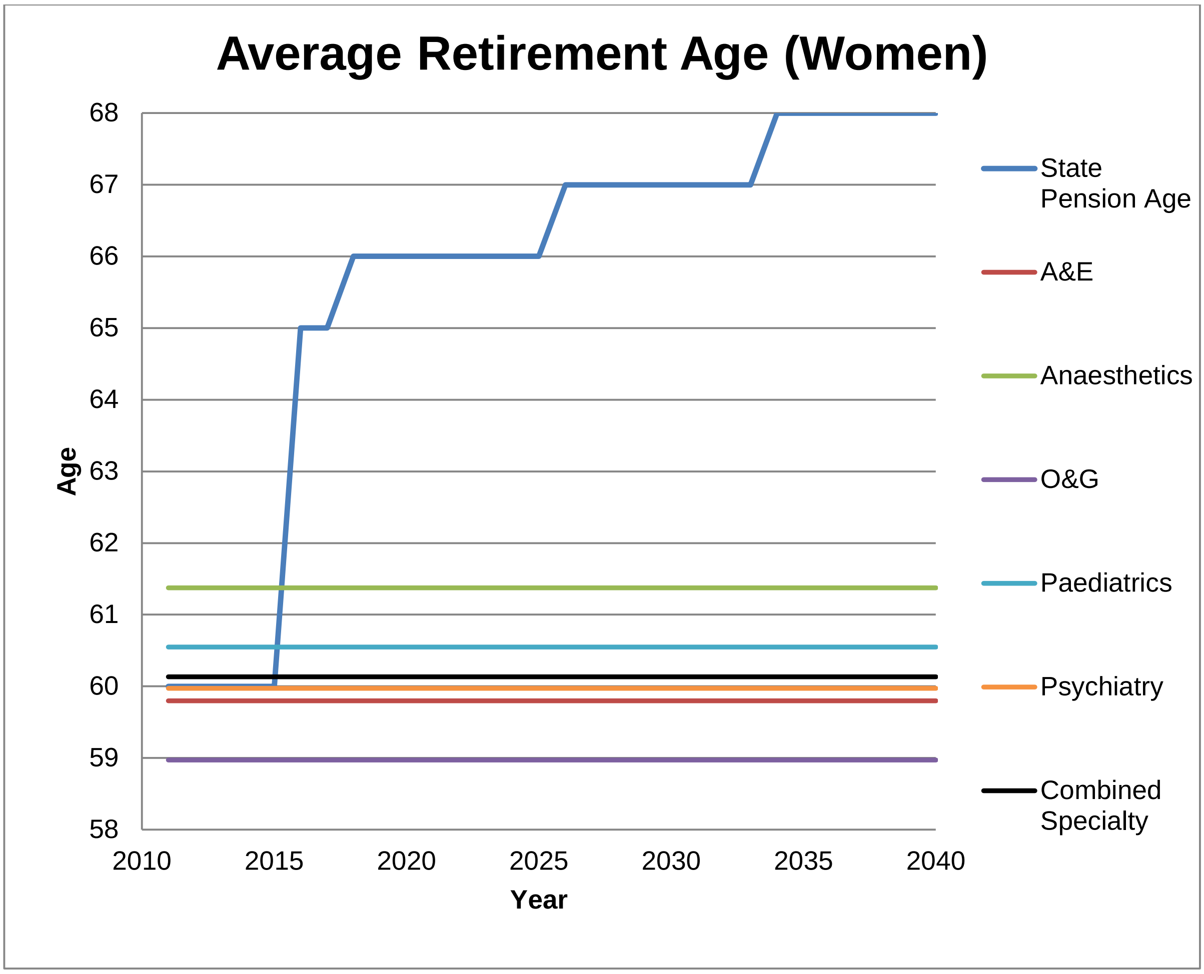


Figure 18 Average Retirement Age (Women)

Figures 17 and 18 shown above indicated that hospital consultants were retiring much earlier than the State Pension Age. Male hospital consultants could be seen retiring three years earlier than the current State Pension Age. On the contrary, female hospital consultants were retiring at the current State Pension Age. However, when the increment of State Pension age to 65 is implemented in year 2016 for females, there would be a gap of approximately four years between the average retirement age and the State Pension age.

These graphs provided an idea to generate scenarios. Since hospital consultants were retiring much earlier than the State Pension age, it is quite unlikely for them to retire in line with the reformation of State Pension age. Part of them might follow the increment and part of them might retire based on the current retirement age. Some hospital consultants would even retire earlier because they would not want to be affected by the reformation of NHS Pensions. Therefore, scenarios with alteration to retirement age and attrition rate would be generated in the following subchapter.

6.4 Average Participation Rate

The average participation rate calculated for both male and female hospital consultants above the age of 55 was 0.89. From the frequency histogram shown below, it could be seen that most of the hospital consultants worked full time. Working part time at the FTE of 0.6 seemed popular among hospital consultants.

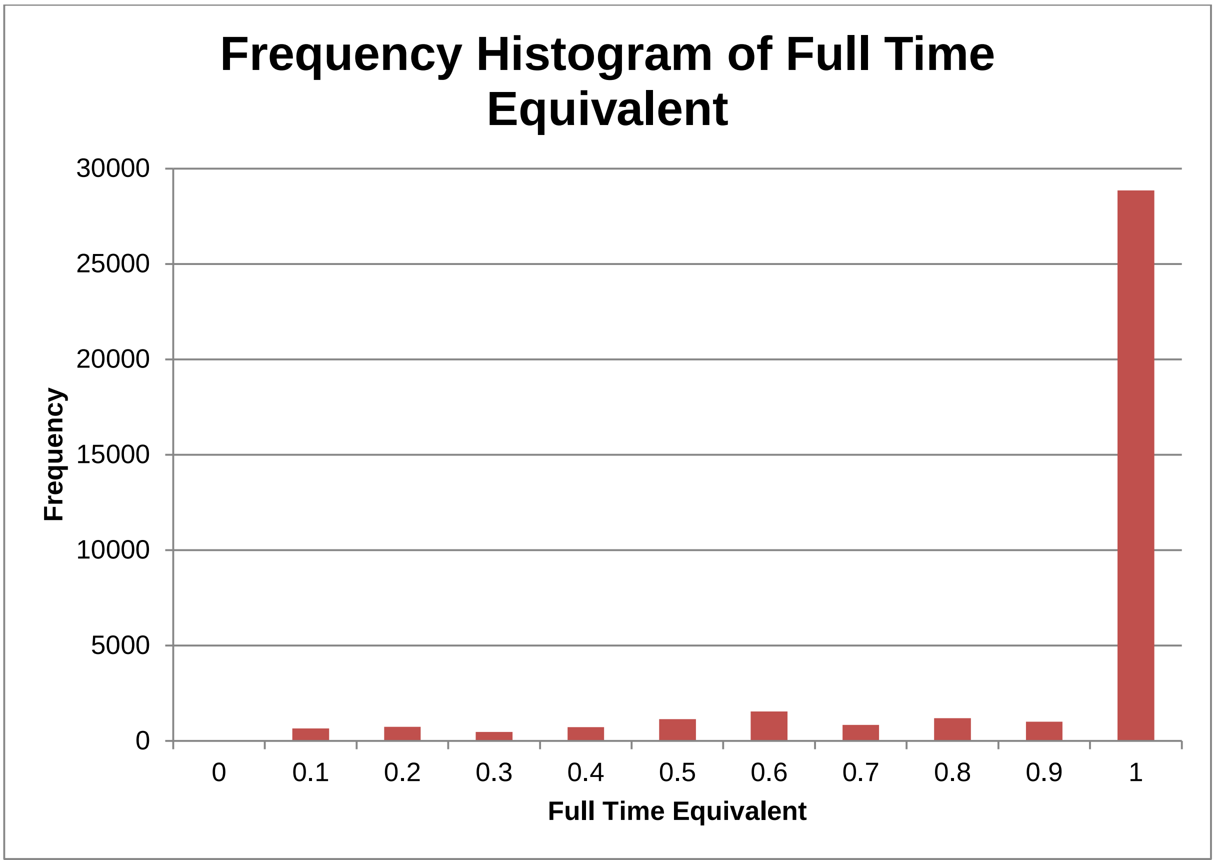


Figure 19 Frequency Histogram of Full Time Equivalent

6.5 Scenario Generation

A total of 26 scenarios were generated based on research conducted. The original MDSI system dynamics model was applied to create scenarios for this study. The average retirement age set in this model was 62 for male THDs and 60 for female THDs. No alteration was made to the average retirement age as the setting was almost similar to the results calculated for the average retirement age. Nonetheless, alteration would be made by changing two parameters, which were the attrition rates and participation rates by age and gender. Retirement age shift would also be done to study the impact of raising the retirement age of hospital consultants.

Combination of scenarios would be explained as plots. Explanations and results for each plot would be shown further in this chapter. The figure below summarised the generation of the seven plots for this model.

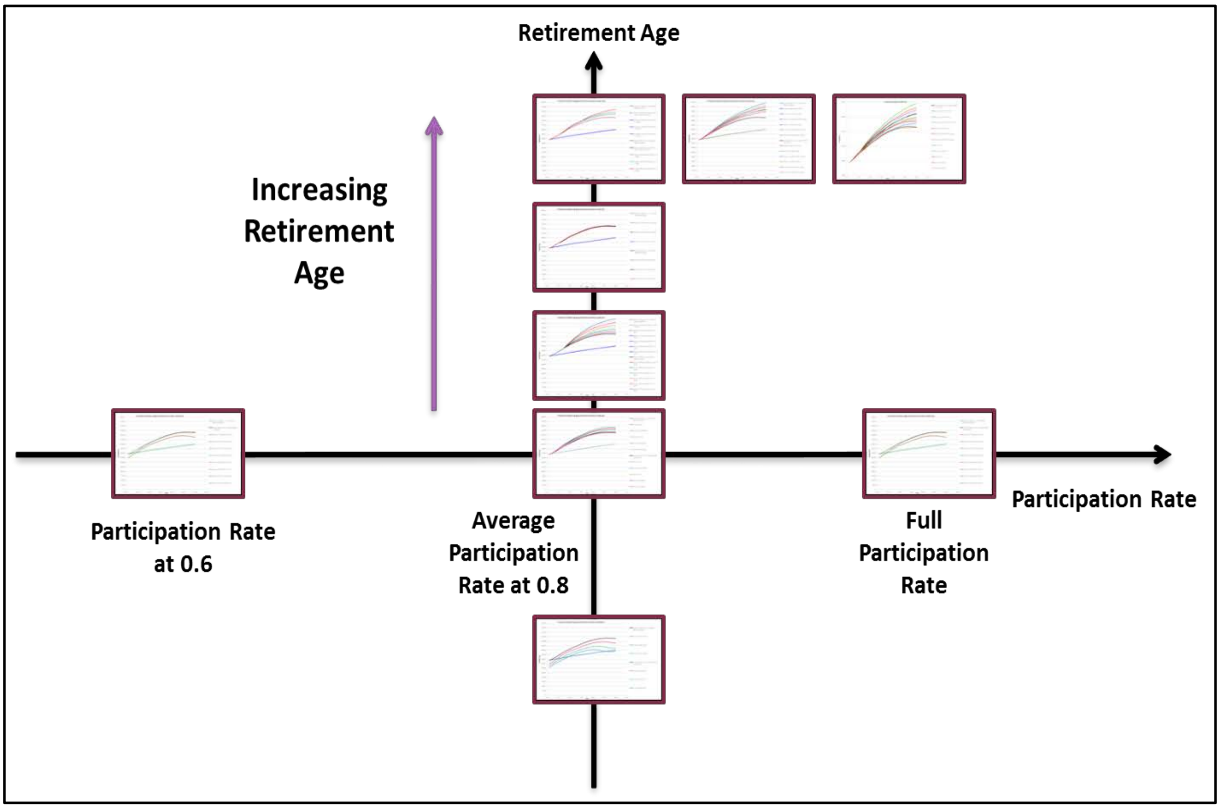


Figure 20 Scenario Generation

6.5.1 Baseline

The baseline represented what happened if the current trend of the hospital consultants remains up to year 2040. Definition of the baseline was not easy (Centre for Workforce Intelligence, 2012). The reason behind the difficulty was the uncertainty to predict the retirement age of the medical workforce. The only factor considered for projecting this baseline by CfWI was the population growth whereas other parameters were remained unchanged. The model did not deal with individual specialties. The baseline of the MDSI model was the baseline for the whole THDs workforce. Graphs below showed the demand and supply for the baseline by headcounts and FTE.

