UNIVERSITY OF SOUTHAMPTON

FACULTY OF BUSINESS, LAW AND ARTS

Southampton Business School

Towards the Design of a Process Management Approach for the Delivery of Unscheduled Urgent and Emergency Healthcare

by

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Thesis for the degree of Doctor of Philosophy

December 2017

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

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Management Science

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TOWARDS THE DESIGN OF A PROCESS MANAGEMENT APPROACH FOR THE DELIVERY OF UNSCHEDULED URGENT AND EMERGENCY HEALTHCARE

Ganye Kwah Driscole

Delivering effective urgent and emergency healthcare continues to challenge developed economies despite recent increased spending. The literature suggests that the current design of accident and emergency departments (A&E) does not reflect the process nature of the delivery of unscheduled urgent and emergency care. The research described in this thesis supports the development of a process model to strengthen unscheduled urgent and emergency healthcare delivery and improve A&E operations.

A comprehensive literature review is undertaken to investigate the extent and efficacy of process management in healthcare delivery. It shows that process management methods such as Business Process Re-engineering and Lean tend to be applied to individual departments. End-to-end process orientated approaches are scarcely applied.

Assessing access to urgent and emergency healthcare in England, a lack of process design and management is found which results in confusion for patients. Based on principles of process orientation, a new proposal is developed that features local urgent healthcare hubs.

To investigate the current process, an analysis of A&E providers by catchment area was carried out for London to understand how features of an area such as number of general practitioners affects demand in A&E. Combining catchment area analysis with regression, a novel methodology is demonstrated that indicates how demand for A&E is affected by local characteristics.

Using simulation analysis informed by Geographic Information System (GIS) location analysis, a new methodology is created to demonstrate the potential for a process orientated approach to management of urgent and emergency healthcare. Using a case study in the London Borough of Hounslow, an analysis was carried out, firstly, of the current situation; secondly, of a National Health Service (NHS) proposal and, thirdly, the proposal put forward for urgent healthcare hubs. Several scenarios are analysed in which patients are diverted to other services, to demonstrate the effects of changes of provision on patient access and queueing efficiency.

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DECLARATION OF AUTHORSHIP

I, Ganye Kwah Driscole

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Towards the design of a process management approach for the delivery of unscheduled urgent and emergency healthcare

confirm that:

This work was done wholly or mainly while in candidature for a research degree at this University;

Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

Where I have consulted the published work of others, this is always clearly attributed;

Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

I have acknowledged all main sources of help;

Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

None of this work has been published before submission

Signed: ....

Date:

Acknowledgements

I would like to start by expressing my sincere gratitude to Dr Honora Smith, my lead supervisor for being patient and supporting to me throughout these 4 years. You have been a wonderful counsellor, encouraging my research thinking and allowing me to grow as a research scientist. Your efforts to make me a disciplined and focused researcher has been priceless. I also want to express my heartfelt appreciation to my other two supervisors Dr. Jonathan Klein and Dr. Yuan Hung for all their professional and nurturing support. Your guidance, support and encouragement in accomplishing this work cannot be express with words. I have been most lucky to have been guided by some of the best supervisory team any aspiring academic can ask for.

With the oversight of my main supervisor, editorial advice has been sought. No changes of intellectual content were made as a result of this advice.

I would like to dedicate this work to my beloved children Seanastef Kwah, Driscolia Gloria Kwah, Gem Xenos Kwah and Gyfeana Inda Kwah for their unflinching sacrifices and wholehearted support to me during this period. You provided me with care, concern and love, which kept me encouraged. To my wife Sanyu Mujjuze Kwah-Driscole for keeping me distracted from time to time during the research period. Thank you for your support.

This research was made possible by funding from the ESRC. My thanks and gratitude goes to the University of Southampton DTC and the superb management team notably, Mr. Glenn Miller and Professor Pauline Leonard for all the advices, directions and wealth of training and development opportunities offered by our Doctoral Training College over the past 4 years.

My final wish is for Peace and Love to reign on all humanity of this our unique and beautiful worlds.

Abbreviations

A&E	Accident and Emergency
AA	Appropriate attendance (relating to A&E attendance)
BBC	British Broadcasting Corporation
BMA	The British Medical Association
BPM	Business process management
BPR	Business process re-engineering
CSV	Comma Separated Values
CDVC	Care delivery value chain
DOH	Department of Health
ED	Emergency Department
FTN	Foundation Trusts Network
GIS	Geographical information system
GP	General Practitioner
HSCIC	Health and Social Care Information Centre
IA	Inappropriate attendance (relating to A&E attendance)
IMD	Index of multiple deprivation
IS	Information Systems
IT	Information Technology
LSOA	Lower Layer Super Output Area
MSOA	Middle Layer Super Output Area
ND	NHS Digital (now replaces HSCIC)
NHS	National Health Service
OECD	The Organisation for Economic Co-operation and Development
OM	Operations Management
OOH	Out of hours (relating to GP out of hours)
OR	Operational Research
PO	Process Orientation
RGO	Research Governance Office
SOA	Super Output Area
TPS	Toyota Production System
TQM	Total Quality Management
UC	Urgent care
UCC	Urgent care centre
UCH	Urgent care hubs
UUC	Unscheduled urgent care
UEC	Urgent and emergency care
VC	Value Chain
WIC	Walk-in-centre
ECU	Emergency care unit
UUEH	Unscheduled urgent and emergency healthcare

Chapter 1 Introduction

1.1 Research background

Healthcare delivery in the advanced developed economies such as England is facing challenges that cannot largely be resolved with increased funding alone (Ham et al., 2016). While many western countries have been increasing spending on healthcare delivery in the past 10 years (OECD, 2015), there is evidence that such spending does not produce an overall better healthcare delivery system (Porter and Teisberg, 2006; OECD, 2015). One major reason for this is that the design of healthcare delivery processes has not properly evolved with changing times. There is resistance to change such that pressure to maintain the immediate post Second World War method of healthcare delivery, dictated by the welfare model, has prevailed. Healthcare delivery design and processes have been influenced by clinicians, based on their training (Berwick *et al.*, 1990; Starfield, 2000). Another perspective is that the complexity of healthcare systems makes it challenging for the conception of holistic thinking for how an integral healthcare delivery process could be designed (Imison *et al.*, 2013; Longenecker and Longenecker, 2014). While there is the view that much is being spent on healthcare delivery, patients' satisfaction, especially in accessing unscheduled urgent and emergency healthcare (UUEH), has remained a major challenge to the healthcare system. Evidence for this is the persistent difficulty in resolving capacity problems in Accident and Emergency (A&E) departments.

The public, healthcare delivery stakeholders, and pressure groups are increasingly calling on healthcare delivery authorities to make UUEH delivery available, accessible, cost effective, sustainable, safe and of best quality. Even though these requests are not new (Øvretveit, 2000; Glouberman and Mintzberg, 2001), most research has tended to seek solutions by focusing on improving the internal operations of the healthcare system. An array of studies has been carried out on how to improve the workings of operating theatres, bed management in wards, scheduling patients and A&E among others. Despite this, the overall healthcare delivery process has remained fragmented even though the reality is that complexity of modern healthcare delivery should be untangled. This makes it necessary for inter-departmental cooperation to be realised since one party is insufficient to provide the complete cycle of healthcare (Drupsteen *et al.*, 2013; Nilsson and Sandoff, 2015).

In UUEH, for example, various studies have shown that patients attend A&E departments inappropriately (see Section 4.3.6). There is the view (for example, Richardson and Mountain, 2009) that this type of action has led to increased volume of demand and thereby contributes to the capacity problems suffered by A&E.

Given the process nature of healthcare delivery (Snyder *et al.*, 2005; vom Brocke and Rosemann, 2015), this research seeks to understand the extent to which process management is a culture within healthcare delivery management. It looks at how it has been researched and implemented, and its efficacy within healthcare delivery management. It determines the relationship between A&E capacity problems and the current process structure of the delivery of unscheduled urgent and emergency healthcare. The process management aspect of UUEH has not been examined in past research.

1.2 Research context

1.2.1 Preparing the healthcare system for operations and management evolution

The National Health Service (NHS) in England has experienced some management changes over the years aimed at improving the quality, outcomes, and effectiveness of the healthcare delivered by the system. Changes were also aimed at modernising NHS management methods to reflect changing socio-economic times (Ham, 2004; Propper *et al.*, 2004; The Health Foundation, 2011). For example, to make the NHS more responsive to patient demand and their changing attitudes, it mimicked the behaviour of private sector organisations by calling patients “customers” (Propper *et al.*, 2004). The Griffith Report of 1983 proposed the creation of the posts of managers in NHS hospitals similar to ordinary businesses so that management ideas could be conceived, designed and adopted (Ham, 2004). Despite this, while treatment of various illnesses has improved, the NHS still struggles to deliver effective UUEH (Ham *et al.*, 2016). This is reflected in the performance of the A&E department (Agarwal *et al.*, 2012; Saghafian *et al.*, 2015). This department is described as persistently operating in crisis mode (Lane *et al.*, 2000) because, on a regular basis, there is excessive demand with which treatment throughput cannot catch up (Foundation Trust Network, 2013). Consequently, within the A&E department, there are long waits, congestion and capacity problems (Freeman *et al.*, 1999; Eatock *et al.*, 2011; Bostock, 2016). One major driver for this problem is directed to poor process design (Foundation Trust Network, 2013). Although the government and researchers have proposed a variety of solutions, the delivery of UUEH and the management of the A&E department has remained problematic (Martin *et al.*, 2002; Land and Meredith, 2013; Cowling *et al.*, 2014).

Today's NHS continues to face economic and social changes which dictate the quest for rapid adoption of management models that counter the problems posed by these challenges (The Health Foundation, 2011; Ham *et al.*, 2016). On the economic front, resources allocated for healthcare delivery have been reduced due to weak economic recovery from the economic crisis of 2008. The limited funding for the NHS that has resulted from this has required that the NHS should provide 'more healthcare with fewer resources,'(OECD, 2013b). On the social, scientific, and technological fronts, the quest to provide expected healthcare by the NHS is being challenged by the following:

- The demographic shift in the UK and medical improvements mean that people now live longer, some with disabilities that demand increased health care (Ham *et al.*, 2016).
- Globalisation has increased movements of people and increases immigration thus leading to higher volumes of demand for healthcare.
- Improvement in technology and science has made it easier for many diseases to be quickly diagnosed, prevented and treated than before. While this means people live longer, treatments have become expensive. Unlike other industries where technological and scientific innovation has led to a reduction in costs, for healthcare it has resulted in increased costs.
- The proliferation of information and the cheapness of information technology has increased knowledge and communication; it is thus possible for technology to influence demand for treatments (McLaughlin and Olson, 2012).

These challenges have called for a change of mind-set in the ways healthcare delivery is designed in the NHS today. While trying to keep the principle of the welfare state intact, where healthcare is free at the point of need, the design of the system needs adjusting to an environment of low cost and higher quality. This is best done by departing from the approach where healthcare delivery is designed around the needs of healthcare operators (functional) rather than patients (processes) (White *et al.*, 2011; Drupsteen *et al.*, 2013). Process methods have transformed many service organisations such that operations costs have reduced. Some examples (Harmon and Wolf, 2016) include hotel bookings, flights and navigating through the airport to the right terminals, managing public transport systems, banking, distribution, and logistics, among others. The healthcare system needs to follow a similar evolution to that observed in these service organisations and develop bespoke methods that ease access to UUEH and so reduce the capacity problems of the A&E department.

1.2.2 Structure of healthcare system and challenge to current process outlook

The healthcare system is made up of departments, silos, and subsystems which are supposed to work in an interrelated manner, showing an end-to-end view of the care delivery process (Gonçalves *et al.*, 2013; Ramlakhan *et al.*, 2016). Healthcare delivery starts in the community with general practitioners (GPs), Walk-in-centres (WICs), and GP Out-of-hours (OOH), and institutional care is provided by hospitals and other treatment centres. The system involves both health advice and treatments of various forms (World Health Organisation, 2005). These departments and providers are expected to work in synchrony within the system so that relationship between the system and patients is effective. The current observation is that harmonious synchronised operations expected within the healthcare system have been difficult to achieve (Ding, 2015).

The processes within hospitals are working more effectively, as evidenced by the growing ease of transfer of patients from one department to another, improvements in scheduling and improvement in the management of operating theatres (Gonçalves *et al.*, 2013; Nilsson and Sandoff, 2015; Crawford *et al.*, 2017). Even though various urgent care (UC) access points such as WICs, GP practices, telephone systems among others, have been created with the aim of reducing the demand for UUEH in A&E departments, there has been increased questioning about their effectiveness and relationship to the 'whole system' (Kalim *et al.*, 2006; Weber *et al.*, 2011). Researchers have acknowledged the importance of process management in improving healthcare delivery and a variety of process approached have been developed and adopted (Gonçalves *et al.*, 2013; vom Brocke and Rosemann, 2015).

However, given seemingly persistent capacity problems in A&E departments, the efficacy of process models adopted in healthcare delivery needs assessing through re-examining the process model attributed to it.

1.3 Background to healthcare operations management (OM)

Healthcare delivery to the population is a complex business and, despite the best efforts of political authorities, organising healthcare on the ground is challenging. There are various stakeholders who must be brought on board, some very vocal and powerful and who must be associated with the design of an operations strategy for it to be successful. The exclusive nature of healthcare delivery, which involves the treatment of humans, means that, from the economic standpoint, it is an inelastic product and must be controlled by governments. As such, managing the operation of healthcare is complex and depends on the nature of healthcare delivery of a country. For example, in the USA where healthcare delivery is market facing, managing operations for healthcare delivery will reflect a market attitude or profit motive (McLaughlin and Olson, 2012; Langabeer and Helton, 2015). In England, where healthcare has a welfare characteristic, is non-market facing, and there is free access at the point of need (Propper *et al.*, 2008), operations management here will reflect a more community-based orientation which makes access easier and more visible (McLaughlin and Olson, 2012).

Whatever the case, healthcare is mostly delivered in a fragmented system, be it in the USA or in the UK; in most cases, the expectation of whole system operation has hardly been achieved (Ding, 2015). For example, several studies (for example, The Nuffield Provincial Hospitals Trust, 1960; Driscoll *et al.*, 1987; Freeman *et al.*, 1999; McHale *et al.*, 2013) have reported that a large number of patients attend A&E departments inappropriately. This has been directly linked to persistent capacity problems witnessed in the department since those patients could have been treated in other sectors of the healthcare system. This example is among various operational failures that have led to calls for more operationally-inclined research to be conducted in healthcare delivery management (Schmenner and Swink, 1998; Shortell and McCurdy, 2009).

While operations management is a broad subject, one topic that reflects the way healthcare delivery could be improved is process management. Therefore, this research focuses on investigating current processes of healthcare delivery in order to determine how it could be improved, especially within the area of UUEH and A&E capacity problems.

1.4 The notion of healthcare delivery

Different meanings could be attributed to the concept of healthcare delivery. Therefore in this research, the definition proposed by the World Health Organisation (2012) is adopted. It suggests that health care delivery refers to the ability of the healthcare provider to make available high quality and sufficient, affordable healthcare to its population at the most convenient time and place for patients themselves. Healthcare delivery is accessible through a system and not only in hospitals. In meeting healthcare needs, components such as diagnosis, referrals, health promotion, disease prevention, treatment, disease management, rehabilitation, and palliative care services should be made available to the population.

From this definition, it can be concluded that the delivery of healthcare in the NHS starts from the community and continues to the hospital. The processes involving these operations need clarification and their levels of efficacy need to be determined.

1.4.1 Efficacy of process management in healthcare operations

In this research, the aim has been to examine whether process management, as designed and adopted by healthcare organisations, and as identified in past research, has met underlying expectations. The term 'efficacy' is borrowed from medicine to explain the ability of medicine to produce the desired or intended result. In that context, to be efficacious means that drugs that have been developed work as intended (Glasgow *et al.*, 2003). In a field pertinent to this research, Lohrmann and Reichert (2012) have suggested that business process efficacy relates to the effectiveness of the processes adopted and an assessment as to whether they achieve the intended business objectives.

Efficacy can be evaluated in many ways depending on the aim of the process design. For this research, healthcare process management will be deemed efficacious when some or all of the following have been realised:

- ➢ Fosters improvement in patient flows within the system, improves outcomes and enhances quality of life.
- ➢ Supports drives to meet cost management efficiencies. Cost efficiency is realised when resources deployed for an intervention are used for it such that desired results are produced with financial break-even.
- ➢ Enables stakeholders to understand the care delivery process.
- ➢ Assures and supports the sustainability of the healthcare delivery system while checking healthcare over-consumption.
- ➢ Meets the changing patterns of demand for healthcare.
- ➢ Provides safety, quality, flexibility and stability.

In Chapter 3, the various process methods and approaches reported in the literature that have been applied to improving healthcare delivery will be evaluated based on these criteria.

1.5 Research motivation

This research is motivated by three main factors.

a) *Persistent capacity problems in the A&E department and challenges in the delivery of urgent and emergency healthcare in the NHS.* Reports and studies suggest that the A&E department is being overwhelmed with demand, thereby putting excessive pressure on its ability to deliver healthcare to patients appropriately (Cowling *et al.*, 2014). Various studies, for example, Driscoll *et al.* (1987); Trzeciak and Rivers (2003); Kolker (2008); Weber *et al.* (2011); Agarwal *et al.* (2012); Land and Meredith (2013); (McHale *et al.*, 2013); Cowling *et al.* (2014); Saghafian *et al.* (2015); Baker (2016); Ramlakhan *et al.* (2016), show that the A&E department has been facing operational problems for a long time. These studies have centred on capacity problems and questions about appropriate and inappropriate attendance (AA and IA). They unanimously hold that many attendances could have been treated at other access points in the community rather than in the A&E department. This led to the interest in examining the drivers of the capacity problems in the A&E department and determining the role played by process design.

b) *Calls for a redesign of the urgent and emergency care process of the NHS*. In a motion presented to British Parliamentarians (the House of Commons) on the 26th July

2013, by the NHS Foundation Trusts Network (FTN), entitled "Written evidence from the NHS Foundation Trusts Network," (House of Commons, 2013a, Section 7), the members of the FTN wrote that the wider NHS healthcare delivery system is not working effectively.

"*Our research indicates that at least 25% of patients currently attending A&E Departments could and should be treated by other parts of the NHS. Therefore, a whole system approach is needed to tackle these issues longer term. This requires fundamental re-design of the whole pathway, including appropriate investment in primary, community and social care services and much better patient signposting to these services…*"

Problems such as long waiting, queueing, congestion and various bottlenecks in the A&E department and wider NHS system are common. Given that these challenges are operational, strategic and managerial in character, it is necessary to probe into whether OM approaches are being adopted in healthcare delivery management. Already, Bertolini *et al.* (2011b); Gonçalves *et al.* (2013), and Hellström *et al.* (2010), for example, show that healthcare organisations have been adopting some forms of process management approach. In this research, a review of several of these methods and approaches are presented in Chapter 3, where their efficacies are also determined.

c) *Curiosity regarding the theoretical formulation guiding research in healthcare delivery management*. The systemic and process nature of healthcare organisations have attracted a significant amount of its theoretical formulation from OM (for example, Mayhew and Smith, 2008). Although the healthcare system is a centre of knowledge, much of it resides in silos with limited propensities for cross boundary and departmental interaction. Given that this is a *sine qua non* requirement for effective operation in a healthcare delivery environment (Porter and Teisberg, 2006), this lack of integration has led to increased complexity of the healthcare delivery process and the system itself (Plsek and Wilson, 2001; The Health Foundation, 2010). The effect has been growing wastes, errors, inefficiencies, constricted access and patient dissatisfaction (Hellström *et al.*, 2010; Gillespie *et al.*, 2016).

The idea of theorising healthcare operation with OM relates to the nature of healthcare delivery, which fits the techniques-based and scientific nature of OM. For example, Joseph Juran, a quality guru of the 1970s in a forward to the book "Curing Healthcare…" (Berwick *et al.*, 1990, p. ix), wrote

"*As the health industry undertakes … change, it is well advised to take into account the experience of other industries in order to understand what has worked and what has not. Of course, in the minds of many, the health industry is different. This is certainly true as to its history, technology and culture. However, the decisive factors in what works and what does not are the managerial processes, which are alike for all industries*."

The benefit of designing and adopting end-to-end processes in healthcare management is broadly agreed in many OM studies, and that such approaches improve the flows of material, knowledge, synergies and relationships that add value and better quality of services for patients (White *et al.*, 2011; Drupsteen *et al.*, 2013). Despite this knowledge, there seems to be an absence of studies and practices that exhibit this. While the idea of supply chain (upstream and downstream) and value chain are closer to the type of process design expected from healthcare delivery, their design has not been properly represented in the research regarding access to the right kind of healthcare demanded by patients. For example, different supply chain management techniques have been adopted mostly to manage inventories and hospital supplies such as medicines from wholesalers to clinic (Al-Mudimigh *et al.*, 2004). Value chain on its part has been fashioned to fit healthcare delivery (see Chapter 3) but it affects mostly known health cases that have been diagnosed.

This study aims to propose a direction that develops an explanatory and predictive theoretical operational process for healthcare delivery management and so strengthen theory within OM. Schmenner and Swink (1998) proposed a variety of perspectives on how theory within OM could be developed from a body of existing knowledge.

1.6 Research problems

The main research problems addressed by this research are as follows:

i. Challenges in meeting public expectations and patients' satisfaction. Efforts pursued in the past decades to make the health care system responsive to patients' needs have largely remained difficult to attain (Glouberman and Mintzberg, 2001; Spear, 2005). Patient satisfaction relates to how they feel when they need healthcare or efforts they make to alleviate their pain by accessing the appropriate access points to healthcare (for example, Proctor *et al.*, 2005; Porter and Teisberg, 2006; Ham *et al.*, 2012). This is influenced by the effectiveness of the processes, and how confused patients are when they try to navigate the system. In addition, the system is judged by whether it is equitable, patient-centred, flexible, innovative and able to employ the latest technology. For example, viewing patient satisfaction over a long period, as shown in Figure 1-1, shows that their satisfaction varied in the period 2000 to 2015. Patient satisfaction started increasing from 2007 until 2010 where the highest ever satisfaction of 70% was recorded. After that period, there have been inconsistencies in satisfaction such that in 2015 satisfaction dropped to 60% (Appleby and Robertson, 2016). This variation in satisfaction is based on periodic interviews that were undertaken with patients during various times in the year.

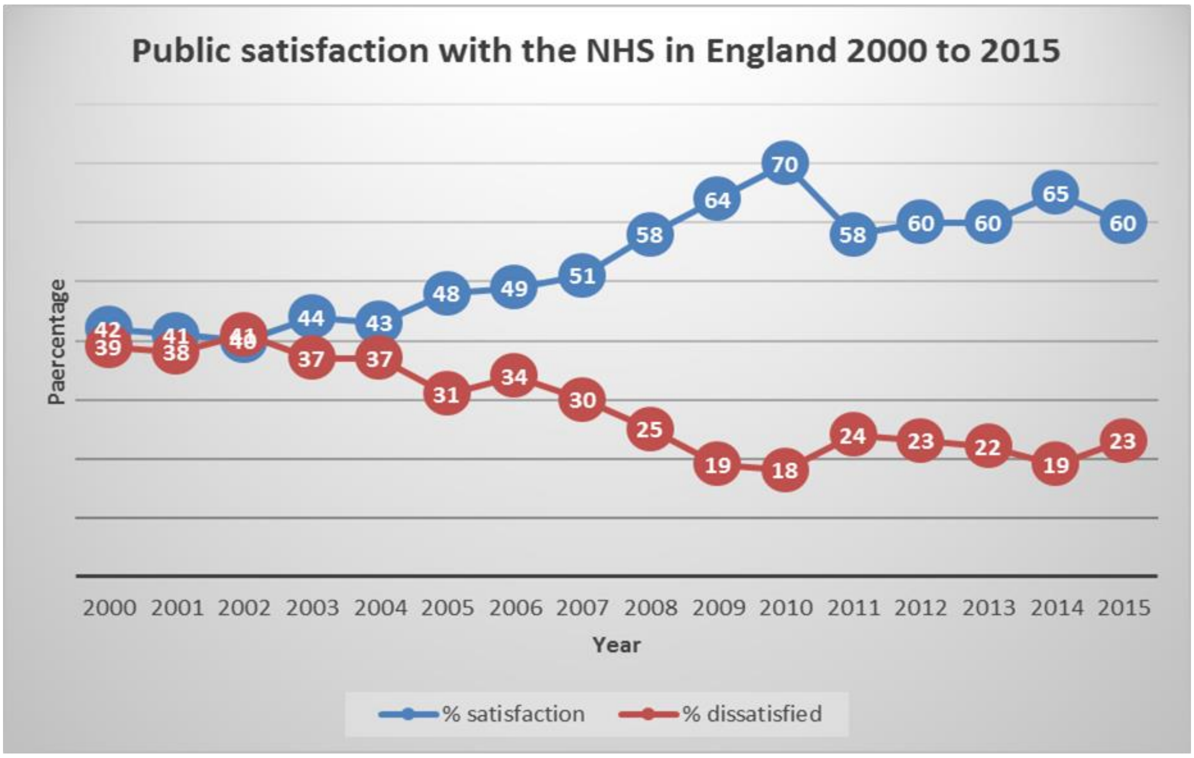


Figure 1-1 Public satisfaction with the NHS 2000 to 2015. Source: Appleby and Robertson (2016)

However, caution should be exercised in interpreting Figure 1-1. Firstly, most of the satisfaction reported was without comparison because healthcare delivery in England, as accessed by the majority of the population, is a public monopoly and free at the point of use. Patients are happy that they can access healthcare even if such experiences are poor. They view healthcare as a core service and so assess complications as sacrifices for the service they get. Secondly, surveys are susceptible to effects of ‘noise’ and external influences. For example, negative news about the UK healthcare system, about A&E overcrowding, and financial problems, among others, could sway results. The results are also presented as a whole and do not show sectors where patients were most satisfied with the healthcare system.

ii. Difficulties in developing management models that fit healthcare delivery. While the manufacturing sector can boast of the existence and adoption of various operational management methods to improve production and delivery of goods and services, for example, process management, it is difficult to see a specific operational management approach adopted by the healthcare systems. Various Operational Research related approaches have been used to analyse healthcare delivery management (see, for example, Rais and Viana, 2011; Saghafian *et al.*, 2015). These approaches, though worthwhile, seem to be limited in their application as they focus on specific problems within the healthcare system, while the systemic process nature of healthcare delivery is usually missed (Akman and Gordon, 1970; Beged-Dov and Klein, 1970; Berwick *et al.*, 1990). Designing and adopting a process management approach which reflects the nature of healthcare delivery, and which integrates and harmonises departments, sectors, processes and steps in the care delivery, has been encouraged (Bergman *et al.*, 2011; Gonçalves *et al.*, 2013). Looking at healthcare delivery from this perspective can improve patient flow through the whole system, rather than the individual units in isolation (Kalim *et al.*, 2006)

Within the NHS, the process governing the delivery of urgent and emergency health care has been described as a ‘confusing system’ (NHS England, 2013a, p. 16). As shown on Figure 1-2 there are many access points open to patients, who are required to access it based on the nature of their illnesses. While this is confusing, it has failed to consider the reasons behind patients’ choice of access when in pain. They will mostly seek the nearest available access point.

Figure 1-2 System of confusion in the non-emergency health care delivery process in England. Source NHS England (2013 p. 16)

This idiosyncrasy of patients, their frequent inability to self-diagnose and fear of serious illness, alongside the complexities in the system, means that they are likely to access health care from access points such as the A&E department even though UC services might be equally suitable.

iii. Seeking means of infusing change management in healthcare delivery. Economically, England's spending on healthcare delivery has been reducing year on year while it is still required that the best quality healthcare continues to be delivered (Ham *et al.*, 2016). As presented in Section 2.1, the NHS faces challenges which must be resolved with improvement in management perspective.

The current healthcare delivery model of the NHS is still rooted in the immediate post Second World War approach where functional management dominates despite the recognition of better healthcare delivery through the adoption of process methods and models (Probert et al., 1999; McNulty and Ferlie, 2004a). While a variety of change management approaches have been infused in the NHS, such as the role of management and managers (Ham, 2004), and the implementation of competition for patients (Propper et al., 2004), most of these management systems seem to have strengthened the functional rather than the process orientated nature of healthcare delivery. Change management, therefore, remains a problem given the long waits, congestion, challenges with throughput and flows through the system as well as access (Berwick et al., 1990; Longenecker and Longenecker, 2014).

1.7 Research objectives

The objectives of this research are three-fold:

First, to assess the extent to which the process management approach has been researched and used to develop models for effective healthcare delivery management. In doing so, it determines the extent to which these models, methods and approaches have been efficacious.

Second, to investigate the role of process management in influencing A&E demand. That is, it examines whether process design rather than (or as well as) patient behaviour influences patient choice of the access point to non-emergency healthcare and the A&E department.

The third objective aims to develop a conceptual model that can improve and support the grounds for a better urgent and emergency care delivery process.

1.8 Research questions

The research questions are as follows:

1. How has the process management approach been researched and implemented to support healthcare delivery management?

2. a) In what ways has this research improved patients' choice of appropriate access points when in need of urgent and emergency health care and what impact has it had on the demand in the A&E department?

2. b) What factors explain demand in the A&E department?

3. In what ways can process management support the design of an optimal process-driven urgent and emergency health care delivery model?

1.9 Organisation of the thesis and research outline

The rest of this thesis is organised as follows.

Chapter 2 reports on the methodology and methods adopted by this research.

Chapter 3 presents the literature review, which explores the nature of research in process management as a concept, its theoretical underpinning and its application to healthcare delivery organisations.

Chapter 4 examines the nature and volume of A&E access in England in the period 2010 to 2015. This helps this research to define the appropriate role of process management in A&E access and thus plan how to examine the current design and identify weak points which could be improved. A design is presented for a new process-oriented proposal for UUEH, based on UC hubs.

In Chapter 5, the way that UUEH is delivered in London is examined. Using catchment area analysis combined with regression analysis, a method is demonstrated for determining factors that can affect demand in A&E.

Chapter 6 presents a methodology incorporating both geographic information system (GIS) location analysis and simulation to investigate the performance of UUEH in a region and analyse "what-if" scenarios. One borough of London, Hounslow, is used as a case study to demonstrate this analysis, which covers the current provision of UUEH, the NHS "pyramid" proposal and the proposal designed for UC hubs.

Chapter 7 concludes with a summary of this research and presents findings, contributions and limitations of the research, as well as opportunities for further studies.

Chapter 2 Research Methodology

2.1 Introduction

This chapter identifies and analyses the philosophy, techniques, methods and tools adopted in this study. The research methods presented here reflect the detailed stages, steps and approaches used to arrive at the research conclusions presented. The essence of the methodology is based on meeting the following objectives of the research:

- To assess the extent to which the process management approach has been researched and used to develop models for effective healthcare delivery management, and thus to determine the extent to which these models, methods and approaches have been efficacious.
- To investigate the role of process management in influencing A&E demand. That is, it examines whether process design rather than (or as well as) patient behaviour influences patient choice of the access point to non-emergency healthcare and the A&E department.
- To develop a conceptual model that can improve and support the grounds for a better urgent and emergency care delivery process.