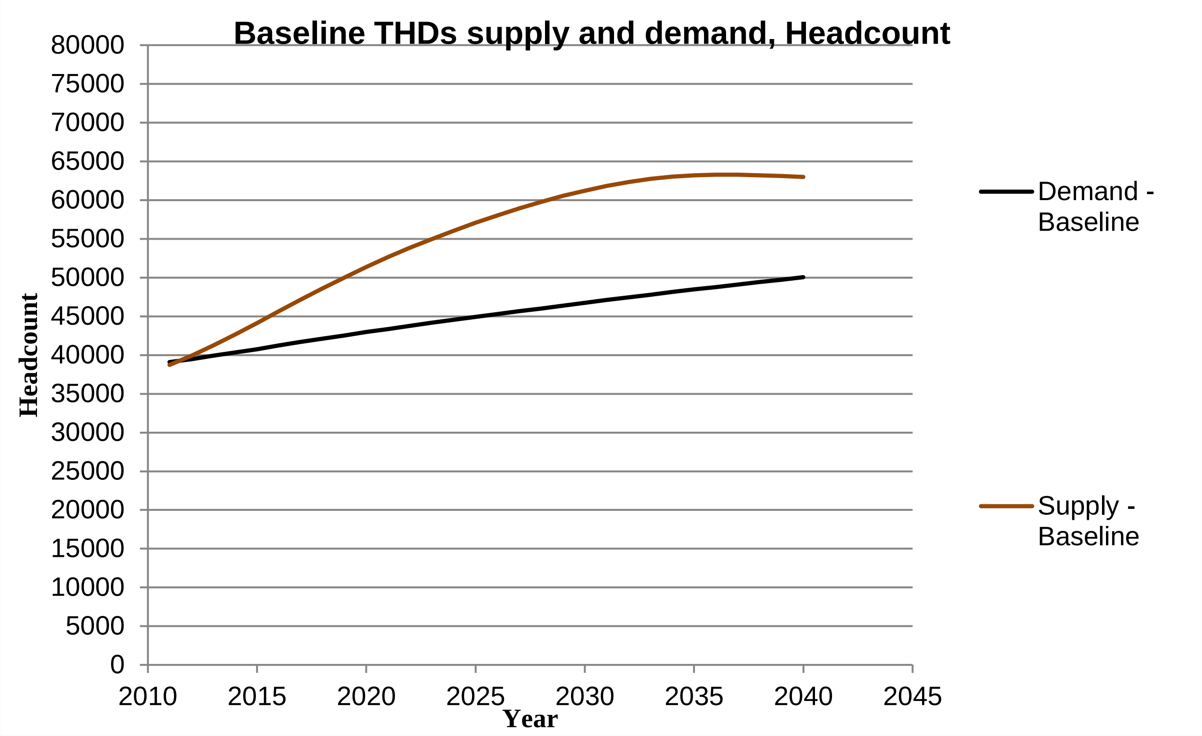


Figure 21 Baseline THDs supply and demand, Headcount

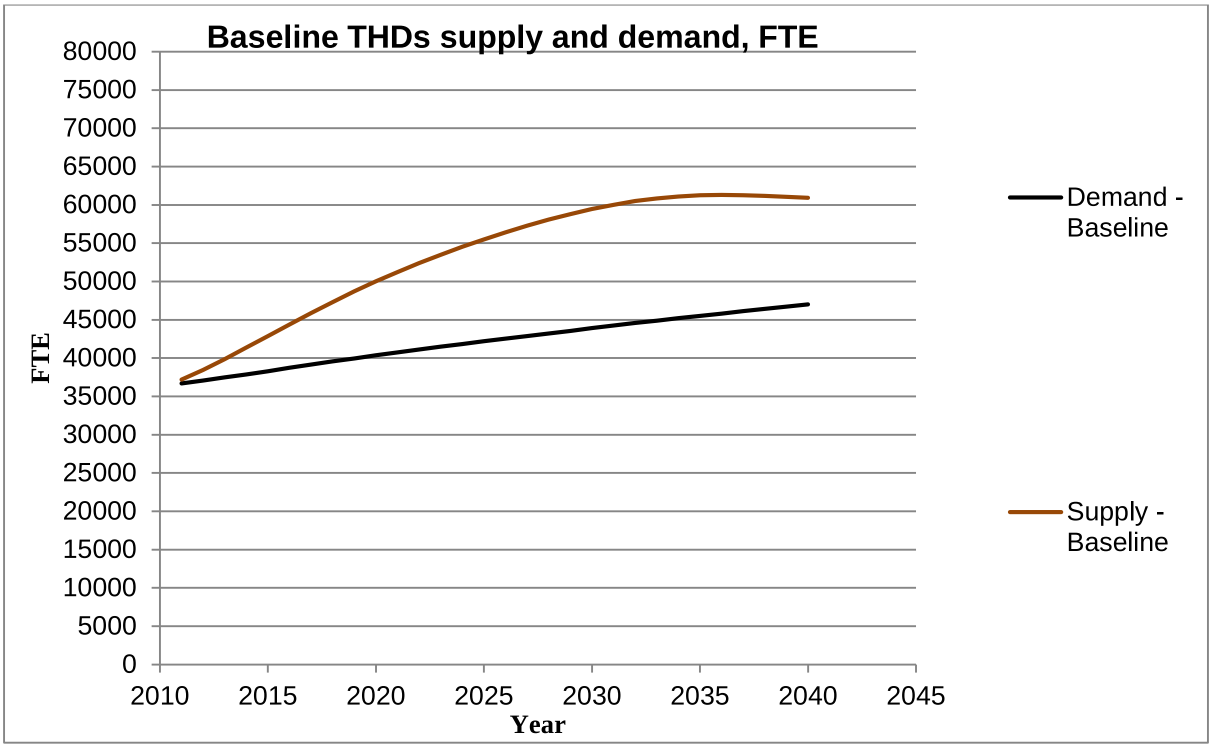


Figure 22 Baseline THDs supply and demand, FTE

Figures 21 and 22 above showed an overall oversupply of THDs workforce. For each headcount that contributes full time, the FTE would equal to 1. However, not every hospital consultant works full time. Therefore, the headcounts and FTE were different for both supply and demand. Headcounts would always be higher than the FTE. Not all hospital consultants will work full time, so FTE represents a better measure of the service they deliver. Therefore, FTE is more important in evaluating the future workforce compared to headcounts. The supply and demand for the following scenarios would only be shown in FTE. However, the supply and demand for other scenarios were included in the appendix.

6.5.2 Plot 1

Scenarios of ‘What if all the THDs retire like the workforce of a particular specialty?’ were generated. Attrition rates from the five specialties were applied respectively into the model to generate this scenario. Five scenarios were generated for this plot and the description for each scenario was shown as follow.

Scenario	Description
1	What if all THDs retire like the A&E workforce?
2	What if all THDs retire like the Anaesthetics workforce?
3	What if all THDs retire like the O&G workforce?
4	What if all THDs retire like the Paediatrics workforce?
5	What if all THDs retire like the Psychiatry workforce?

Table 5 Scenario Description for Plot 1

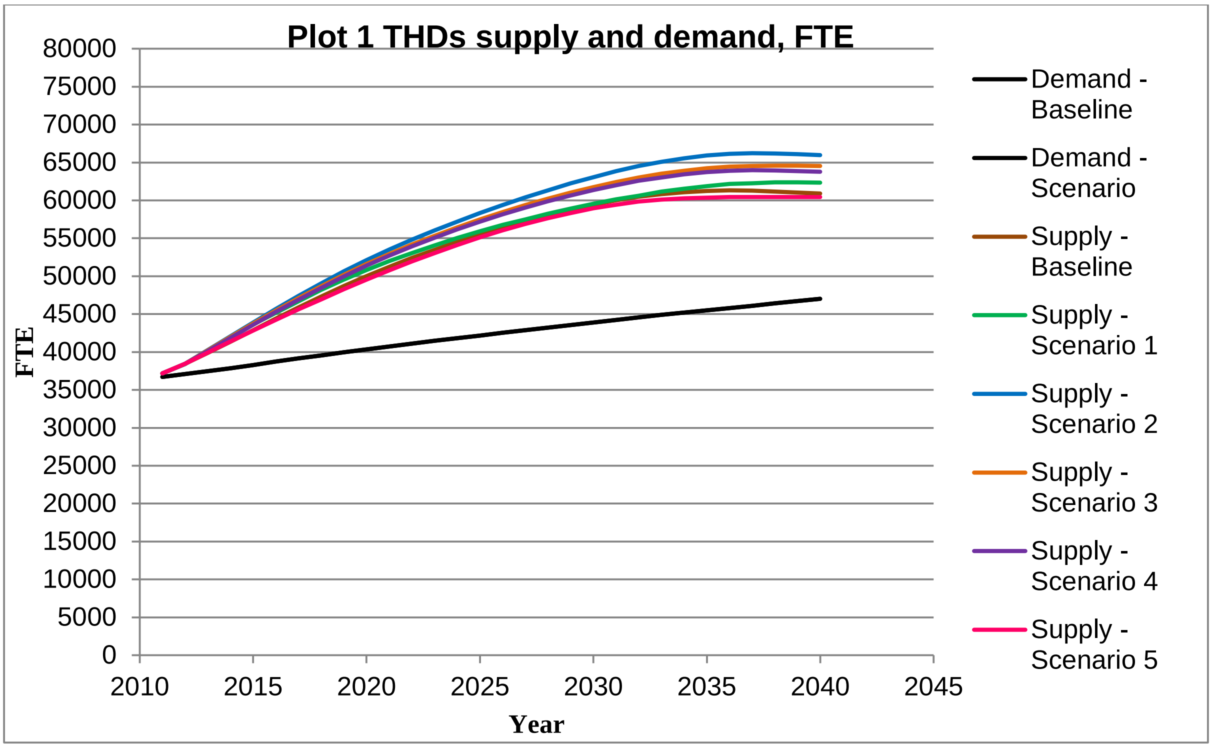


Figure 23 Plot 1 THDs supply and demand, FTE

Figure 23 showed the demand and supply for the baseline and these five scenarios. The demand for the baseline is similar to the demand for the scenarios. However, the supply for each scenario differed from the baseline. The workforce would have smaller FTE if their retirement behaviour followed the Psychiatry workforce compared to the baseline and other specialties. This was caused by early retirement among Psychiatrists due to high level of mental stress. The workforce would have bigger FTE if their retirement behaviour followed the Anaesthetics workforce. Based on the calculation of average retirement age, the Anaesthetics workforce retired the latest. From these observations, it can be concluded that the FTE of the supply and demand of the THDs is quite sensitive to different behaviours, and would increase when the THDs retire later.

6.5.3 Plot 2

The second plot would explain 'What happen if THDs retire later than their average retirement age?'. Four scenarios were generated for this plot and the description for each scenario was shown as follow.

Scenario	Description
6	What if THDs retire 1 year later than their average retirement age from year 2018?
7	What if THDs retire 2 years later than their average retirement age from year 2018?
8	What if THDs retire 3 years later than their average retirement age from year 2018?
9	What if THDs retire 5 years later than their average retirement age from year 2018?

Table 6 Scenario Description for Plot 2

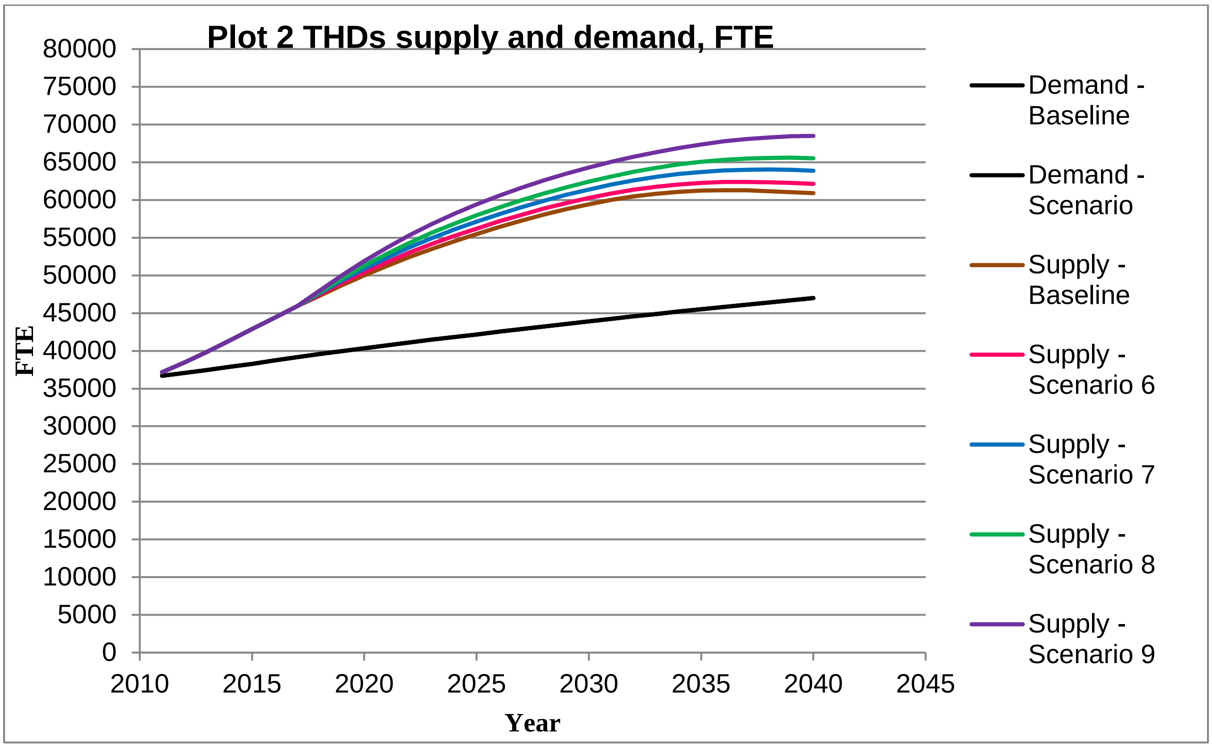


Figure 24 Plot 2 THDs supply and demand, FTE

Figure 24 showed the supply and demand of FTE for baseline and four other scenarios. Retirement age shift were done from the year 2018 because the increment of State Pension age for both gender would happen in year 2018. As shown, the supply of each scenario would be greater than the supply for baseline from year 2018. The implementation of retirement age shift would increase the FTE in the future. The retirement age shift was only done up to five years due to the capping of State Pension age. Therefore, if overall THDs retire later than they currently did, the future THD workforce would increase.

6.5.4 Plot 3

This plot would explain 'What happen if THDs retire according to the reformation of State Pension age?'. Four scenarios were generated for this plot and the description for each scenario was shown as follow. Each scenario was a continuation from the previous scenario in this plot.

Scenario	Description
10	What if female THDs retire 5 years later and male THDs retire 3 years than their average retirement age from year 2016?
11	What if THDs retire 1 year later than their average retirement age from year 2018?
12	What if THDs retire 1 year later than their average retirement age from year 2026?
13	What if THDs retire 1 year later than their average retirement age from year 2034?

Table 7 Scenario Description for Plot 3

The retirement age was set at 62 for male THDs and 60 for female THDs. As explained in background, the State Pension age for women would be increased to 65 between year 2016 and year 2018, from 65 to 66 for both genders between year 2018 and year 2020, from 66 to 67 for both genders between year 2026 and year 2028. Scenario 10 would therefore increase the retirement age to 65 for both genders. The same applied for scenario 11 and 12.

Lastly, the increment of State Pension age to 68 was planned to start between year 2044 and year 2046. However, this increment is still under review and might be dragged earlier. Therefore, it was assumed that the increment of State Pension age to 68 would be done in year 2034, as generated in scenario 13. Figure 25 shows the result for these scenarios generation.