In so doing, the following research questions were posed:

1. How has the process management approach been researched and implemented to support healthcare delivery management?

2. a) In what ways has this research improved patients' choice of appropriate access points when in need of urgent and emergency health care and what impact has it had on demand in the A&E department?

2. b) What factors explain demand in the A&E department?

3. In what ways can process management support the design?

The value of a research methodology that guides the epistemological assumptions and direction of a research study such as this PhD is emphasised by leading methodological writers (see for example, Bryman, 2006; Rubin and Rubin, 2012). Although research in Operations Management (OM) and process management (scientific management) has traditionally followed the positivist tradition, this research adds case studies, which is also a strong feature in OM research methodology. By doing so it defines the research areas and questions, it delineates the research objectives and shows how these components are addressed in the thesis. This research is being conducted in an area where limited previous studies have been undertaken; a case study is used to explain and support a detailed exploration of a particular situation rather than relying on extensive statistical analysis. It aims to narrow down a very broad field of healthcare management research into one that focuses on a specific research topic, and thereby provides a better understanding of how this contributes to knowledge in OM.

The framework for managing complex healthcare delivery processes using business process models is relatively new (Nilsson and Sandoff, 2015; vom Brocke and Rosemann, 2015). Given the limited available data for looking at the integration between methods in the healthcare setting, this research methodology uses inductive and deductive perspectives. It moves from specific observations to broader generalisations and concepts. The deductive approach primarily tests and validates the framework being developed. A case study is then used as a research strategy to achieve the research objectives. Several techniques for data collection are employed to harness publicly available data stored in databases of public institutions. A detailed discussion about the aforementioned steps is presented in the sections below.

This chapter continues with Section 2.2, which provides the research methodology, and epistemological conception for this research. Section 2.3 provides the research method and design used in this research, while Section 2.4 reports on the study setting, data collection and strategy. Section 2.5 discusses and explains the data analysis while Section 2.6 reports on how the simulation and GIS are combined. Section 2.7 presents the case study development applied in the research and Section 2.8 provides a summary of the chapter and conclusions.

2.2 Research methodology and epistemological conception

2.2.1 Epistemological development

OM as a subject has largely followed the positivist methodological tradition for the design of research methods (Meredith, 1998). Process management, which is a subset of OM, was developed and modified within the Scientific Management theory

(MacCarthy *et al.*, 2013). Research in healthcare delivery has also followed positivism through Operational Research (OR). Here specific techniques have been developed and applied to particular problems areas. For example, A&E queuing (Siddharthan *et al.*, 1996; Mayhew and Smith, 2008), bed management in hospital wards (Proudlove *et al.*, 2003; Dixon *et al.*, 2004), and scheduling of patients to operation theatres (Murray and Berwick, 2003; Mageshwari and Grace, 2012). While OM is considered a technique-based specialisation, whereby its practical nature usually leads to the development of solutions and techniques that can be readily adopted in real life situations (Kiridena and Fitzgerald, 2006), its presence in healthcare remains ambiguous. Currently perceived lapses in process management in healthcare delivery (for example, Gonçalves *et al.*, 2013; Nilsson and Sandoff, 2015) and difficulties in properly explaining the relationship between healthcare delivery process and capacity problems in the A&E department suggest gaps in research methodologies in healthcare OM research. For example, there seems to be a lack of process and systemic views when developing research methods for capacity management or queueing techniques for internal hospital management (White *et al.*, 2011; Drupsteen *et al.*, 2013). This calls for a robust methodological approach in investigating and designing systems that consider the unique characteristics of healthcare delivery. As such, this research holds that adopting a positivist epistemology fits that perspective.

With positivist epistemology, this research develops quantitative approaches so that with the use of data, model are developed which can explain the phenomena under examination, answer the research questions and meet the research objectives. Given that research in healthcare is complex and complicated because it deals with life, the healthcare system is expensive to establish and run, and there are many powerful stakeholders and interest groups seeking to follow one route or the other (Porter and Teisberg, 2006), the aim in this research is to be effective and objective when considering the issue of healthcare capacity and demand.. This eliminates subjective bias (Johnson and Onwuegbuzie, 2004). The neutrality of this approach is promoted by case studies, which test and empirically justify the stated hypotheses that A&E capacity problems are driven by poor process design.

Another challenge with healthcare delivery research is the presence of diverging points of view and disagreement about fundamental operating principles with the delivery process. Research on A&E capacity problems dates back to the 1960s (see, for example, The Nuffield Provincial Hospitals Trust, 1960). Since then many researchers (for example, Prince and Worth, 1992; Lowy *et al.*, 1994; Wise, 1997; Murphy, 1998; Martin *et al.*, 2002; McHale *et al.*, 2013) have suggested that patients have been attending A&E departments inappropriately. There is still disagreement on what constitutes inappropriate attendances in the A&E department, the circumstances leading to their occurrence, and the role of the A&E department in relation to them.

In addition to the challenges of the rationality of healthcare delivery in a low-cost welfare system such as the NHS (Long and Feldstein, 1967; Iglehart, 1999; Porter and Teisberg, 2006), proper process design has remained contentious. Given calls for improvement and redesign (for example, Foundation Trust Network, 2013), there is the need continuously to seek ways to present the 'objective truth' through scientific approaches which positivism promotes (Alvesson and Sandberg, 2011). With the use of available data and scientific techniques, a factual analysis of causes of capacity problems in A&E could be shown and its constituents justified. "Factual" knowledge according to positivism can be gained through scientific approaches such as measuring and hypothesis testing (Bryman, 2012). Given that positivists believe that predictions can be made on the basis of previously observed and explained realities and their inter-relationships (Alvesson and Sandberg, 2011), the role of this research will be to demonstrate the relationship between demand management, access, process, and capacity problems in the A&E department. To reduce ambiguity and improve credibility, it is being done through data collection and interpretation in an objective manner so that the findings are observable and quantifiable through statistical analysis.

To gain knowledge of the way process management thinking has been pursued within the healthcare sector, a thorough literature review was performed. The background to this was based on the view that healthcare delivery is naturally a process activity and so it was possible that past studies would have examined how such processes have been designed and improved over time. The review of the literature indicated process management has been researched and its thinking within the healthcare delivery system has been developed to reflect the healthcare system's characteristic where healthcare is delivered in stages, steps and processes (Reijers, 2006; Kohlbacher, 2010). The observation of bottlenecks and capacity problems in the A&E, therefore, support the views of Deming (1985) that after a decade of studying complexities in organisations such as healthcare and their failure to meet quality expectation, poor responsiveness from processes continued to preoccupy researchers. This follows the postulation of researchers such as Alvesson *et al.* (2009); (Bryman, 2012) who posit that the truth is out there and the researcher's responsibility is to get it. Chapter 3 of this thesis shows the extent to which the process management literature is reviewed. It shows that process management thinking takes the form of process orientation (PO), process methods an approaches that follow the value chain.

It is a PO viewpoint that is applied in Chapter 4 to examine the current process structure of unscheduled urgent and emergency healthcare (UUEH) of the NHS in England. Chapter 4 demonstrates that design is responsible for congestion, bottlenecks and long waiting times over a period (2010-2015) (Prince and Worth, 1992; Wise, 1997). This supports the design proposal of UC hubs, whereby UUEH demand should have a system so that emergency and UC routes are differentiated and UC patients do not access the A&E department.

2.2.2 Case studies

Case studies used in this research aim to bring an understanding and clarity to the complex area of process design within healthcare delivery. This addresses aspects of the research, where questions of "how" and "why" are posed. Even though healthcare delivery is a practical community-based activity, the complexity surrounding its study, solution design and practical application has remained contentious (Jun *et al.*, 2009; Longenecker and Longenecker, 2014). The case study application in this research also adopts a positivist perspective. This is done by capturing as many variables as possible, which identify how a complex set of circumstances unite to produce the types of behaviour displayed. It also contributes to the research design by supporting and improving the answers to the research questions.

Healthcare research not only has to consider the complexity of healthcare delivery, but also the complexity of definition and justification of terms (Plsek and Greenhalgh, 2001; Mowles *et al.*, 2010). In this research, it is found that terms such as "access," "appropriateness" and "inappropriateness of attendances" as well as capacity problems in the A&E department, for example, have remained contentious. Case studies are empirical enquiries that carry out detailed investigations of key phenomena within a real life context; they can be used to clarify complexities (Bandara *et al.*, 2005; Kiridena and Fitzgerald, 2006) especially in situations where boundaries between phenomenon and context are not clearly evident (Yin, 1994). Moreover, the techniques characteristic of OM can best be exhibited by use of case studies (Voss *et al.*, 2002).

In Chapter 5, the process design being developed is explained and variables are developed. This takes an investigative, exploratory and historic approach to the case study methodology. It analyses the causes and consequences of the situation and discusses the outcomes from data developed. This approach tries to look at "why" patients access A&E departments in London by examining the current process structure of the area. The assumption is that capacity problems in the A&E departments in London are the result of poor process design.

In Chapter 6, various scenarios are conceived to support the development of answers to the question "how or in what ways?" From the investigation as to why capacity problems develop in A&E, a case study is developed to provide a possible solution. It explores scenarios from specific geographic areas to test circumstances where a particular design method could contribute to reducing capacity problems in the A&E department. This is a problem oriented case study approach because it encourages solution conception where a new design is being contemplated. Voss *et al.* (2002), for example, proposed that case study research is important in OM because within OM it is necessary to develop solutions that can counter operational difficulties caused by changing technology and managerial approaches, as well as to develop new theories and directions of thinking.

To achieve the requirements for the case studies design and analysis, a Geographical Information Section (GIS) was used to visually show the area of research. The GIS methodology is used within the ArcGIS platform; the methodological approach is described in Section 2.5.1. In this research, catchment area analysis is used to examine the design structure of UUEH in London. The analysis variables, which are tested in correlations, regressions and multiple regression are presented in Chapter 5. Models are developed and analysed using Simul8 software on the computer. The modalities of how that is done are explained in Chapter 6 and Section 2.5.4.

Although case studies have been criticised for lacking robustness and generalisability (Mans *et al.*, 2009), this research overcomes these limitations by developing a multiple-case approach in Greater London and London Borough of Hounslow. For Greater London, a specific in-depth examination investigates the nature of current design within the catchment areas. In the Borough of Hounslow, the case study tests and carries out experiments and visualisation on how an alternative UUEH process model can be pursued.

To conclude in relation to the methodological development, positivism has been criticised because it lays much emphasis on quantification while overlooking important aspects that are not quantifiable (Rubin and Rubin, 2012). The positivist research methodology adopted in this research adheres to the view that complexity in healthcare research can be made clear when using scientific methods. The design nature of this research aims to show that healthcare delivery can be effective when processes interrelate and interconnect. By adopting an unbiased perspective which reflects the silo nature of healthcare operation complexity, the disagreements that exist over key aspects can be clarified. The methodologies and process design are contributions in themselves for they show practically how systems, subsystems and processes are identified, linked, and tested. They also show best locations, methods of calculation and identification and how situations can be simulated to mimic real life within the healthcare setting to meet local needs.

2.3 Research method and research design

This section clarifies the methods adopted in answering the research questions presented in this study as well as the research design.

2.3.1 Literature selection method

In order to establish this research, it was necessary to review the field of process management and determine how it has influenced the design of process models for healthcare within the healthcare management sector. Literature within the area of process management and its relationship to healthcare delivery operation was identified. A critical examination was undertaken in order to determine where there were gaps in current knowledge, to avoid repetition of research and to learn from mistakes made by past research (Bryman, 2012).

The LibGuides@Southampton, a portal at the University of Southampton's Library, was used to develop strategy for the best sources to obtain academic materials for the topics within process management and their application to healthcare delivery. The DelphiS, web of Science, WebCat, and Google Scholar were accessed for literature on the subject. In all, about 150 articles, books, reports from government and NHS sources, academic journals, working papers, websites and media sources were identified. These included professional institutes and consultancies such as The World Health Organisation (WHO), for definitions and description of healthcare systems, the Organisation for Economic Co-operation and Development (OECD), and media sources such as the BBC, The Guardian Newspaper, The Telegraph, The Economist and The Independent.

Search terms and keywords used included terms such as healthcare system, NHS, operations management and process management in healthcare, the history of operations management, healthcare operations management service, evolution of process management, structure of process management in services, production and operations management in services and healthcare, process management research in healthcare, healthcare pathways, process management modelling, process design, simulation, GIS and ArcGIS. In Chapter 3, a fuller presentation of the way the literature review was carried out is provided.

2.4 Study setting, data collection and strategy

This research examined the design of process management governing the delivery of urgent and emergency healthcare as well as its role in driving capacity problems in the A&E department of the NHS in England. The focus was on the role played by access, processes, and input from affiliated delivery points and how they could have led to the capacity problems in A&E departments. The internal working of the A&E department was outside the remit of this research. Terms reported in Section 4.3.5 attributing internal operation merely justify causality of process design. This research assumes that when the A&E department performs its perceived functions of being a route into the hospital for admission and deals with emergency cases such as resuscitation, capacity can be minimised. This research therefore examines the process of UUEH access and the drivers of capacity problems of the A&E department.

The practical and technical nature of this research called for data collection from various sources as explained below.

2.4.1 Data collection

Different types of data were collected for this research, but all the data used were publicly available. Data for unscheduled urgent and emergency care in England for the period 1st April 2010 to 30th June 2015 provided details of A&E attendance in England, the registered population, number of GPs and number of patients admitted to hospital. These were available from the official databases of Health and Social Care Information Centre (2015b). These data supported the assessment of A&E attendance by examining the type of demand, the capacity of the A&E department and provided a year-on-year comparison to determine the intensity of A&E pressure.

Data were collected to examine the structure of urgent and emergency care delivery in London. In this section, the data requirement was for one particular year - 2014. The reason for this was that there had been a great deal of restructuring of the ways urgent and emergency health care was being designed and delivered in London. As shown in Figure 5-12, providers had come and gone over the years, and thus accessing consistent data for a five year period was not possible. Also, providers had changed management and ownership over the years (as explained in 5.3.1) such that delivery data had been either changed to new providers, or recorded in a way that could not be attributed to a particular provider. The best possible method of understanding the structure of delivery was to examine data for one year, which was 2014-2015.

The data collected included the resident population, the number of registered patients, the number of GPs and the number of practices, as identified within the Health and Social Care Information Centre (2015b). This provided data on both demand for and supply of healthcare delivery in London.

In order to understand the current process design, possible impediments to health care delivery and bottlenecks within the processes, number of connections and strength of points' connectivity to the various subsystems and silos, GIS data on Middle Super Output Areas (MSOAs) (see Section 2.6.1) were collected from the Office for National Statistics (2014). To understand the environment and possible effects on access, the levels of deprivation within the MSOAs of London were examined. Data on the index of multiple deprivations (IMD) were obtained from the Department for Communities and Local Government (2011). Data on patients perception and how they perceived health care access were obtained from a survey conducted by Ipsos MORI (2014).

For the modelling and simulation, detailed data were obtained from a variety of databases and website that stored geographic information data. Given the diversity of data needed, Greater London Authority and Office for National Statistics (2014), Ordnance Survey Open Data from website https://www.ordnancesurvey.co.uk, UK government open data website, www.data.go.uk and Health and Social Care Information Centre (2015b) provided various highly detailed data that were necessary for both GIS and simulation modelling.

Table 2-1 Summary of data sets used in the research and their sources

Data type	Data details	Sections applied	Data Source
Resident Population	➢ England population ➢ Resident population in London and Borough of Hounslow	➢ 2.4.4, 5.1, 5.4 and 6.3	Greater London Authority and Office for National Statistics (2014) London Borough of Hounslow (2014)
Registered population	➢ Record of patients who are registered in GP practices	➢ 2.4,	Office for National Statistics and Greater London Authority (2015)
Healthcare attendance	➢ Number of A&E attendances for the period 2010 to 2015	➢ 2.4, 6.9,	Health and Social Care Information Centre (2015b)
Details on GP and Practices	➢ Number of GPs and GP practices	➢ 2.4.1, 2.4.4, 2.5, 3.4, 3.4, 3.8, Ch.4 Ch.5, Ch.6 & Ch.7	Health and Social Care Information Centre (2015a)

GIS	➢ Populations, households, concentration of households by LSOA, MSOA	➢ 2.4.1, 2.4.3, 2.5, Ch.5.	Office for National Statistics (2014)
Geographic Network data	➢ Ordnance Survey Open Data ➢ Spatial database – UK open data	➢ 2.4.1, Ch. 6, Ch. 5, & Ch.6	Downloadable from https://www.ordnancesurvey.co.uk Downloadable from website, www.data.go.uk
GP-patient consultation	➢ Trends in Consultation Rates in General Practice - 1995-2009	➢ 4.6, 4.5,	Q-Research (2009)
GP- patient on healthcare access	➢ GP-Patient survey	➢ 4.6.1, 5.4,	Q-Research (2009); Ipsos MORI (2014)
Multiple deprivation	➢ Index of multiple deprivation (IMD)	➢ 5.2.5, 5.4	Department for Communities and Local Government (2011); Ipsos MORI (2014)
MSOA, Borough CCG	➢ CCG and IMD rank ➢ postcodes	➢ 5.2.5, 5.4, Ch. 6	(NHS England, 2014a) Department for Communities and Local Government (2011)

2.4.2 Data quality

In all research, data quality is paramount (Chapman, 2005). Data quality means that the data used in research reflect the true phenomena being researched (Wang and Strong, 1996). Quality data can be obtained in different ways, and various authorities look at data quality differently. Some emphasise the data collection method while others refer to the method of storage, update and retrieval (Chapman, 2005). Irrespective of how well a data management system is perceived, there are possibilities that data can be contaminated in various ways, for example, by a storage method, transference from one point to another or the mode of retrieving the data (Ballou and Pazer, 1985; Wang and Strong, 1996). Since all databases have potential errors, “fitness for use” has been adopted as one of the ways researchers can assess the quality of real data (Wang and Strong, 1996). Data quality for this research was assessed in two ways:

1) The Fitness of use. This is where the data are deemed strong enough to support the conclusions and interpretations of the queries raised in the research (see, for example, Nahm, 2012).
2) Data Source. Most of the data sources were those of the British government. As such, these databases were deemed reputable and respected. The data possessed characteristics such as being contemporary, up-to-date, relevant, consistent across sources, reliable and accessible. It is suggested that the government has the means to define, collect and store data that can be considered to be of good quality.

2.4.3 The Output Areas (OAs)

According to the Office for National Statistics (2011), Output Areas (OAs) are the smallest areas where census data have been collected. OAs have been used in Britain to report on particular aspects of small areas. To expand the usage of OAs beyond population and census, Super Output Areas (SOAs) have been created. SOA relates to an area where a given set of data is collected to explain the characteristics of the area in terms of its resources and services. From the geographic and economic stand point, it explains the trajectory of the transformation of the area and the wellbeing of the population especially its level of deprivation (Office for National Statistics, 2011). SOAs are made up of Middle Layer Super Output Areas (MSOAs) which in turn are composed of Lower Layer Super Output Areas (LSOAs). This is explained in the sections below and further details can be found in Appendix 7B. In this research, MSOAs and LSOAs are used to examine the relationship between process design, healthcare demand and effects on A&E attendance.

LSOA and MSOA

Data have been collected from LSOAs, which are smaller areas in England and Wales, providing detailed characteristics of those area. A typical LSOA possesses a postcode and has a minimum population size of 1,000 and maximum 3,000, a minimum number of households of 400 and a maximum of 1,200 (Office for National Statistics, 2011). In this research LSOA data have been useful in the case study design of the London Borough of Hounslow.

MSOAs are larger areas in England and Wales with a minimum population size of 5,000, maximum 15,000, and a minimum number of 2,000 households and maximum of 6,000. A borough is made up of a number of MSOAs. In this research MSOAs were used in the London case study design for the development of catchment areas for A&E operations (see Appendix 8 for details).

2.4.4 Registered and resident population

Registered patients or GP-registered patients are people whose personal and medical details are recorded and held in the register of a doctor. By registering, they become the market of healthcare in the country and can demand and access healthcare anywhere in England even though affiliated with a particular practice usually near their residence. However, they may not reside in the particular borough or town where their GP or hospital is located (HSCIC, 2014b).

Resident population, on the other hand, is the actual number of people who normally live in a region, town, borough or SOA. There are instances, though, where registered population is higher that resident population. For example, in the MSOAs of London, the total numbers of registered patients was recorded to be higher than the resident population (Office for National Statistics and Greater London Authority, 2015). In the London Borough of Hounslow (2014), 13% of registered patients lived outside the borough.

There are more GP registered patients than registered population for reasons such as registered patients residing outside the area but accessing healthcare in the area and vice versa. Patients may have moved or died but their data are still maintained in the database. Also, GP practices may have inflated patient numbers, compared to the reality (Harper and Rai, 2014; Savage, 2015). Both population and registered patient data are used in this study in various ways.

2.4.5 Ethical consideration

Ethical approval for this study was obtained from the Research Governance Office (RGO) at the University of Southampton, through the ERGO system administered by the Southampton Business School. Given that this research was not associated with direct interaction with individual patients or hospitals, this level of ethical clearance was deemed sufficient.

2.5 Data analysis

The data analysis was undertaken in the following ways.

2.5.1 Spatial data analysis and ArcGIS application

Spatial data analysis is done through analysing data developed from geographic information. Thus this is examined through the geographic information system (GIS) which analyses and calculates locations, both for the catchment area analysis in London, and for the locational analysis in the Borough of Hounslow. The ArcGIS extension, location-allocation, was used to solve location-allocation problems related to choosing the best locations from a set of input locations. It was also used to calculate and illustrate population density, postcode structure and population intention to access the nearest healthcare delivery points.

The aim of adopting GIS was to support the process design perspective of this research. The academic attribute of GIS has been shown to be useful in practice, whereby data developed and applied to research are mathematically analysed to reflect spatial analysis, predictive modelling, cartography, and visualisation in maps (Pratt *et al.*, 2014). This makes the exact location and survey coordinates of a place with specific characteristics to provide answers to queries with the aid of a computer system (Doi *et al.*, 2013). From the OM perspective, one of the challenges faced by healthcare managers, planners and policy makers in the past has been to locate healthcare facilities without considerable attention given to the optimal location attributes (Pratt *et al.*, 2014). Location-allocation is one of the core benefits of using GIS in this research. Its power was to support the undertanding of improve access, identify sources of problems, especially operational problems such as impedances, distances, support improvement in process connectivity and flows, and ease system congestion by relocating care delivery points to other accessible areas.

The GIS provides a computer generated model where the assembling, processing, keeping, visualising and presenting of geographic information is carried out (ArcGIS, 2014). Its success lies in the careful application of the geographic, scientific framework

(GISci), which governs the methodological assumptions that data analysed would be objective, transparent and can be the reproduced (ArcGIS, 2014; Luo, 2014).

To apply ArcGIS in this study, Esri's ArcGIS 10.3™ software was downloaded from the iSolutions platform of the University of Southampton and installed on the computer. The data that were imputed into the software were obtained from the London Councils (2014); Office for National Statistics and Greater London Authority (2015). This was both spatial data arranged in Microsoft Excel and saved in Comma Separated Values (CSV) format, which fits the software better. The location of A&E departments were obtained using grid references which were collected manually. The reason for this was to adjust for departments no longer operational and relate A&E departments that were managed by one provider (see for example Section 5.3.1, Table 5-5). For example, it was possible to identify that two A&E providers were located in the same place in Croydon - Croydon Health Services NHS Trust and Croydon Urgent Care Centre (UCC). (Appendix 9A and 9B).

To perform location-allocation analysis, network infrastructure was collected separately from Ordnance Survey Opendata (2016). This map was made up of all recently updated road networks in the UK. The section that fitted London was shaped and extracted, and unnecessary layers that could affect the solution were removed. The network was calibrated to conform to the base map obtained from the ONS since the network and base map came from separate sources. When this was successfully adjusted, the base map was set, followed by the network, next by postcodes and finally population. The candidate locations for hubs were selected. Chapter 6 provides additional explanation of this, including how the Near tool in ArcGIS was used to locate GP practices and access directions, and how Google Map was used to calculate distances within catchment areas from patient locations to A&E access points.

2.5.2 Descriptive statistical analysis

Descriptive statistics were used to summarise and explain the variation of results obtained from the large sets of quantitative data on A&E, LSOAs and MSOAs in England, London and the London Borough of Hounslow. This also helped to filter and clean the data such that the various phenomena presented in this study could be better explained. In this regard, graphs, tables and charts have been used to explain various results. Data filtering and cleaning is explained and presented in Chapter 5 (Section 5.2.2).

2.5.3 Regression analysis

Regression analysis was combined with the results of the catchment area analysis to assist the explanation as to why patients choose to access A&E over other urgent care delivery access points. From the data, large number of patients (68%) who accessed A&E in London were not admitted and so regression analysis was carried out to examine the drivers for this. As such, the dependent variable was non-admitted A&E patients. It was observed that increases or decreases in the number of non-admitted patients could be driven by the following (see Section 5.1)

i. Process design or accessibility factors
ii. Patient behavioural factors
iii. Population factors

The independent variables also included the numbers of GPs, the number of practices and their sizes (number of single-headed GP surgeries), the population, registered patients, IMD, timely patient access (24hr) to GPs, distances from A&E, and more. Regression and multiple regression (MR) approaches were used because, given a small number of data points, there could be skewed outcomes and data over-fitting. More detail on the regression analysis is presented in Chapter 5.

2.5.4 Simulation analysis

The simulation approach was used to investigate the process related problems affecting unscheduled urgent and emergency healthcare and its effects on A&E capacity. The software, Simul8 (http://www.simul8.com/), was obtained from the University of Southampton's I-solution software portal. The student version was sufficient to to build the models needed, as shown in Chapter 6. Simulation modelling was used in three ways: (1) To investigate the current operations situation in UUEC, (2) To perform what-if scenarios that test the robustness of the NHS "pyramid" proposal (see Section 4.9). For example, what will be the effects on A&E capacity of 50% or 25% of patients accessing urgent and emergency health care the "right" way according to the NHS proposal? The simulation analysis is described in Chapter 6. (3) To develop and test models of the UC hub proposal (see Chapter 4) and scenarios as presented in Chapter 6.

2.6 Combining GIS and simulation

GIS modelling and simulation were combined to present hybrid models presented in this study. Since this research involved UUEH, it was imperative to examine the effects of influences that lie far beyond the care delivery points (for example, Richardson and Mountain, 2009). The modelling posits a situation where UC was decentralised away from the A&E department. As such, the location of these points were geographically selected and tested for location efficiency and then simulated to determine effect on access to them and on A&E capacity. This phenomenon can be seen in Chapter 6.

2.7 Experimental Case Studies

The case studies were developed to demonstrate experimentally the model of how a UUEH delivery process could be designed. Using London and the London Borough of Hounslow as case studies, data for their analysis were generated from Greater London Authority and Office for National Statistics (2014) to investigate problems and perform various location allocations of UCHs to test the effects of demand on selected locations with ArcGIS. Then simulation was used to perform different scenarios to determine their appropriateness. The use of these case studies demonstrated how process management models can be applied to real world situations.

2.8 Summary and conclusion

This chapter has described the research methodology and methods used to conduct this research. This research is in the positivist paradigm, utilising quantitative methods. Case studies are added to support the development of new theory and seek a better research design in a fast-changing environment. After a comprehensive literature review, the grounds for adopting a positivist approach were strengthened by the fact that although process management has been researched, there was the need for an analytical approach to show the extent to which it has been efficacious given the structural process manner in which healthcare is delivered. This is problematized in that effective management in the area requires a “process view”, similar to that described by,(for example, Lockamy and McCormack, 2004; Maddern *et al.*, 2013)). Using existing theory of process management, the scientific base is developed and formulated in a deterministic manner. This is done by assuming that, under current circumstances, poor process management causes the type of capacity and demand issues faced by the A&E department. The approach therefore is to discover the specific nature of cause and effect relationships with reference to the delivery and management of UUEH. The hypotheses developed and tested in the research process relate to process orientation (see for example, Kohlbacher, 2010).

Chapter 3 A review of process management methods, their design and implementation in healthcare delivery

This chapter is influenced by the research question:

How has the process management approach been researched and implemented to support healthcare delivery management?

The chapter, therefore, presents definitions of different process management methods, reviews the literature and summarises their usefulness to healthcare delivery management. It concludes by assessing the efficacy of process management methods within healthcare delivery management.

3.1 Background

The growing complexity of production systems has attracted increased calls for the expansion of research in process management in most operations including services (Maddern *et al.*, 2013). This is because, while processes are sequences of activities that convert inputs into outputs, they are implemented within systems (Van Der Aalst *et al.*, 2003; Schonenberg *et al.*, 2008). As such, the past 10 to 20 years have seen an expansion of the research and adoption of various process management methods and models in production operations within different types of sectors (Lusk *et al.*, 2005).

It is increasing held that organisations that adopt process management observe positive benefits in their operations (Hellström *et al.*, 2010; Kohlbacher, 2010). So far, an enthusiasm for the benefits of process management has been shown more by non-healthcare delivery organisations. Within the healthcare sector, various reports (for example, Appleby *et al.*, 2011; Foundation Trust Network, 2013) and studies (for example, Proudlove *et al.*, 2007; Weber *et al.*, 2011), have cast doubt on whether the efforts to improve performance through process management are being realised. Given that process management is more than just the application of a process method to the organisations' operational processes (Armistead and Machin, 1997), the following sections will examine how the healthcare sector has defined and applied process management, and the level of efficacy thereof. Before considering further "Process management", the term "process" is examined.

3.1.1 Definition of "Process."

Different authors and organisations have defined the terms 'process' differently, given its wide usage within a variety of environments. The following is adopted as the working definition of process from the operations management (OM) perspective.

A process in OM refers to an organisational method conceived to enable the use of productive resources reliably, consistently and in a repeatable manner, aimed at meeting fundamental economic objectives (Zairi, 1997, p. 64). According to the above definition, a process:

- is predictable and possessing definable inputs;
- contains a linear, logical sequence or flow;
- is made up of a set of clearly definable tasks or activities;
- produces a predictable and desired outcome or result.

Other characteristics of a process according to Bal (1998) include the following:

- Functional design, which reflects the activities or elements of the process that is being performed.
- Behavioural aspects, which relate to when and how the process is being performed.
- The organisational considerations, which reflect "who" is performing the process and the mechanism through which there is interaction or transfer of content.
- The informational view, which represents the information details or entities that are being manipulated by the process; these can be data, product and entity details.

Many researchers of healthcare delivery management (for example, Kohlbacher, 2010; Nilsson and Sandoff, 2015) recognise these characteristics and, as such, these types of attributes will be used in the analysis that follows. Nevertheless, the complex nature of processes in OM means that processes have to be managed so that they behave as expected.

3.1.2 Process management and its origin

Process management is the rigorous effort made to define, map and design processes as required by an organisation's production and delivery expectations (Ding, 2015). The rationale for this is that an organisation's system is made up of various processes, crisscrossing the organisation's departmental boundaries, which need to function and adhere to the organisation's production expectation collectively. Processes, if left unchecked, have the tendency to promote and foster bottlenecks, barriers and holdups that create operational 'islands' within organisations. The quest to make processes work in an interlinked manner to promote the flow of synergy is one of the most difficult issues faced by healthcare deliverers (Hellström et al., 2010). However, many organisations within the manufacturing sector have been benefiting from better process management for many years. It has been argued that this situation has helped transform operations in those sectors, leading to consumers enjoying cheaper and higher quality products (Langabeer and Helton, 2015).