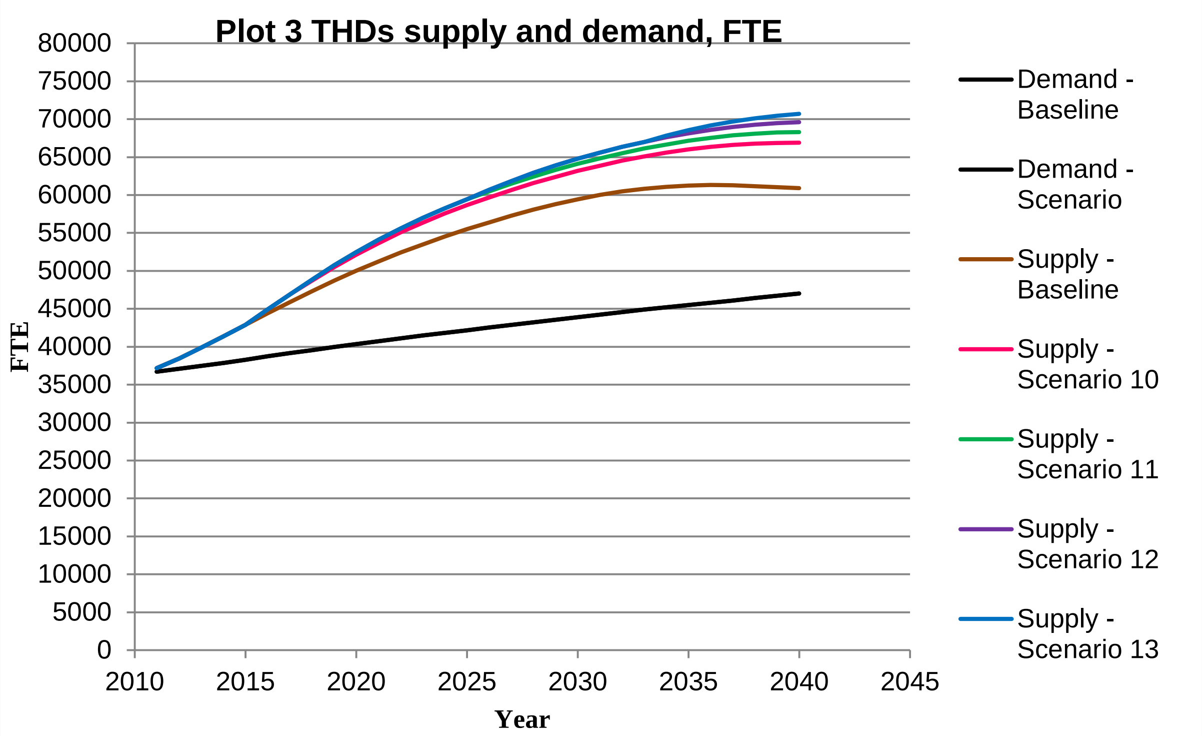


Figure 25 Plot 3 THDs supply and demand, FTE

The supply of FTE increased gradually across the scenarios. The supply therefore increase if THDs retire in line with State Pension age which resulted in increase of approximately 10000 FTE in year 2040 compared to the baseline. The largest increase comes from scenario 10 when women are assumed to work five years later than at present.

6.5.5 Plot 4

Plot 4 would explain 'What happen if THDs behave like the five specialties and retire according to the increment of State Pension age?'. Five scenarios were generated for this plot and the description for each scenario was shown as follow.

Scenario	Description
14	What if THDs retire like the A&E workforce and retire according to the increment of State Pension age?
15	What if THDs retire like the Anaesthetics workforce and retire according to the increment of State Pension age?
16	What if THDs retire like the O&G workforce and retire according to the increment of State Pension age?

17	What if THDs retire like the Paediatrics workforce and retire according to the increment of State Pension age?
18	What if THDs retire like the Psychiatry workforce and retire according to the increment of State Pension age?

Table 8 Scenario Description for Plot 4

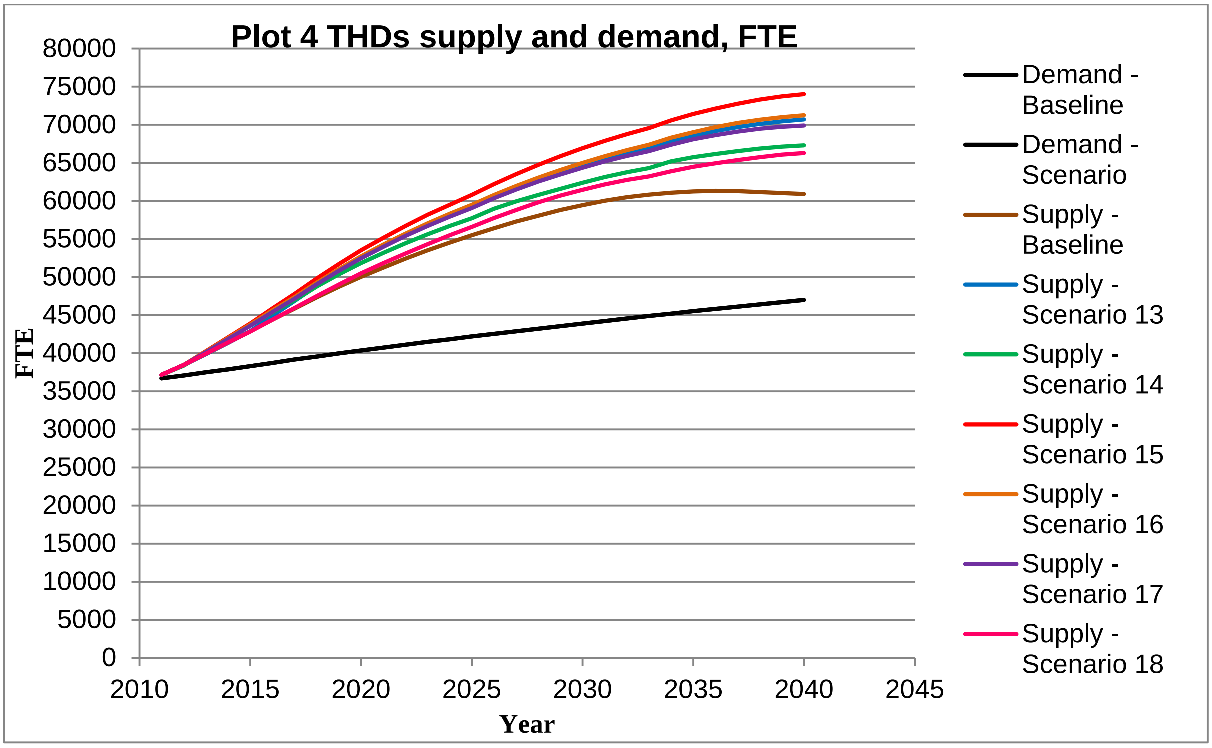


Figure 26 Plot 4 THDs supply and demand, FTE

Scenario 13 was included in figure 26 for comparison purpose. Scenarios 14 to 18 were not indicating the workforce retire at 66 in year 2018, 67 in year 2026 and 68 in year 2034. These scenarios were generated by following the increment pattern of the reformation of the State Pension age. For example, Scenario 15 was generated based on the combination of policy 13 and policy 2. Scenario 15 resulted in highest FTE compared to the baseline and other scenarios. This can be explained by extremely late retirement in the Anaesthetics workforce when they retire according to the increment of State Pension age.

6.5.6 Plot 5

Plot 5 would explain 'What happen if THDs aged over 55 work only half time?'. The participation rate for hospital consultants aged over 55 was replaced by 0.6. The previous frequency histogram showed that of consultants that worked part time, working at an FTE of 0.6 was popular. Hospital consultants might consider working half time when they are preparing to retire or start to withdraw their pension and come back to work part time on a new contract. Scenario 19 was therefore generated as follow.

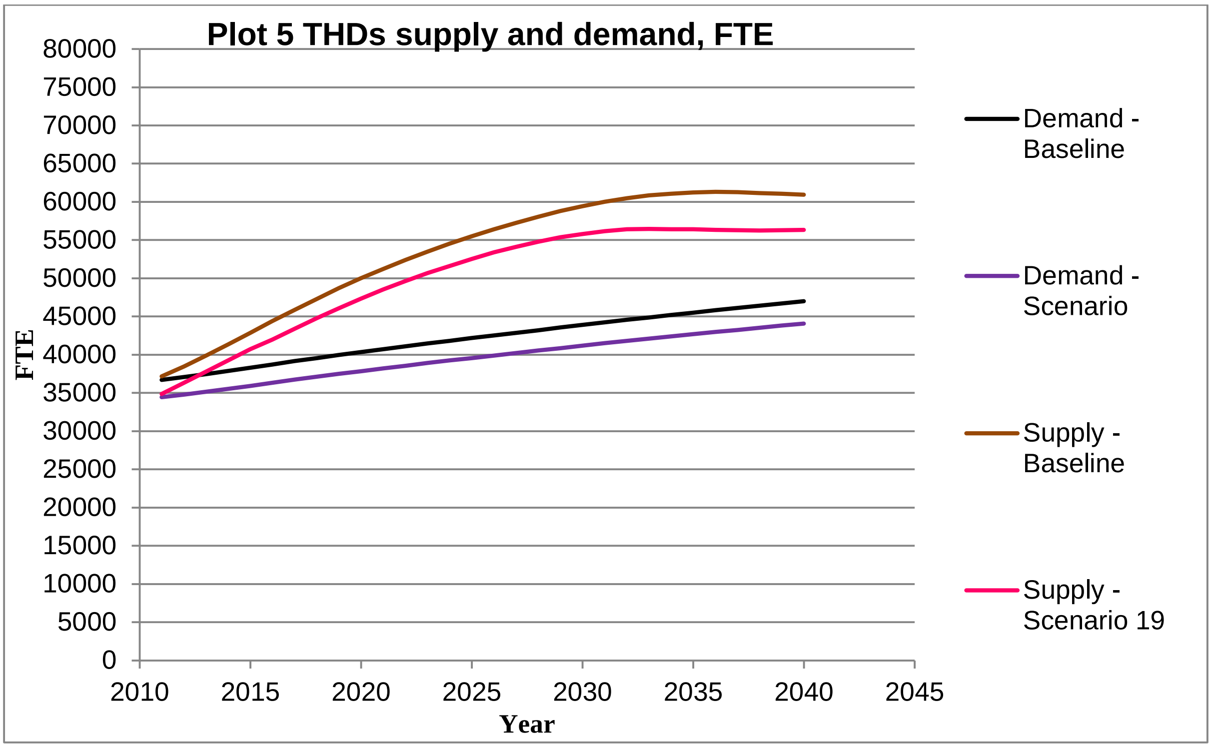


Figure 27 Plot 5 THDs supply and demand, FTE

Scenario 19 was the first scenario that resulted in different demand as compared to the baseline due to demand in the base year being set equal to the base year FTE. This scenario also resulted in significant reduction of FTE supply across the simulated years. However, the overall oversupply of THDs still occurs even though the older workforce chose to work at the FTE of 0.6. The supply has dropped considerably from the supply, which shows a risk to the future supply if consultants work lower FTE from more part time contracts.

6.5.7 Plot 6

Plot 6 would explain 'What happen if THDs aged over 55 work full time?' where this scenario would be unlikely to happen. The participation rate for hospital consultants aged over 55 was replaced by 1.0 and simulated over a period of 30 years. Figure 28 showed the simulation results for this scenario. This scenario resulted in more supply and demand FTE compared to the baseline. However, the participation rate replaced did not differ much from the participation rate of the current workforce.

Therefore, the difference of supply and demand FTE was not significant for this scenario.

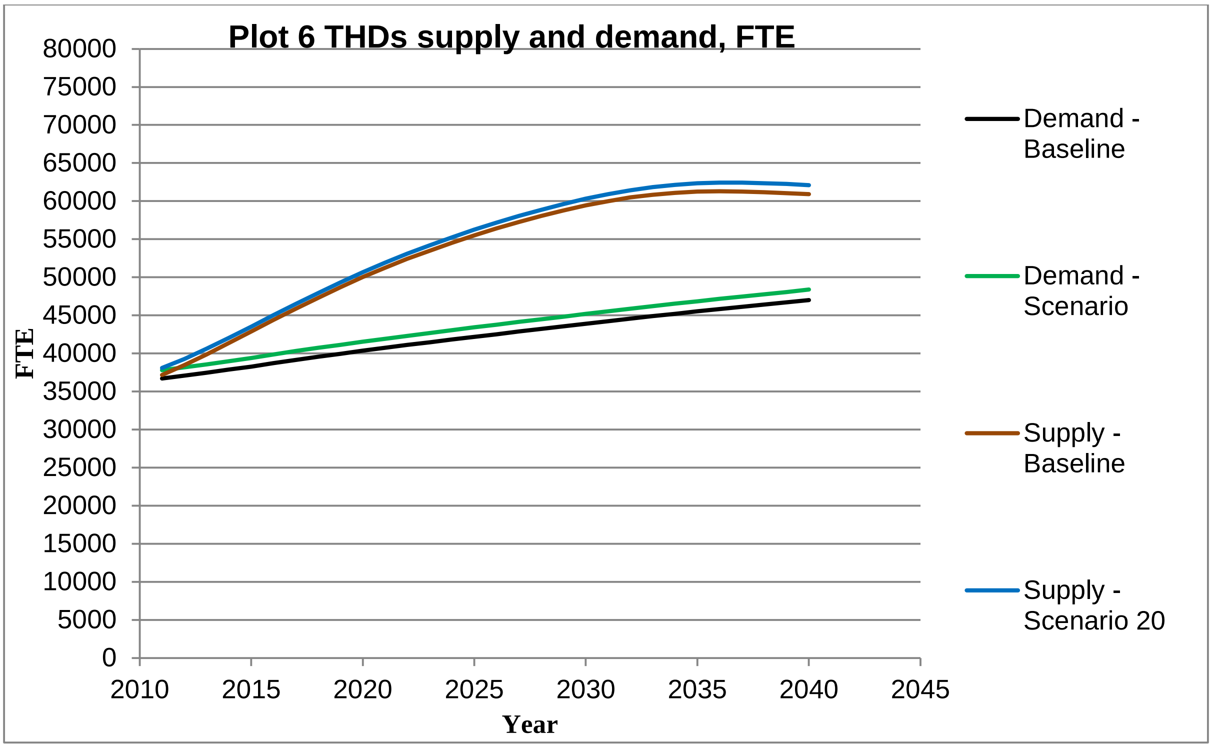


Figure 28 Plot 6 THDs supply and demand, FTE

6.5.8 Plot 7

This plot would explain 'What happen if THDs retire earlier than their average retirement age?' which was the opposite of plot 2. Three scenarios were generated for this plot and the description for each scenario was shown as follow.

Scenario	Description
21	What if THDs retire 1 year earlier than their average retirement age from year 2018?
22	What if THDs retire 2 years earlier than their average retirement age from year 2018?
23	What if THDs retire 3 years earlier than their average retirement age from year 2018?