The demand for increased process management in modern times can be traced to the work of advocates of quality improvements and the quest to adopt Total Quality Management (TQM) in organisations (Oakland, 2003). It can also be attributed to the Japanese who have included quality in both organisational, production and product output (Cooper and Slagmulder, 1997). Further, process management has been rooted in studies such as economics, theology, anthropology, sociology and psychology (Armistead *et al.*, 1999). Process management can also be detected in Systems thinking (Checkland, 2000), system dynamics and cybernetics (Beer, 1966), Operational Research (Churchman, 1970) and Information Systems (IS) (Earl, 1994; Jansen-Vullers and Reijers, 2005b). Today the drive to adopt and apply process management continues, and has spread to various aspects of production and almost all industries.

Process management has a long history, emerging from the manufacturing sector in the 1700s, where there was the need to understand how to make the various intricate links that were developing within expanding manufacturing work well (Mansir and Schacht, 1989). This transformed into the paradigm which became known as "process thinking", postulated by early economists such as Adam Smith and engineers such as Frederick Taylor (vom Brocke and Rosemann, 2015). Process management enabled the study and development of means to improve steps and stages of production such that they are organised and traceable in the pursuit of better production practices. With the need to understand how to record, test, assess, improve and assign management oversight to process and production (Weske, 2007), scientific approaches became established, for example, Taylorism (Voss, 1995). Scientific management enables process researchers and managers to advocate and seek scientific ways of understanding and designing processes so that they become efficient, effective, and cheaper to aid production and outcomes.

Frederick Taylor, back in 1911, measured operations within manufacturing processes by recording and measuring time and motion, which were statistically analysed, justifying the term scientific management (Chase, 1980). This led to the emergence of various related techniques, methods and approaches as observed today. Most of these techniques and methods have different ways of analysing process management, for example, Lean management, just-in-time (JIT) and Toyota production system (TPS), which seek efficiency of resource utilisation and cost management (Voss, 1995; Nahmias, 2005). Other process methods are aimed at improving quality in the production process and products, for example, Total Quality Management (Oakland, 2003) and the quality improvement theory (Deming, 1986). Others used the process idea to strengthen the development of organisation theory (Burrell and Morgan, 2005).

The success of process management in the manufacturing and other sectors, whilst healthcare delivery struggled with process inefficiencies, encouraged many researchers to seek ways to migrate the knowledge into the health care sector (Hellström *et al.*, 2010). In the mid-1960s, Donabedian (1966) examined and proposed process thinking in healthcare to assist the integration of its fractured processes with the delivery method. He pointed out that the nature of healthcare delivery favours robust process improvement models in line with manufacturing. According to Chase and Apte (2007), the principles of scientific management provided the origins of process management when first applied in health care management. They identified studies which showed the design of a lateral organisation of operating rooms and how they could be set up in a more process-facing manner, which in turn facilitated the work of the doctors and nurses, and eased supplies.

From the above, it shows that process management has evolved within many organisations and in the healthcare sector. This makes it necessary to examine the ways that process management methods have been defined and adopted, and how they have been efficacious in aiding and improving healthcare delivery management.

3.1.3 The main approaches to Process Management

There are many ways process management can be designed to reflect an organisation's needs (Nilsson and Sandoff, 2015). One of the ways is through the implementation of process orientation (PO). By this approach, the organisation adopts a process management method and applies it to the whole production unit (Kohlbacher, 2010). Authors such as Maddern *et al.* (2013) identify this type of approach as end-to-end because the process architecture is mapped from the initial customer request to customer fulfilment.

A second way is to apply process methods independently in different sectors. Here a particular process approach is adopted and applied to particular departments sequentially or incrementally. This can occur by adopting process method like Business Process Re-engineering (BPR) or Lean, and could be described as a cure to a particular management problem in that sector (Grover and Malhotra, 1997). Many types of process management such as Business Process Management (BPM) or Lean follow this line of thinking. For example, Houy *et al.* (2010) argued that many studies of so-called BPM mostly concentrate on narrow research questions, with limited attention given to the end-to-end aspects of process management.

Thirdly, a process implementation can also be achieved when a process method is applied to specific operations, for example, a particular treatment approach where a specific Value Chain (VC) is designed (Porter and Teisberg, 2006). It shows how a treatment, for example, is performed and defines all those process components that make the treatment economically viable.

3.1.4 Why adopt process management in healthcare

There may be many reasons why healthcare organisations want to adopt process management in their operations' practices. Looking at it from the NHS perspective, the following are reasons why process management may be deemed valuable for healthcare delivery management:

➢ Producing care delivery steps that are valuable for a particular healthcare structure. Elimination of non-value-added steps or stages.

➢ Making healthcare delivery visible to both patients and workers, for example, making access points clearer.

- Managing costs
- Integrating various departments to reflect the nature of healthcare delivery; reducing bureaucracy and bottlenecks and managing capacities.
- Improving the management of the healthcare system and making it sustainable
- Functional management is found to be unproductive in many studies when compared to a process management approach.
- Making the healthcare system dynamic and able to welcome new ideas and technologies.
- Meeting quality, wellness, and safety and patient satisfaction requirements.

To investigate how process management in healthcare reflects the above and to determine the level of efficacy, the first step is to pursue a comprehensive literature review beginning with process orientation.

3.1.5 Process orientation (PO)

One of the ways organisations are adopting process management is to adhere to the principles of PO. This idea has been articulated, for example, in the works of Davenport and Short (1990), Porter (2008) and vom Brocke and Rosemann (2015). The main idea about PO is that organisations operate in an integrated and systemic manner rather than as a collection of individual functions (Reijers, 2006).

Advocates for PO argue that the fact that production operations run from end to end makes operation and outcomes better visible and the production process can be adjusted to meet the demands of changing times (Maddern *et al.*, 2013). The increased flexibility facilitates an understanding of customer needs and quickly translates them into production, alongside meeting modern day requirements such as tailoring products and services to individual customers. It also provides a rapid market presence and delivery, and ensures overall customer loyalty and cost reduction (Maddern *et al.*, 2013). With departments fully integrated, there is an increase in the flow of information and knowledge such that an error in any part can be quickly resolved before any damage to the production line occurs (Ding, 2015). In adopting PO the following actions are taken by the organisation as suggested by Kohlbacher (2010).

- Process design and documentation. To realise PO, the process structures, links, points and direction of operations need to be known. These are production and delivery steps and stages, relations with internal and external activities and businesses linked to the main frame of the organisation's operations. Because they are documented, they are re-examined over time to assess the extent to which they meet changing times.

➢ Top and middle management support for process management efforts and related programmes. Lack of such support would be one of the reasons for the failure of a process structure even if the best approach were developed and adopted (Van Der Aalst *et al.*, 2003).

➢ The presence of a process owner. The owner, who has the requisite authority, agrees to the type of process that the organisation will develop and execute, and confirms the type of model to be implemented. The owner appoints the process manager and ensures that the process is designed and implemented efficaciously (Kohlbacher, 2010).

➢ The process is measured, monitored and assessed for performance effectiveness (Al-Mashari *et al.*, 2003).

➢ PO as organisational culture. Where the organisation chooses to design operations along process rather than functional lines. A typical example is the Toyota Production System (TPS) which has made Lean, and TPS look like a management model just because of its process nature (Spear, 2005; MacCarthy *et al.*, 2013).

➢ Where there is a start point and an end point, for example, lateral end-to-end relating from customer need to customer satisfaction (Kohlbacher, 2010; Maddern *et al.*, 2013).

Achieving PO is hard. According to Hellström *et al.* (2010), discussing, planning and implementing PO is easier than achieving it. They suggested that challenges such as the organisation itself have the potential to be an obstacle to implementation. This relates to issues such as culture that can be difficult to change. For example, strong employment representation in the workplace might interpret a PO drive as a way or plan to reduce the workforce and other workers' benefits. In other cases, top and middle management might not see the reasons to support PO efforts if it weakens their authority and progression prospects (Grover and Malhotra, 1997). Some departments enjoy isolation and could resist an attempt to encourage PO. Other factors such as poor communication, lack of readiness to change, lack of cross-functional co-operation or the pressure to adopt PO may become stronger than the capacity to absorb it (Al-Mashari and Zairi, 1999).

While there has been interest in PO, tailoring process approaches to particular industries and the development of a specific strategy for its implementation could be a leading success factor. Process management and related philosophies in OM are usually very conservative in nature, given its techniques structured outlook. There is the need to explore in-depth the relationships among organisational architectures, production strategy, management behaviours, and innovation tendencies in order to achieve process management in organisations.

However, despite the view that PO is perceived to be a better approach for organised operations and organisations that adopt it, there is limited empirical data which show that organisations adopt PO in real world operations (McCormack and Johnson, 2001; vom Brocke and Rosemann, 2015).

3.1.6 Process orientation in healthcare delivery management

Healthcare delivery is a process operation but attaining PO within the healthcare system has remained a major challenge (Gonçalves et al., 2013). The perceived benefits of PO to organisations according to the plethora of literature, added to the need for modern health care delivery to improve interdepartmental co-operations, has increased the drive to instil PO in healthcare delivery (Drupsteen et al., 2013; Nilsson and Sandoff, 2015).

PO in healthcare presupposes a situation where the process management attributes presented in Section 3.1.5 are recognised as a standard operational approach throughout the care delivery chain. One of the ways PO is justified in healthcare delivery management is through the use of pathways (Maycock and Shaw, 1994; Vissers and Beech, 2005). A care pathway is a guide or route, which patients take to access health care within the system. Care pathways set out a process of best practice expected to be followed in the treatment of a patient with a particular condition or need (Endacott *et al.*, 2011). A well-designed pathway shows a map or steps patients use to access the treatment that is necessary for them at the time of demand. It can also demonstrate the movement of patient records within the system. As such, a dynamic care pathway enhances the quality of care by improving patient outcomes, promoting patient safety, increasing patient satisfaction, and optimising the use of resources in changing times (Mould *et al.*, 2010; Endacott *et al.*, 2011). Despite this though, care pathways have been criticised for lacking the benefits of person centred care and dynamism, for failing to adhere to changing times, and for regressing to a tick-box exercise with “too much pathway and too little care” (see, for example, Julia *et al.*, 2013). The lack of PO is supported by a report in which the Liverpool Care Pathway exposed vulnerable patients to life threatening harm because the pathways were not well managed and they included very weak controls (Julia *et al.*, 2013 p. 16). On the whole, studies show that healthcare delivery organisations that adopt PO benefit from operational efficiency (Vera and Kuntz, 2007; Nilsson and Sandoff, 2015).

Despite the enthusiasm and promises of PO, there are some challenges to meeting PO in healthcare. Drupsteen *et al.* (2013) found in a study of PO in some Dutch hospitals that, when process improvement approaches such as sharing waiting list information, sharing planning information, cross-departmental planning, and combining appointments were observed, performances improved. They also pointed out that the overall level of integration in the hospitals studied was poor.

Nilsson and Sandoff (2015) explored the role of the process managers in attempts at introduction of process management in the Swedish healthcare system, and found a lack of clarity regarding their responsibilities and work content. There was also poor communication of the role of process managers to staff involved in the patient care and treatment process. Within the NHS, there is evidence that effort to improve processes and related management of care delivery has been affected by the fear of embracing change (National Institution for Health and Clinical Excellence, 2007).

One of the criticisms of the application of process management in health care delivery is that much focus is granted to the internal workings of the treatment centres such as hospitals and A&E departments. The optimisation of the whole healthcare system to understand how all the access points interact during different times and circumstances has been limited (Richardson and Mountain, 2009). This has created an opportunity to seek other ways of identifying the impact of alternative emergency care pathways for the delivery of UUEH and how to manage capacity problems within the A&E department (Crawford *et al.*, 2017)

Many of the process management related research studies in healthcare management have been designed for scheduled healthcare needs. Unscheduled healthcare management does not seem to have received much attention. While efforts have been made to design access points aimed at connecting such patients to healthcare, there is evidence to suggest that these points are either underused, unknown by patients, confusing to patients or poorly located (NHS England, 2013b).

It has been said that PO has potential for the healthcare sector, given that care delivery is a process activity, and those that have attempted to enforce it report benefits. However, the general healthcare delivery efforts continue to be negatively impacted by process and management operations' failures (Longenecker and Longenecker, 2014; Crawford *et al.*, 2017). Implementation of PO models are varied, complex and time-consuming. This is why different factors influence the ease of and the success, if any, of process management in organisations. From the healthcare perspective, there is limited evidence from the studies described in the current section of this research that PO has been efficacious, as most of the criteria presented in Section 3.1.5 have not been met.

In the next section, process methods and their application in healthcare delivery are considered.

3.2 Process methods

Process methods are specific techniques adopted to pursue process management in organisations including healthcare delivery. While PO primarily calls for the management of processes, process methods adopt particular models, which are believed to contain attributes that support process efforts in organisations. Examples of the most common ones are Care Delivery Value Chain (CDVC), Business Process Reengineering (BPR), Business Process Management (BPM), Lean Management, Process mining (PM) and Total Quality Management (TQM).

3.3 The Care Delivery Value Chain

CDVC is developed from Value Chain (VC) analysis which comes from the work of Porter (1990). Its main idea is that organisations can become competitive by transforming their systems and subsystems into processes that form an interlinked chain. To achieve operational effectiveness, each chain is monitored, and its contribution in value to the organisation is assessed. That chain is then eliminated, modified or maintained, depending on its contribution or value to production delivery within the system. Burns *et al.* (2002) presented two major chains within the VC, namely the systemic and the sub-system chains.

1. The systemic chain governs the productive activities within the whole firm that allows it to produce and deliver as a unit. At this point, the firm acquires inputs such as raw materials, capital, labour, and so on, and integrates and processes them to achieve products and services (output) through various stages.

2. The subsystem chains link activities across firms. Here the production process occurs such that the outputs of one set of firms become an input for another set of firms. These firms deal with the contribution of suppliers, competitors, distributors, and customers. The level of value creation by a given firm within the chain helps relate its contribution to the value creation of the whole inter-firm chain of the operation.

This classic way that VC is viewed and applied to business operations has been deemed effective in making organisations achieve PO (Nahmias and Olsen, 2015). This idea has also been transferred to the organisation of healthcare delivery management (Burns *et al.*, 2002). In healthcare, it is known as the Care Delivery Value Chain (CDVC).

The CDVC works in a similar way as described above and is used to visualise the healthcare system; it breaks down the various delivery units of the value creation process into primary activities and support activities (Burns *et al.*, 2002; Porter and Teisberg, 2006). It provides the steps and stages a treatment takes both within and outside the healthcare system for particular types of illness. Treatment outside the healthcare system occurs in communities and residential areas. CDVC shows the life cycles of treatments, their associated costs and how care deliverers can be reimbursed. It also demonstrates how care can be easily integrated across separate facilities of the healthcare system such that they operate in an integrated manner. It supports dynamism and attracts new ideas of production such as changes in technology, for example, the use of IT platforms aimed at improving patient flows and access.

One important aspect of the CDVC has been shown in the work of Rhatigan et al. (2009). Here they describe and illustrate how the CDVC was designed and applied in the treatment process for HIV/AIDS in a challenging environment with limited resources. The VC itself had been criticised for providing limited accompanying theory in the literature to aid the identification of specific hypotheses and propositions, which can be tested (Al-Mudimigh *et al.*, 2004). Despite the criticism of VC or its subset CDVC, this application to HIV/AIDS was an excellent way to exhibit the utility of the CDVC.

This study examined a situation where HIV/AIDS, a deadly disease, faced treatment challenges in areas where poverty, malnutrition, political instability, bad infrastructure and difficult data gathering were common. The principles of the CDVC enabled the development of a systemic approach beginning with a care cycle. The cycle shows the situation before patient infection and the journey through the struggle with the disease until death. This helped build activities within the chain as treatment interventions within the care cycle. It describes how it was possible to evaluate the sequences of activities needed to provide value for patients. It demonstrates how improving coordination across activities was carried out with the appropriate human resources and how they were strategically deployed across the care cycle. It also presents how facilities should best be designed to enhance value, and how information should be shared among activities (Rhatigan *et al.*, 2009).

One challenge with this study, as with many related studies of CDVC, is that the design fitted one particular health problem only. The cost-effectiveness of these types of single interventions could be improved if a more complex set of delivery value attributes were performed.

The CDVC is a process model that seems to have been effective in supporting the delivery of healthcare. Despite that, a weakness of CDVC includes limited consideration of unscheduled care demand. There seems to be more interest in managing cost than other attributes within the healthcare delivery cycle. This could explain why the US healthcare system, which appears to adopt CDVC more, is characterised by over-medication of patients as opposed to the investigation and identification of causes, and provision of long term treatment cycles (Morgan and Kennedy, 2010). Despite many CDVCs for various individual treatments, there are none that govern the working of the whole healthcare delivery system. Also, it appears that post-hospital care shown in the CDVC is mostly ignored in the real-life strategic treatment process (Rebuge and Ferreira, 2012).

The process idea contained in CDVC exhibits efforts to apply various forms of process management within healthcare delivery. The fact that it has been applied sparingly has not solved common outside-hospital and unscheduled healthcare problems and so its efficacy as a whole system process is questioned.

3.4 Business process re-engineering (BPR)

Although the BPR concept became popular in the 1990s, some researchers suggest that re-engineering thinking has its roots in the management theories of the 19th century (Nahmias and Olsen, 2015). For example, Taylor suggested back in the 1880s that organisations should adopt a process re-engineering perspective rather than functional approach to improve production operations (Earl, 1994).

BPR, as it is known today, emerged from the need to improve organisations' operation processes (Al-Mashari and Zairi, 1999). After the publication of the book *"Reengineering the Corporation"* (Hammer and Champy, 1993), BPR immediately became popular. This popularity expanded research and gave rise to many other connotations and attributes (see Appendix 1B).

3.4.1 Definition of BPR

Different authors have defined BPR variously as the need for a process rather than functional design of operations became important. In this research the definition provided by Hammer and Champy (1993 p. 32) has been adopted whereby BPR is " a fundamental rethink and radical redesign of a business process to obtain dramatic and sustained improvements in quality, cost, service, lead time, flexibility and innovation"..
The main characteristics of BPR include:

- A total redesign or restart of an organisation's production process
- A specific sequencing of work activities across time and space
- A visible beginning and an end of operations (orderly structure of operations)
- Clear definition of inputs and outputs
- Customer-focus and customer value (internal or external)
- Defined use of resources

- Horizontal rather than top-down organisation and operations
- Strong application of IT

The need for operational efficiency, cost reduction, quality enhancement, service quality, response time to the market and competitors were attributes that organisations needed to achieve through the adoption of BPR (Davenport, 1993; Hammer and Stanton, 1999). Success is assessed from improved financial benefits, increased sales, returns on investment and expanded market share, and an organisation's sustainability with changing times (Hammer and Champy, 1993).

BPR gave a picture of how organisations' operations could change in the future; increasing process application is observed in today's changing business landscape (Hammer, 2015; vom Brocke and Rosemann, 2015; Harmon and Wolf, 2016). Healthcare organisations are also applying the BPR attributes to their operations (Nwabueze, 2000; Elkhuizen *et al.*, 2006).

3.4.2 Business process re-engineering in the healthcare sector

The process characteristics promoted by the BPR and its promise to promote the interaction among the different sub-systems within the healthcare delivery system encouraged its exploration and adoption in healthcare delivery management (Nwabueze, 2000; Helfert, 2009). For example, Ho *et al.* (1999) found, in an investigation of possible BPR adoption in hospital management in the USA and Canada, that about 215 managers agreed to apply BPR. They also reported positive benefits such as improvement in service quality and financial performances.

In the NHS, McNulty and Ferlie (2004b, p. 1399) provided an example of the evolution of a BPR program in a hospital. In September 1992, five projects were started as part of the Regional Health Authority's project called Sigma Initiative. It was a form of re-engineering to improve management aimed at meeting quality expectations in outpatient services. This initiative continued with incremental programmes until August 1997 where the language shifted from radical performance transformation to re-engineering intervention. Other BPR initiatives were launched as health authorities struggled to improve quality, reduce costs and increase access and flows (Leverment *et al.*, 1998; Nwabueze, 2000).

One main problem that has affected the NHS has been fragmentation and sectorial independence. Since BPR promised solutions to these types of problems, adapting it to the healthcare systems was an opportunity to infuse a new management 'blood' learned from its success in other industries (Shortell *et al.*, 1995; Lapouchnian *et al.*, 2007). BPR possesses attributes that link organisations, departments and sectors together through cross–reengineering modelling where orgaisational transformation is encouraged to ease lateral movement of operations. For example Elkhuizen *et al.* (2006) showed in a study the extent to which BPR was being adopted to meet these limitations. They concluded that there was a strong relationship between meeting outcomes, reducing costs, improving access, patient flows, low waiting times, system sustainability and reliability with integration and process connectivity. They investigated the extent to which applying BPR in a healthcare organisation helped solve the problems above.

A total of 86 studies was found that conformed to the criteria of BPR. Most of the studies presented aspects related to BPR application to healthcare, and some possessed measurable variables. Significant inconsistencies were reported in the articles reviewed. There were inconsistencies between study objectives, and the reported results lacked conformity; for example, there were more issues reported in the results than mentioned in the study aims. Therefore, while many projects reported success, proper process design such as process maps, trails, and interconnectivity on processes was not exhibited. The successes reported therefore could not be justified, and the reason for these successes remains ambiguous.

Bertolini *et al.* (2011b) reported on efforts made to use BPR in optimising healthcare delivery efficiency in the Neurosurgery Ward of Parma Hospital in Italy. The aim was to indicate the most critical aspects of ward management processes and to propose alternative solutions for improving the service offered to the patients. They adopted a framework method based on event-driven process chains (EPCs) and discrete event simulation to define and investigate the way in which the neurosurgery ward was designed. They also assessed it, with a focus on improving service quality and workflow. A Delphi technique was used to overcome the difficulties that emerged due to the complexity of the healthcare system, which also hampered communication across departments. Combining these methodologies, the authors could concretely identify specific aspects such as the numbers of operating sessions, how each operating room was prepared for operation, the availability of specific surgical instruments among others as areas for improvement. Modelling Methodology, which supports the reuse of model-driven and component-based techniques and tools in application software modelling and design for workflow modelling, was proposed. As such, health information systems (HIS) were integrated through the adoption of stronger network communication technologies. Such integration aims at supporting collaborative healthcare workflows (CHWF) which are useful in sharing healthcare information and resources.

Despite all the methods used, Bertolini et al's (2011b) study did not provide the reasons for carrying out the re-engineering or describe how the re-engineering model design was different from that adopted by other industries. The healthcare system has various barriers and regulations compared to other sectors. The study did not show how these obstacles were being overcome, for example, "doctors [were] unwilling to accept change and … administrators [had] a short-term outlook," (Bertolini *et al.*, 2011b, p. 43) so that BPR efforts could be efficacious. With no clear reason for the project and targeted intervention, it has been hard to assess the effectiveness of BPR in this case. Even if there has been success, it would have been hard to tell whether it was a direct effect of the process design or model.

Hospital Care Assistance Process Re-engineering (Coulson-Thomas, 1997) was a project carried out to show how and what effect the application of BPR could have on healthcare delivery management. The research was supported by the European Commission (EC), the British NHS and Spanish care delivery organisations and it focused more on in-hospital operations rather than the whole healthcare system. Although no specific driver for the launch of the project was provided, the author suggested that process complexity in healthcare delivery inhibiting quality care delivery as well as cost management was a problem. To demonstrate the effectiveness of BPR, two pilot projects were carried out in two hospitals, where the cataracts ophthalmology process at the Luton and Dunstable Hospital in the UK and the oncology process at the Hospital General de Manresa, Spain were selected for the BPR operations. Hospital Care Assistance Process Re-engineering that required integrated Information Technologies (HOCAPRIT) and an IT-enabled solution as a core was pursued.

Coulson-Thomas (1997) concluded that “re-engineering” can be applied beneficially to hospital and healthcare processes. However, the specific process structure described was not very clear. Instead of narrating the general problems already known to affect the healthcare system, specific problems that triggered the research and the two pilot projects were not properly explained. While the BPR model as described by Hammer and Champy (1993) referred to radical redesign, the BPR model here failed to provide a general perspective and how the type applied in healthcare could be modified to fit that industry. One benefit of this study was the utilisation of IT, a technology that showed signs of a greater role for enabling process management; the fact that the re-engineering involved hospitals in the UK and Spain shows efforts for cross-organisational co-operation.

In a similar vein, Francis and Alley (1996) examined the value of BPR in a surgical suite of a public hospital in Auckland, New Zealand. Change had been sweeping the New Zealand society since 1984, driven by the evolution of the country’s social welfare system in which a gradual introduction of the competitive market-orientated environment was taking place. In the midst, healthcare delivery was also caught in the change process. When new private healthcare providers came into the market, they met hospital and healthcare delivery processes that had been created in the 1960s, whereby the care delivery process followed a cost-plus model. This cost plus model, with it strong bureaucratic component, meant that final health care delivery became extremely expensive and made it hard for the new providers to get proper compensation for the healthcare provided. Also, staff attitudes and work practices had not changed, meaning that delivering required value was becoming challenging. Change was needed, and one of the models thought likely to improve the situation was the adoption of BPR. Improving communication with the adoption of IT systems, human resources department re-engineering and creating physical space were some of the ways BPR was designed for the improvement of patient-focus surgical services in public healthcare in Auckland, New Zealand.

One problem with this project was that even though it was adopting BPR and termed “process-aware”, re-engineering seems to have occurred in selected sectors of the hospitals and whole systems were not redesigned as well. Business processes are a series of interrelated activities, crossing functional boundaries with inputs and outputs, yet it was not shown how links were created from one department to the other. Some changes were indeed realised due to re-engineering, but the fact that re-engineering was not a whole system benefit meant that many operational problems faced by patients and workers remained and, as such, the efficacy of BPR in this case remains unconvincing.

Kwak and Lee (2002) observed that BPR could work well in healthcare process design but that it would be beneficial if the methodological structure were to be improved. As such, they proposed that a multi-criteria mathematical programming model (MCMP) with a goal-programming attribute in the model be adopted and applied in healthcare management. Their attempt was to improve the way BPR could be used in a complex organisations such as healthcare systems. As such, their aim was to improve on the concept by proposing another way in which it could be effectively applied.

After identifying that these problems could be tackled with the adoption of BPR, Kwak and Lee (2002)suggested that the BPR model should be modified with a proper mathematical design. They noted that although MCMP utilisation within BPR has been popularly used more in the financial sector and in OR related studies, it has not been adequately applied to operations that reflect a technological and strategic facing policies outlook of an organisation. As such, they argued that MCMP provides more power for BPR decision making when used to design strategic planning for business process infrastructure development. The complexity of the healthcare system and the fact that it has invested significantly in technological development to catch up with changing times, yet still struggles to reap the rewards regarding value, is important. Adopting the MCDM model will support improvements to the decision-making planning process and managerial policy within the whole healthcare delivery planning settings. Practically, however, it has not been shown to have been tested and assessed. Thus the efficacy of the approach remains obscure but provides a boost for theory development in OM research in healthcare.

Buchanan (1998) on his part examined the value of BPR for the construction and management of patient pathways to acute treatment in a Leicester General Hospital (LGH), an NHS Trust. The hospital, described as a 740-bed acute teaching hospital with 2,000 employees, struggled to provide the quality of services required, and this was blamed on operational problems with unaligned organisational and professional culture, values, structures and procedures. Additionally, common problems were observed in scheduling operating theatres, due apparently to unpredictability and variations such as patient conditions. This led to increased complaints from surgeons and anaesthetists; the clinical director for surgery was invited to seek solutions, and thus the director of human resources proposed BPR. Following the BPR approach, Buchanan (1998) recommended that they followed a revisionist approach rather than a redesigning perspective. In this way, the politics of problem definition and problem-solving, the importation of new working practices, and the visual representation of process were the directions of the model design. This was because the author agreed with the view that the term 're-engineering' was not appropriate for use in healthcare but that the concept of process orientation could make a significant contribution and should be considered.

3.4.3 Patient Process Re-engineering (PPR)

Patient Process Re-engineering (PPR) emerged out of a similar ideology to BPR, but this time the focus was on patient care in hospitals or the healthcare system. The perception was that placing the patient at the centre of the healthcare delivery process, just as customers are in normal businesses, can help improve care designed for them (Jansen-Vullers and Reijers, 2005a; Bertolini *et al.*, 2011b). According to Probert *et al.* (1999), PPR was designed to radically re-examine the way healthcare was delivered in hospitals in the UK. The model made it possible to carry out better scrutiny of the structural processes that drive healthcare delivery and a realignment of care delivery so that the patients are centralised. The work, therefore, is theoretically grounded through the definition and interpretation of the BPR concept.

Patient-focused health care, a core aspect of PPR, is challenging to define since it has been used differently in related studies. For example, terms such as "patient-focused care", "patient-focused restructuring" and "patient-centred care" have been used to refer to the same aspect (Newman, 1997). Therefore, there is a general lack of consensus on the key components that make up patient focus. However, according to the NHS Commissioning Board (2013), patient-focused healthcare refers to the tendency to design healthcare delivery systems such that patients are treated as customers, given respect, treated with compassion and their interests put first. It also relates to an organisational transformation where service offerings in the healthcare system operate in a way that patients take control and make choices that are more informed in their quest for healthcare.

According to PPR, patient care process improvement shifted from a departmental focus towards a process method where "patient-focused" was significant (Vogel, 1993). In exhibiting proper PPR, McNulty and Ferlie (2004a) presented six case studies in their book: "Reengineering Health Care: The Complexities of Organisational Transformation." It showed how the PPR or the Patient Focused Care approach was used to design and improve healthcare delivery in an NHS Trust: the Leicester Royal Infirmary Teaching Hospital, in the UK. The introduction of the NHS internal market, aimed at fostering competition similar to that observed in the private sector and in which patients were treated as clients or customers (Propper *et al.*, 2004), precipitated the adoption of BPR in the NHS. A milestone of the Re-engineering Programme in the NHS was mapped within the periods 1992 to 1997. For these particular departments and the Leicester Royal Infirmary Teaching Hospital, in particular, the reason for the request for transformation was that the Trust was under pressure to improve its management approach to meet the expected quality and value of healthcare delivered. Although BPR was being considered as a "Management Fad" in various quarters, the authors argued that, with the support from top management, various departments such as the A&E department among others benefited from process improvement (McNulty and Ferlie, 2004a).

Despite all efforts, McNulty and Ferlie (2004a) observed that obstacles to the success of process improvement were apparent. BPR and similar efforts should be designed to go well beyond re-engineering in order for any expected impact to be realised. For example, they suggested that re-engineering within UK hospitals was limited because managers and clinicians persistently operated along organisational forms characterised by vertical management principles (McNulty and Ferlie, 2004a).

Applying "Patient-Focused Care" through the PPR approach in Leicester Royal Infirmary (LRI) and the Peterborough Hospitals NHS Trust, Probert *et al.* (1999) identified reasons for transformation or re-engineering the health care process. These problems are similar to the socio-political, scientific-technical and environmental challenges reported in the introduction of this research. The main approach used to design expected process solutions was through the adoption and ownership of information systems (IS). Using IS, they streamlined admission systems, and brought workers together to foster communication and discussion at personal levels. Also, the new process was designed to link primary and secondary care to improve flows. Next, they re-engineered the dermatology diagnostic patient process where again, the IS model enabled faster, more effective communication between GPs and consultants. GPs could film the skin of a patient and wire the sample to consultants in hospitals, reducing problems such as slow transfer of samples, poor labelling, and loss of samples, among others.

Probert *et al.* (1999) identified a variety of successes of the PPR approach especially that it contributed to improved delivery and functioning of the healthcare delivery processes where the PPR approach was implemented. However, the authors stressed that re-engineering was not for all situations. It may go well with some patient processes or certain hospitals but fail in others where conditions are not favourable.

BPR for healthcare shows benefits to both organisation and patients (McNulty and Ferlie, 2004a). Re-engineering has contributed to reducing the pressure posed by out-of-date processes that were based on the welfare-humanitarian models which healthcare delivery was founded upon. Due to this, delivery operations were characterised by time wasting, and lack of accountability in process stages led to increased costs (Probert *et al.*, 1999). BPR ignited a different line of thinking about how to challenge the ways healthcare provision was pursued, thereby stimulating expanded studies of process improvement in healthcare delivery (Elkhuizen *et al.*, 2006). As such, researchers and practitioners have increasingly observed that the health care sector has some similarities with many non-healthcare delivery organisations regarding the ways processes could be conceived, designed and planned, but implementation could remain challenging (O'Neill and Sohal, 1999; Suvojit and Prashant, 2000).

3.4.4 Challenges of BPR in healthcare and assessment of efficacy

Despite the purported benefits of BPR in healthcare delivery, some major challenges have been identified in its pursuit. Firstly, despite increased reports of successes in areas of adoption, there has been caution in the reporting of these achievements. In the NHS for example, according to the NHS Foundation Trust Network (House of Commons, 2013b), problems that could be tackled by BPR still remain; lack of integration, excessive bureaucracy, capacity problems in the A&E department and the need to redesign the care delivery process characterise NHS operations today. This questions the efficacy of BPR within the NHS setting.

It is logical to question therefore whether BPR fitted the type of process model needed to support the challenges presented by the NHS. It has not been clear how the BPR concept has been interpreted, designed and applied to healthcare delivery management. Most work on BPR points to the fact the concept does not fit all organisations. Although healthcare is delivered in a process manner, it is still different from the non-healthcare organisations in the private sector. Particularly, the health care system is made up of various professional, ethical and stakeholder barriers which make it challenging to adapt BPR fully. Studies have not clearly explained how the model has been modified to fit the health care delivery management, taking into consideration these barriers.

Operations in the healthcare delivery system relate to saving lives; as such all components are expected and required to work quickly in a synchronised manner,Therefore slowness in adopting IT systems, challenges posed by specific new languages and jargon, among others, brings confusion in the healthcare environment, and require continuing support from Information Systems (IS) consultants. This slowed down process uptake and negated any expected successes that would have been gained (Deakins and Makgill, 1997). Some organisations spent heavily to set up IT departments but, as the IT technology evolved faster, new equipment and knowledge upgrades were needed at additional costs. This brought stresses in healthcare systems and made IT implementation slow (Helfert, 2009). After spending £10 billion on an IT system, the NHS became a perfect example of an organisation that failed to realise full implementation (Syal, 2013).

It has been hard to find studies where BPR was adopted as a whole system model. Many of the attempts were limited to sectors and departments so that the benefits, if any, were cancelled by failures in areas where it was not adopted. For example, most of the literature reviewed gives case studies in hospitals and departments with no indication that other parts of the healthcare system adopted BPR. Given that BPR calls for the radical rethink of the organisation's operations and a complete re-design of its main organisational processes, this was not observed in most literature.

With these weaknesses of BPR and the fact that implementation might have led to limited impact, its efficacy as a process management model in healthcare delivery management can be assessed as negative (that is, not efficacious). Even though it ushered in the IT revolution in healthcare organisations, its general profile diminished within the decades of the 1990s and 2000s. However, with the continued quest for process management in healthcare, Business Process Management (BPM) has emerged as an improved approach.

3.5 Business Process Management (BPM)

Business process management (BPM) has been described as the reincarnation of the BPR because it emerged after BPR became unpopular (Weske, 2007; Smart *et al.*, 2009). Because BPR promised much but delivered little, the "re-engineering" term in BPR was modified to "management," hence BPM (Hill, 2012). However, there are differences between the two concepts. While BPR calls for the rebuilding of an organisation's processes (Armistead *et al.*, 1995), BPM is involved with the continuous on-going improvement of an organisation's processes based on its business, nature of products and market expectations (Zairi, 1997).

BPM is also described as an extension of Workflow Management (WFM) which mainly focuses on the automation of business processes (Van Der Aalst *et al.*, 2003). This means the concept employs extensive use of various IT techniques and related infrastructures (Helfert, 2009). Therefore it possesses a much broader scope which extends from process automation and process analysis to operations management and the organisation of activities and processes (Weske, 2007).

3.5.1 Definition of BPM

The literature has not properly provided a robust definition of BPM. Probably this has to do with the broadness of its application. This perception is captured by van der Aalst (2013) who defined BPM as a discipline that makes it possible to combine the knowledge from information technology and management sciences and apply it to operational business processes. This is because BPM is concerned with how to continuously manage processes rather than the one-off radical changes associated with BPR (Armistead and Machin, 1997).

3.5.2 How and why organisations apply BPM

BPM is implemented in various organisations differently where it is also uses alternative terms. For example Schonenberg *et al.* (2008); Mendling *et al.* (2010) reported that BPM is also referred to in some organisations as “Business Performance Management.” Others see it as a general approach to the introduction, enforcement and management of process change, especially in the adoption and use of software techniques to ease the control work processes (Reijers, 2006).

Armistead *et al.* (1999) identified that the quest to seek business excellence relates to the adoption of BPM. They argued that the difficulty in interpreting and defining the term ‘process’ by many organisations presented them with difficulty in adopting BPM. This difference in view and interpretation of BPM means that processes in organisations may be restricted to selected functional activities while others are shaded from its application. The resulting ambiguity leads to a lack of shared understanding followed by wasted efforts, confusion and frustration. Managerial harmony is thus recognised as a strong driver for effective process management implementation.

Houy *et al.* (2010) concluded from a comprehensive literature review that BPM has expanded in scientific publications, thereby exhibiting its need and importance. Even though Helfert (2009) had argued that, empirically, BPM implementation was weak, Houy *et al.* (2010) argued that the application was improving, given the establishment of specialised journals such as the Business Process Management Journal, and specific conferences, such as the International conferences on BPM. Also, the development of various degree programmes in universities that study subjects with a bias towards BPM, for example, constitutes some of the strongest influences on BPM. Increased skills in IT have contributed to the improvement of attributes such as workflow management, work planning, strategy, and contact with customers and suppliers (Van Der Aalst *et al.*, 2003), thereby boosting BPM.

In summary, drawing from the literature, for example, Armistead and Machin (1997); Lusk *et al.* (2005), organisations adopt BPM to meet the following objectives:

- To improve process connectivity and efficiency within organisations (lateral and horizontal).
- To improve workflow effectiveness and better relationships within the organisations' value chains.
- To improve productivity and increase value to end users (quality, functionality and prices)
- To harness profitability for the investors and owners and make the business sustainable
- To withstand the challenges of competition, changing times, technology and strive for market leadership
- To meet stakeholders' interests such as their values. Depending on the organisation, stakeholders are usually the employees, customers, suppliers, investors, the government, community, and Trade Unions or related associations.

Although BPM emerged from manufacturing as an alternative to BPR, it has been largely applied to service organisations such as banks, call centres, logistics and distribution, among others (Lusk *et al.*, 2005; van der Aalst, 2013). Healthcare delivery management is also one of those service sectors that has embraced BPM.

3.5.3 Application of BPM to healthcare

The aim of applying BPM to healthcare is to seek solutions for process related problems in healthcare delivery. These problems are workflows, challenges within the pathways, decision making, decision execution, internal and external linkages, problems with resource allocation with the departments, scheduling, strategy, involving with and understanding patients' needs (see, for example, Ko *et al.*, 2009; Rebuge and Ferreira, 2012).

Poulymenopoulou *et al.* (2003) examined ways of using some of the design features of BPM to improve the emergency services in Athens, Greece, by mainly improving workflow techniques with technological and web service methods. The essence was to design a model that could foster integration and improved faster process flows through process automation within the boundaries of a health district in Athens Greece. As such, they sought to automate processes related to emergency cases served by ground ambulance vehicles so that information improvement, information exchange and process integration for operations relating to patients' support for pre-hospital and in-hospital emergency healthcare could be fostered. Hence, the exchange would ease the operation between Athens ambulance services and the emergency department of the Genimatas District General Hospital of Athens (GDGHA) by exchange of information through the internet between ambulances in circulation and the district hospital. The authors showed how such IT systems are implemented, for example with the use of the IBM WebSphere suite, although this would be challenging in the real world. They acknowledged other problems such as security and implementation problems. On the whole, the authors concluded that the implementation of the type of IS as defined in their study was efficacious as it led to improved collaboration and cooperation among the various bodies involved with emergency healthcare delivery within the boundaries of the study area in Athens.

Snyder *et al.* (2005) examined how process mapping, a core component of BPM, could be applied to improve integration of two community-based healthcare clinics for a small community with limited resources in the USA. As part of an extensive study, the researchers found that process mapping and process management were necessary to provide ways of supporting these clinics to meet challenges such as improved quality and continuous "value added" in the process of health care delivery. Additionally, there was the need for improved strategy, reduced waste and costs and to be able to compete with two large hospitals nearby. Therefore, an improved methodology that guaranteed the conception, design and maintenance of processes, which met these objectives, was necessary. With the aid of IT, understanding and managing information would improve conservation of resources, manage and monitor costs and quality of care, thereby delivering the expected benefit to the community. "Reinvent" became the new 'buzzword' for their health system; as such, mapping their processes using the new internet and related technologies became a route worth pursuing. In adopting value-stream mapping, they designed it such that it became a standardised way of documenting a process. A clinic-mapping model was conceived in which divisions such as lab, x-ray, physician service, front office, nursing, transcription/dictation, and supplies ordering could be clearly shown. Using a software integrated management approach and the internet to help foster integration and strengthen the network, process improvement in the two clinics, especially the information system, was made visual. It supported healthcare personnel and improved workflows. According to the research, adopting process mapping in both clinics reduced boundaries since all patients' medical history was now inputted to the central computer system. This improved the output and quality of clerical-related work for nurses and secretaries, led to quick services, and increased income. The clinic's competitive position improved though the project was still ongoing.

Proposing a less radical BPM approach for healthcare delivery management, Becker *et al.* (2007) reported the potential for process optimisation in which existing medical IS can be improved with the knowledge from BPM. This will help solve the problems of cost reduction, ease the routine work of staff and improve patient safety without *de facto* re-engineering the organisation. Employing IT within BPM can reduce the frequency of human errors in healthcare organisations. They demonstrated this by presenting a case study from the U.S. where BPM was set up to improve the efficiency of a hospital, and to reduce hospital-acquired infections (HAIs). They concluded that, both on a conceptual and a practical level, BPM seemed likely to provide the expected cost reduction, increases in patient safety and improved working conditions of health workers especially in relation to carrying out routine tasks.

BPM has supported the healthcare delivery system through the designs of processes such as the Workflow Management Systems (WfMSs), a tool that supports, streamlines, and automates workflow systems within healthcare delivery (Anyanwu *et al.*, 2003; Van Der Aalst *et al.*, 2003). Through a BPM approach, IT systems that support scheduling and demand estimations could be used for simulating patient trails (Cayirli and Veral, 2003; Clark *et al.*, 2013). One example of this support from BPM is shown in Figure 3-1 in which a clinical pathway for proximal femoral fracture was designed using an IT scheduling approach (Lenz and Reichert, 2007). A similar observation was made by Reichert (2011) who pointed that even though healthcare organisations are required to use the IT system to design healthcare systems that are effective, the required agility is often hindered by a lack of flexibility in the hospital information culture. They found that to overcome this downside, a new generation of information systems, namely process-aware information systems (PAISs), had emerged. This system is different from most other systems in that a PAIS operates a separate process logic, which provides an additional layer in its design.

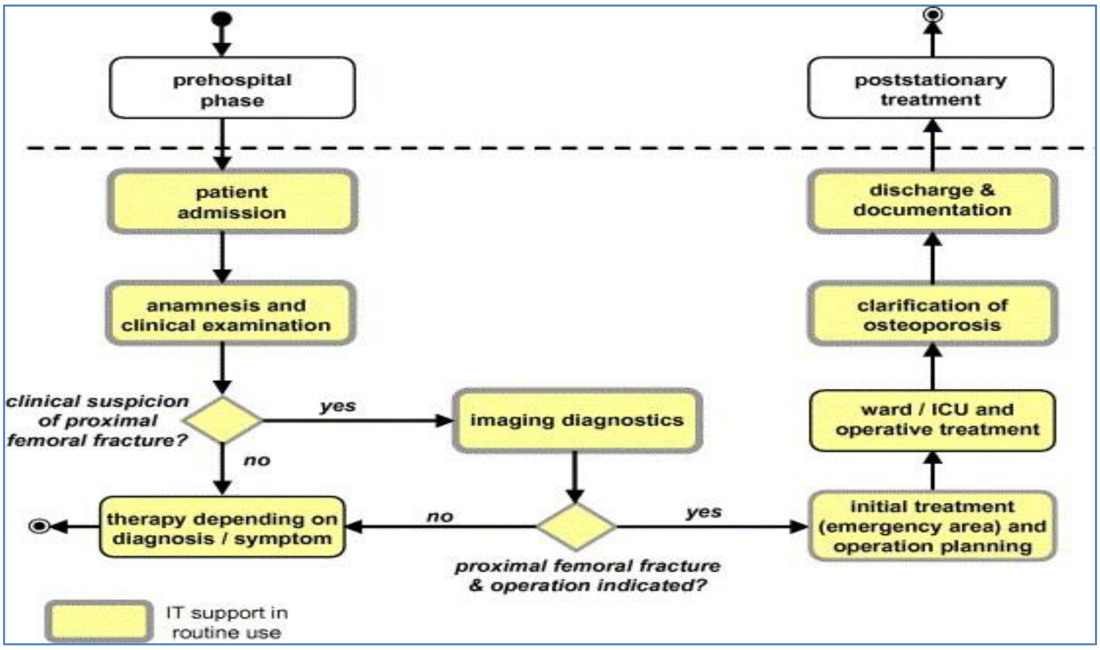


Figure 3-1 Clinical pathway for proximal femoral fracture: an example of IT support. Adapted from Lenz and Reichert (2007).

BPM is one of those management approaches that have instilled the idea of process thinking in the healthcare sector. Though many healthcare delivery organisations are interested in BPM, but because of government interference, in most countries, it has been notable how few health care systems have adopted process management thinking (Rothgang *et al.*, 2010).

Given the growing popularity of BPM, some authors have contributed and captured different facets of the thinking, and the literature comprises a diversity of aspects that have been examined (see, for example, vom Brocke and Rosemann, 2015). Despite this, BPM research in healthcare still lacks research which provides a consolidated understanding of the real scope, methods, research maps and outcomes of a comprehensively defined BPM, tailored to healthcare delivery management. For example, from the selected literature reviewed, the role of processes are broadly recognised, but researchers lack an all-encompassing design that develops a methodology which promotes integrated BPM methodologies and reports on the implementation or how it can work for healthcare delivery management.

Hammer (2015) discussed a process management cycle, that is, a BPM approach made up of an integrated system for managing business performance in the form of an end-to-end business process. Despite this work most of the studies of BPM in health care delivery have not exhibited research that purports to be an end-to-end process paradigm. Research has focused on IT installation as an enabler of process realisation or as an enforcer of process management (see benefits of IT to health care delivery in Appendix 1B). The notions of end-to-end, such as process documentation, process metrics and measurement, process infrastructure and process owners among others (McCormack and Johnson, 2001; Kohlbacher, 2010; Hammer, 2015), have not been adequately elucidated in BPM in the field of healthcare delivery management.

3.5.4 Challenges of BPM in healthcare

While healthcare organisations are seeking ways of improving processes with the adoption and application of BPM, various problems have been identified as to why there has not been an effective uptake of the process paradigm in healthcare delivery management.

The healthcare sector has traditionally faced difficulties absorbing management ideas from the market sector (Porter and Teisberg, 2006) and this has been the case with the adoption of BPM in healthcare delivery. Resistance to change at different management levels in healthcare organisations can lead to weak process management application in the health care sector. The idea of integrating processes is usually challenged due to the strong silo mentality in the sector (Shortell *et al.*, 1995). It is hard to design a BPM intervention without crossing the boundary from medical treatment processes into general organisational processes (Lenz and Reichert, 2007; Rebuge and Ferreira, 2012). These realms must work together for coherent healthcare to be delivered. The optimisation of these processes is driven by the need for routine cross-functional operations in zones within and outside the organisation or those crossing the organisation’s boundaries (Pourshahid *et al.*, 2009). Gathering the required information related to such processes from different sources, monitoring these processes, and aligning them with the organisation’s strategies and goals are major issues for decision makers in health care delivery organisations.

Begun *et al.*(2003) and The Health Foundation (2010) identified that resistance to change is one of the leading factors influencing stagnation in management change in the healthcare system. The strong relationship between healthcare delivery and welfare systems means that many BPM methodologies are challenged by fears of healthcare privatisation, health care rationing and access limitations (Hellström *et al.*, 2010).

Despite the perceived proliferation of the BPM paradigm in healthcare delivery processes, process-related problems such as scheduling, queueing, waiting, delays, operational costs, re-admissions, failed discharge planning, limiting access, confusion on multiple access points and reliance on patients' self-diagnosis continue to exist despite the success stories in the literature. This shows the deep gulf between theory and practice, thereby questioning the efficacy of BPM thinking and application in healthcare delivery management.

3.6 Process mining

Process mining uses data generated by IT systems in supporting process management; it is a recent concept that has emerged within the process management research community (van Dongen *et al.*, 2005). It is a model whereby information about processes is extracted from transaction logs. The assumption holds that events can be recorded such that each shows a clear step in the process or activity when they occur. Each event is related to a process instance or a case. Events have associated time stamps, a sources or originator and an end of a process (van Dongen *et al.*, 2005). With the proliferation of information systems, high utilisation of IT and improvement in the knowledge of its application, such techniques may be popular in the future (van der Aalst *et al.*, 2007). The value of mining techniques is that the recording logs and events are easier to collect and associated data can instantly be read, tracked, observed, followed-up and used to improve processes (Mans *et al.*, 2009; Rebuge and Ferreira, 2012).

In a healthcare application, Mans *et al.* (2009) examined the applicability of process mining in the healthcare sector in the Netherlands. They argued that since healthcare is a human labour intensive activity, getting feedback on process performance is difficult and reporting always contains errors. With process mining, healthcare managers can greatly benefit from its direct point release system, in which data are generated and communicated directly. This gives the “care flows” under consideration an accurate view, for example discovering the typical paths taken by particular groups of patients.

The fact that current applications seem to have focused on hospitals and not the whole healthcare system suggests that processes that are sensitive to external influences have the potential to be missed by this model. It is easier to examine patient activities when they are within the hospital environment, but when it comes to the forces outside the hospital such as environmental or government policies, which can influence patient actions, process mining is not likely to be effective. For example, hospital effectiveness might be affected by IA because patients could not get the right referrals when they needed health care. This type of action will influence the result of process mining but will not show that poor GP contact might have been the driver. Also deploying process mining for the whole healthcare system could be difficult and costly. If a health care system starts from the GP surgery, then gathering such data would be expensive and challenging since GP surgeries are spread across a geographical area.

3.7 Lean Management and the Toyota Production System (TPS)

The Lean management model is another popular process management approach being used to improve healthcare delivery processes. It also is known as the Toyota Production System (TPS) (for example, Chalice (2005); Spear (2005)) or just “Lean” and has been used to define and develop processes for healthcare delivery management. Inspired by the success of Japanese companies, many healthcare organisations are now examining Lean closely and asking if it can assist them to improve care delivery processes. In the industrial sector, Cooper and Slagmulder (1997) for example showed that in seeking a balance between cost, prices, functionality and quality, Japanese companies adopted Value Engineering alongside Lean to attain that. In the section below, the way in which Lean is applied in process management in healthcare to achieve two objectives, treatment of waste and improvement of flows, is discussed

3.7.1 How Lean is implemented in healthcare management

Lean management is applied to healthcare delivery management to achieve two main objectives, the elimination of waste and improvement of flows (for example, De Souza, 2009).

3.7.1.1 Lean and waste management

Womack *et al.* (2005) drew from the successes of Lean in manufacturing and argued that its main application in healthcare has been to challenge waste as well as to strengthen the process of healthcare delivery. They pointed out that waste of money, time, goodwill and supplies were value-reduction attributes. They cited a case study, Virginia Mason Medical Centre in Seattle, Washington, USA where the Lean management model was applied. There the hospital had been using Lean management principles since 2002 to eliminate waste, which improved capacity and created savings. Other improvements included training of staff on Lean principles, leadership, management culture, process management and presenting patients as the drivers for all process conceptions and designs.

Manos *et al.* (2006) and Wellman *et al.* (2010) listed some wastes affecting effective healthcare delivery. They included over-production, waiting, transport, IA processing, unnecessary inventory, unnecessary motion, defects, correcting mistakes, rushing, reworks or readmissions and staff underutilisation. They suggested that these wastes could be eliminated with Lean application. Radnor *et al.* (2006); (2011), for example, pointed to a variety of Lean applications in healthcare management and public services where tools such as “5s”, “modder”, “pull and push”, “value stream”, “continuous flow” and “kaizen blitz”, among others, were used.

3.7.1.2 Lean process and flow improvement

Radnor (2011) presented findings from three studies in which an evaluation of Lean was carried out in two hospitals and a Mental Health Trust in England. The main success factors here were improved process and flow patterns of patients. Spear (2005) showed how the TPS transformed the fortunes of a healthcare delivery organisation with process improvement through mapping and coding as contained in Lean’s 5S. Relating his study to Western Pennsylvania Hospital in Pittsburgh USA, he showed how healthcare organisations could benefit from the tools of Lean and move from an ambiguous environment to a more structured one with defined processes. Fillingham (2007) presented a viewpoint, which showed how Lean application in healthcare led to the improvement of care delivery in the Bolton Hospitals NHS Trust, helping it reduce complexities and manage costs while delivering expected levels of healthcare quality.

Ben-Tovim *et al.* (2007) showed in a study of Lean thinking across hospitals that one of its benefits was to facilitate operations by moving from a mass production manner to a flow pattern, thereby improving the flow of patients through clinical and related healthcare systems. Poksinska (2010), looking at the current Lean implementation in healthcare, argued that Lean application in healthcare is mostly geared to achieving process improvement. This is done through focusing on defining the value for patients, mapping value streams and eliminating waste.

Despite enthusiasm generated by Lean application in organisations and earlier extensive research on how it could be used to improve operations and processes within healthcare delivery, there has been debatable success reported (Radnor *et al.*, 2012). Table 3.3 shows the healthcare sectors that have applied Lean.

Some of the challenges identified in the literature, which should act as lessons for future improvement, start with an understanding of the philosophical grounds of the Lean concept and a proper definition of how it should be used in healthcare management. For example, what Lean may describe as waste, and work to reduce, may be interpreted as a means to cut jobs and might not get support from staff. Efforts pursued to increase the pace of flow may be construed as abuse of workers. As such, the time needed to liaise with worker representatives to clarify such situations might end up reducing the zeal to continue with Lean. In Japan, where Lean is a culture, these attributes are considered as ways of process and performance improvement, unlike in western organisations where Lean principles must be learned and thus may be challenged by opponents (for example, Doss and Orr, 2007).

Lean appears to be used more as a waste reduction tool than a whole system model that utilises pull and push on the process (George, 2003; Fillingham, 2007). Not realising pull and push as required for system integration remains a major challenge in the health care setting and shows the limit of the model. It may be applied in some wards, sectors or departments but systemic use must affect all departments. Successes in some areas are cancelled by failures elsewhere where Lean does not extend (Fillingham, 2008). Other problems of Lean application in healthcare include the quest for a quick fix. Lean is a gradual process, and when quick fixes are pursued due to political or managerial pressures, for example, the process is usually abandoned before it could work. As such, the propagated success of Lean seems to have been exaggerated by pressure groups interested in pushing for a model that fits their agendas (Papadopoulos et al., 2011). The inability of Lean to largely reflect the effects of process need and the fact that waste and flow problems persist today in areas where Lean has been adopted (Poksinska, 2010; Radnor *et al.*, 2012), suggests that the efficacy of Lean remains obscured.

Table 3-1 Examples of Lean applications in healthcare

Organisation	**Methodology**	**Impact**
Scotland cancer treatment	Lean	➢ Reduced patients' first appointment time from an average 23 to 12 days. ➢ Customer flow time improved by 48%
Royal Bolton Hospital	Bolton Improving Care Systems (Lean)	➢ Improvement in savings of £3.1m ➢ Improvement in turnaround time in pathology from over 24 hours to 2-3 hours ➢ One third decrease in in-patient death rate. ➢ The time taken to process relevant categories of blood fell from 2 days to 2 hours.
Nebraska Medical Centre	Lean principles to redesign the work area in the sterile processing centre and the clinical laboratories	➢ Reduced staff walking by 167 miles a year. ➢ Reduced lab space by 825 sq. ft. and specimen processing turnaround time by 20%. ➢ Reduced workers by 11 FTEs, who were redirected to other critical work. ➢ The average length of stay decreased from 6.29 days to 5.72 days.
The Pittsburgh General Hospital	Lean techniques	➢ Change to the procedure for intravenous line insertion giving a 90% drop in the number of infections after just 90 days. ➢ The new procedures saved almost $500,000 a year in intensive-care-unit costs.
Flinders Medical Centre	Lean Thinking	➢ 15-20% more work, fewer safety incidents, same budget, same infrastructure, staff, and technology.

Adapted from Radnor (2011, p. 4)

3.8 Quality as a process issue

3.8.1 Background

The quest for quality is one of the reasons that led to the emergence of process management, because for a product or service to become competitive and sustain an organisation's return on investment they must exhibit acceptable quality (Nahmias and Olsen, 2015). Quality must be such that people are willing to pay the market price for it. Quality is vital for an organisation, and efforts to ensure that production delivers quality are a necessity for any organisation's strategy (Isaksson, 2006). Quality not only refers to the nature of the final product or service. Quality is a matter of the whole production and delivery process and organisation's strategy (Nahmias and Olsen, 2015). The emergence of the Japanese as quality leaders in the 1970s propelled quality discussions in different organisations to heightened levels. This attracted research questions into what constitutes quality and how it could be developed, delivered and sustained (Cooper and Slagmulder, 1997). Quality components have also changed over the years as customers' assessment and demand for quality products or services have become dynamic.

Within the service and healthcare sectors, quality is examined differently, and since quality research is broad, the focus here will be on the relationship between quality and process management in healthcare delivery.

3.8.2 Perception of quality in healthcare delivery

The term quality in healthcare delivery is hard to define. Health quality could mean wellness but how patients feel when they demand and receive healthcare matters to both patients and healthcare providers (Øvretveit and Gustafson, 2002). As such the cost and effectiveness of healthcare delivery can only influence quality if the processes are properly designed (Golder *et al.*, 2012; Mosadeghrad, 2013).

As well as being difficult to define, quality in health care is hard to measure since it can mean different things for providers and patients (Nwabueze, 2011). For patients, quality is a perception, hardly deemed quantifiable by them, but it can reflect the way they feel about the healthcare system. This can be surveyed and analysed (see for example, Proctor *et al.*, 2005; Tucker *et al.*, 2014). Quality can be considered from multiple different perspectives, rather than by outcomes alone (Tucker *et al.*, 2014). When patients attend the A&E for unscheduled urgent healthcare and leave satisfied, this meets the definition of quality from the patient's point of view. From the deliverers' side, A&E attendance for non-urgent needs could be costly and might not provide long-term treatment for those patients. This type of attendance has been described as inappropriate (Cowling *et al.*, 2013). From the side of the deliverers, quality can be assessed from aspects such as costs, wellness, readmission rates, access point utilisation rate, outcomes and preventative measures (Nwabueze, 2011). The quality of the outcome is a product of the quality of the delivery process.

The lack of an explicitly established relationship between quality aspects and process management has meant that organisations and the healthcare system continuously seek ways of improving processes and thus quality. Total Quality Management research has attempted to examine the relationship between process improvement and quality.

3.8.3 Total Quality Management (TQM) - Definition

Feigenbaum (1951) has been credited for originating the term TQM. He assumed that total quality control was attainable by integrating the quality development, quality maintenance and quality improvement efforts of various groups in organisations. However, the concept of TQM has evolved, and a variety of descriptions of it have been developed in different fields. From the healthcare delivery management perspective where quality is the outcome of process and process is the driver of desirable outcomes, the definition proposed by Miller (1996, p.157) best suits this line of research:
TQM is "*an on-going process whereby top management make whatever steps [are] necessary to enable everyone in the organisation in the course of performing all duties to establish and achieve standards which meet or exceed the need and expectations of their customers, both external and internal*."

One of the sectors that has been struggling to adapt and translate this definition into service delivery efficiency is healthcare. For a broad-based application that could affect healthcare systems, Garvin (1988) suggested that several components be included in the features of TQM. They are: reliability, conformance, durability, serviceability, aesthetics, perceived quality and the ease of reflecting an organisation's end-to-end structure. Within the NHS, adoption and application of TQM has evolved, suggesting a wide variation of its possible application as shown in Table 3-2. It shows the stages and approaches taken to adopt TQM in the NHS.

Table 3-2 Four approaches to defining TQM in the NHS.

Approach 1	Approach 2	Approach 3	Approach 4
Quality as a professional issue	Quality as a piecemeal activity	Quality as a planned and co-ordinated activity	Quality as strategic development
Quality emanates from professional practice	Top management views TQM as a cost saving programme	Top-down co-ordination	Quality a key organisational integrator
TQM viewed as meeting professional standards	Departmental/ bottom up initiatives focused on TQM as "doing my job"	TQM initiatives Quality policy and structure voiced by management	TQM focused on patient needs Quality high on agenda

Source: Nwabueze (2014, p. 502)

3.8.4 TQM application in healthcare delivery

As identified earlier, measuring the quality of health care is difficult, but two main routes are popular in the literature, namely patient outcomes and operational processes.

3.8.5 Patients and outcomes approach

This situation relates to how patients access health care, and whether they obtain the treatment they require (Øvretveit and Gustafson, 2002). Therefore, the relationship between patients and the care delivery system should operate such that patients do not have to "strain" to get the treatment they need. Care deliverers should be able to deal with patients in the right place and at the right time (Ham *et al.*, 2012). When patients find it difficult to get support to ease their condition, their impression of the healthcare system will be negative even if they finally have a good outcome (Porter and Teisberg, 2006).