Table 9 Scenario Description for Plot 7

Similar to plot 2, retirement age shifts were made from the year 2018, but in the opposite direction. As shown in the figure 29, the supply of each scenario would be reduced compared to the baseline supply from year 2018. Therefore, if overall THDs retire earlier than they currently do, the future THD workforce would decrease.

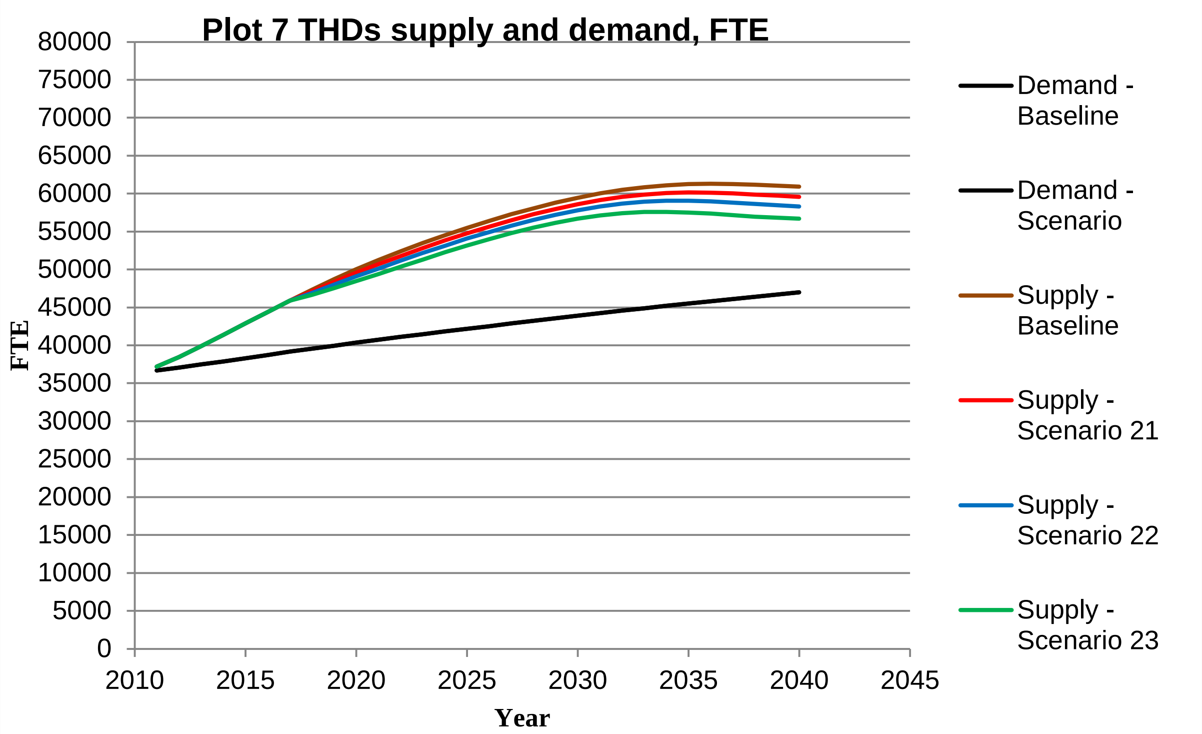


Figure 29 Plot 7 THDs supply and demand, FTE

6.5.9 Plot 8

The three scenarios below were generated based on Psychiatrists' retirement behaviour. As shown in 6.1, the Psychiatrists workforce retired significantly earlier among the five specialties. Mears et al. (2004) had conducted a survey regarding the retirement intention among the older English consultant Psychiatrists. Respondents intended to retire at the age of 60 because of heavy workload and lack of personal leisure. Another survey was conducted by Eagles et al. (2005) regarding the retirement intention among the Scottish consultant Psychiatrists. This survey resulted in mean planned retirement age at 58. Female respondents intended to retire significantly earlier than males. However, most respondents could be convinced to retire later through changes in service.

Since hospital consultants were retiring much earlier than the State Pension age, it is quite unlikely for them to retire in line with the reformation of State Pension age. Plot 8 was therefore created to structure the possible significant retirement among older hospital consultants but later retirement for younger workforce. Hospital consultants employed on old contract would retire earlier within these few years. They would not want to be affected by the reformation of NHS Pensions. However, younger workforce could be persuaded to retire later.

This plot would explain 'What happen if older THDs retire earlier before the implementation of new State Pension age but younger THDs retire later?'. Three scenarios were generated for this plot and the description for each scenario was shown as follow.

Scenario	Year	Description
24	2013 to 2016	What if THDs aged above 60 retire at the rate of 100%?
	2017 to 2040	What if THDs retire 1 year later from year 2017 to year 2025, 2 years later from year 2026 to year 2028, and 3 years later from year 2034 to year 2040?
25	2013 to 2018	What if THDs aged above 60 retire at the rate of 100%?
	2019 to 2040	What if THDs retire 1 year later from year 2019 to year 2025, 2 years later from year 2026 to year 2028, and 3 years later from year 2034 to year 2040?
26	2013 to 2020	What if THDs aged above 60 retire at the rate of 100%?
	2021 to 2040	What if THDs retire 1 year later from year 2021 to year 2025, 2 years later from year 2026 to year 2028, and 3 years later from year 2034 to year 2040?

Table 10 Scenario Description for Plot 8

The changes to the State Pension age would be officially implemented on the 6 April 2016. Therefore, Scenario 24 would explain the early retirement among older consultants before the reformation. Scenario 25 and 26 explained the difficulty in persuading younger workforce to retire later, hence having more early retirement within these few years compared to Scenario 24.

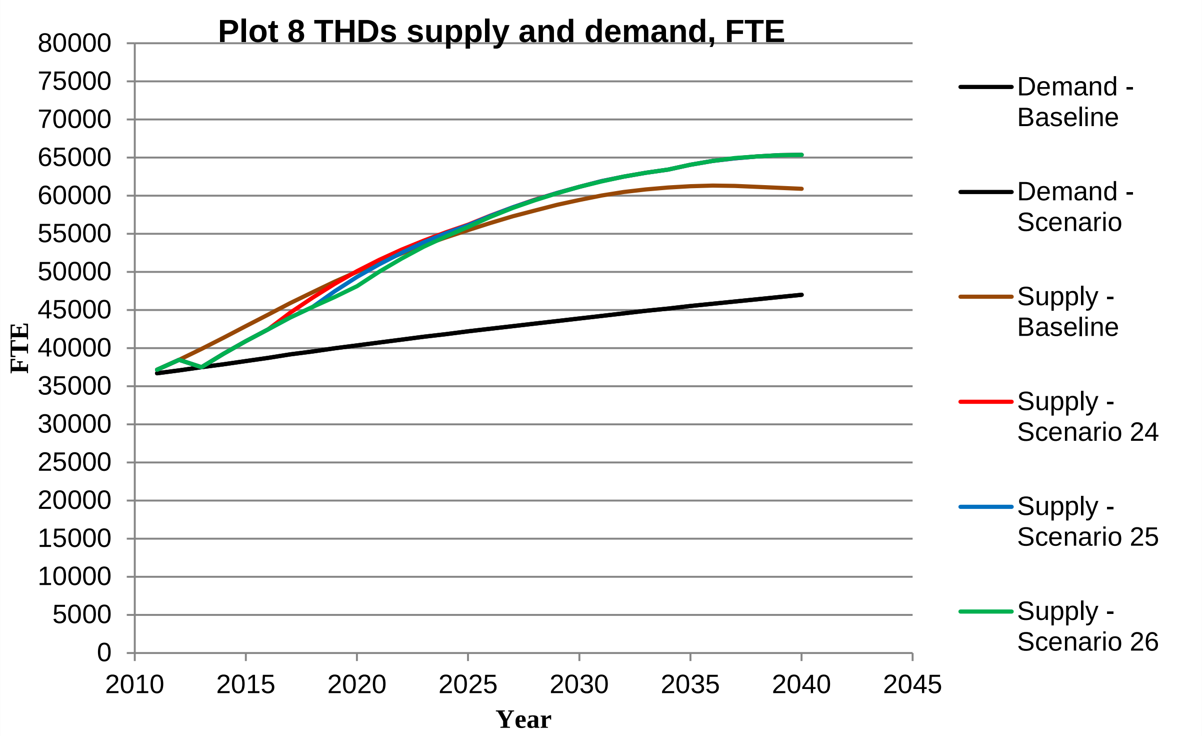


Figure 30 Plot 8 THDs supply and demand, FTE

Figure 30 showed the results for plot 8. All three scenarios resulted in sudden decline of hospital consultants supply compared to the baseline supply in year 2012. However, the sudden drop did not cause any shortage of the THD workforce. Scenario 24, 25 and 26 started to exhibit an upward trend from the year of 2013, reducing the gap between the scenarios supply and baseline supply. The scenarios supply and baseline supply became equal, depending on which year THDs started to retire later in each scenario. The scenarios supply continued to increase and provided more THDs supply than the baseline.

7.0 Discussions and Recommendations

7.1 Key Findings

The retirement profile tool concluded that most hospital consultants retire earlier than the normal retirement age. Premature retirement among female hospital consultants was significant as compared to male hospital consultants. Psychiatrists workforce had the most premature retirement compared to other four specialties which was arguably be due to high level of work stress. Although some hospital consultants retire before the age of 50, they however were considered as leaving the workforce due to other reasons.

Vensim DSS modelling has tested and came out with various results, depending on scenarios. Since hospital consultants were retiring much earlier than the State Pension age, it is quite unlikely for them to retire in line with the reformation of State Pension age. Some of them might follow the increment where the rest of them might retire based on the current retirement age. Some hospital consultants would even retire earlier because they would not want to be affected by the reformation of NHS Pensions.

The supply of hospital consultants would increase compared to the baseline supply if THDs were to retire later or retire in line with the State Pension age, as shown in plots 2 and 3. This could cause the oversupply of THDs and resulted in overspent on cost of paying and training medical doctors. Although the State Pension could be saved, more money were spent on paying for extra doctors. However, the possibility of THDs retire later is very low and unlikely to happen.

The supply of hospital consultants would decrease compared to the baseline supply if THDs were to retire earlier than the average retirement age, as shown in plot 7. If THDs aged over 55 chose to work part time, as shown in plot 6, the supply would decrease as well. These scenarios are having a higher possibility to take place if compared to later retirement. These scenarios would reduce the current oversupply of THDs, therefore saving on the governments’ spending.

Plot 8 was generated because early retirement among the elder hospital consultants and later retirement among younger hospital consultants were expected. Although there was a sudden drop in the first few years, hospital consultants is still considered to be oversupplied.

7.2 Research Limitations

There exist some limitations and difficulties in planning for the future medical workforce. First and foremost, there were abundant of uncertainties related to the variables that would affect the need and supply of medical workforce. The duration required to train a medical doctor was extremely long and varied, which brought to high level of imprecision and a need for long term planning. Furthermore, the difficulty to predict new joiners from other countries or private sector had caused certain complication.

Medical workforce planning was relatively complicated because of the changing of skill-mix of the health care workforce (Sibbald et al., 2004). Medical doctors would require alteration as their professional roles and medical organisations changed over time. Buchan (2006) mentioned the international mobility and recruitment which had consequential and expanding impact on the market for medical doctors. Therefore, the limitation of medical workforce planning to only the national territory was rather impractical due to the growing trend of international mobility.

7.3 Recommendations

The MDSI model showed an oversupply of THDs in the future. The results from the scenario generation showed increase in headcounts and FTE for the supply of THDs if THDs retire later than they did at present. If THDs really retire later, this would worsen the anticipated oversupply. However, if THDs retire earlier compared to their current retirement behaviour, the overall oversupply could be relieved.

Premature retirements among medical doctors have increased in recent years due to the changes made to NHS and State Pension. Medical doctors seemed to retire as early as they could after they considered themselves financially stable. Most of them did not want to be affected by the reformation. A considerable number of retirements are expected in the coming few years from older workforce who were registered in 1995 Section. This would result in sudden drop of supply in medical workforce.

Younger workforce in 2008 Section might retire later as they need to wait to collect their pension. The medical workforce supply would then balance and still resulted in an overall oversupply.

7.4 Further Work

This model focused only on hospital consultants because of time constraints. Further work could be done on General Practitioners and other medical workforces to compare their retirement behaviour. Dental workforce could exhibit extremely different retirement behaviour and therefore should be included in further work too. Only five specialties were chosen as comparison to the whole workforce in this model due to extremely large workforce. Other specialties such as Radiology, Surgical and Pathology could be modelled specifically. Further work should also be done to study the level of performance of medical doctors if they were to work beyond their normal retirement age.

This project would also inform the company regarding the baseline forecast of the medical supply, which currently does not include the changes in State Pension age. This project would greatly contribute to the company on their recent robust medical workforce planning. Other than that, this project would also improve the understanding of likely changes to future workforce numbers and capability. Further research would be required to investigate on which medical specialties are most likely to be impacted to work longer.

8. Conclusions

The model projected suggested the possible impact on the size of medical workforce when the State Pension age is increased. The retirement profile tool resulted in most of the hospital consultants retired earlier than the current State Pension age. Since hospital consultants were retiring much earlier, it is quite unlikely for them to retire in line with the reformation of State Pension age. They could either retire based on the current retirement age, in line with the reformation or even retire earlier than they do now. Results showed an oversupply of hospital consultants if they continue to retire at the current retirement age. The oversupply would worsen if they are to retire later or in line with the changes to the State Pension age. Although the number of retiree would decrease, however more money were spent on paying for extra doctors. Early retirement among hospital consultants would result in more retirees and burden the government's spending on State Pension. Nonetheless, the oversupply problem would become better. Therefore, there are both positive and negative impacts on the size of medical workforce when the State pension age is increased. More review and research should be done on the changes to the State Pension age in order to accomplish the intention of managing the State Pension.

References

Barber, P., and López-Valcárcel, B. G. (2010). Forecasting the need for medical specialists in Spain: application of a system dynamics model. *Human resources for health*, *8*(1), 24.

Bloor, K., Hendry, V., and Maynard, A. (2006). Do we need more doctors?. *Journal of the Royal Society of Medicine*, *99*(6), 281-287.

Blundell, R. and Emmerson, C. (2007). *Fiscal Effects of Reforming the UK State Pension System.* [Online]
Available at: http://www.nber.org/chapters/c0061 [Accessed 30 July 2013].