Poor impressions of healthcare mean that criticisms for aspects such as long wait times, constrained access, mix-ups and errors, poor scheduling, low workers' morale, among others, have been identified within the healthcare system as signs of poor quality (Mosadeghrad, 2013). In this vein, Khorramshahgol *et al.* (1995) reporting on why and how many hospitals in the USA were adopting TQM, related it to heavy criticisms for the poor quality on the one hand, but pointed to very high costs for healthcare on the other hand. This high cost is driven by poor quality of processes characterised by delays, bottlenecks, poor outcomes and confusion in the system.

Learning from successful TQM adopters in other service organisations, US healthcare delivery organisations starting learning about its principles. To avoid resistance and disruption of the current system, a TQM approach linked to Information Systems (IS) was proposed, known as the Hospital Information System (Khorramshahgol *et al.*, 1995). Here, nurses, doctors, consultants and administrators could be easily interconnected thereby eliminating the barriers caused by department dichotomy common in the healthcare system. External clients such as patients, customers, suppliers and stakeholders were also linked to the care services such that scheduling, access and the like were easily assessed. As communication developed, processes got better, and service quality and the overall healthcare delivery process, as defined by TQM, improved (Khorramshahgol *et al.*, 1995).

3.8.6 Process operation quality approach

Process operation quality relates to the type of process in place to deliver healthcare when demanded. The idea is that the types of processes in place will influence the quality of healthcare delivered (Nwabueze, 2011). As such, to develop better process methods for healthcare delivery, the expected quality should be the target (Murray and Berwick, 2003). Despite many healthcare organisations wishing this to be the case, it has mostly been rhetoric rather than reality (Nwabueze, 2011). Evidence of this is observed today whereby, despite extensive research in the area of TQM, which means quality and process improvement, quality in the healthcare delivery process, outcomes and costs have remained serious challenges to many healthcare systems (Mosadeghrad, 2014). It has been argued that wherever health care quality is a challenge, there will be an associated process management problem (Isaksson, 2006).

An operational process quality is designed to obtain the expected process and quality outcomes. This construction is governed by attributes such as organisational culture, quality improvement drive, expected results and knowledge of the expected process, environment and quality need (Ferlie and Shortell, 2001). Success in merging these attributes is one of the difficulties faced when attempting to achieve quality and process effectiveness.

When quality efforts are performed on a one-stage basis while other stages remained unaffected or unprocessed for quality attainment, quality efforts will fail (Deming, 1986; Ferlie and Shortell, 2001). When quality attainment is a culture, and the quest to pay attention to detail is a common one observed by all in an organisation, along with the need to test, and retest quality endeavours, the chances are that quality effectiveness will be met (Øvretveit and Gustafson, 2002).

To attain TQM, the healthcare organisation must be made ready and compatible to instil the required quality attributes needed (Mosadeghrad, 2014). It is hard to dismantle hierarchical structural organisations in healthcare environments since many are aligned with specialisation (Porter and Teisberg, 2006). However, instead of making TQM approaches top down, they can be achieved laterally and linked with each other such that bureaucratic managerial practices are broken down, to give way for quality synergies to flow (Isaksson, 2006). With such a structure, that does not amplify negative aspects such as bureaucracy and authoritarian attitudes, which tend to dissuade employees from the empowerment which is needed to foster the success of TQM (Mosadeghrad, 2014). Weak and uncommitted quality-oriented culture, unconcerned top management support, poor planning and insufficient training are some of the challenges facing TQM and process management in healthcare delivery (Isaksson, 2006).

3.8.7 TQM in the NHS

A brief background of TQM application in the NHS suggests that it was introduced in the period 1989 to 1990, when it was agreed that the quality of healthcare delivery in various English hospitals was below expectations while at the same time cost was running contrary to care provided (Hart, 1996; Nwabueze, 2014). As a result, the Department of Health (DOH) provided incentives and general funding to the health authorities that presented acceptable proposals for successful TQM implementation. The outcome of this phenomenon has been shown in the works of Hart (1996); Nwabueze (2014). Leicester General Hospital has been cited in various studies as one of the hospitals where a pilot study was carried out on how TQM could be applied. In seeking to attain the expected quality of outpatient services in the NHS, Hart (1996) identified that when TQM was applied over a period of one year, improvements were observed. According to the improvement observed, over 80% of patients were examined within 30 minutes in outpatient clinics. This showed that TQM could work very well in the NHS and thus additional efforts were pursued for it to be rolled out to the rest of the NHS Trusts in the country. As a result, both the government and patients agreed that the service had improved. However, this claim was challenged by evidence from Leicester General Hospital, which revealed poor quality of care. This raised various questions about how the term “quality” had been used and how it was being defined, measured and assessed (Hart, 1996). The fact that TQM was a model imported from manufacturing seems to have been a possible reason for the difficulties in determining quality in the NHS. The history and culture of the NHS was one factor, as well as the fact that the UK healthcare organisation had barriers which market-facing firms in Japan and the USA, who had reported success, did not face. Therefore, while there are various challenges, for example, in developing better and suitable definitions and measurements for quality, the pursuit of quality continues to remain a long-term objective for the healthcare system today.

The failures of TQM in the NHS and factors that would have prevented this failure have been examined by (Nwabueze, 2011). The author recalled there was a recommendation for a change in management in the NHS, proposed by Griffiths (2003), which called for the quality attribute to be included in the new management model being conceived for the NHS. This heightened the interest in TQM to assist the NHS quality drive, given that the model can improve endeavours in the care delivery process. The author argued that while the NHS was pursuing TQM, encouraged by the DOH, leadership failed to support its implementation. By 1991, only two hospitals out of a sample of 30 had attempted any form of TQM implementation. The study showed that the failure to succeed in implementation was due to a lack of leadership. It was also “over-managed, but under-led”, lacked adequate planning, exhibited professional tribalism and lacked staff development. In a subsequent paper, Nwabueze (2014) outlined the factors responsible for the decline of TQM in the NHS. Again, he cited poor and lacklustre management, lack of strategy and the view that TQM was not an issue for the NHS but useful for other organisations. There was a general lack of knowledge and interest in the model. The author pointed to some stages NHS managers would have followed to guarantee the survival of TQM in the NHS. The following were suggested:

1. At the defining stage, there would have been a breakthrough in attitudes.
2. At the measurement stage, more energy would have been accorded to the few core areas while the many trivial ones would have been relegated to the rear.

3. At the analysis stage, the focus should have been placed on the symptoms for poor care and development of hypotheses and experiments to find the real cause(s) of poor provision of care. Various alternatives in meeting changing needs of patients would have been conducted.

4. At the improvement stage, efforts would have been taken to determine how to overcome resistance to change.

5. Control measures would have been in place to coordinate and monitor, to ensure that process improvement was sustainable and take corrective action if a problem arose.

Laying the blame for the failure of TQM on managers, the author concluded that the success of TQM application in the NHS was incumbent on the quality of the leaders that were committed to addressing the quality problems faced by the NHS.

3.8.8 General reasons for challenges of TQM in healthcare

Many studies have presented reports of failure of TQM efforts in healthcare. Zabada *et al.* (1998), examining obstacles for applying TQM in healthcare organisations, found that most healthcare organisations are inward looking and tend to focus more on the needs of caregivers and professionals than on the needs of external customers. They argued that in large healthcare organisations hierarchical management and bureaucratic cultures is still rife. This makes TQM efforts more resisted by employees and middle managers. Also, management and leadership styles of healthcare organisations are characterised by command and control, whereby managers' performance is praised rather than that of general workers. This makes managers unable to display broad-based motivational and coaching orientated management; as such, middle managers perceive TQM support as a threat to their jobs and careers.

Mosadeghrad (2013) provided a broad perspective as to why TQM has failed to be implemented in healthcare delivery management. In a review of the literature, the author argued that successful implementation of TQM and impact after that relies heavily on the ability of managers to influence the adoption and adaptation of the TQM values and concepts within healthcare organisations. Various barriers are, for example, strong departmental autonomies, bureaucratic and hierarchical structures within the health care system, strong professional perceptions and independence, disagreement between managers and professionals on strategies and quality management perceptions and challenges in evaluating healthcare processes and outcomes.

Other problems in adopting TQM and reasons for its subsequent failure in healthcare organisations have to do with the theory itself. There is variation in the definition of what TQM is and what constitutes it when applied to healthcare (Yasin *et al.*, 1998; Nwabueze, 2011). As shown in Table 3-2, the NHS defines and describes TQM differently from most of the definitions presented above. As this definition and description have evolved over the years, it is hard to develop a coherent way of adopting and maintaining TQM. In some areas, TQM is being taken to be re-engineering rather than a continuous quality improvement. Therefore, after the building blocks for TQM have been established, top managers fail to continue quality pursuits, believing that the process will work automatically (Mosadeghrad, 2013). The fact that the theory underpinning TQM possesses complex terms, process structures and variants of charts which non-management specialists could understand (Shortell *et al.*, 1996; Alexander *et al.*, 2007), it might be considered by possible adopters and workers as a passing trend and not taken seriously. Similarly, Øvretveit and Gustafson (2002) acknowledged that even though research evidence exhibits effectiveness in some discrete quality team projects, evidence that large-scale quality programmes bring the significant benefits promised or even reflect the value worth of the costs remain ambiguous. Since there is no strong evidence of benefits gained, there are possibilities that resources might even have been wasted in the pursuit of quality (Øvretveit and Gustafson, 2002).

However, researchers believe that the concept of continuous improvement embedded in TQM means that there are chances for reviews, retesting and simulation modelling to renew processes such that in the future the healthcare sector can gain maximum efficiency (Nwabueze, 2011; Mosadeghrad, 2013; Wong, 2013). The emergence of many quality establishments and programmes such as the European Foundation for Quality Management (EFQM) (Øvretveit and Gustafson, 2002; Slack *et al.*, 2010) is evidence of a continuous drive for the search for a quality management approach. Aimed at supporting various organisations including the healthcare systems to implement the EFQM Excellence Model, it shows that efforts will be made to search for ways of attaining a platform for quality delivery (Nabitz *et al.*, 2000; Van den Heuvel *et al.*, 2005).

3.9 Summary and assessment

This chapter has reviewed the literature on research relating to process management. It has examined the definitions, characteristics, importance and application of process management to operations and to healthcare delivery management in particular. The driver for this review in relation to healthcare delivery was the desire to investigate how the process management approach had been researched and implemented to support healthcare delivery management and thus address research question 1a. This question came about because, while healthcare delivery is performed in a process manner, evidence that current process design is efficacious has remained contentious. The capacity problems of the A&E departments of the NHS which have persisted for many years despite various approaches to improve patient flow and throughput within the healthcare system (Haraden and Resar, 2004; Jun *et al.*, 2009; Jones, 2014) is a case in point. Capacity problems in OM are usually attributed to factors such as process inefficiency or poor process design and attribution (Hill, 2012; Nahmias and Olsen, 2015). With the A&E and its capacity problems, the intention was to uncover what was already known from existing research in relation to the role of process management as attributed to healthcare delivery, before progressing with the current research.

This literature review found that there has been a plethora of works on ideas relating to process management. The driver for this growth in interest, especially in healthcare delivery management, is the realisation that process management contains a complex package of skills and accumulated knowledge that best meet process requirement of healthcare delivery (Maddern *et al.*, 2013; vom Brocke and Rosemann, 2015). The adoption of a proper process management model could fit the need for a design for solutions to the challenges presented in Section 1.2.

The literature also reported that healthcare organisations were adopting process management through PO, CDVC, and through various process methods. Despite this, there is limited evidence that these process approaches adopted were efficacious. Efficacy would be determined if some or all of the attributes pointed out in Section 1.4.3 were met by the process approach adopted. It was also expected that, since the healthcare sector is dynamic and characterised by fast-moving activities with demand for healthcare that is continuously changing, a form of PO would be found. This is because healthcare delivery is performed through processes. PO supports the administration of process management and assures its efficacy (see for example, Hellström *et al.*, 2010; Maddern *et al.*, 2013; vom Brocke and Rosemann, 2015). While the literature presents various process methods adopted, which claimed to have worked for the departments and sectors they were designed for, the lack of the expected systemic end-to-end attribute shows that efficacy was not attained.

3.9.1 Conclusion

Although healthcare delivery is a process operation, there is a gap in the study of process management in relation to UUEH delivery. This has led to the absence of a consistent end-to-end process management model governing that sector. Appendix 1 provides a summary of efficacy demonstrated by research into the process management methods described in this chapter. Even though some of the process methods shown in research claimed to have been effective in solving particularly targeted problems, the efficacy of process management in healthcare delivery as a whole has remained questionable. As such, developing an end-to-end process model that benefits the whole healthcare system should be the priority of OM researchers. A practical way of showing the need for such an approach is examined in Chapter 4. There, it is held that better process management will support the strengthening and development of various access points for UUEH while liberating the A&E to concentrate on emergency treatments (see, for example, Crawford *et al.*, 2017). A proposal follows for urgent care hubs made along PO lines. Chapter 5 continues with demonstration of a methodology for determining factors that influence capacity problems in the A&E department.

Chapter 4 Assessing process management in A&E access in England

4.1 Introduction

Following on from Chapter 3's discussion of process orientation (PO), this chapter examines from a PO viewpoint the process model of the delivery of unscheduled urgent and emergency healthcare (UUEH) in England and its effect on A&E capacity and demand. An assessment follows of an NHS proposal for unscheduled urgent and emergency healthcare, the "pyramid" model, and a proposal designed on PO principles, for urgent care (UC) hubs.

The research approach used is introduced in Chapter 2, Section 2.2; in particular, justification for the approach taken in this assessment is found in Section 2.2.1. Section 2.4.1 describes the data collected and Section 2.5.2 the descriptive statistical analysis.

The term 'capacity' relates to the ability of the A&E department to treat all the patients that access it within the limits of its given resources and time to the satisfaction of both patients and NHS. A marked rise in A&E attendances in England in the past 5 years does not seem to have led to increased hospitalisation but has increased congestion and waiting times. A call for an examination of the relations between demand, quality and A&E capacity has been made (House of Commons, 2013b). The expectation is that the volume of patients that access healthcare in A&E could be treated there, with adequate resources, in a timely fashion and to their satisfaction.

One of the main challenges faced by the A&E department of the NHS is that of capacity (Land and Meredith, 2013). Capacity problems exist because, given the resources available, A&E finds it hard to cope with demand for UUEH within an expected time span, defined as meeting 95% of demand within 4 hours (Adenso-Diaz *et al.*, 2002; Green, 2004; Higginson *et al.*, 2011). The belief that demand for healthcare surpasses the ability of the department to treat patients on time and within the limits of its given resources is realistic (Laing and Shiroyama, 1995; Silvester *et al.*, 2004). This contributes to problems in the A&E department such as bottlenecks, long waits, and congestion (Silvester *et al.*, 2004; The Health Foundation, 2011).

The structure of the chapter is as follows. Section 4.2 presents an understanding of A&E capacity problems. Section 4.3 examines the ways problems of the A&E have been defined, analysed, and addressed, to determine if process management has been employed. Section 4.4 examines the role played by the healthcare system in influencing the demand for healthcare, types of demand and choice of points of access. This includes sources of patients and referral methods justifying the role of a process approach. Section 4.5 presents literature concerning the challenges faced by A&Es. Section 4.6 looks at the alternative access points to A&E for urgent care. Section 4.7 assesses A&E access from several standpoints. Section 4.8 describes initiatives for redirecting patients away from A&E, including this research's proposal for UC hubs. Section 4.9 discusses A&E operations in England, with a critique of the NHS "pyramid" proposal for UUEH. The chapter concludes with a summary of how improved process management could be developed to solve current problems with A&E and urgent care.

4.2 Understanding A&E capacity problems

In seeking solutions for capacity problems in A&E departments, past studies have adopted and applied approaches such as queuing models (for example, Murray and Berwick, 2003; Mayhew and Smith, 2008), bed management in the wards (Egan, 1999; Proudlove *et al.*, 2003), and the application of various OR techniques (Saghafian *et al.*, 2015). The importance of the relationship between capacity problems in the A&E department caused by external process factors has received limited attention in past research (Richardson and Mountain, 2009). Drawing from more recent research such as He *et al.* (2011); Higginson *et al.* (2011); Lengu *et al.* (2012a); Boyd *et al.* (2014); Jones (2014), the following factors have been found to contributed to increased demand in the A&E department

- Absence of proper sign posting and patient information about the right access points in any particular situation of healthcare need. Recently the NHS has developed communication models to inform patients about accessing A&E (NHS Choices, 2014)
- There are multiple access points in primary care settings, thus causing confusion to patients on the right access point at the right time
- Treatment can be obtained from the A&E department with no prior booking and limited constraints on access, unlike seeking to access a GP.

- Continuous changes in UUEH access over time give rise to further confusion – A&E departments, WICs and telehealth systems have changed over time making it challenging for patients to understand the right access points.
- Government policy creating the 4-hour target for processing of patients in A&E means that patients feel they can access UC from the A&E and thus affect demand.
- The fact that any patient can access urgent and emergency healthcare from the A&E department.
- Patients' perception when sick: they see their pain as an emergency.

In OM terms, one way that capacity problems could be managed is through improved scheduling and referral systems. This supposes that patients are able to access UUEH from their GPs and related access points and are referred to the appropriate treatment centres. However, given the current system where all patients can access healthcare from the A&E, demand tends to surpass the ability to treat with given resources.

The next approach is to investigate the nature of demand and redesign the process – this approach requires the knowledge of the type and sources of demand. It also helps determine the effectiveness of the current process and its relations with demand. For example, some authors such as Richardson and Mountain (2009) believe that solutions for A&E capacity problems should be pursued outside the A&E department.

This chapter, therefore, will try to examine the relationship between demand and its effects on capacity problems and process management. Various process management approaches have been discussed already in Chapter 3. To get a better understanding of the relationship between demand and capacity in order to understand the extent to which process management is employed within UUEH delivery, how UUEH has been delivered in England over the past five years will be explored. Prior to this, however, it is important to clarify some key terms of this research area.

4.3 Clarification of terms

4.3.1 Emergency admissions

There are differences between A&E attendance and emergency admission. To reduce ambiguity and confusion, it is necessary to differentiate them and show how they relate to this research.

An emergency admission is a situation of immediate unplanned admission to the hospital. It occurs when a patient is provided with a bed overnight (Comptroller and Auditor General, 2013). Three-quarters of all emergency admissions in the NHS take place through A&E departments. In 2015/16, there were 4.1 million emergency admissions to hospital through the A&E making an increase of 2.8% compared to 2014/15. Over a five-year period, there was an increase of 12.5% (Baker, 2016). There are various factors influencing emergency admissions, ranging from operational and economic factors to the effects of demographic changes.

Hospital admissions can be planned or unplanned. Planned admission can take place immediately after diagnosis or at a later date, whereas unplanned admission occurs because the patient needed immediate, unexpected medical attention which leads to a hospital stay (Purdy *et al.*, 2012; NHS Choices, 2014). This study will focus on unscheduled urgent and emergency (UUEH) health care demand and its possible effects on A&E capacity problems.

4.3.2 Unscheduled urgent and emergency healthcare (UUEH)

Unscheduled healthcare (UH) results from any sudden or unplanned approach a patient makes to seek health care from a provider (Purdy *et al.*, 2012; NHS Choices, 2014). This can be due to an accident or a sudden failure in health and requires immediate medical attention, usually within 24 hours. Therefore, the character of UH ranges from very severe accidents (emergency) to mild discomforts (urgent), needing varying degrees of immediate healthcare interventions (see Figure 4-1). Not all UH demand leads to hospitalisation that is, being cared for in a ward for more than 24 hours; emergency healthcare demand has a greater chance of hospitalisation than non-emergency.

UC demand also occurs at other healthcare delivery access points such as GPs, WICs, GP out-of-hours (OOH) and the use of the NHS 111 telephone system, whereas emergency healthcare demand is made at A&E departments. However, it is reported that both urgent and emergency patients have been accessing healthcare from the A&E department (Prince and Worth, 1992; Saghafian *et al.*, 2015). This use of A&E by UC patients has been blamed for congestion and capacity problems in the A&E (Driscoll *et al.*, 1987; Ramlakhan *et al.*, 2016).

4.4 Accident and emergency departments

A&E departments are named and defined differently in different environments; for example, in many places they are referred to as emergency departments (EDs) (Saghafian *et al.*, 2015). In this study, the focus will be directed towards the English A&E operational approach. Here, although the term A&E refers to the department or sub-system that provides medical treatment to patients who need urgent or emergency care, it is composed of a variety of departments classed, according to the Health and Social Care Information Centre (2015b), as follows:

1) A Type 1 A&E department refers to a major emergency unit or department, which is consultant-led, possesses full resuscitation facilities and operates 24 hours a day, 7 days a week. This tends to be the more expensive department to run, and it is designed to receive patients who are suffering from life-threatening or debilitating illnesses who need immediate attention.
2) A Type 2 A&E department is a single specialty department.
3) Type 3 A&E departments and "other" A&E departments, including Minor Injury Units (MIUs) and WICs.

In this research, the interest will be on the Type 1 A&E department and on access to it. The reason is that it is the most visible of all the departments, receiving the largest number of patients. It is also the place where capacity is most challenged and which epitomises operations' problems in healthcare management.

However, the internal problems presented in Sections 4.7 and 4.8 mainly demonstrate the outcomes that develop due to poor process management. This means the effect of poor process management drives demand which causes stresses in internal operations. Rather than examining the internal operation of the A&E department, this research considers the processes external to A&E.

4.4.1 Assessment of emergency in healthcare

According to Lane *et al.* (2000); Lengu *et al.* (2012b), A&E provides access to medical treatment to patients who need urgent or emergency care. The fact that A&E is used both by individuals brought in by ambulance and by those self-referring means that the A&E performs a sorting function which questions the real role of the department. This phenomenon is shown in Figure 4-1. The Type 1 A&E department is supposed to deal with real emergencies and patients needing hospital admission (Weber *et al.*, 2011). Therefore, it is significant to question what an emergency is and how it influences the way patients demand and access the A&E department.

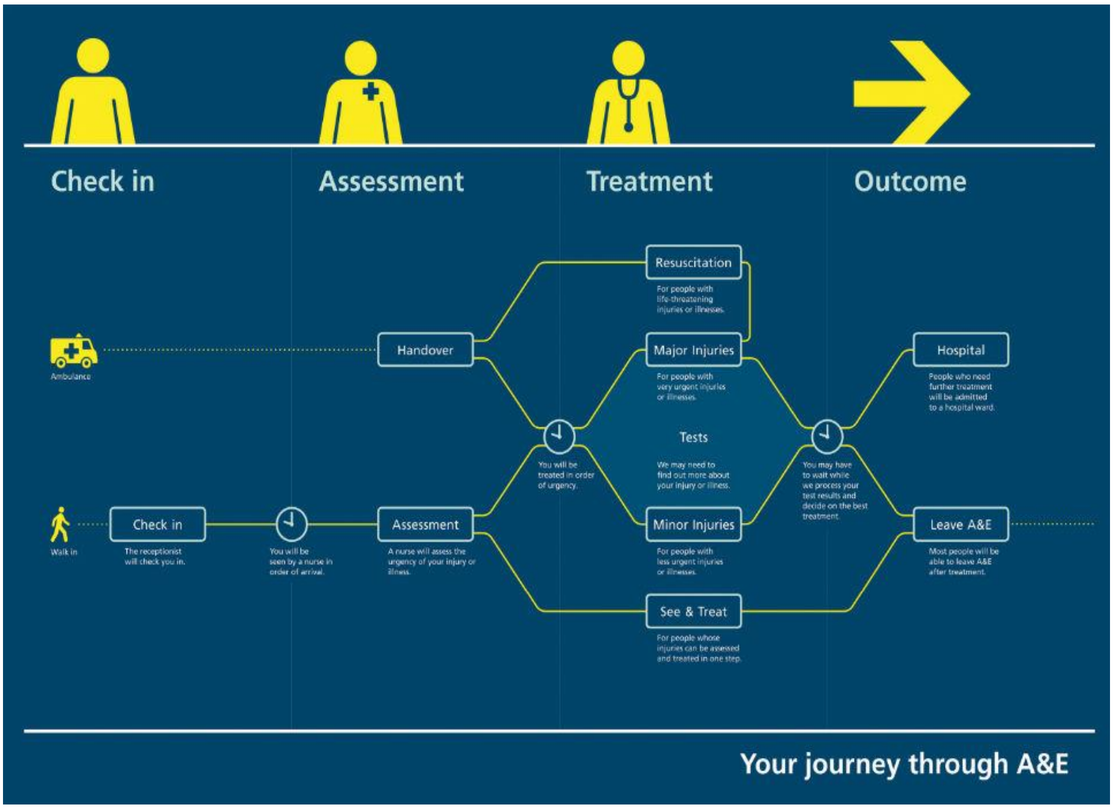


Figure 4-1 An NHS process map showing the journey through the A&E. Source: Pearson Lloyd deliver A Better A&E (2015)

Webster's Dictionary (2002) defines an emergency as an "An unforeseen situation demanding immediate action. A serious medical condition demanding instant treatment". This definition, though, is not enough to determine an assessment of emergency from the patient perspective. This is because when patients are in pain, for them that is an emergency. For this reason, a better definition is required to fit the A&E department narrative.

The British Association of Emergency Medicine (BAEM) and the College of Emergency Medicine on their part define emergency concerning healthcare as follows: "*a condition where the patient is, or believed to be, suffering from an illness or injury requiring early assessment and or management, either to save life or limb, to relieve pain and/or suffering, or to prevent further deterioration in a treatable condition in order to reduce morbidity and mortality,"* (Heyworth *et al.*, 2005 p. 9).

While this definition presents the impression that most patients seeking healthcare from the A&E department would be those that are very sick, the A&E department is also required to

"…*provide care for patients presenting with conditions that do not satisfy the definition of an emergency, but whose needs could be met by other services. It is the responsibility of EDs (A&E) to provide care, or facilitate access to appropriate access care, for all patients who present, by whatever route,"* (Heyworth *et al.*, 2005 p. 9).

This definition justifies the view that UUEH need not follow laid down process routes. Patients can access the A&E, which is more visible and needs no pre-booking while ignoring WICs, the NHS 111 telehealth system and GP practices. One major problem here is that A&E, which is a subsystem, has finite resources. The fact that these resources are not expanded to cater for UUEH demand can also lead to cost pressures on the sector. The evidence of this is that staff resources are not frequently expanded to cover additional demand for UUEH need (House of Commons, 2013b)

Due to the lack of a process approach, the A&E in England has redefined and reclassified patients who should access A&E department in two categories based on the seriousness of their illnesses (NHS Choices, 2014) as follows:

a) A&E access is reserved for patients facing life-threatening emergencies listed below. They will access the A&E usually through a 999 call followed by ambulance conveyance.

- Loss of consciousness
- An acute confused state
- Fits that are not stopping

- Persistent, severe chest pain
- Breathing difficulties
- Severe bleeding that cannot be stopped
- Severe allergic reactions
- Severe burns or scalds
- Heart attack or stroke
- A major trauma, which may develop from a serious road traffic accident, a stabbing, shooting, a fall from a height, or a severe head injury.

b) Patients with non-life-threatening emergencies, i.e. having a health situation not on the list (a) above, can get alternative treatment through the following means. They are not required to access the A&E department for it.

- Self-care at home
- Calling NHS 111
- Talking to a pharmacist
- Visiting or calling a GP
- Going to a local NHS walk-in centre
- Attending an UC centre or minor injuries unit

This division (a and b) presented above is based on the seriousness of illness. However, the NHS continues to deal with capacity problems that are perceived to be driven by avoidable emergency department attendances. This has raised the question about the role of the A&E department.

4.4.2 Role of the A&E

The lack of clarity from patients' perspective on the type of patients the A&E is required to treat, and the fact that the A&E is devising an attendance approach based on the seriousness of illness has questioned the function of the A&E department. Therefore the role of the A&E department according to BAEM (Heyworth *et al.*, 2005 p. 9), are as follows:

- It is consultant led, open 24 hours a day and 365 days a year with full resuscitation facilities.
- It assesses and manages acute illness and injury in patients of all ages by the use of appropriately trained staff, according to national and local standards.

- Referrals to the A&E department are made by GPs, or practice nurses, after discussion with the A&E and for patients in possession of a referral letter (Heyworth *et al.*, 2005).
- It acts as a major route for patients to have access to the hospital especially when a bed is to be provided (Lane *et al.*, 1998).

These functions do not indicate, however, that the A&E department has a responsibility to treat ordinarily sick patients. The NHS has advised patients with slogans such as “Is A&E right for me?” (NHS England, 2014d). Advising them to follow the steps reported in list (b) of Section 4.4.1. The NHS stresses that A&E attendance is only recommended for severe illnesses (NHS England, 2014d p. 2).

Although several organisations such as the King's Fund (2014) and BAEM have pointed out that patients who have attended the A&E ‘inappropriately’ can still be treated. The terms ‘appropriate’ attendance (AA) and ‘inappropriate’ attendance (IA) have been used prominently by researchers like Driscoll *et al.* (1987); Prince and Worth (1992); Martin *et al.* (2002) to explain different contributions to demand in the A&E department. It is of value to examine how IA and AA affect the A&E department and if a process model can recommend a solution.

4.4.3 The concept of appropriate and inappropriate A&E attendance

While attempting to understand the reasons for persistent capacity problems in the A&E department, researchers have been looking at the demand side of care delivery. They have been questioning whether all patients accessing the A&E department are attending appropriately. The view, as already pointed out above, is that the presence of IA patients in A&E could be responsible for congestion. To examine this phenomenon, various studies have looked into AA and IA (see, for example, Lowy *et al.*, 1994; Murphy, 1998; Martin *et al.*, 2002; McHale *et al.*, 2013).

However, the term “appropriate” itself is subjective, creating confusion between practitioners and patients (Martin *et al.*, 2002). Gill (1994), for example, presented a study in which 84% of A&E attendees whom nurses deemed attended inappropriately did not themselves think that they had. Therefore, what staff perceive as ‘IA’ did not necessarily reflect what patients thought. Two problems were highlighted:

- ➢ Patients could not properly self-diagnose themselves to determine which point to access healthcare from (Gill, 1994)
- ➢ When patients are in pain, they consider that to be an emergency even though it might not be life–threatening.

One of the ways this problem of AA and IA is being approached is through classification of illnesses. Here patients suffering from a defined level of pain are classed as needing emergency treatment (Lane *et al.*, 1998). In this light when such patients are taken to the A&E department, treated, kept for observation, admitted or lodged, they can be classed as AA A&E patients (Lane *et al.*, 1998; He *et al.*, 2011; Agarwal *et al.*, 2012). However, the term does not seem to be satisfactory because, from the NHS perspective, there is no appropriate and inappropriate attendance. This is because healthcare in the NHS is free at the point of need. Thus researchers have attributed different terms such as "clinical urgency" and "treatable by a GP" to explain the appropriateness or otherwise of A&E attendance (for example, Driscoll *et al.*, 1987). Practically, Coleman *et al.* (2001) identified the types of A&E arrivals who can be classed as suitable for treatment elsewhere as follows.

Suitable for treatment by a GP

- ✓ Self-referred
- ✓ Registered with a GP
- ✓ Not due to an accident except at home
- ✓ The nature or type of diagnosis carried out, for example, back pain, rash, a cold or illnesses, which could have been treated by a nurse at their GP surgery.
- ✓ At the A&E their visit ends with no treatment other than a prescription, or dressing, sling, bandage or advice
- ✓ No investigations carried out while in A&E
- ✓ Discharged and sent home or referred to a GP

Suitable for treatment in a minor injury unit

- ✓ Self-referred (for example, Dale *et al.*, 1995)
- ✓ Not referred to other hospital services on the day of attendance
- ✓ Patient seeking treatment for a wide range of injuries, such as cuts, burns, sprains, wound infections and simple fractures for patients aged over one year (NHS Choices, 2014)
- ✓ Patient seeking advice and health promotion
- ✓ Mostly illnesses related to (NHS Choices, 2014)

    - Cuts requiring stitching, or other simple closure technique

- Bruises, superficial burns and scalds
- Blows to head, without loss of consciousness
- Minor dislocations of fingers or toes
- Minor accident to hands, feet or limbs
- Recent injury of a severity not suitable for simple domestic first aid
- Foreign bodies superficially embedded in tissue
- Foreign bodies aggravating eye, but not penetrating

Suitable for treatment in a WIC

- ✓ Self-referred to A&E
- ✓ No treatment other than a prescription in line with nurse practitioner protocols, or dressing, sling, bandage or advice
- ✓ No hospital-based investigation services (for example, radiography, computed tomography, and similar).
- ✓ Not referred to other hospital services on the day of attendance
- ✓ Availability of the walk-in service all round the clock or most of the hours of the days of the week.
- ✓ In most cases illnesses, according to NHS Choices (2014), that are related to the following
    - Minor ear, nose and throat problems
    - Sprains and strains, wound infections, minor burns and scalds
    - Minor head injuries, skin conditions, minor eye injuries
    - Minor respiratory conditions such as cough
    - Mild abdominal pain or discomfort
    - Insect and animal bites and stings
    - Minor injuries to the back, shoulder and chest

Suitable for advice from NHS Direct for self-care

- ✓ Patients self-referred to A&E
- ✓ Access to a telephone at home if the health problem occurred in the home
- ✓ No investigations or prescription of medicine
- ✓ No treatment other than advice
- ✓ No known barriers (language or health problems) prohibiting use of the telephone

Suitable for treatment in an A&E department

- ✓ Ambulance service
- ✓ Seriously sick and criteria for inclusion elsewhere are not met.

While this classification shows that there is a need to separate access for patients seeking urgent and emergency healthcare, A&E departments continue to face difficulties with demand and capacity challenges. This has attracted studies as to the nature of factors and the drivers influencing continuous capacity problems in the A&E department.

4.5 Literature on the challenges of A&E delivery

Increased demand for A&E services has led to the following problems in the department: congestion, long waiting times, care quality degradation, and higher costs (Endacott *et al.*, 2011; Higginson *et al.*, 2011). The persistence of these problems has placed the NHS in continual crisis mode (Lane *et al.*, 2000). After identifying increased demand for A&E healthcare, McHale *et al*. (2013) questioned the types of patients who access it and whether they demanded it appropriately. They examined attendance from the whole of England within the period April 2011 to March 2012. They defined IA as patients who attended the A&E department on their own or who referred themselves to the department. These patients were not responding to a follow-up treatment, received no health-related investigation, had either no treatment or were given 'guidance/advice only,' and were discharged with or without GP follow-up. They used the IMD to describe patients' area of residency and used multivariate analysis to predict the possible relationships between IA patients, their demographics states and period of A&E demand. They found that, of all the attendances, 11.7% fell into the category of IA A&E attendance. In their study, there were higher numbers of A&E attendance among younger people (late teens and young adults), with an increasing reduction in attendance from age 27 years and older. There were also increases in attendance in the most deprived populations.

These results related to a similar finding by Martin *et al.* (2002) who examined the relationship between 'IA' at an A&E department by GP registered adult patients. Their sample comprised 452 patients aged 15 years and above, drawn from two health centres in South Essex in England. They used a case-control approach in conjunction with their main method, described as a modified Sheffield process. The Sheffield process, though not properly defined, was used to identify cases of inappropriate A&E attendance (Martin *et al.*, 2002).

They found that the rate of IA was 16.8%. This was higher compared to recent findings, for example, McHale *et al.* (2013). It is worth pointing out some differences between the two studies. While McHale *et al.* (2013) looked at the phenomenon nationwide, Martin *et al.* (2002) examined it within the local urban area of Essex. The second difference was the definition of IA. Even though the two studies defined IA similarly, variations in attendance based on regions are not properly reflected in a nation-wide study. While the nationwide study showed an 11.7% IA, there were several eliminations from the final data used in the analysis, namely:

- attendees with missing or unknown gender,
- missing age, an age that was unreliable, such as people aged 100 or above (extreme old age),
- patients with missing areas of residence and with the category attendance "not known",
- patients who left the A&E before they were called for treatment or those who were not given any treatment.

Land and Meredith (2013) argued that some 20–40% of patients who attend A&E lack knowledge of the existence of other urgent care services. The view that emergency care is confusing is also held by the NHS itself (NHS England, 2013b).

"*…A short history of the last 30 years reveals that we have opened 'walk-in centres', 'minor injury units', 'urgent care centres' and a vast range of similarly named facilities that all offer slightly different services, at slightly different times, in different places…" All the public want when they need urgent care is where to access the right care. "They do not want to decide whether they should go to an MIU, a WIC or A&E, or whether they should ring their GP, 111 or 999,"* (NHS England, 2013b, p. 17).

NHS England added that the system should not expect patients to be able to make informed, rational decisions during a crisis point in their lives. The system should be designed to be intuitive, and be helpful to people to enable them to make the right decision.

"We have created a complicated system which in itself has contributed to increasing demand by sending people around various services, confused about who to call and where to go…" (NHS England, 2013b, p. 17).

4.5.1 Assessing the Role of Doctors in A&E access

Researchers (for example, Lengu *et al.*, 2012b) have examined the benefits of a patient deflection scheme and its effect on A&E. The scheme aimed at placing GPs or other primary care clinicians and A&E Triage nurses at the front door of A&E departments as gatekeepers to reduce IA at A&E. The acknowledgment is that attending A&E inappropriately is unhelpful for efficient management of the subsector (Land and Meredith, 2013). This approach poses an inherent risk in that those triaging may make the wrong judgment and deflect from A&E those patients who actually need emergency care. As such, this may compromise the quality of care and endanger patients' safety (Lengu *et al.*, 2012b). There is also the possibility that patients and clinicians may disagree with the deflection guidelines set by A&E. This could lead to conflict and distrust between the different parties at the point of access. The best option to mitigate these types of challenges is to examine the role that GPs and primary care clinicians play in the delivery management of urgent and emergency health care.

GPs are non-specialised medical doctors working in the community, treating various types of non-emergency illnesses (Youngson, 1999). They are the first point of contact for the patient when they need healthcare. GPs treat, examine and refer patients to care delivery points in the healthcare system. Other duties include supporting disease prevention and promoting public health requirements of the community (NHS England, 2014c). Most GPs, as part of CCGs, take part in commissioning healthcare services within their local area. CCGs replaced Primary Care Trusts which managed healthcare commissioning until 2012 (NHS England, 2014a). There were about 267,323 doctors registered as medical practitioners in England in 2014 (General Medical Council, 2014). Since GPs are supposed to be the first point of contact for patients when they are sick, it is important that they be available when patients need them, to assure the balance between demand and supply (Porter and Teisberg, 2007). However, it cannot be determined if there are enough doctors to meet the demands of patients. Also, it is not yet properly established how these doctors have been distributed within regions and how their distribution affects patient list or panel size in their various practice areas.

When a patient feels sick, they are required to book an appointment to discuss their health problem with the GP with whom they have registered. Some doctors also visit patients at home, usually outside their normal surgery hours; this is known as the GP out-of-hours service (NHS England, 2014c). Whether through traditional surgery visits or out-of-hour operations, GPs can make referrals of patients with acute trauma to the A&E department after discussion with that A&E (Heyworth *et al.*, 2005). Since GPs are the first point of contact for patients seeking UUEH, they play a pivotal role in regulating and influencing the volume of patients flowing into the A&E department (Baker *et al.*, 2011).

The number of GPs in an area could explain, among other things, the level and amount of consultations they perform and the level of referrals. Since GPs work from various practices which can be described as 'mini organisations' or 'subsystems' of varied sizes, their relationships with patients could explain patient behaviour and access to A&E.

4.5.2 Understanding the work and role of General Practitioners (GPs)

GP practices or surgeries are mini organisations that offer medical services, confidential patient consultations and first medical care within the community by qualified GPs (The Health and Social Care Information Centre, 2013). Since the establishment of the CCGs, GP surgeries operate as small businesses contracted by the NHS Primary Care Organisations (PCOs) to provide healthcare to patients. In 2013, there were about 8,100 GP surgeries contracted by the NHS in England (Monitor, 2013). In 2014, though, there were 7,875 officially registered GP surgeries in England, according to the practice head count of the period (Health and Social Care Information Centre, 2015a).

GPs and their practices connect patients with hospitals and A&E departments. They also regulate patient access to other parts of the healthcare system such as referring them for specific tests such as X-rays and providing advice on healthy living. Research has suggested that easing access to GPs is key to keeping A&E demand under control. For example, Veena *et al.* (2012); Gilbert (2013) found that in areas where patients reported that they had better access to GPs, A&E attendance, use of ambulances and emergency admissions to hospital were lower (Baker *et al.*, 2011). Policy makers have followed this hypothesis and have motivated GPs by awarding additional incentive schemes such as financial rewards so that they attract more patients to seek healthcare from their practices, thereby reducing patients' possible access to A&E departments

(Campbell, 1994; Baker *et al.*, 2011). Despite this, numbers of patients accessing UC directly from A&E continue to increase year on year (Freeman *et al.*, 1999; Cowling *et al.*, 2014). The challenge, therefore, has been to understand the role GP practices play and reasons why their interventions are not reducing A&E capacity problems.

One of the challenges face by GPs is that demand for their services is also higher than they can supply (BMA, 2016). This means GP practices have difficulty offering enough appointments to meet the demands of patients, leading to patients accessing health care from A&E or elsewhere. There are challenges in recruiting GPs as the numbers leaving the profession or already preparing for retirement are steadily increasing. Besides queuing at GP practices, patients can also face several weeks waiting for a pre-booked appointment and could wait for up to an hour to book a slot by phone. Patients who believe they cannot wait that long tend to access healthcare from the A&E (Monitor, 2013).

Furthermore, Baker and Streatfield (1995) suggested that if GP practices were able to provide services to meet the needs of patients, this can make patients more inclined to use them, in the same way as businesses attract customers. They identified that patients need the following from their GP practices:

- Accessibility – the ease with which to get to the GP surgeries,
- Availability – the extent to which it is easy to get an appointment with doctors, or talk to them on telephone,
- Continuity of care – where it is possible to see the same GP when needed,
- Medical care - where the doctors listen and care for the worries of patients and direct them appropriately to the right point of care.
- Premises - where the GP surgery is comfortable, up to date such that patients feel comfortable to sit and wait to be called.

Although many GP practices have done a lot to attract patients, there is doubt as to their success in contributing to the effectiveness of the care delivery process. This is because the number of GPs and the sizes of their practices provide a skewed view of this observation. Where there are smaller GP practice sizes, and when there are not enough doctors to meet the above mentioned factors, there will be variation in A&E attendances from different GP practices. For example, Baker *et al.* (2011) examined whether A&E

attendance rates were lower for patients with GP practices which focused on maintaining higher Quality and Outcomes Framework performance (clinical, organisational and patient experience) or in practices with better access for patients. They examined variation in GP access and effect on A&E attendance within two English primary-care trusts in Leicestershire that had 145 GP practices. They found that GP practices that focused on attaining Quality and Outcomes Framework performance, instead of combining it with improved access to GPs, reported higher rates of their patients accessing A&E. On the other hand, practices that concentrated on improving access to GPs reported a general reduction in patients who attended the A&E department.

Examining whether GP practices in England that are more accessible could influence the rate at which patients visit the A&E, Cowling *et al.* (2013) reviewed the behaviour of registered patients and their attitudes toward their GPs and decision to access A&E rather than GPs when in need of non-emergency health care. There was a 23% rise in the numbers attending A&E in England between the period 2007 and 2008 and so the authors set to examine whether, in situations where more patients had access to GP, there would still be a higher rate of A&E attendance. This is because they observed that many patients who accessed the A&E department would have been treated by their GPs. They found that GP practices where there was enough timely access to their services had fewer of their patients seeking healthcare from the A&E. Therefore, the authors recommended that efforts should be made to improve timely access to primary care when designing approaches to reduce A&E utilisation.

These studies provide some perspectives on the problems faced by the A&E and support the view that factors outside A&E play a decisive role in its capacity problems. Table 4-1 show the changes in the number of registered patients in England, the number of patients per GP, per surgery practice and GP per thousand patients over the years.

Table 4-1 Showing changes in registered patients, patients per practices, patients per GP and GP per 100,000 patients in England

Year	Registered patients	No. of practices	Patients/ practice	% Change in patients per practice	No. of GPs	Patients / GP	% change in patient/ GP
2006/7	53,400,000	8,325	6,414		38,205	1,398	
2007/8	53,900,000	8,261	6,525	1.7%	37,736	1,428	2%
2008/9	53,900,000	8,230	6,549	0.4%	38,343	1,406	-2%
2009/10	54,609,309	8,228	6,637	1.3%	39,232	1,392	-1%
2010/11	55,019,190	8,324	6,610	-0.4%	38,324	1,436	3%
2011/12	55,308,092	8,316	6,651	0.6%	39,347	1,406	-2%
2012/13	55,736,847	8,188	6,807	2.4%	39,420	1,414	1%
2013/14	56,007,348	7,962	7,034	3.3%	39,858	1,405	-1%
2014/15	56,469,999	7,875	7,171	1.9%	40,124	1,407	0%

Analysed from general and personal medical service, data obtainable from Health and Social Care Information Centre (2015b).

GPs and practices play a lead role in reducing the demand for UUEH in the A&E department and thus reduce capacity problems. Patients want quick access and enough time to explain their problems to the GPs. Their perceived satisfaction will make them always seek GPs when they need healthcare since they are mostly located within their community. There is the need for enough GPs to be available to meet the changing patterns of patients' healthcare demand. This is not only through the increase in their head count (numbers) but also through an increase in the different ways in which they deal with the demand for healthcare. Evidence that the current GP system is not properly configured within the health care system is that more patients are accessing healthcare directly from the A&E department. However, there could be differences in approach between urban and rural areas. In London for example, GP practice sizes are smaller and this could influence access (Veena *et al.*, 2012).

4.6 Assessing the role of other access points in the healthcare system

In England, GPs are not the only access points available to patients seeking UUEH. As explained later in this section, access to urgent healthcare is essential to patients, and for this reason, patients can access urgent healthcare from the following points.

4.6.1 Tele-health 111

This is a telephone service, NHS 111, created in 2010, which enables patients in England to make contact with the healthcare delivery services if they need UC help (Monitor, 2014a). Its main feature is that it focuses on non-emergency health queries, is open to patients 24 hours a day, 365 days a year and is free to patients from landlines and mobile phones. It has evolved from the defunct NHS Direct, which was introduced in 1998 and closed down in 2014. Patients who access the 111 service are given advice and directed to the appropriate healthcare delivery point.

The 111 services have been criticised in the past for employing call centre operators who have no medical training and, as a result, have sometimes been directing patients to the wrong access points and to A&E departments (Smith, 2014). There are suggestions that nurses or people with medical training should work in these services so that they have a better knowledge of where best to direct patients to A&E, GP or other referral services (Ibid).

4.6.2 Walk-in centres

Walk-in centres (WIC) are healthcare care units that were introduced between 2000 and 2010 in England by the DOH to provide fluid urgent and emergency health care to the public (Mountford and Rosen, 2000). They were designed to be the most convenient place where patients could access NHS treatment and advice for minor illnesses and injuries without the need to make appointments as with GP services. Operationally, it was aimed to meet three main goals, namely to improve access to primary care, to meet the modernisation quest of the NHS so that it could become more responsive to patients' needs and lifestyles, and to offer more choice to patients (Monitor, 2014b).

Most WICs are managed by nurses and a few by GPs who make periodic visits. WICs can treat minor illnesses such as rashes, aches, burns, sprains, stomach problems, provide contraception, and related. They can also refer patients to A&E and GP practices if necessary.

Official data on WIC attendances are scarce, but the NHS England (2013b) reports that 6.8 million patients attended walk-in centres and minor injury units in 2012/13. However, in recent years there have been rapid closures of the centres blamed on various reasons including poor location, low attendance, confusion of access, over-consumption of healthcare and other reasons (see Monitor, 2014b for example, pages 5, 6 and 7).

4.6.3 Minor injury units (MIUs)

Minor Injuries Units (MIUs) are healthcare facilities which provide direct access to health care services that care for minor injuries. Here patients do not need specialist investigative and support services common in acute general hospitals (Dale and Dolan, 1996). Nurses or GPs can run these facilities; their services have some overlap with the work of the A&E department and GPs (Ibid). There have been limited studies on the working of the MIU, and it is not very clear how useful they have been in reducing pressures on the A&E department. However, it seems to have added to the layers of confusion affecting patients when they seek urgent and emergency health care (NHS England, 2013b). As such, official data on the numbers of MIU services in the country and the number of patients that attend them is scarce.

4.6.4 GP out of hours (GP OOH)

According to the National Audit Office and Department of Health (2014), GP Out-of-hours are healthcare services provided to patients who demand primary care when traditional GP practices have closed after their normal daily times of operation. They work from 6.30 pm to 8.00 am on weekdays and all day at weekends and bank holidays. Data on the effect of GP OOH and its contribution to UUEH management were not available to this research. However, the National Audit Office and Department of Health (2014) estimated that GP OOH in England handled around 5.8 million patient contacts within the period 2013/14, including 3.3 million face-to-face patient consultations. Among them, 800,000 were home visits.

According to NHS Choices (2014), GP OOH care is provided in different ways such as at UC centres, minor injury units, A&E departments or walk-in and primary care centres and home visits. Also, ambulance services may convey patients to meet a doctor or nurse, thereby limiting the need for home visits.

4.6.5 Other access points

According to NHS England (2013b) various categories of access points have come and gone, and some which are in operation have similar names, offering similar or at most slightly different services, at different times. It was difficult to attribute their contribution to this research because they were inconsistent and irregular in certain areas and regions. For example, data for Care UK and Virgin Care access points were limited compared to those of NHS A&E access points.

This plethora of access points (see Figure 1-2) were intended to support patients and reduce access to A&E departments. However, they have not been linked with a proper process protocol; for example, there does not seem to have been consideration of process ownership and process managers. The introduction of CCGs has compounded and made the process more haphazard, leaving patients and health workers in the urgent and emergency care delivery area confused. This situation gives rise to a silo mentality in urgent and emergency care delivery, and hence the nature of problems with A&E attendance observed today.

4.7 Access to A&E

This section reports findings within the A&E operations in England. It starts by examining access to health care and identifying the sources of patients to the A&E. It proceeds to look at referral methods, that is, probing various ways in which patients get to A&E. Then it examines the different ways in which patients attend A&E from their clinical need. It concludes by assessing access based on the type of illnesses diagnosed and treated to justify classification of attendance as AA and IA as well as the nature of the process.

4.7.1 Healthcare access

One can describe "access" to healthcare as the first point where patients gain entry into the healthcare system. Despite this perception, the term 'healthcare access' as presented in the literature is complex, generating no unanimously agreed definition or description (Ahmed *et al.*, 2001). Aday and Andersen (1974) presented two views about access as used in healthcare studies. In one perspective, they suggested that health care access could be driven by population characteristics, for example, nature of family income, attitudes toward medical care and their ability to pay (insurance). Access could also be driven by the nature of the design of the healthcare delivery system itself. This relates to how it organises its workforce, facilities (design and location), and its distribution. In another perspective, Aday and Andersen (1974) argued that access is viewed as an evaluation of outcome indicators of how individuals who pass through the system portray it. They can use their utilisation rating or satisfaction scores to assess it.

To summarise, access to UUEH varies within zones and even within care deliverers. Spatial factors such as uneven distributions of healthcare providers and consumers and non-spatial factors such as variation among population groups due to different socioeconomic and demographic characteristics are possible factors to drive such variations (see for example, Wang and Luo, 2005).

Consultations with GPs can provide a better measure of how the first access point for patients and their relationship with the healthcare system in England is used. Official data on patient-GP consultations are limited and were last collected in 2008 (Q-Research, 2009; NHS England, 2014c). NHS England (2013b) estimated that 340 million GP consultations were made in England in 2013. In a straight-line extrapolation (Figure 4-2) the NHS estimated that, by 2014, the GP consultation rate in England would be 6.3 consultations per registered patient per year.

It has already been reported in Section 4.4.3 that insufficient GPs (GP headcount) and their proper distribution in various regions of the country could have been responsible for patients lacking access to initial healthcare. With the lack of real data on consultation to justify arguments, it is now assumed that the process needed to support patient access to UC is absent.

According to the GP-patient survey (Ipsos MORI, 2014), many patients prefer to access their GPs when they are unwell rather than elsewhere. However, there is also an indication that patients are finding it hard to book appointments to consult with a GP (Monitor, 2013; BMA, 2015). To get a better perspective as to the relationship between patient consultations and A&E attendance, Figure 4-3 shows the changes in consultation numbers over the period 2006/7 to 2014/15. In England, the number of consultations made at GP practices increased gradually over the years, and it showed that it played a leading role in controlling A&E attendance.

The fact that there was increased GP access and at the same time increased A&E attendance suggests that the increased attendance did not show that many patients were treated by GPs. As such there could have been longer waits which discouraged many to access healthcare the A&E. The size of a general practice could mean that increased access did not reflect throughput; for example smaller practices could report higher access but lower throughput from access to treatment and discharge.

While this was the case, A&E attendance also increased year on year and this could be explained either by the size of the GP practices or the number of GPs available to deal with patients.

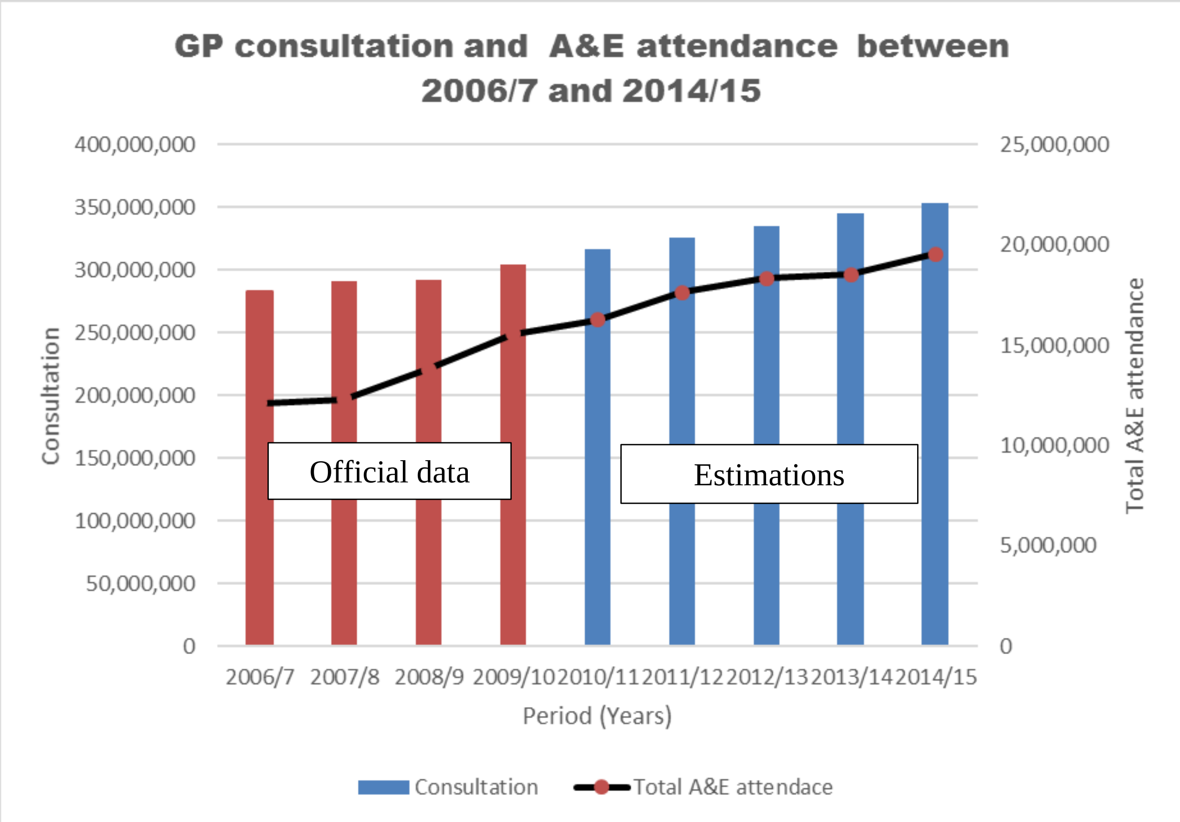


Figure 4-2 levels of GP consultation in England between 2006/7 and 2014/5 and A&E attendance for the same period. Data source: Q-Research (2009); Health and Social Care Information Centre (2015b)

The number of patients registered with a GP practice could help to explain the level of consultations made and thus the number of patients who attend A&E for UC. The view is that, when it is easy for patients to consult their GP practices, their tendency to attend A&E UC will reduce. The level of specialisation of a practice could foster increased GP-patient interactions and hence reduction in A&E attendance. For example, some GP practices specialise in providing particular services and complete consultations such as managing respiratory problems like asthma, high blood pressure, heart problems, diabetes, and stroke as well as accepting consultations from UC patients. Complete consultation occurs where patients access and are treated or referred. Smaller practices will lack these types of capacities and so contribute to higher A&E attendance. This situation is demonstrated in Figure 4-3.

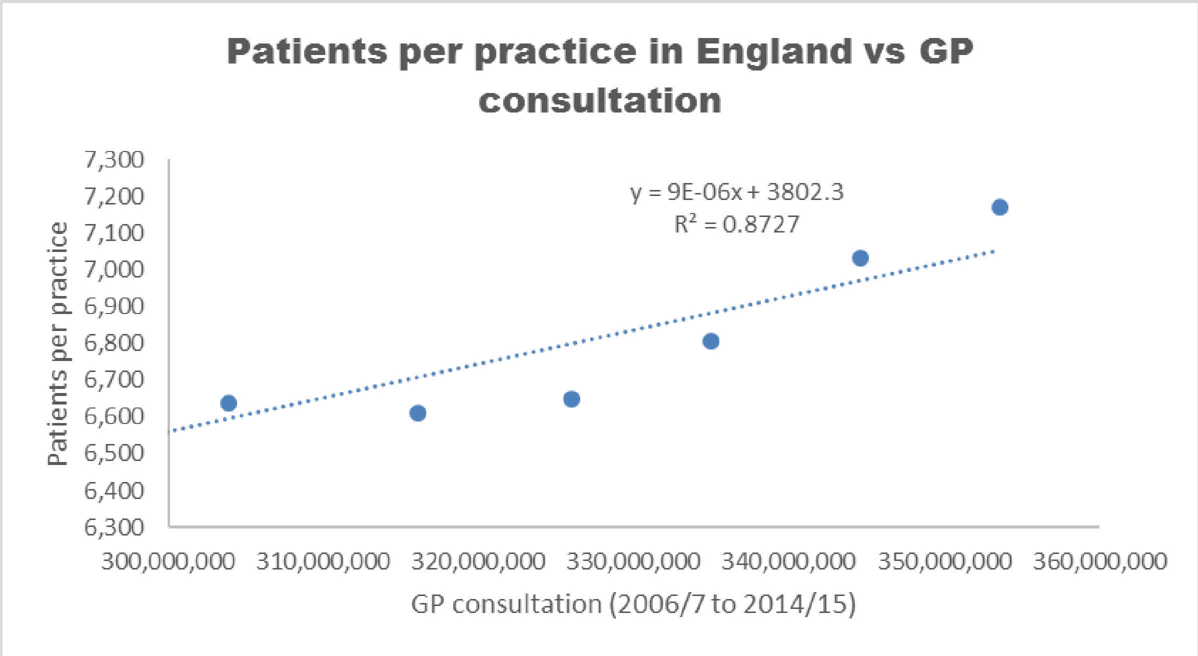


Figure 4-3 Relationships between patients per practice and GP consultation. Data Source: Q-Research (2009); Health and Social Care Information Centre (2015b)

From the analysis presented on the scatter plot in Figure 4-3, there was a positive relationship between patients per practice and the number of GP consultations. This supports the GP-patient survey which shows that patients always wish to access their GPs in the first instance when they need urgent healthcare. However, the higher the number of patients per GP practice, the higher the level of consultations. Nevertheless, it does not show the number of consultations per patient.

Another dimension is also to assess the role of patients per GP. Assessing patients per GP (Figure 4-4), that is the number of patients a GP can handle when they demand healthcare services, could explain the level of consultations that are performed within a given period.

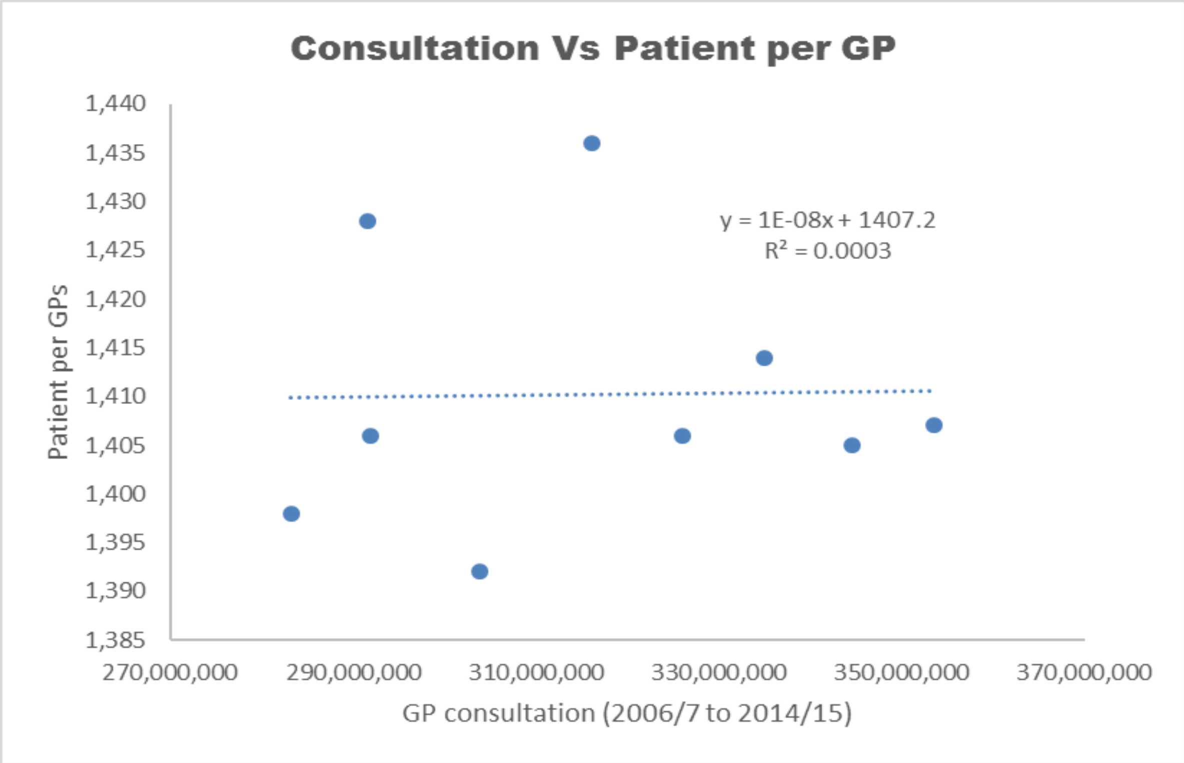


Figure 4-4 Relationship between patients per GP and numbers of GP consultations. Data source: Q-Research (2009); Health and Social Care Information Centre (2015b)

The number of patients per GP explains the number of patients a GP is associated with, that is those registered under their care. It is expected that they will have access to their GPs when they need urgent healthcare. Figure 4-4 shows that there is little relationship between patients per GP and the levels of consultations. This means patients struggle to have access to their GPs when in need of UC. Several reasons account for this including:

- Reorganisation of healthcare operations in the NHS, for example, where pathologies, which were previously performed in hospitals, such as managing respiratory problems, diabetes, cardiovascular disease, and tests and retesting, are now moved to GPs (Ham *et al.*, 2016). This is more time consuming and reduces their ability to perform consultations on UUEH cases.
- The fact that GPs individually play a limited role in influencing consultation. In areas where there are one or two GPs per practices it has been shown that UUEH A&E attendance is high (Veena *et al.*, 2012).
- GPs are compensated by the number of patients on their registers. In some cases, in order to provide a GP service for all patients, GPs may register more

patients than they can comfortably handle. If demand for their services is high, patients may find they cannot access their GP when in need of urgent healthcare (BMA, 2014). These factors mean that the number of registered patients per GP tends not to reflect the total number of consultations made.