Brailsford, S. C., and Hilton, N. A. (2001). A comparison of discrete event simulation and system dynamics for modelling health care systems.

Brailsford, S. C., Lattimer, V. A., Tarnaras, P., and Turnbull, J. C. (2004). Emergency and on-demand health care: modelling a large complex system. *Journal of the Operational Research Society*, *55*(1), 34-42.

Bronkhorst, E. M., Wiersma, T., and Truin, G. J. (1991). Using complex system dynamics models: an example concerning the Dutch dental health care system. In *Proceedings of the 1991 International System Dynamics Conference. Bangkok, Thailand* (pp. 155-163).

British Medical Association (2011). *National survey of GP opinion 2011.* [Online]
Available at:
www.bma.org.uk/representation/branch_committees/general_prac/gpnationalsurveyresults2011.jsp [Accessed 30 July 2013].

British Medical Association (2012). *Reforms could set off GP retirement time bomb.* [Online]
Available at: http://bma.org.uk/news-views-analysis/news/2012/may/reforms-could-set-off-gp-retirement-time-bomb [Accessed 1 September 2013].

British Medical Association (2013). *Press Briefing Papers.* [Online]
Available at: http://bma.org.uk/-/media/Files/Word%20files/News%20views%20analysis/pressbriefing_cost_of_training_doctors.docx [Accessed 30 July 2013].

Centre for Workforce Intelligence (2012). *A strategic review of the future healthcare workforce: Informing medical and dental student intake,* s.l.: Centre for Workforce Intelligence.

Centre for Workforce Intelligence (2013). *How We Work.* [Online]
Available at: http://www.cfwi.org.uk/how-we-work [Accessed 23 July 2013].

Centre for Workforce Intelligence (2013). *Robust Workforce Planning Framework Introduction,* Centre for Workforce Intelligence.

Centre for Workforce Intelligence (2013). *Robust Workforce Planning Medical Model Technical Description,* Centre for Workforce Intelligence.

Coyle, R. G. (1984). A systems approach to the management of a hospital for short-term patients. *Socio-Economic Planning Sciences*, *18*(4), 219-226.

Departmen for Work and Pensions (2013). *The single-tier pension: a simple foundation for saving.* [Online]
Available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181237/single-tier-pension-fact-sheet.pdf [Accessed 30 July 2013].

Department for Work and Pensions (2013). *Making the State Pension simpler and fairer.* [Online]
Available at: https://www.gov.uk/government/policies/making-the-state-pension-simpler-and-fairer [Accessed 30 July 2013].

Department for Work and Pensions (2013). *Reviewing the State Pension age.* [Online]
Available at: https://www.gov.uk/government/policies/reviewing-the-state-pension-age [Accessed 30 July 2013].

Forrester, J. W. (1968). Industrial dynamics—after the first decade. *Management Science*, *14*(7), 398-415.

General Medical Council (2013). *General Information about Registration and Licensing.* [Online]
Available at: http://www.gmc-uk.org/information_for_you/registration_factsheet.asp#GP [Accessed 24 July 2013].

General Medical Council (2013). *Undergraduate Education.* [Online]
Available at: http://www.gmc-uk.org/education/undergraduate.asp [Accessed 20 July 2013].

Glance, L. G. (2000). The cost effectiveness of anesthesia workforce models: A simulation approach using decision-analysis modeling. *Anesthesia & Analgesia*, *90*(3), 584-592.

GOV.UK (2013). *Benefits & Credits, Additional State Pension.* [Online]
Available at: https://www.gov.uk/additional-state-pension [Accessed 23 July 2013].

GOV.UK (2013). *Benefits & Credits, The basic State Pension.* [Online]
Available at: https://www.gov.uk/state-pension [Accessed 23 July 2013].

Ishikawa, T., Ohba, H., Yokooka, Y., Nakamura, K., and Ogasawara, K. (2013). Forecasting the absolute and relative shortage of physicians in Japan using a system dynamics model approach. *Human resources for health*, *11*(1), 41.

Jacques, H. (2011). *More consultants opt for early retirement as dissatisfaction with NHS grows.* [Online]
Available at: http://careers.bmj.com/careers/advice/view-article.html?id=20005504 [Accessed 30 August 2013].

Jacques, H. (2013). *Many consultants are considering leaving NHS or retiring early over pay changes.* [Online]
Available at: http://careers.bmj.com/careers/advice/view-article.html?id=20011702 [Accessed 30 August 2013].

Jacoby, I., Meyer, G. S., Haffner, W., Cheng, E. Y., Potter, A. L., and Pearse, W. H. (1998). Modeling the future workforce of obstetrics and gynecology. *Obstetrics & Gynecology*, *92*(3), 450-456.

Kendell, R. E., and Pearce, A. (1997). Consultant psychiatrists who retired prematurely in 1995 and 1996. *Psychiatric Bulletin*, *21*(12), 741-745.

Lane, D. C., Monefeldt, C., and Rosenhead, J. V. (2000). Looking in the wrong place for healthcare improvements: A system dynamics study of an accident and emergency department. *Journal of the Operational Research Society*, 518-531.

Lane, D. C. (2000). Should system dynamics be described as a 'hard' or 'deterministic' systems approach?. *Systems Research and Behavioral Science*, *17*(1), 3-22.

Lavieri, M. S., and Puterman, M. L. (2009). Optimizing nursing human resource planning in British Columbia. *Health care management science*, *12*(2), 119-128.

Macleod, P. et al. (2012). *Attitudes to Pensions: The 2012 survey,* s.l.: Department for Work and Pensions.

Medical Specialty Training (England) (2009). *Quick Guide to Specialty Training 2013.* [Online]
Available at: http://www.mmc.nhs.uk/pdf/Quick%20Guide%20FINAL.pdf [Accessed 30 July 2013].

Modernising Medical Career (2013). *Training Structure 2013.* [Online]
Available at:
http://www.mmc.nhs.uk/specialty_training_2010/specialty_training_2012/introduction_to_training/training_structure_2012.aspx [Accessed 30 July 2013].

Motawa, I. A., and Banfill, P. F. A dynamic hypothesis for developing energy-efficiency technologies in housing industry.

NHS Careers (2013). *Pay and benefits.* [Online]
Available at: http://www.nhscareers.nhs.uk/working-in-the-nhs/pay-and-benefits/
[Accessed 12 August 2013].

NHS Pensions (2013). *NHS Pensions Home.* [Online]
Available at: http://www.nhsbsa.nhs.uk/Documents/Pensions/SD_guide_-_Online_%28V11%29_09.2013.pdf [Accessed 12 August 2013].

O'Dowd, A. (2010). *NHS will see more doctors retiring early and working abroad as result of squeeze, BMA head says.* [Online]
Available at: http://www.bmj.com/content/341/bmj.c6444 [Accessed 30 August 2013].

Personal Social Service Research Unit (2012). *Unit Costs of Health and Social Care 2012.* [Online]
Available at: http://www.pssru.ac.uk/project-pages/unit-costs/2012/ [Accessed 1 August 2013].

Review Body on Doctors' and Dentists' Remuneration (2012). *Review of compensation levels, incentives and the Clinical Excellence and Distinction Award schemes for NHS consultants.* [Online]
Available at: http://www.ome.uk.com/DDRB_CEA_review.aspx [Accessed 1 September 2013].

Sapiri, H., Kamil, A. A., Tahar, R. M., and Tumin, H. (2010). Dynamics Simulation Approach in Analyzing Pension Expenditure. In *International Conference on Computer Electrical, System Science and Engineering*.

Sibbald, B., Shen, J., and McBride, A. (2004). Changing the skill-mix of the health care workforce. *Journal of health services research & policy*, *9*(suppl 1), 28-38.
Starkeine, L., Smigelskas, K., Padaiga, Z. & Reamy, J. (2005). The future prospects of Lithuanian family physicians: a 10-year forecasting study. *BMC Family Practice,* 6(1), p. 41.

Takata, H., Nagata, H., Nogawa, H. and Tanaka, H. (2011). The current shortage and future surplus of doctors: a projection of the future growth of the Japanese medical workforce. *Human Resources for Health,* 9(14).

Taylor, S. (2005) People Resourcing. Chartered Institute of Personnel and Development, London, UK

The Foundation Programme (2013). *About the Programme.* [Online]
Available at: http://www.foundationprogramme.nhs.uk/pages/home/about-the-foundation-programme [Accessed 23 July 2013].

The National Recruitment Office for GP Training (2013). *GP Careers.* [Online]
Available at: http://gprecruitment.hee.nhs.uk/gpcareers.html#id6 [Accessed 24 July 2013].

The Official Home of UK Legislation (1995). *Pensions Act 1995.* [Online]
Available at: http://www.legislation.gov.uk/ukpga/1995/26/contents/enacted
[Accessed 10 August 2013].

The Official Home of UK Legislation (2007). *Pensions Act 2007.* [Online]
Available at: http://www.legislation.gov.uk/ukpga/2007/22/contents
[Accessed 20 August 2013].

The Official Home of UK Legislation (2011). *Pension Act 2011.* [Online]
Available at: http://www.legislation.gov.uk/ukpga/2011/19/contents
[Accessed 20 August 2013].

The Official Home of UK Legislation (2013). *Public Service Pensions Act 2013.* [Online]
Available at: http://www.legislation.gov.uk/ukpga/2013/25/contents
[Accessed 20 August 2013].

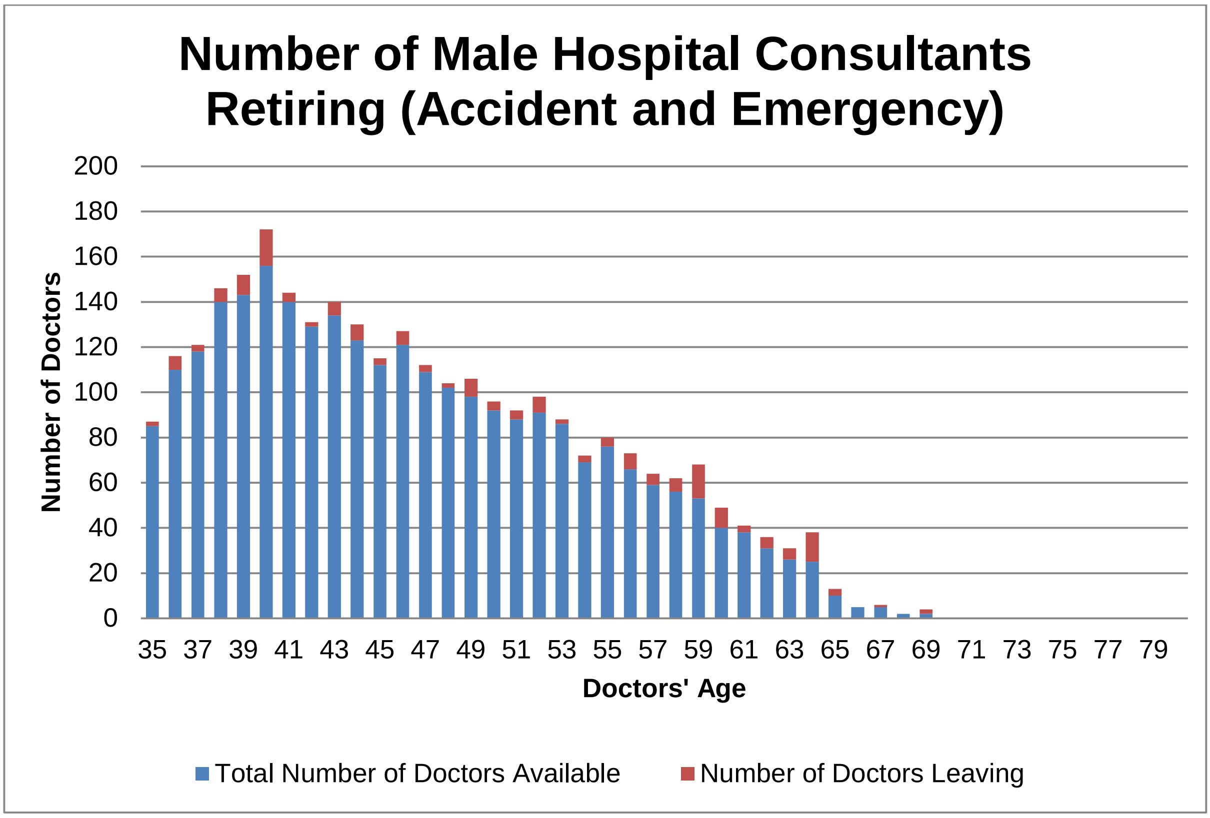
Townshend, J. R. P., and Turner, H. S. (2000). Analysing the effectiveness of Chlamydia screening. *Journal of the Operational Research Society*, 812-824.

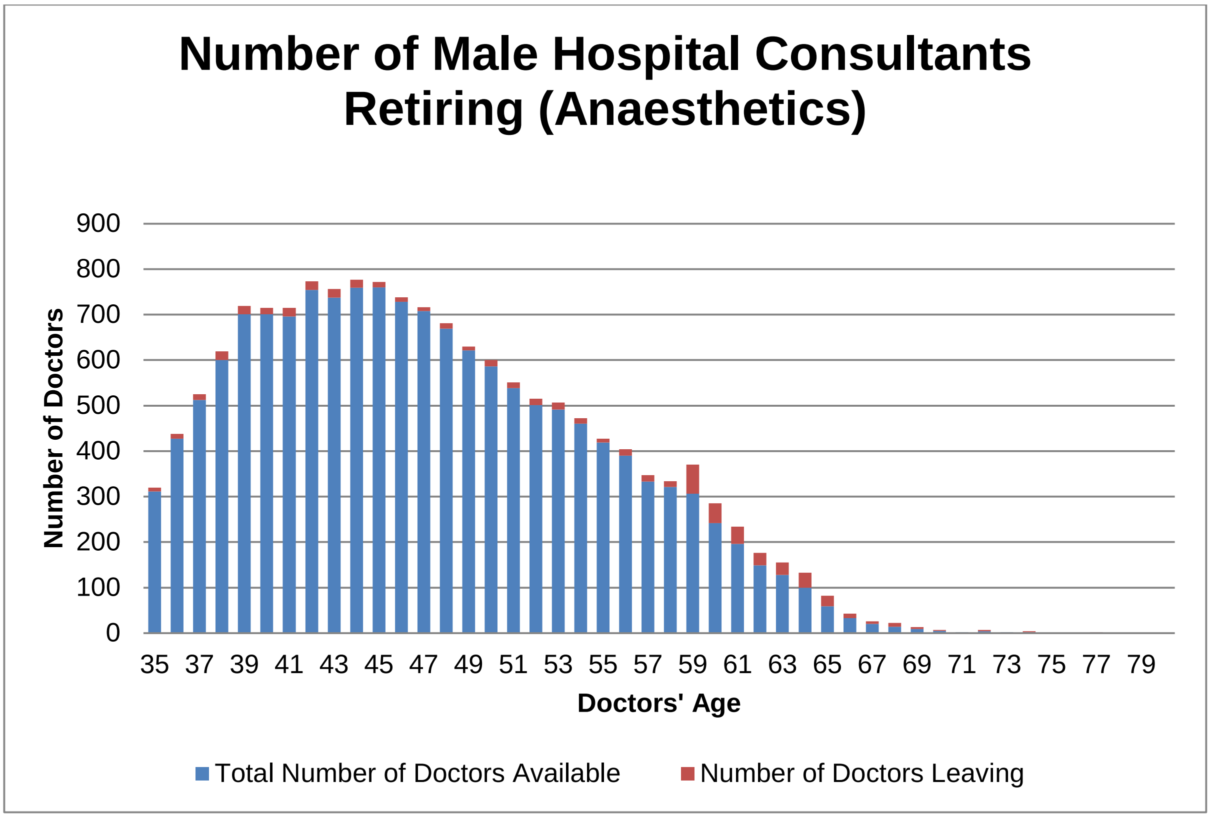
Vanderby, S. A., Carter, M. W., Latham, T., and Feindel, C. (2013). Modelling the future of the Canadian cardiac surgery workforce using system dynamics. *Journal of the Operational Research Society*.