The lack of reliable and current data on GP consultation in the England is a deterrent to understanding the relationship between GPs and patients, and a better picture of initial patient access to healthcare delivery is required.

4.7.2 Sources of patients in A&E

Before considering the details of sources of patients, this section starts by presenting the total attendances at A&E over the period from 2009/10 to 2014/15, and thus identifies the demographic groups that attend most frequently.

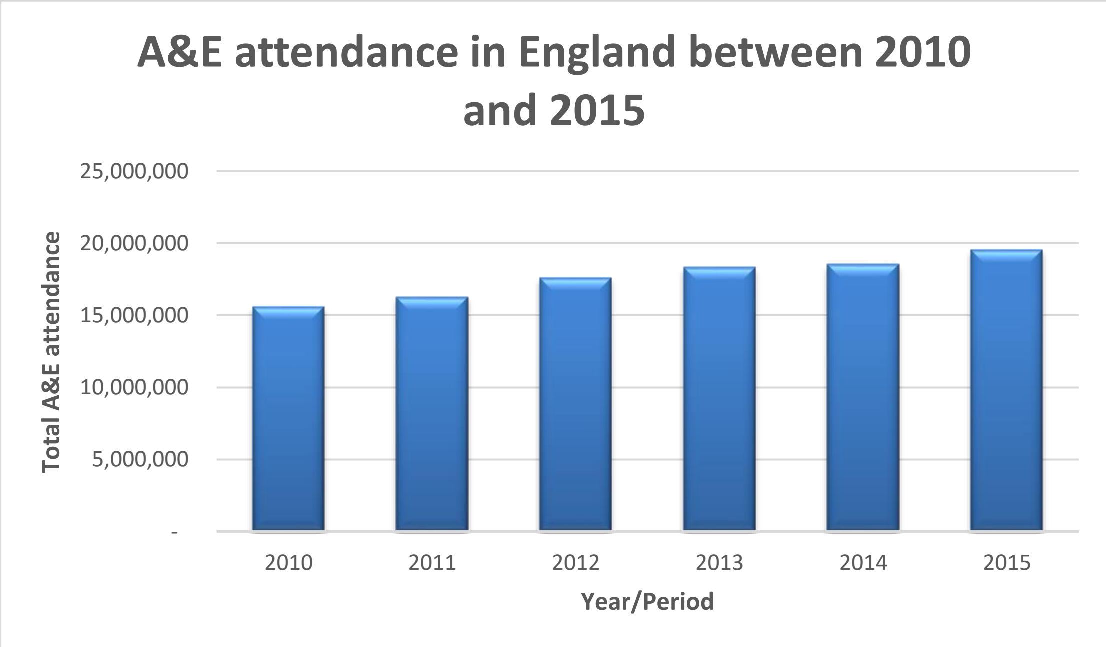


Figure 4-5 Total A&E attendance in England and the value of patients in A&E. Data Source: Compiled with data from Health and Social Care Information Centre (2015b)

For the period 2009/10 to 2014/15, the average A&E attendance in England was 17,639,573 (median 18,517,381). It was observed that on average A&E attendance grew by 4% during that period. Within this period the average population change was 5%, from 52,642,500 in 2010 to 54,786,300 in 2015.

Figure 4.5 shows the total A&E attendances each year (2010 – 2015). Breaking this down to attendance by gender, Figure 4.6 indicates that on average there was similar attendance for men and women over the period, with 'others' relating to those patients whose gender was not recorded.

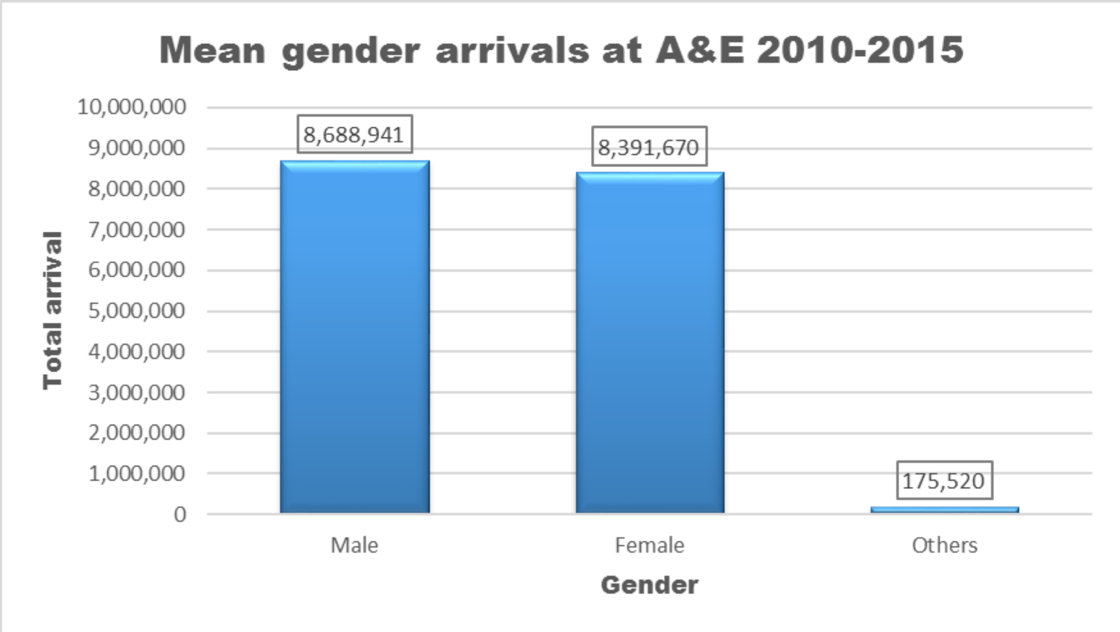


Figure 4-6 Mean A&E attendance for the period 2010 to 2015 by gender. Data Source: Compiled from Health and Social Care Information Centre (2015b).

It was also observed that there was a significant variation in the age groups that accessed healthcare from the A&E. As Figure 4-8 shows, the age groups 0-9, 10-19 and 20-29 on average accessed A&E more.

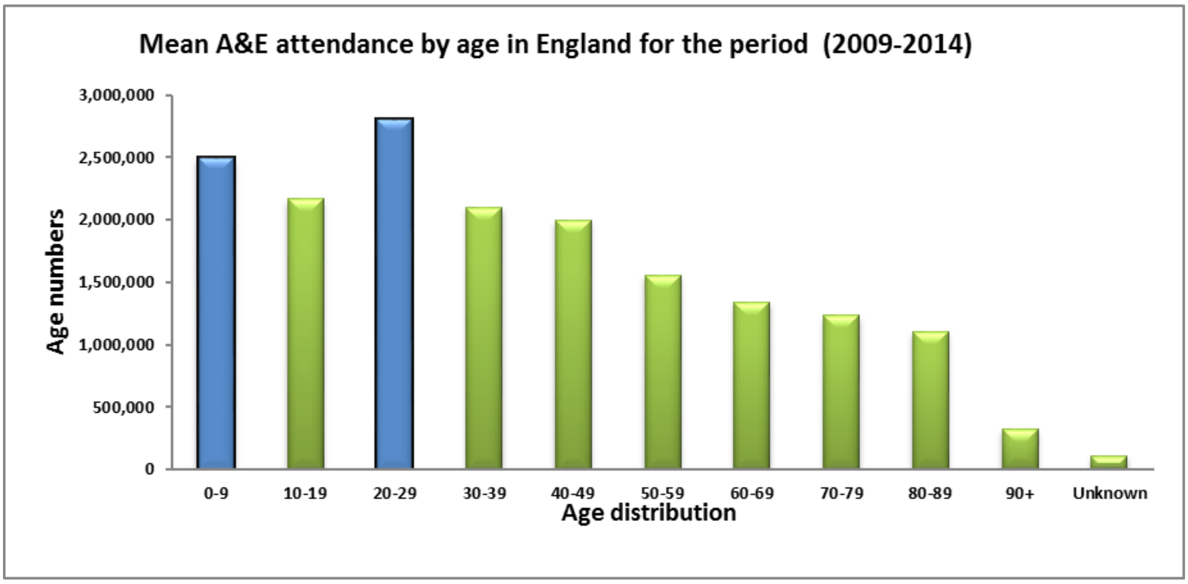


Figure 4-7 A&E attendance in England according to age for the period 2009/10 and 2013/14. Data Source: Health and Social Care Information Centre (2015b)

Reasons for accessing A&E were also examined. This could provide a better explanation of the process and patient differentiation in access. For the period 2009/10 to 2014/15, the various reasons why patients accessed A&E are shown in Table 4-2.

Table 4-2 A&E attendance by patient group from 2009/10 to 2014/15

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Mean	Std. Dev
Other	64%	66%	67%	69%	70%	69%	67%	2%
Other accident	25%	24%	22%	21%	21%	22%	23%	2%
Not known	5%	5%	5%	5%	5%	4%	5%	0%
Sports injury	2%	2%	2%	2%	2%	2%	2%	0%
Road traffic accident	2%	2%	2%	1%	1%	1%	1%	0%
Assault	1%	1%	1%	1%	1%	1%	1%	0%
Deliberate self-harm	1%	1%	1%	1%	1%	1%	1%	0%
Firework injury	0%	0%	0%	0%	0%	0%	0%	0%
Brought in dead	0%	0%	0%	0%	0%	0%	0%	0%

Compiled from A&E attendance between 2009/10 to 2014/15 Health and Social Care Information Centre (2015b)

The data shown in Table 4.2 suggest that on average 67% of patients who attended A&E for the period 2009/10 and 2014/15 access the A&E for reasons classed as "other." "Other" does not ally to any particular reason identified in the Health and Social Care Information Centre dictionary of reasons for A&E attendance and is thus not specific, compared to a sports injury or road accident. Therefore, it can be hypothesised from these data that these are patients who could have been treated elsewhere and can be referred to as IA attendance. If they had been treated for a particular ailment, it would have been coded and registered. Being 'other' means their illnesses where unknown, they were not treated at all, they left after registering, or they were rejected by the A&E department. The data did not suggest that they were admitted or referred elsewhere for further treatment. For the period of this study, therefore, it can be deduced that on average 67% of patients who attended A&E did so for medical reasons not known, or not classifiable or "other".

Researchers of A&E operations have pointed out that most patients who attend the A&E on their own (self-referred) can be considered as IA (Wise, 1997; Coleman *et al.*, 2001; Cowling *et al.*, 2013). They based this on the fact that they were not referred to the A&E department as would traditionally be anticipated in a process operation.

According to the process nature of the healthcare delivery, it was expected that patients would be referred to the A&E department by clinicians who have assessed the seriousness of their illnesses (The Nuffield Provincial Hospitals Trust, 1960; Lowy *et al.*, 1994). They view patients' preference and self-referrals to the A&E department as actions which are inappropriate. It is thus worth examining those attendances that were referred and referral sources.

4.7.3 Referral methods – how they get to the A&E

If the A&E is designed for emergency illnesses, the expectation is that most patients who access it do so by ambulance or are referred by a GP. Looking at the data presented in Table 4-3, variations in referrals modes can be detected.

Table 4-3 A&E referral method in England 2009/10 to 2014/15

	2009-10	2010-11	2011-21	2012-13	2013-14	2014/15	Mean	Std. Dev
Self-referral	65%	66%	65%	64%	63%	64%	65%	1%
Attendance Others	13%	13%	13%	13%	12%	13%	13%	0%
Emergency services (Ambulance)	9%	10%	10%	10%	11%	10%	10%	1%
General medical practitioner	6%	6%	5%	5%	5%	5%	5%	1%
Not known	3%	3%	3%	3%	3%	4%	3%	0%
Health care provider: same or other	1%	1%	3%	3%	4%	3%	2%	1%
Work	1%	1%	1%	1%	1%	1%	1%	0%
Police	1%	1%	1%	0%	0%	0%	0%	0%
Educational establishment	0%	0%	0%	0%	0%	0%	0%	0%
Local authority social services	0%	0%	0%	0%	0%	0%	0%	0%

Data source: Health and Social Care Information Centre (2015b)

From Table 4-3, within the period 2009/10 and 2014/15, on average, at least 65% of patients who attended A&E were patients termed 'self-referred'. This means they accessed A&E by themselves and were not taken there by the emergency services (ambulance, for example). Attendance by ambulance was only 10 percent on average for the period. Referrals by GPs were only 5 percent and referrals from health care providers on the same day, were only 3 percent. Patients recorded as 'not known' (3%) and 'others' (13%) in the overall data were also identified. The "not known" attributes are those with no known source and, with the 'self-referred', can be defined as IA. The reason for this has not been properly defined in past studies. Self-referrals could be justifiable and non-justifiable. Justifiable self-referrals occur when a patient seeking emergency treatment drives themself to the A&E due to delays or unresponsive official emergency transport (Singer and Donoso, 2008; Cairns and Marshall, 2011). On the other hand, non- justifiable self-referral is when urgent care patients access healthcare at the A&E, most probably because they could not access it from their GPs or WIC. Given the process nature of healthcare delivery, data on this are usually classified as "other" and assumed to be IA.

However, attributing all self-referrals to IA is not correct. Although it is hard from the data to determine if self-referred patients were admitted, it is known that many who self-refer access A&E due to slow and unresponsive official emergency transport (Singer and Donoso, 2008; Cairns and Marshall, 2011). Evidence from the NHS system shows that patients suffering from intense pain and ambulance delay will seek another means of transport to the A&E department (Workforce and Facilities Team, 2014; Triggle, 2015). As such, instead of consigning 'self-referred' to the IA category, the data should be filtered according to the types of illnesses that were treated when patients came to the A&E.

'Not known' means patients who access A&E department but were not referred there and it was not known why they were there, that is the coding system for referral access was not known. As such their attendance was not related to an emergency and so could be referred to as IA.

4.7.4 Assessing A&E attendance based on clinical need

One way to gain a precise measurement of A&E attendance and ascertain whether patient attendances followed the appropriate process is to examine the reasons for attending, treatment received and how they were disposed of after diagnosis. This approach is seen to be more objective because it is linked to information about the treatment process the patients attained instead of subjective opinions about the appropriateness of their conditions. Subjective opinions and perceptions as to whether the utilisation of the A&E by patients was right or wrong are put on one side, and comparisons of performance based on the needs of patients can easily be validated. This type of thinking led The Nuffield Provincial Hospitals Trust (1960), (NPHT) to develop methods that can classify patient A&E attendance based on illnesses.

In the approach taken, patients were grouped according to their clinical management needs, starting from the point of diagnosis. Patients who presented conditions diagnosed in the department which were not considered to fit that A&E's operations were referred to as 'IA' attenders. To minimise confusion, various codes were designed to depict patients that could be treated by general practice. (P = General Practice facilities or clinical need required). Cases which were unclear as to whether they fitted A&E facilities or not, those that were doubtful, were coded "P-H=General Practitioner and/or hospital skills required." Conditions that in most cases needed to be treated in an A&E department were referred to as H=Hospital facilities or clinical need required (see The Nuffield Provincial Hospitals Trust, 1960, footnote on p. 60).

A classification of A&E attendees is shown in Figure 4-8, using a similar scheme as the NPHT.

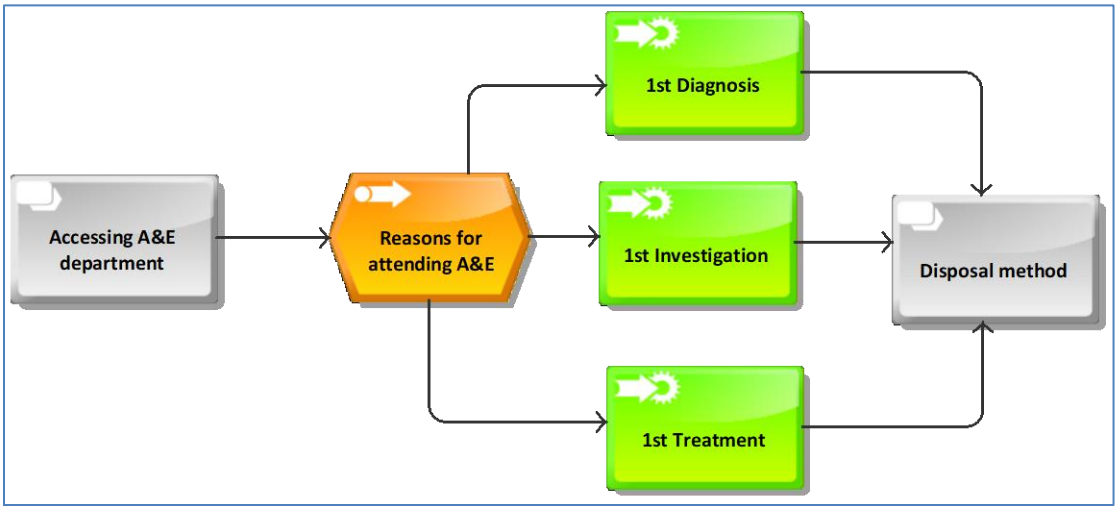


Figure 4-8 components of data used to define the level of A&E attendance. Data source: HSCIC (2014a)

From the six points presented in Figure 4-8, it was determined whether

i. Attendants' conditions were those that would have been treated in GP surgeries;

ii. Attendants' conditions – was it possible for them to have been treated in an A&E department or not – facility for treatment unknown.

iii. Attendants' conditions in most cases fit an A&E department.

1. **First investigation carried out in A&E**

First investigation relates to the initial medical checks carried out when patients first visit the A&E. The term 'investigation' is defined here as "to observe or study by close examination and systematic inquiry," (Webster's Dictionary, 2002). The first investigation was expected to show the type of illnesses that drove patients to the A&E. Using a similar classification approach as presented by the NPHT, the first investigation was classified in line with data from the period 2009/10 to 2014/15.

Table 4-4 First investigation carried out in A&E department compared between 2009 and 2014.

First investigation carried out in A&E	2009	2010	2011	2012	2013	2014
Arterial/capillary blood gas	NA	0.21%	0.29%	0.40%	0.59%	0.77%
Bacteriology	1.10%	0.72%	0.69%	0.65%	0.79%	0.86%
Biochemistry	6.10%	4.25%	4.92%	4.78%	4.94%	5.71%
Blood culture	NA	0.04%	0.04%	0.06%	0.07%	0.08%
Cardiac enzymes	NA	0.10%	0.08%	0.16%	0.18%	0.18%
Clotting studies	NA	0.26%	0.45%	0.61%	0.59%	0.72%
Computerised tomography (exc genito urinary contrast examination/tomography)	1.20%	1.08%	1.36%	1.54%	1.83%	0.00%
Computerised tomography (retired 2006)	NA	0.20%	0.15%	0.02%	0.00%	2.11%
Cross match blood/group & save serum for later cross match	1.20%	0.71%	0.65%	0.40%	0.33%	0.32%
Dental investigation	NA	0.01%	0.01%	0.09%	0.08%	0.08%
Electrocardiogram	4.00%	2.85%	3.23%	3.25%	3.36%	3.32%
Genito urinary contrast examination/tomography	NA	0.02%	0.03%	0.02%	0.03%	0.03%
Haematology	6.20%	4.87%	5.36%	6.37%	6.93%	7.18%
Histology	NA	0.04%	0.02%	0.02%	0.02%	0.03%
Immunology	NA	0.05%	0.09%	0.07%	0.05%	0.09%
Magnetic resonance imaging	NA	0.05%	0.06%	0.06%	0.06%	0.07%
None	25%	26%	33%	40%	41%	40%
Other	11.20%	5.77%	4.65%	5.45%	5.32%	5.44%
Pregnancy test	NA	0.19%	0.22%	0.28%	0.31%	0.29%
Refraction, orthoptic tests and computerised visual fields	NA	0.33%	0.47%	0.64%	0.60%	0.52%
Serology	NA	0.02%	0.03%	0.05%	0.05%	0.05%
Toxicology	NA	0.03%	0.03%	0.03%	0.04%	0.04%
Ultrasound	NA	0.42%	0.42%	0.51%	0.54%	0.55%
Urinalysis	3%	2%	2%	2%	2%	2%
X-ray plain film	38.70%	27.93%	28.79%	26.60%	25.12%	24.36%

IA

Questionable attendances

Calculated with data from Health and Social Care Information Centre (2015b)

From Table 4-4, it can be observed that the highest proportion of investigations carried out on patients who arrived at the A&E were classified as 'none' and 'others.' The adjective 'none' is defined in Webster's Dictionary (2002) as "nothing" or "not any". It can be held that this same definition applies to the first investigation in healthcare and reports a finding where nothing is found. From Table 4-4, of the patients who arrived in the A&E seeking care between 2009 and 2014, based on the medical investigation carried out, nothing was found for 35% of the patients. Also, 'other' used here can be defined as something different. Webster's Dictionary (2002) describes the term 'other' as "not the same," "different," "something other than it seems to be." This means on average for the period 2009, and 2014, of all A&E attendances, 6.3% of investigations provided something different from an illness. On average, therefore, about 40% of patients who attended A&E, based on findings from the first investigation, were IA. There are also questionable attendances for investigations, which showed the need for pregnancy tests, ultrasound and X-rays. It appears that these treatments could have been carried out elsewhere (The Nuffield Provincial Hospitals Trust, 1960; Wise, 1997; Murphy, 1998). With a better process method such as a healthcare hub, away from an A&E department, these services could be provided much effectively.

2. First diagnosis

Another way of assessing the effectiveness of both the healthcare system and whether patients in A&E are AA was to consider the first diagnosis conducted. First diagnosis relates to the first process carried out by identifying the disease which brought the patient to the A&E in the first place. These are the signs and symptoms the patient presents which explain the pain they are feeling (Youngson, 2006). Based on data from 2009 to 2013 (Appendix 3), it was shown that 14.2% of first diagnoses of patients visiting the A&E in England were classified as 'not known'. Additionally, 2.6% were classified as 'nothing abnormal detected' while 1% were identified as 'linked to social problems'.

3. First treatment

Another area that was examined was the first treatment that patients who accessed A&E received. This determines whether they were admitted, were kept for observation in A&E or generally how serious their illnesses were. For the period 2009 and 2014, the Table in Appendix 4 provides details on the types of treatment that patients received. Table 4-5 presents a summary of the types of treatment received which has been determined to fit IA.

Table 4-5 Treatments received by patients in A&E for the period 2010 and 2014

First treatment	2010	2011	2012	2013	2014	Mean	StdDEV
Dressing	2%	2%	2%	2%	2%	2%	0%
Guidance/advice only	25%	27%	34%	34%	34%	31%	5%
Intravenous cannula	3%	4%	4%	4%	4%	4%	0%
Medication administered	3%	4%	6%	7%	7%	6%	2%
None (consider guidance/advice optio	8%	11%	13%	13%	12%	11%	2%
Bandage/support	1%	1%	1%	1%	1%	1%	0%

Source: Calculated with data from Health and Social Care Information Centre (2015b).

Of all patients who were treated in the A&E for the period 2009 and 2014, an average of 31% received "guidance or advice" while 11% received no treatment at all. As such these were the two highest categories. The treatment categories provided in Table 4-5 reflect the type of treatments classified elsewhere as IA (see, for example, The Nuffield Provincial Hospitals Trust, 1960; Prince and Worth, 1992; Wise, 1997). All the treatments provided in Table 4-5 were not supposed to have been carried out in the A&E.

4. Disposal method - what happened to the patients while in A&E

Disposal method refers to the ways A&E patients are released from A&E departments. According to the 4-hour processing guidelines, 95% of patients are expected to be either treated, admitted, referredor released from the department within 4 hours (see, for example, Eatock *et al.*, 2011). The ways patients are treated and released can provide knowledge about the process of UUEH access and how it could affect capacity. Looking into the data for the period between 2009 and 2014 to assess the pattern of patients admitted, treated or released, Table 4-7 shows that an average of 78% of patients who attended the A&E could be considered as IA while only 22% who were admitted could be considered AA. All the patients who were discharged with GP follow-up, no GP follow-up and those referred to other sectors of the healthcare system could have been handled elsewhere such as by GPs or within a healthcare hub.

Table 4-6 How the patients have been released from the A&E department for the period 2009 and 2014

	2009	2010	2011	2012	2013	2014	Mean	Std. Dev.
Admitted /bed provided	22%	22%	22%	21%	21%	23%	22%	1%
Discharged - follow up by GP	18%	19%	19%	20%	20%	19%	19%	1%
Discharged - no follow up required	40%	39%	39%	39%	39%	40%	39%	1%
Referred to Fracture Clinic	4%	3%	3%	4%	4%	3%	3%	1%
Referred to other OP Clinic	4%	4%	4%	4%	4%	3%	4%	0%
Referred to A&E Clinic	3%	4%	4%	3%	2%	2%	3%	1%
Referred to other health care professional	2%	2%	2%	2%	2%	2%	2%	0%
Left Department before being treated	3%	3%	3%	3%	3%	2%	3%	1%
Transferred to other Health Care Provider	2%	1%	2%	2%	2%	2%	2%	0%
Left Department having refused treatment	0%	0%	0%	1%	1%	1%	1%	0%
Not known	0%	0%	0%	0%	1%	1%	0%	0%
Died in Department	0%	0%	0%	0%	0%	0%	0%	0%

Calculated with data from Health and Social Care Information Centre (2015b)

5. A&E waiting and A&E performance

In 2001, the British government instituted a policy report "Reforming Emergency Care" (Department of Health, 2001, p. 1) in which it stressed:

"*By 2004 no-one will wait more than 4 hours in an A&E department from arrival to admission to bed in the hospital, transfer elsewhere or discharge...*"

Since then this has been a benchmark NHS operational standard procedure and has required that at least 95% of patients who accessed the A&E department in England must be seen, treated and then admitted or discharged in under four hours. Various studies (see, for example, Eatock *et al.*, 2011; Weber *et al.*, 2011) have examined this phenomenon, questioned its efficacy and proposed ways in which throughput could meet expected targets. However, currently, as in past years, the capacity situation in the A&E department continues to remain challenging. Figure 4-9 shows that for the period 2010 to 2015, most of the A&E providers failed to meet throughput targets of 98% and

95%. In 2010, A&E departments were expected to put through 98% of patients who sought health care from there. At that time, only 96% throughput was achieved. Then from 2011, the target was reduced to 95%, and since then, the 4 hours standard has hardly been reached. By 2015, only 91% throughput could be attained.

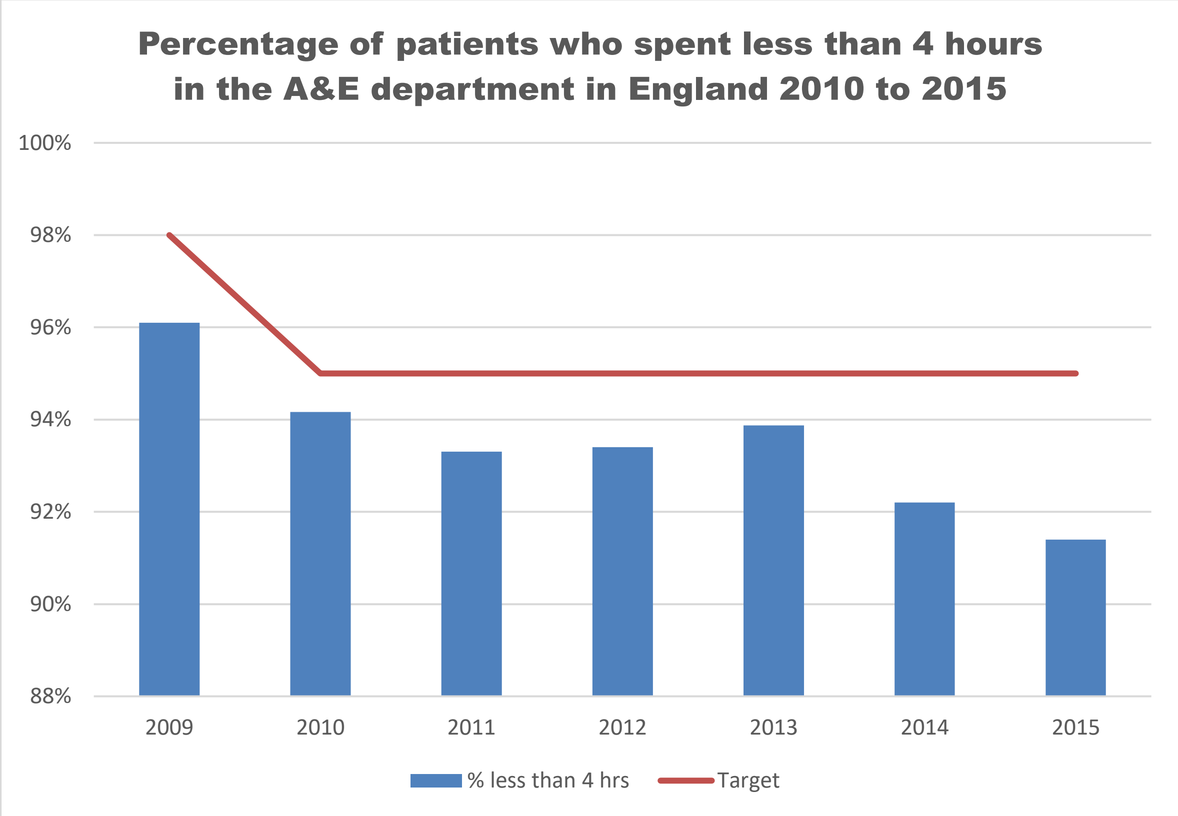


Figure 4-9 How the A&E departments processed 95% of patients within 4 hours. Data source: Health and Social Care Information Centre (2015b)

4.8 Assessment of proposals for redirection of flows of patients away from A&E

In Section 4.7.4, there is the call for a design of UC hubs (UCHs) as a means to redirect patients from the A&E department. This section continues with descriptions of previous initiatives for redirection of patients: polyclinics, primary care services located within (or close to) A&E departments and, more recently, walk-in centres and GP cooperatives.