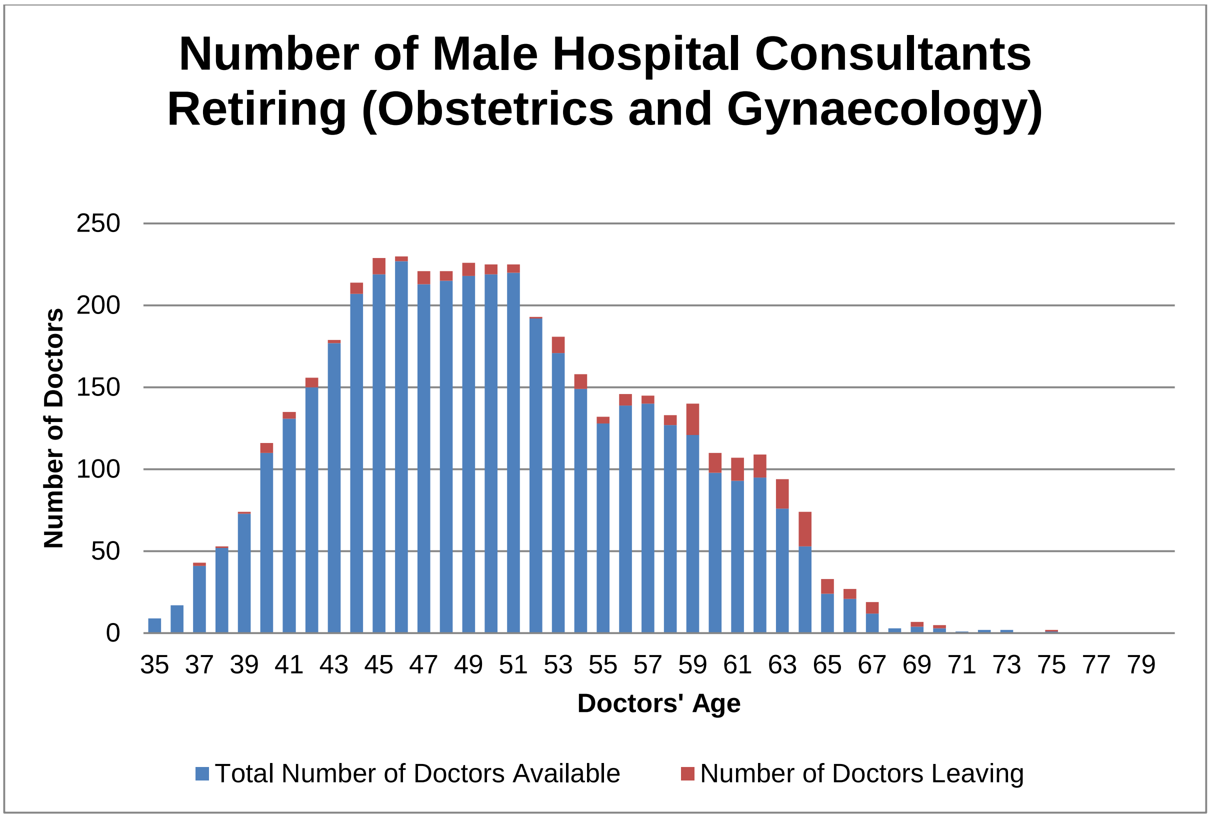
Wolstenholme, E. F. (1993). A case study in community care using systems thinking. *Journal of the Operational Research Society*, 925-934.

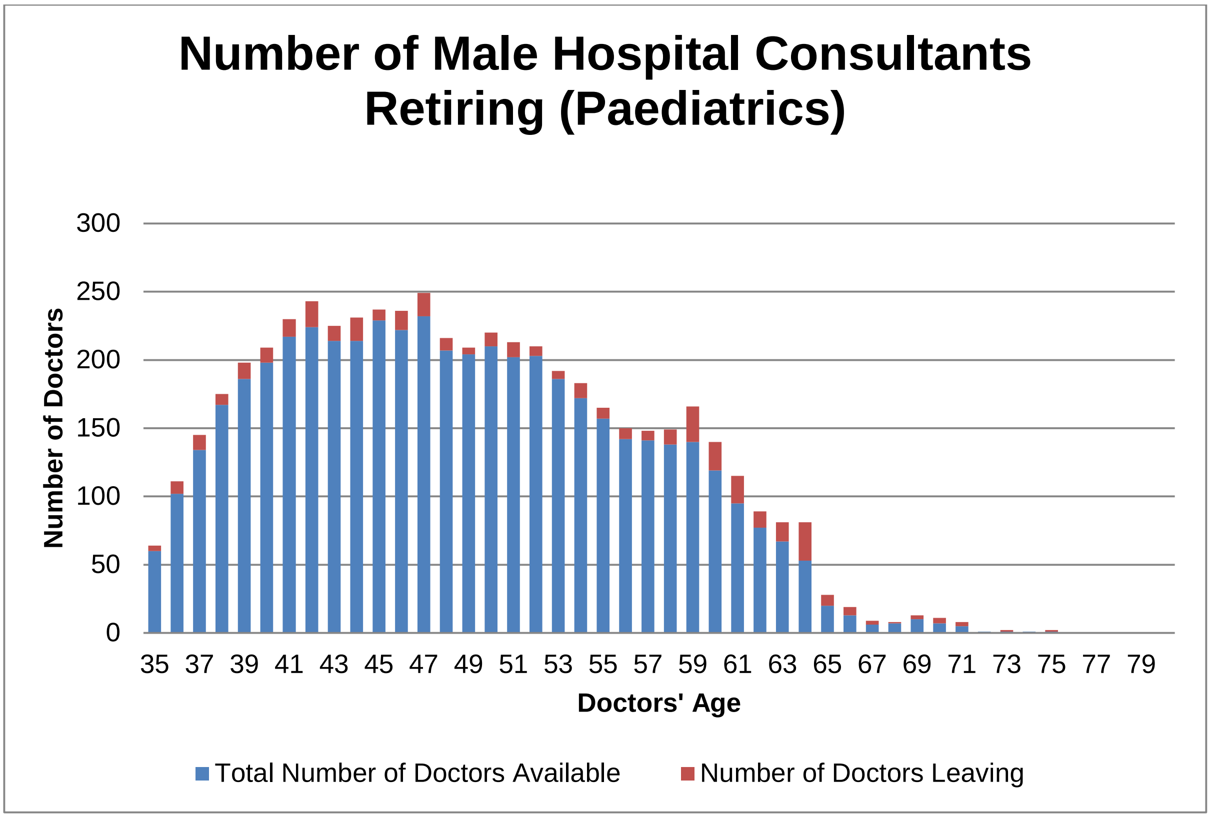
Wu, M. H., Yu, J. Y., and Huang, C. H. (2013). Theoretical System Dynamics Modeling for Taiwan Pediatric Workforce in an Era of National Health Insurance and Low Birth Rates. *Pediatrics & Neonatology*. 1-8

Appendix 1 Number of Male Hospital Consultants Retiring

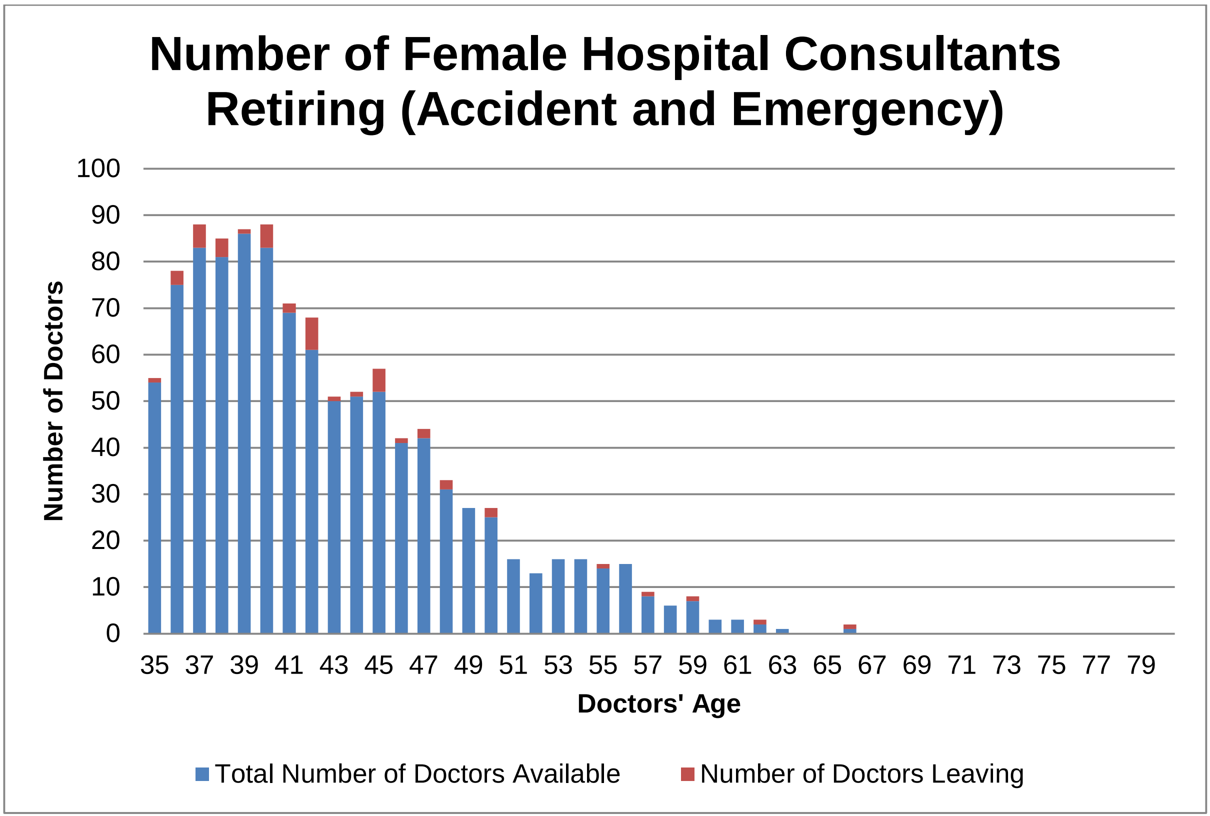


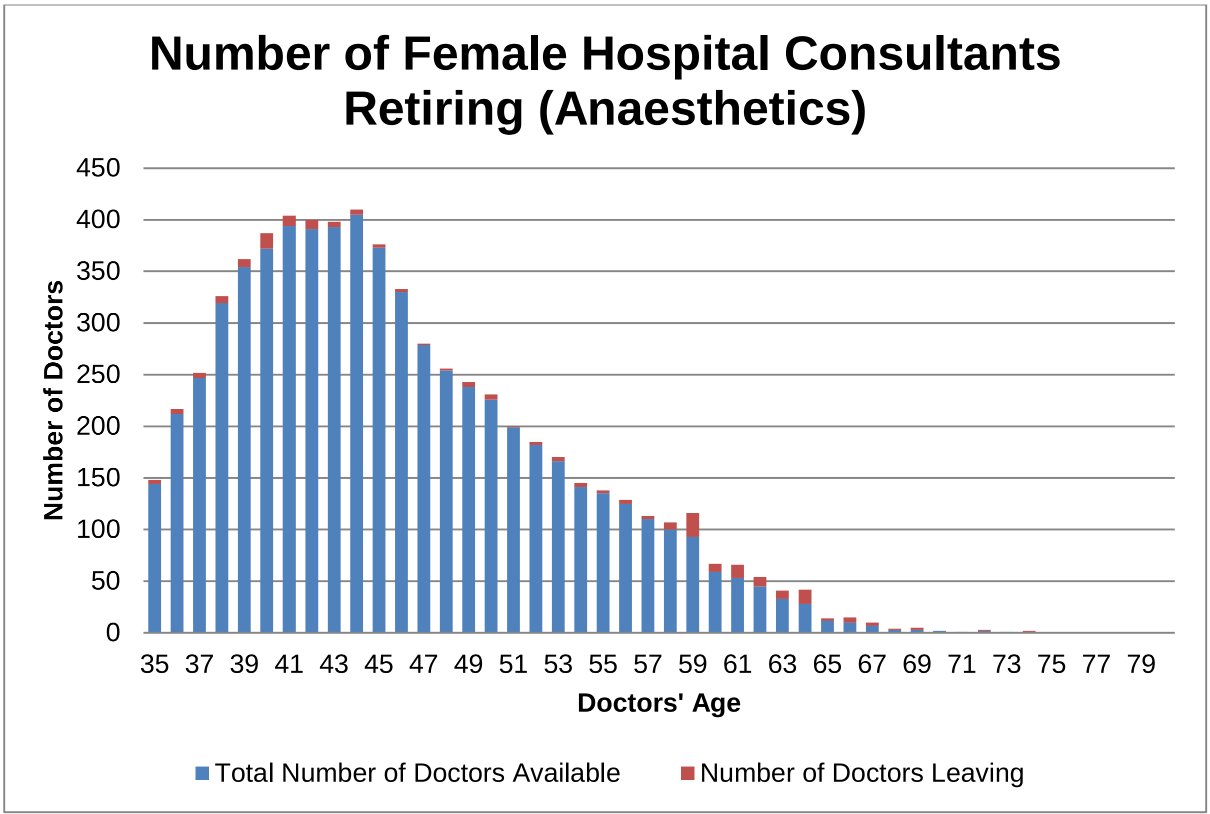


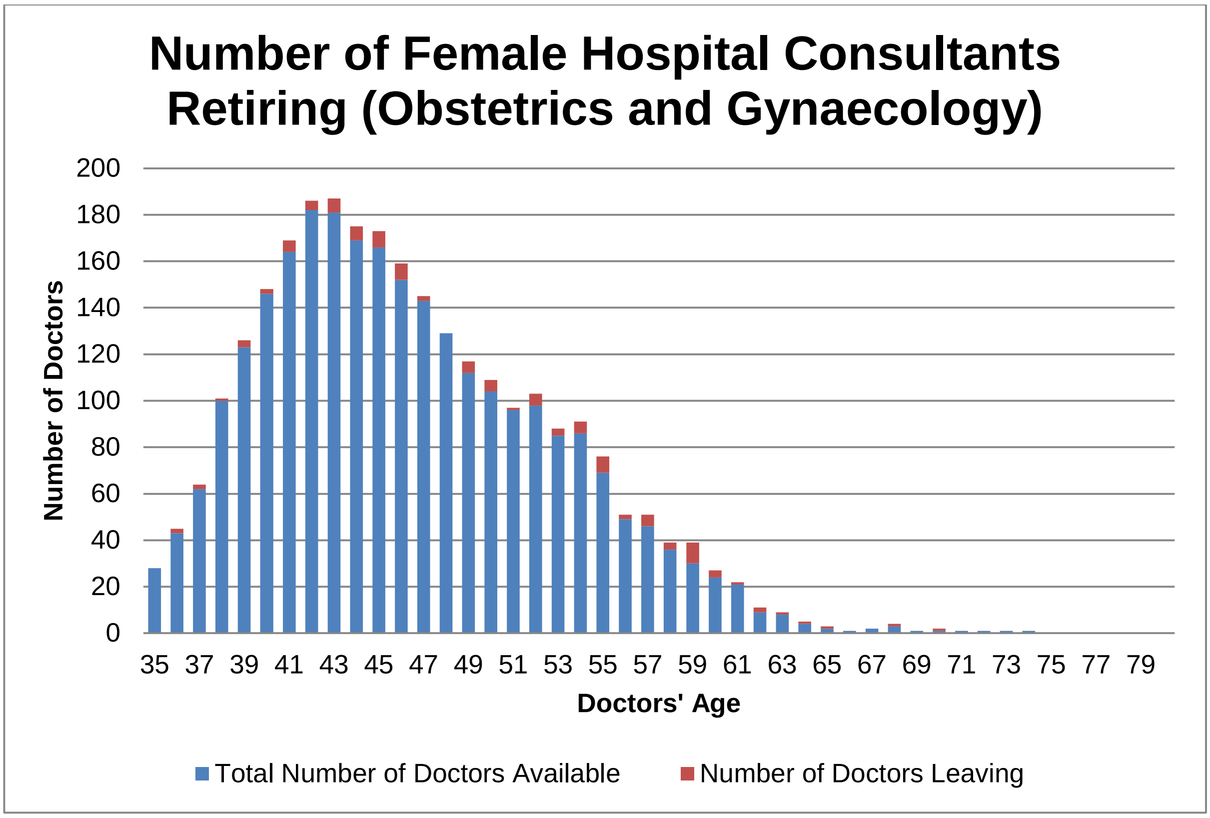

Number of Male Hospital Consultants
Retiring (Obstetrics and Gynaecology)
Number of Doctors
250
200
150
100
50
0
35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79
Doctors' Age
Total Number of Doctors Available
Number of Doctors Leaving

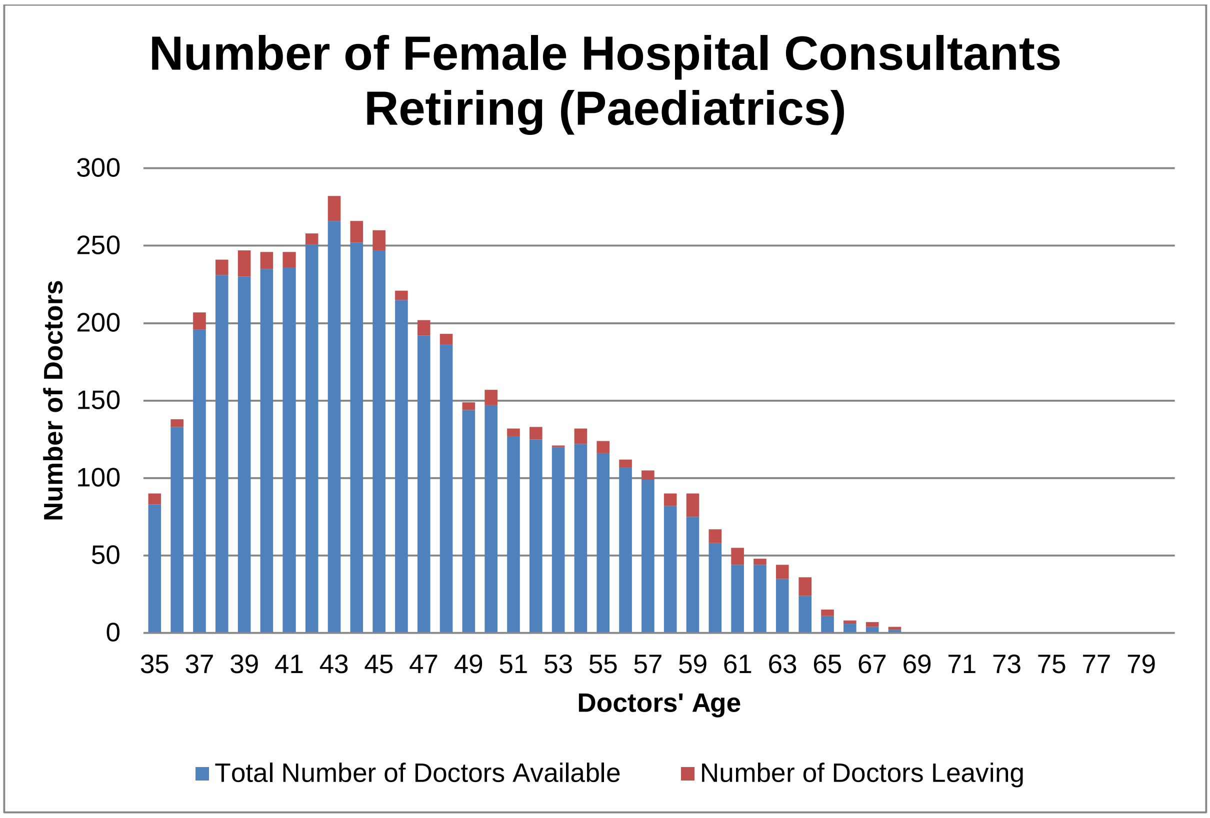

Number of Male Hospital Consultants
Retiring (Paediatrics)
Number of Doctors
300
250
200
150
100
50
0
35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79
Doctors' Age
Total Number of Doctors Available
Number of Doctors Leaving

Appendix 2 Number of Female Hospital Consultants Retiring

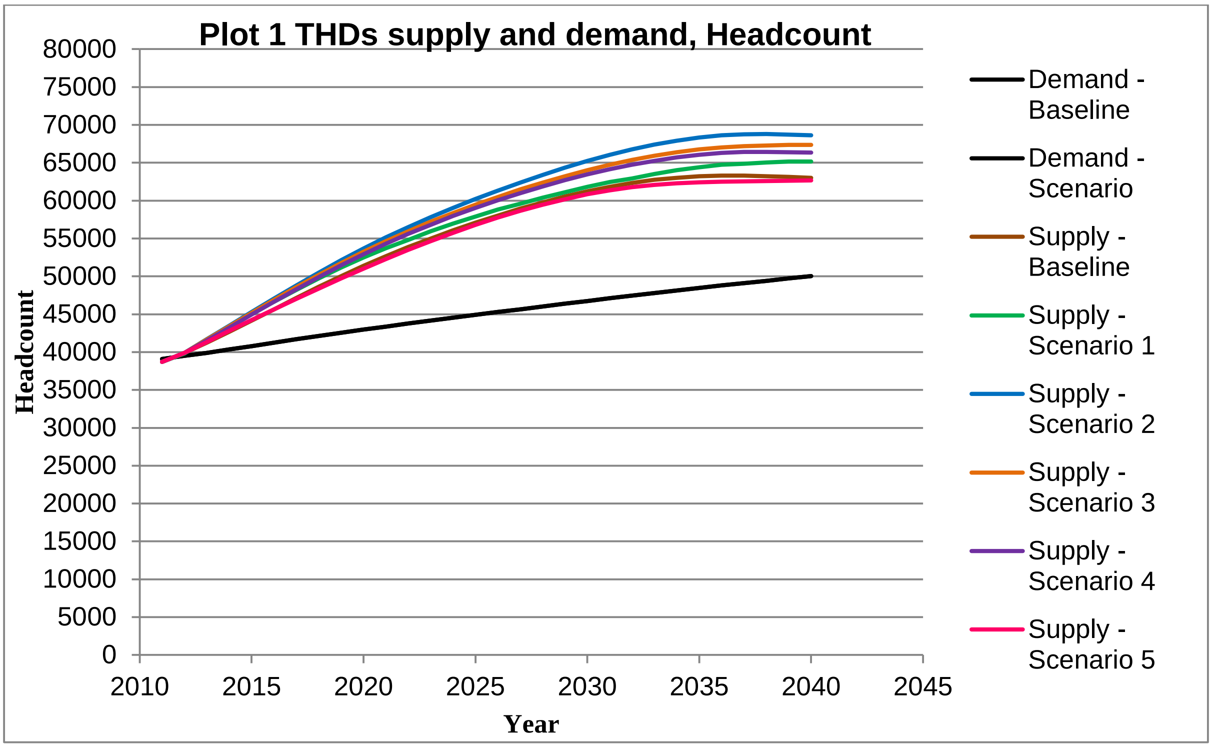




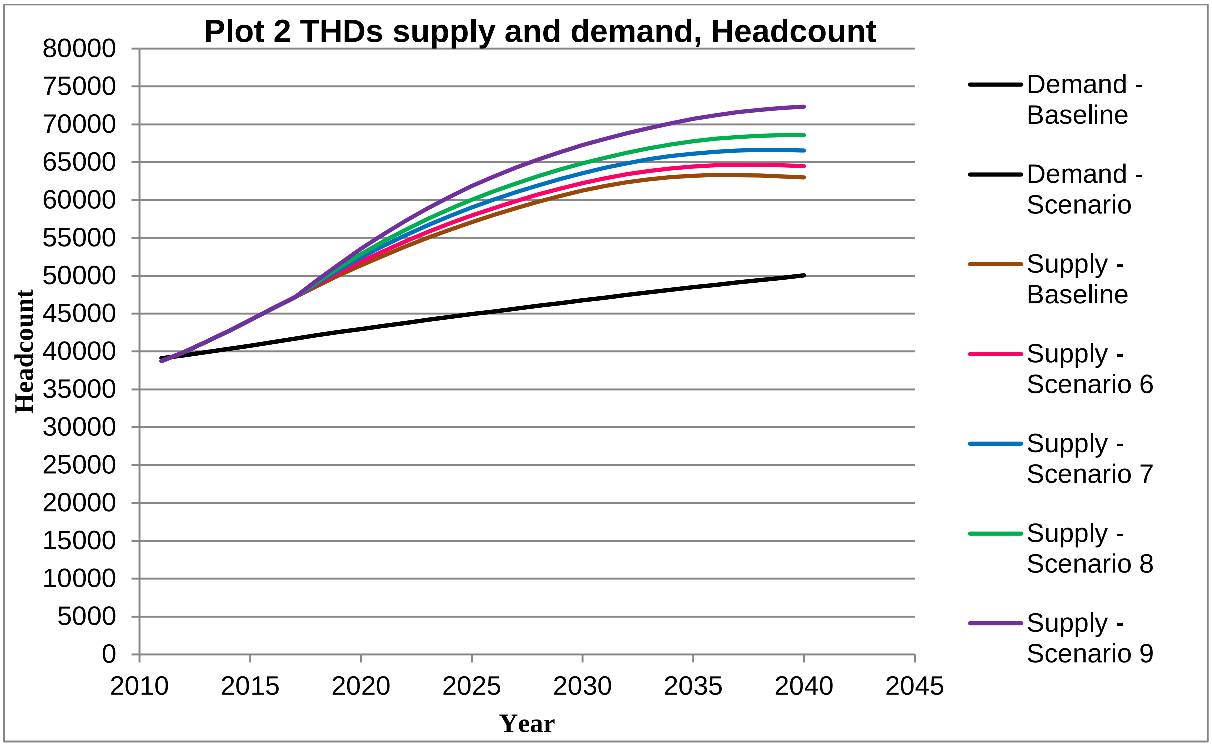

Number of Female Hospital Consultants Retiring (Obstetrics and Gynaecology)
Number of Doctors
200
180
160
140
120
100
80
60
40
20
0
35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79
Doctors' Age
Total Number of Doctors Available
Number of Doctors Leaving


Number of Female Hospital Consultants Retiring (Paediatrics)
Number of Doctors
300
250
200
150
100
50
0
35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79
Doctors' Age
Total Number of Doctors Available
Number of Doctors Leaving

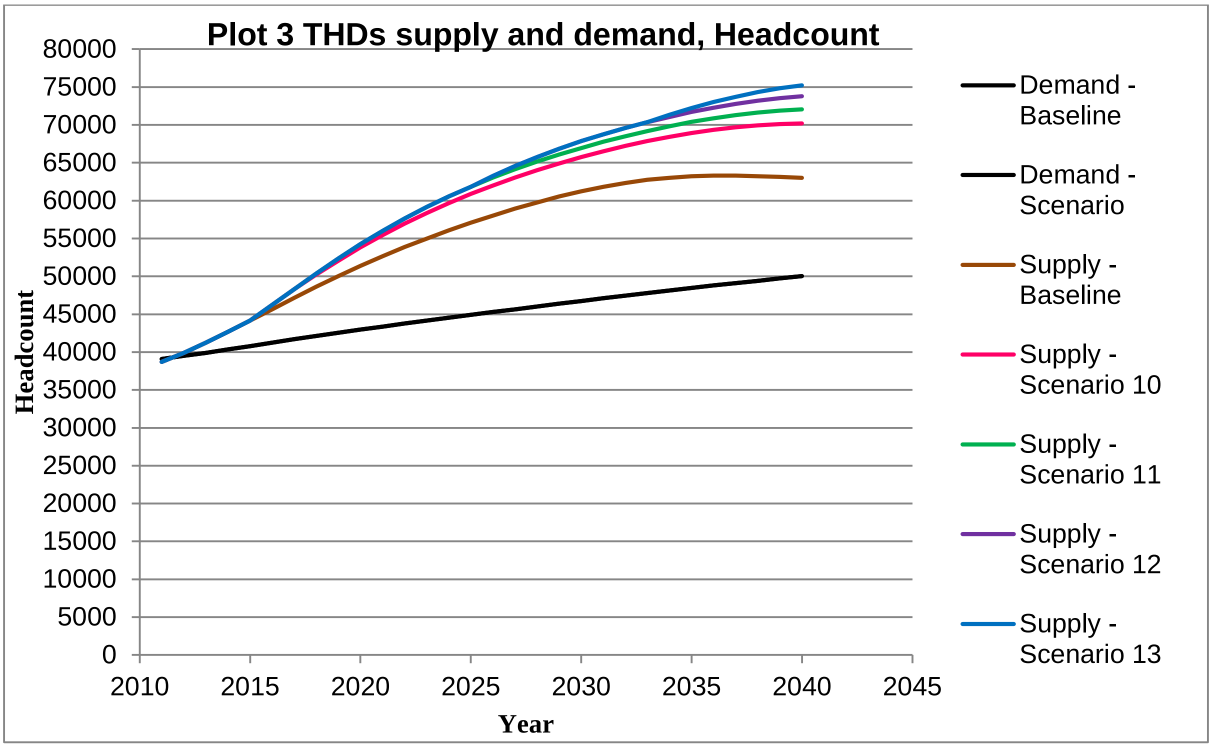
Appendix 3 Plot 1 THDs supply and demand, Headcount



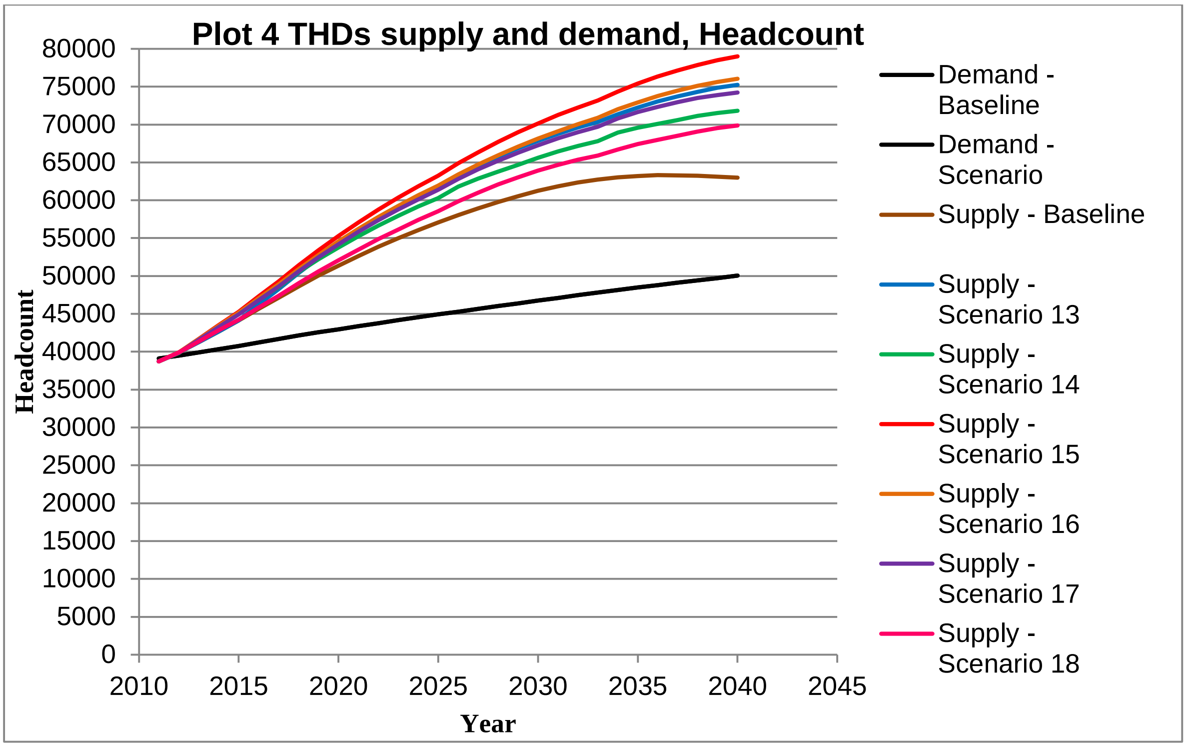
Appendix 4 Plot 2 THDs supply and demand, Headcount



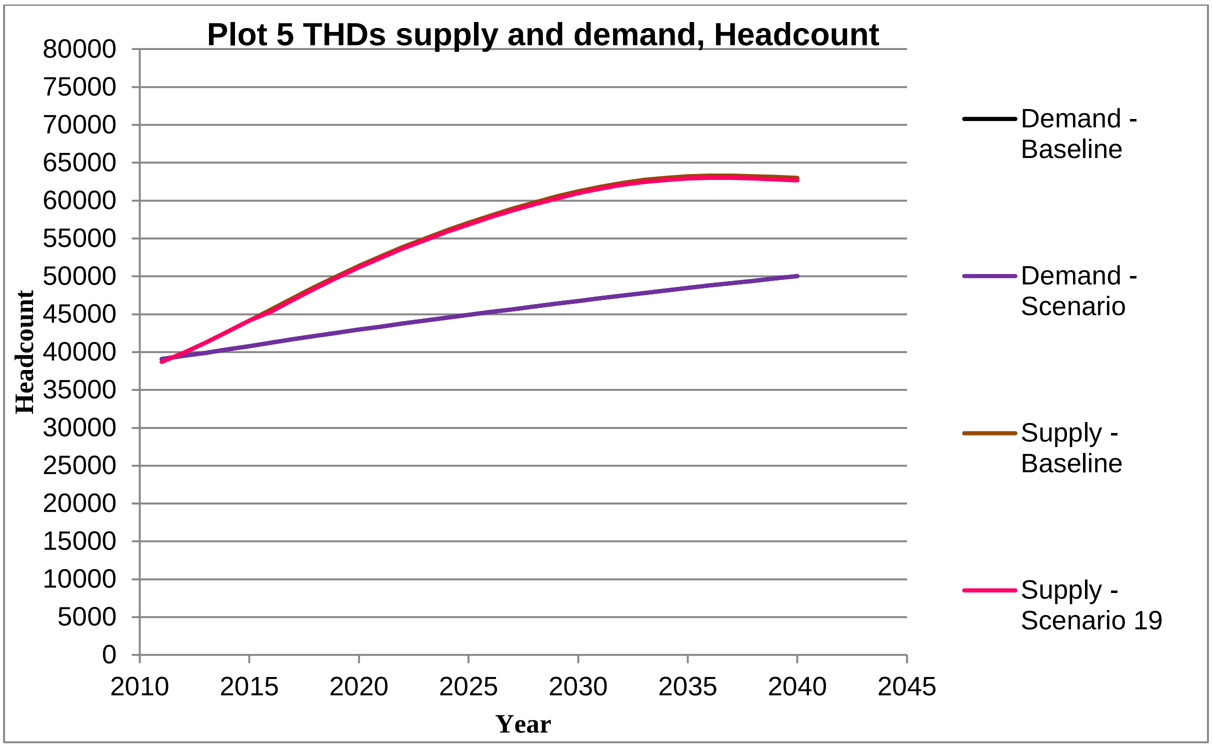
Appendix 5 Plot 3 THDs supply and demand, Headcount



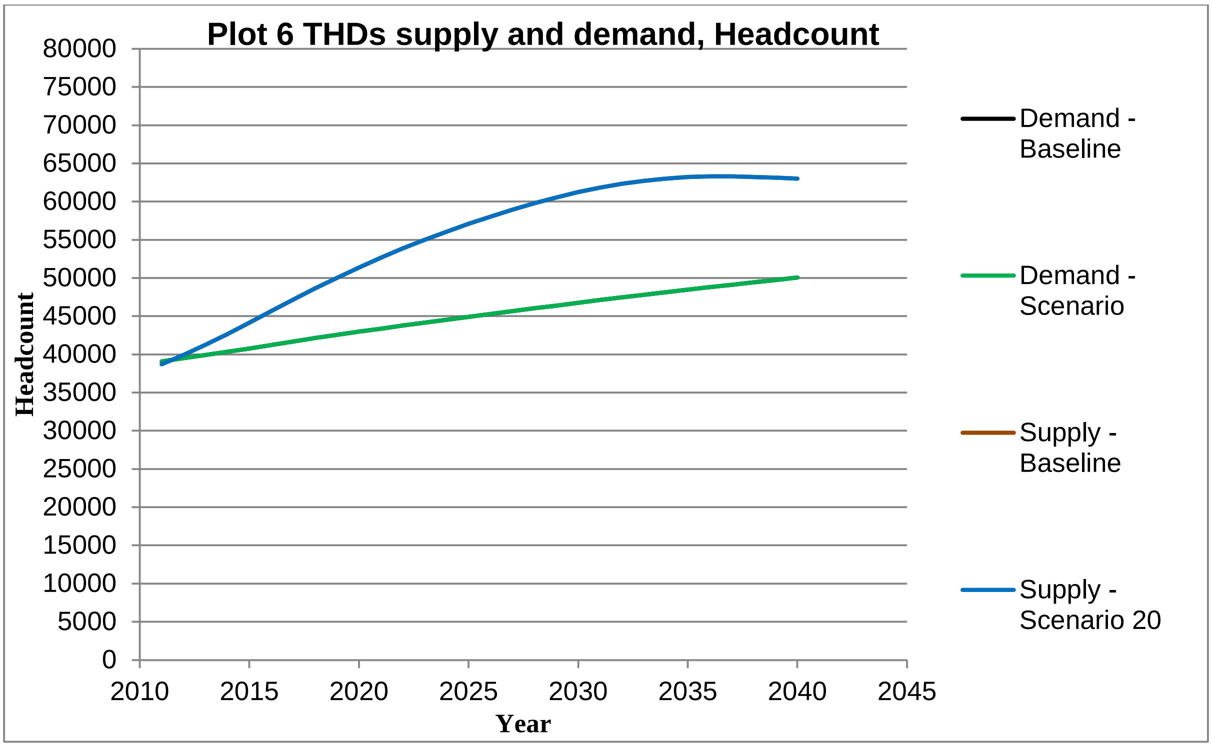
Appendix 6 Plot 4 THDs supply and demand, Headcount



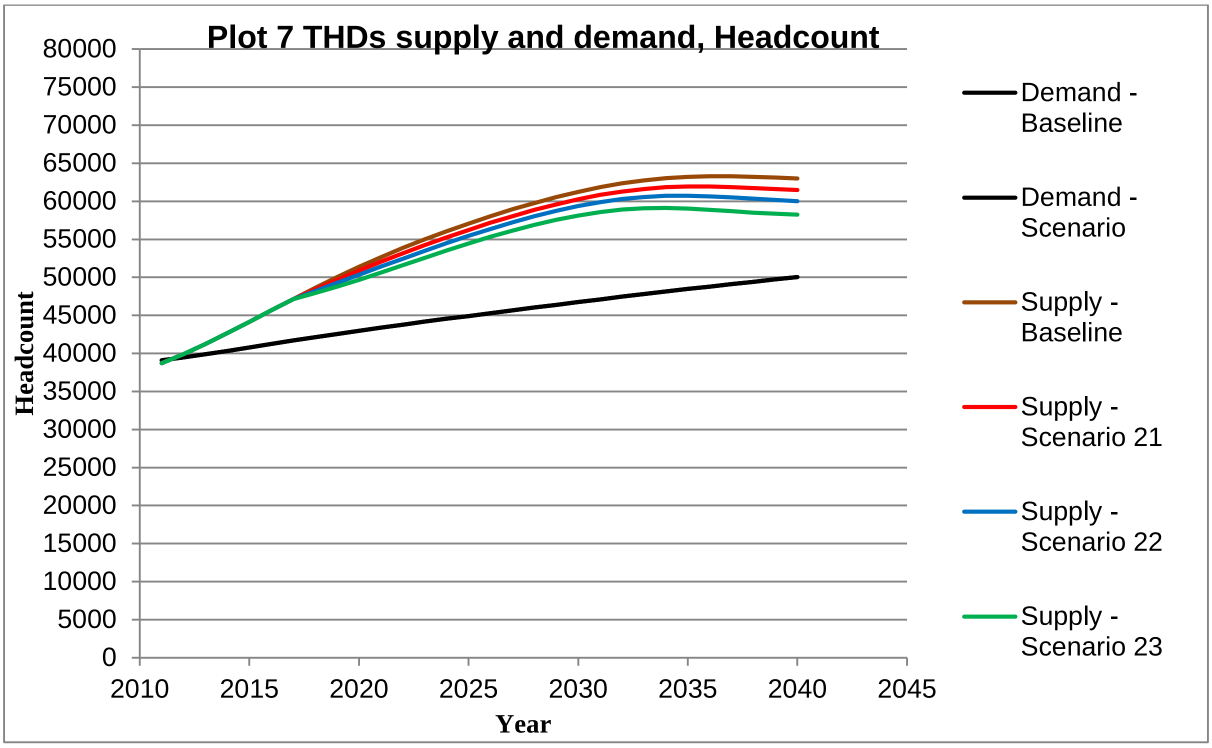
Appendix 7 Plot 5 THDs supply and demand, Headcount



Appendix 8 Plot 6 THDs supply and demand, Headcount



Appendix 9 Plot 7 THDs supply and demand, Headcount



Appendix 10 Plot 8 THDs supply and demand, Headcount