4.8.1 An earlier proposal – polyclinics

The idea of UCHs proposed in this research is influenced by the “polyclinic” approach (Imison *et al.*, 2008). Polyclinics were large, community-based health centres housing a variety of primary, community and secondary care professionals (The NHS Confederation, 2008).

Different views of polyclinics in England provided evolving descriptions of the model. The NHS Confederation (2008) described polyclinics as a network of GP practices forming a ‘virtual’ primary care centre or super-surgeries with up to 25 GPs providing hospital services such as X-rays, minor surgery and out-patient treatment. A less complex model of polyclinics involved several GP practices operating under one roof, sharing many services but remaining distinct practices with their own registered patients (Smith *et al.*, 2008; Sharp, 2009). Iacobucci (2013) argued that polyclinics were designed to improve access to primary care while reducing reliance on hospitals. They were designed to be “one-stop shops” for both registered and walk-in patients. The NHS Confederation (2008) suggested that polyclinics could be beneficial for improving out-patient treatment and good for busy urban centres with challenges regarding integrated health services. They also reduce travel to hospital and have the potential to develop into a healthcare delivery knowledge centre since smaller care providers can work together and share resources and new ideas.

Despite their perceived benefits, polyclinics do not seem to have been developed in England as expected (Imison et al., 2008). Some reasons for their decline include access challenges. Polyclinics could be located far away from good transport connections and so would not be easily accessible by patients (Imison et al., 2008). When GPs work there, it could pull practices away from the heart of communities to a centralised location, thereby limiting access. The cost of setting up and running them, as well as lack of cooperation with primary care authorities on their protocol, led to their failure to deliver expected outcomes in England. After 2008 many were closed (Iacobucci, 2013). Some, however, could be operating under different names, such as WICs.

4.8.2 Primary care services located within A&E departments

One of the suggestions for improving capacity in A&E departments has been to schedule GPs and primary care staff to work there (Salisbury *et al.*, 2002; Taj *et al.*, 2013; Crawford *et al.*, 2017). This could be effective in quickly dealing with patients who could be treated in primary care rather than emergency settings. A number of recent studies (for example, Dale *et al.*, 1995; Krakau and Hassler, 1999; Coleman *et al.*, 2001; Nagree *et al.*, 2004; van Uden and Crebolder, 2004; Jimenez *et al.*, 2005;

Salisbury *et al.*, 2007; Ramlakhan *et al.*, 2016; Crawford *et al.*, 2017) have examined the impact of GP co-location adjacent to or within the A&E department. The aim has been to determine whether the presence of the GPs reduced congestion in A&E.

Dale *et al.* (1995); Murphy *et al.* (1996) argued that having GPs in A&E departments to manage primary care treatable patients appears to result in a reduced rates of investigations, prescriptions, and referrals by GPs in their own practices. While these are cost gains, there is limited evidence about treatment outcomes and benefits for patients.

Co-locating GPs in A&E departments has been criticised, moreover, for being ineffective in reducing demand for A&E services. A systematic review of this approach (Khangura *et al.*, 2012) was carried out in England and it showed that having GPs in the A&E did not reduce inappropriate A&E attendance. Ramlakhan *et al.* (2016) reviewed many studies that evaluated the effectiveness of co-locating GPs in A&E departments in several countries such as the UK, Netherlands, Australia, Spain, New Zealand, Sweden and Ireland. They reported that co-locating GPs in A&E or surgeries close to A&E departments instead increased inappropriate A&E attendance and increased overall demand. They identified that

- It creates another line of treatment within the A&E department and so consolidates the department as an open treatment centre. The presence of GPs allows the A&E to be seen as a normal access point (Bostock, 2016).
- It fractures and distorts the care delivery process, making efforts to reduce A&E congestion a continuous activity rather than being based on a process that affects the whole system from end-to-end.
- GP practice workload tends to reduce as more patients seek UUEH from the A&E department. As such, quality of care could be compromised since A&E-located GPs will start behaving like emergency doctors and will focus on disposing, treating and referring (Ward *et al.*, 1996). Continuity of care, and health advice common in primary care settings could become limited and risk creating confusion, longer pathways and lower degrees of satisfaction with services (Bostock, 2016).
- Cost – care delivery in the A&E department is expensive (Department of Health, 2014b), whereas treatments in GP practices tend to be cheaper (Murphy *et al.*, 1996). The fixed resource of the A&E department can be eroded with treatment of patients

who are not accounted for in A&E budgeting, thereby erasing any economic gains (Bostock, 2016).

4.8.3 GP cooperatives and walk-in centres

In a recent international systematic review, Crawford *et al.* (2017) examined the impact of alternative emergency care pathways on A&E attendance – specifically GP cooperatives and walk-in centres. They found that WICs have the potential to reduce inappropriate A&E attendance, even though evidence of their efficacy remained low. The study found that GP cooperatives offer an alternative care stream for patients accessing UC and so can significantly reduce IA in the local A&E department. Although the definition and composition of "GP cooperatives" is not defined in detail in (Crawford *et al.*, 2017) study, the current research believes that it could mean groupings of GPs similar to a hub system or polyclinics.

The RCGP (2014) reported an exploratory approach in the NHS in which GPs are supported to form federations or networks that enable them to provide a wider range of healthcare services, integrate with other services, and provide high-quality out-of-hours care. There is evidence that such groupings are taking place in care delivery in England. Iacobucci (2013) described the Frome Medical Centre, a health complex in Somerset, which, with more than 130 permanent health professionals including 30 GPs, aims to provide easily accessible primary and secondary care to more than 30,000 patients. In Southampton, Better Local Care (NHS England, 2016) is an initiative in which local GPs and other health providers are working together to make access to primary healthcare easier. As such, they have established six sites or hubs across the city supporting over 270,000 residents, providing longer opening hours and access to healthcare between 8am – 8pm, seven days a week. The Leicester City Healthcare Hub (CCG Leicester City, 2017) is a hub made up of numbers of GPs and nurses available every day of the week to improve access to healthcare for Leicester patients. It is open to GP-registered patients who can access UC during evenings, weekends, bank holidays and daytime. Patients can access care both through pre-book and through walk-in, and be served by a GP who might not be their preferred doctor. While the functioning of GP cooperatives has been reported in Somerset, Southampton and Leicester, no evidence exists that these approaches have reduced A&E congestion problems. It has not yet been established how they should be designed, their constituent structures and their whole system attributes.

4.8.4 Characteristics of an ideal UCH

The hub approach proposed in this research will contribute to designing a dual-system model where:

1) Patients seeking UUC, for what could include mental health and minor health problems, receive treatment at hubs that are located close to home, at locations where locally-known GPs can provide service. This minimises disruption and inconvenience for patients and their families, and provides confidence in locally-run services. Such hubs would be open for 24 hours, each day of the week, to provide clarity of direction for patients at all times.
2) Patients suffering from serious illness or life-threatening emergencies take the emergency route to A&E. They can be admitted to hospital and receive treatments that maximise their chances of survival and good recovery.

The UCH model proposed in this research is guided by the process orientation model and so should hold the following features:

- Patients can access without pre-booking or with only minimal efforts needed to book
- Patients can have face-to-face contact with a GP or doctor when needed, with short notice
- Patient can access UC hubs at any time when they feel unwell (24 hours)
- UC hubs are visible to patients, and approachable at any time. There is no duplication of access points, to reduce confusion.
- Care is affordable to patients and there is sufficient capacity.
- UC hubs should be close to residential areas (House of Commons (2013a, p.36).
- In accordance with research findings described in Section 4.8.2, UC hubs should not be located close to A&E departments.

4.8.5 Designing UUEH hubs from existing access points and processes

Existing access points are used to design the new hubs rather than pursuing a radically new design. The model presented in Figure 4-10 is conceived by merging and regrouping existing access points to provide the UC model being developed in this research. A redesign is preferred over re-engineering because there are access points that are already known but are perceived to be redundant or ineffective. The intension also is not to reengineer the UUEH delivery system but to seek improvement with existing process attributes. The design is as follows:

- Daycare delivery points: They are created from those care delivery points, which today provide healthcare in the daytime such as WICs, UCUs, Minor Injury units and some GP practices and urgent access. These elements would make up the day section of the UC hubs. In doing so, it eliminates the multitude of access points and leaves only the UC hubs.
- The night delivery point is merely a day-care delivery point that is used for the GP out-of-hours delivery at night time. They become a physical contact point at night in defined location.
- Telehealth NHS 111 remains a 24-hour telephone service as at the current time.

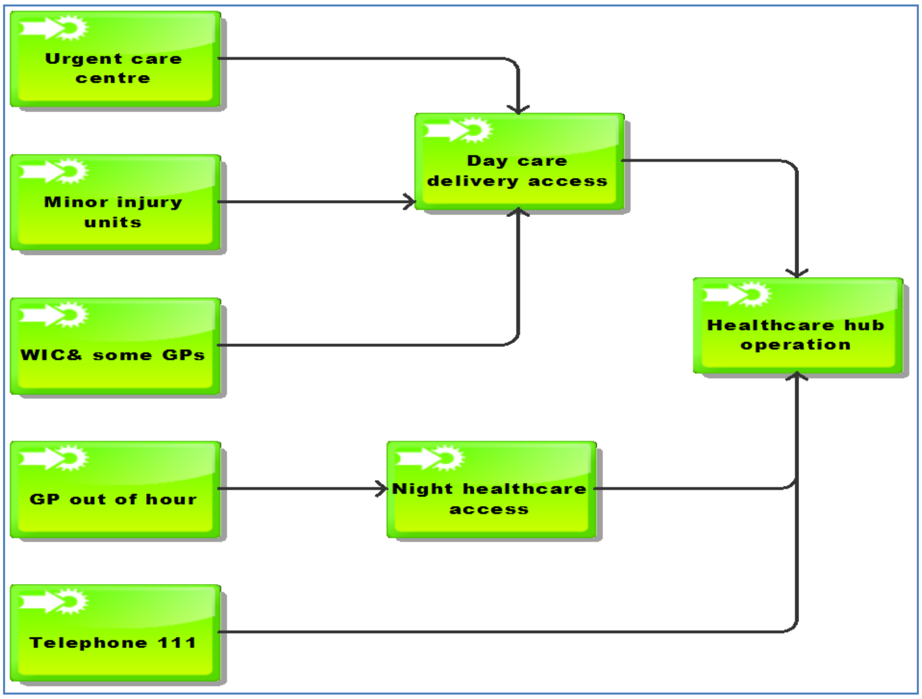


Figure 4-10 UC hub formation

A chart of systemic, process and patient factors influencing the UC Hub proposal is given in Table 4-7.

Table 4-7 Drivers for developing UC hubs as access points to urgently needed care

Systemic factors	Process factors	Patient factors
➢ Need for end-to-end view of delivery ➢ Need to reduce A&E demand	➢ Need for process ownership ➢ Need for process managers	➢ Wish to see a GP or doctor rather than nurses

➢ Need to manage healthcare delivery ➢ Pressure to meet and provide patients satisfaction ➢ Quest to make the system sustainable ➢ Ways of managing shortages of GPs, surgeries, space and labour.	➢ Need for process renewal, update and redesign ➢ Need for process measurement ➢ Need to develop a process map and make accesses visible ➢ Infuse process orientation in unscheduled urgent and emergency care delivery	➢ Lack of self-diagnosis skills ➢ When patients are in pain, it is an emergency for them ➢ Need for medical care with 24 hours ➢ Create visible locally-accessible care delivery points ➢ Reduce confusion in access points ➢ Make access to healthcare structured and organised

4.9 Discussion

The second objective of this research is to investigate the role of process management in influencing A&E demand. That is, to examine the role played by current process design in influencing patients' choice of healthcare access. From the data analysed in this chapter, many patients accessing the A&E department could have been treated elsewhere within the various primary care access points. From the analysis one can draw the following:

i. Throughput has persistently been challenging. The four-hour policy which means that 95% of patients must be treated, discharged or admitted has also hardly been met as can be seen in Figure 4-9. The reason for this is mainly due to volumes of demand that are higher than resources in A&E. Increased demand for UC drive this high demand because from the Table 4-6 it can be observed that of all attendances to A&E between 2009 and 2015, only 22% on average were admitted to the hospital. Therefore, 78% were considered needing UC and it is safe to say that this type of demand increased demand for A&E resources.

ii. Evidence of lack of process protocol

Inappropriate attendance at A&E means that the other access points such as GP, WIC, NHS 111 telehealth systems and GP OOH are being under-employed or are over-worked. Also, the current process model has not considered situations where patients prefer a GP or doctor when demanding healthcare, rather than nurse-led WICs. Patients' lack of skills in performing self-diagnosis, the need for treatment or health advice within 24 hours, pressures of work which make patients inflexible with regards to appointment times proposed by GPs, and other factors are examined in Chapter 5. Capacity problems in the A&E department suggest that the process, steps, and paths (see, for example, Snyder *et al.*, 2005) are not being followed.

iii. Resource utilisation and economic effects

The cost of attending A&E for UC is very high. Treatment at A&E departments costs £125 per attendance compared to £136 per year per registered patient at the GP surgeries (Department of Health, 2014b). Patients can consult with GPs over the year at no extra costs (ibid).

Researchers have argued that there are problems with treatment effectiveness in the A&E department. For example, Lowy *et al.* (1994); Benger and Jones (2008) argued that some preconditions such as asthmatic and diabetic illnesses are best managed through preventive treatment and advice, to avoid emergencies occurring that require A&E access. Since the A&E department is designed for “emergencies”, A&E treatment will only give temporary respite for such conditions, but long-term health problems might remain unresolved (see, for example, Lowy *et al.*, 1994; Benger and Jones, 2008). In addition, with more UC patients demanding healthcare from the A&E, this forces competition of scarce resource within the department and diverts resources from the most serious health cases (Lowy *et al.*, 1994).

In recent years, to seek and devise solutions to problems in the A&E, the NHS England (2013b) proposed a two-way “pyramid” model for urgent and emergency healthcare (Figure 4-11). They argued that healthcare delivery starts with equipping unscheduled patients with self-diagnosis skills and ways of making healthcare close to home. Then for people with more severe or life-threatening emergency care needs, they will have the means to access healthcare from centres with the best expertise to improve survival and recovery rates.

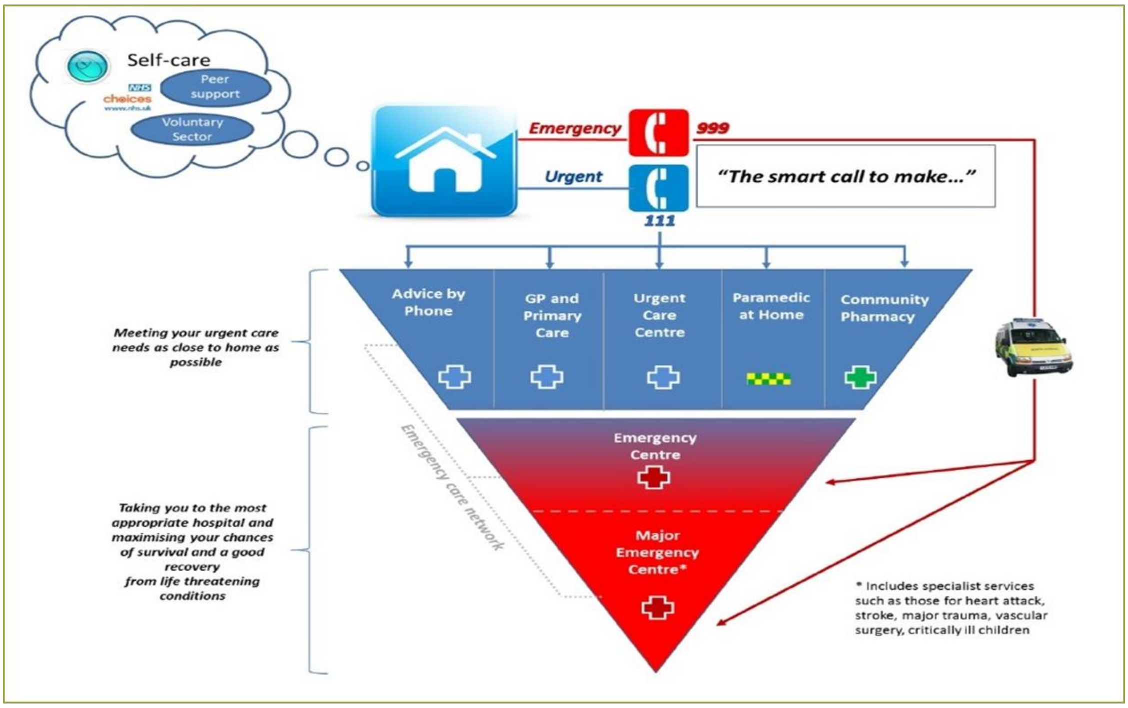


Figure 4-11 NHS two-way "pyramid" model for UUEH. Source: NHS England (2013)

The goal of the model in Figure 4-11 is to support self-care and assist people with UC needs so that they can access healthcare appropriately at the first time of need. Also it aims to provide a highly responsive UC service away from the hospital to reduce queuing in A&E departments, and to connect urgent and emergency care together with various networks.

However, the proposal lacks robustness for tackling current A&E problems. Similar weaknesses such as duplication of functions, lack of clarity and differences between emergency centre and major emergency centres remain unresolved. Again, GPs, UCCs, a paramedic at home, community pharmacies give a number of access points that could confuse patients. For example, a paramedic at home will suit patients whose conditions are known, the old and frail and young children (0-4 years), but active people who are mobile need a more dynamic system, flexible to meet their demand pattern. To know how to use these access points the self-diagnosis skills of patients also need to improve, and GPs have to be available when needed. The approach proposed in Figure 4-11, therefore, seems to be a recycle of the current situation and not robust enough.

4.9.1 The case for urgent care hubs in changing times

Some authorities (for example, Richardson and Mountain, 2009; Crawford *et al.*, 2017) have proposed that the problems faced by the A&E department are driven by external process challenges and so solutions should be sought from outside the department. This has given this research the opportunity to consider the development of Urgent Care hub (UCH) which could be used to improving the delivery of UUEH.

UCH is a term coined in this research to mean a place in the community where UC is provided for direct access by patients demanding UUEH. This comes from the term “hub” which means the central point in a region or area where core activities are operated or provided (Webster's Dictionary, 2002).

4.10 Conclusion

This aim of this chapter was to investigate the role of process management in influencing A&E demand, that is, to examine whether process design rather than patient behaviour influences patient choice of the access point to non-emergency healthcare and the A&E department.

As a result, the chapter has examined the delivery of UUEH in England to build up the relationship between current A&E capacity problems and the process model. The term capacity and its problems has been contextualised. A&E attendances in England for the past 5 years is examined and it has been argued that increased demand for A&E services while hospitalisation remains low indicates misdirected demand. This led to growing congestion and long waits in the A&E department and so creating problems in its operation. Through the chapter, it is observed that the misdirected demand to A&E could have been due to poor process design such that patients become confused owing to the multiple access points, which might mean different things to them. Theoretically, it showed that existing process of UUEH has mostly evolved on its own and adapted to current particular circumstances. As such, the care delivery process is ‘produced and consumed’ on the spot, which does not reflect the nature of healthcare delivery that works according to precise standards of hand over and transfers (Snyder *et al.*, 2005).

The chapter also examined the view that patient could have been attending A&E inappropriately. Although the terms IA and AA have been used in past studies, the scopes of these terms have varied between researchers. To summarise, the literature expresses a range of different views and metrics concerning appropriate and inappropriate attendance. For example, differing percentages of IA are estimated by

House of Commons (2013a, see section 7) as at least 25%, McHale *et al.* (2013) as 11.7%, Martin *et al.* (2002) at 16.8%. The use of these acronyms could be interpreted as a way to communicate the view that some patients attending A&E should have been treated elsewhere. Despite the contentious nature of the terms, this chapter found that first diagnosis, first treatment, and referrals/admittance to hospital did not justify the process relations in Type 1 A&E access. The lack of agreement on the use of terms inappropriate and appropriate attendance means that the remainder of this research will not use these terms. Instead, the terms ‘primary care treatable’ (see Section 4.8.2) and ‘GP treatable’ (Sections 4.4.3 and 4.8.2) will be employed.

Moreover, the view of this research is that the NHS “pyramid” model of UEC delivery is flawed in that patients are assumed willing and able to make the “right” decisions on accessing healthcare. Hence, a UEC delivery model is proposed that is designed on process orientation principles and based on UC hubs, which are available 24 hours per day in accessible locations.

From this chapter, it can be concluded that patients attend A&E department mostly due to the nature of the current care delivery process. The characteristics of this process are investigated in Chapter 5 so that the relations between process structure and drivers for A&E demand can be understood. London is selected as a case study due to its complex nature as a very large modern city, which struggles with the challenges of balancing the demands and delivery of UUEH.

Chapter 5 Catchment area analysis of factors influencing A&E attendance in London

5.1 Introduction

In this chapter, a methodology for assessing factors influencing demand at A&E, a novel combination of catchment area analysis and regression is described. This methodology is applied to assess demand in A&E departments in London, with a case study of London A&E providers. In assessing process management of A&E access in England, Chapter 4 found that demand in A&E may be influenced by features of primary care delivery external to A&E; various studies have shown that some patients who attend the A&E department in England could have accessed healthcare from other primary care points (Driscoll *et al.*, 1987; Coleman *et al.*, 2001). The analysis in this chapter is used to confirm the influences of primary care provision on A&E attendance.

The methodology and case study are introduced in Chapter 2, with data sources and the GIS analysis described in Section 2.4, the analyses in Section 2.5 and the case study in Sections 2.2.2 and 2.7.

London is one of the areas in England where A&E attendance has been increasing in the past years. Between 2012 and 2014, the attendance rates per 1,000 head of population at major A&E departments was greater in Greater London areas than in most other places in England (Health and Social Care Information Centre, 2014). A specific example worth noting is Barts Health NHS Trust in London. The A&E department has registered the highest total amount of patients who accessed unscheduled urgent and emergency healthcare in any A&E department (Baker, 2014). This leads to an examination of the factors affecting attendances at A&E departments in London.

In this chapter the catchment areas of A&E departments in London are first determined. In relation to these catchment areas, the various factors that are likely to affect attendance at A&E departments are quantified. Correlations are used to assess relationships between these factors and regression analysis to explain variations in non-admitted attendance at London A&E providers.

Factors are classified within the catchment areas of A&E departments affecting demand at A&E using the following categories: process design or accessibility factors, patient behavioural factors and population factors. These are explained as follows:

i. Process design or accessibility factors: operational factors such as opportunities to make GP appointments, online appointment booking, and numbers of nurses, GPs and related clinicians (and their workload, working hours' directives). Relative locations of GP surgeries, A&E and other healthcare delivery points also affect accessibility.

ii. Patient behavioural factors: patient attitude, whether patients understand the steps needed to access the healthcare they need, such as through GPs, NHS 111, 999, WICs, or GP out-of-hours service. Deprivation and cultural factors can influence where patients choose to access healthcare (Butler *et al.*, 2013).

iii. Population factors: at a strategic level, the population of the catchment area and those registered with GPs in the area.

In all these three aspects, the data available to this study (described in Chapter 2) enable the quantification of the following in the catchment areas of A&E departments in London: (process/accessibility factors) numbers of GPs, numbers of practices and their sizes (including numbers of single- and two-headed GP surgeries) and distances travelled to A&E; (patient behavioural factors) patients' use of online appointment systems and desired accessibility to GPs, deprivation, as well as (population factors) the resident population and registered patient numbers, .

Data from GP practices indicating how regularly their patients attended A&E departments were not available.

The chapter is organised as follows: Section 5.2 discusses catchment area concept and its application in healthcare planning. Section 5.3 presents the London background to this case study and presents descriptive statistics on access to A&E in London. Section 5.4 describes analysis of the catchment areas of hospitals with A&E departments, with the use of GIS. Here some key factors related to the catchment areas are determined.

Section 5.5 presents regression analysis to assess factors influencing A&E attendance and Section 5.6 gives a conclusion to the chapter.

5.2 Catchment area concept and its application in healthcare planning

The term catchment area has been used in healthcare research, particularly in relation to assessing health delivery, facility utilisation, access, location and interaction of population and healthcare resources within the community (Schuurman et al., 2006). Using the catchment area idea, researchers have attempted to develop ways of determining how, with limited resources, healthcare services could be properly aligned to reflect relative the needs of the population within specific local areas. Within health delivery management service research, different approaches in defining catchment areas have been developed (Alexandrescu et al., 2008), for example the two-step floating catchment area method, pioneered by Luo and Wang (Luo, 2014) which builds upon the framework of provider- or physician-population ratios. However, it applies a floating catchment area thinking which overlaps, thereby capturing real life healthcare access behaviour with unrestricted utilisation. Other approaches have been presented in the literature; this research is not designed to expand on them.

5.2.1 Understanding the meaning of catchment area in healthcare research

From the geographic perspective, GIS proposes a range of spatial analysis methods that can be used to define a catchment area. In this research, a catchment area will be defined as a geographical area outlined around an institution or a business that describes the population that utilises its services (Alexandrescu *et al.*, 2008). This means a catchment area in relation to healthcare delivery relates to the ability to link healthcare services with potential patients and the population that might utilise them. Accessibility and outcomes are very important in fostering the essence of a catchment area (Esri, ND).

Practically, catchments areas are manifested through dividing geographic space into adjoining regions, although it is known that they will in most cases overlap. This explains the existence of competition within an area between service providers (Luo, 2014). The size and composition of a catchment also varies depending on the nature of the service provided. For example, GP practices may register both residents in their locality and also those who live further afield. This causes GP practice catchment areas to have large overlaps even though most households live within the locality of their practices (Watson *et al.*, 2009). This makes GP practice catchment areas, however, unsuitable for comparative analysis in assessing different catchments. As such, when analysing data at GP practice level, registered practice population is preferred, rather than a geographically defined one.

One way of determining the boundaries of a catchment area is to use distance from the facility – either the straight-line distance, the distance patients have to travel or the distance travelled by patients in a given time (Schuurman et al., 2006; Zinszer et al., 2014). Under this approach, it is assumed that people will visit the closest facility, which implies that distance is the overriding factor influencing attendance. However, distance is only one of many factors that influence the choice of healthcare facility such as the A&E department. Others factor include services available and the perceived quality of care (Luo, 2014; Zinszer et al., 2014).

5.3 Background to London case study

In this section, London, its boroughs and the locations of A&E departments, is described. Descriptive statistics are provided for A&E attendances by provider, in total and by non-admitted patients; by day of the week and by age group. Attainment of the 4-hour targets for A&E and demonstrate population growth and growth in A&E attendance is considered. Finally, the varying levels of deprivation in the capital are described.

London is chosen for the detailed study of A&E access for the following reasons:

i) A&E attendance is high in London compared to other regions of the country (Baker, 2014; Health and Social Care Information Centre, 2014). A&E departments in London are more frequently failing the performance benchmark target of assessing 95% of patients within a four-hour period.

ii) London has a large and diverse population. There are boroughs with very high levels of deprivation (see Section 5.2.1). It is of interest to determine if deprivation affects A&E attendance.

iii) London is the largest urban area in the UK, where patients can access urgent and emergency care from a number of centres. Comparisons are made between the different urban catchment areas of the study.

iv) A King’s Fund study (Veena *et al.*, 2012) highlights the large number of single- and two-headed GP practices in London. These are investigated to see whether this affects A&E access in the catchment areas.

5.3.1 London and its boroughs

London is a large city with an overall population of more than 9 million people (Greater London Authority and Office for National Statistics, 2014). It is made up of 32 separate administrative municipalities known as boroughs (see for example, Greater London Authority and Office for National Statistics, 2014; Office for National Statistics and Greater London Authority, 2015), shown in Figure 5-1. The “City” of London is not officially classified as a borough; for healthcare delivery, the City of London is usually linked with the Borough of Hackney. Central London is shown in Figure 5-2. Figures 5-1, 5-2 and the maps following in this chapter were drawn using ArcGIS.

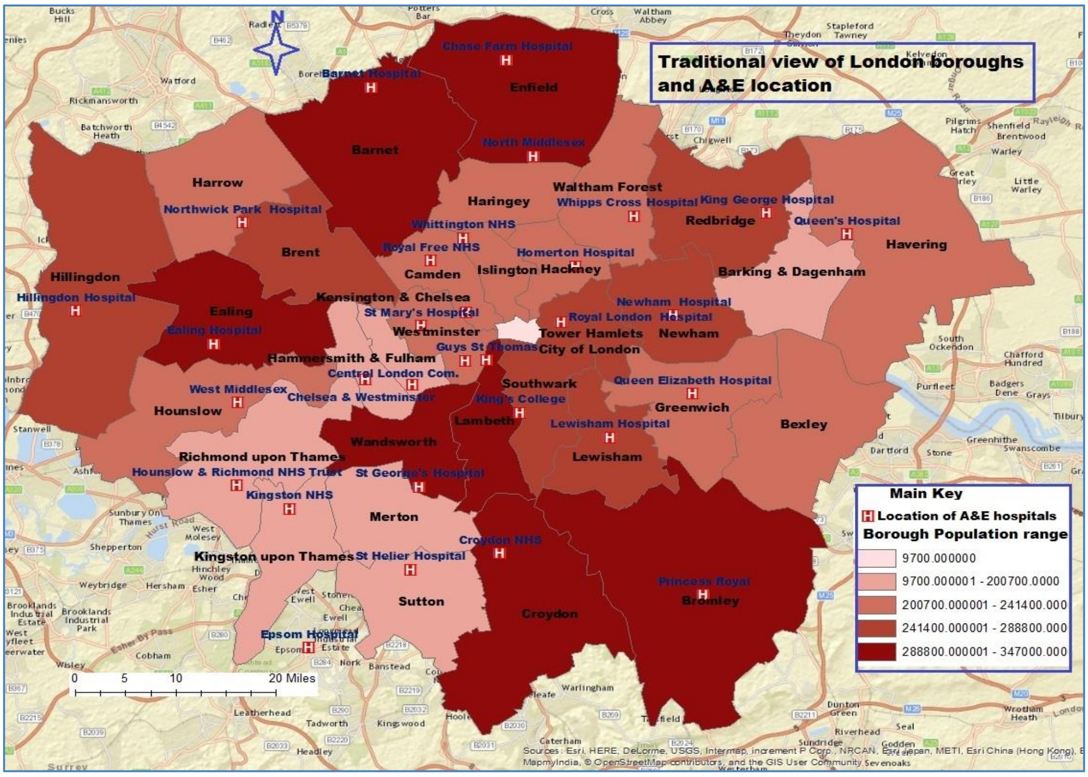


Figure 5-1 London borough populations and hospitals

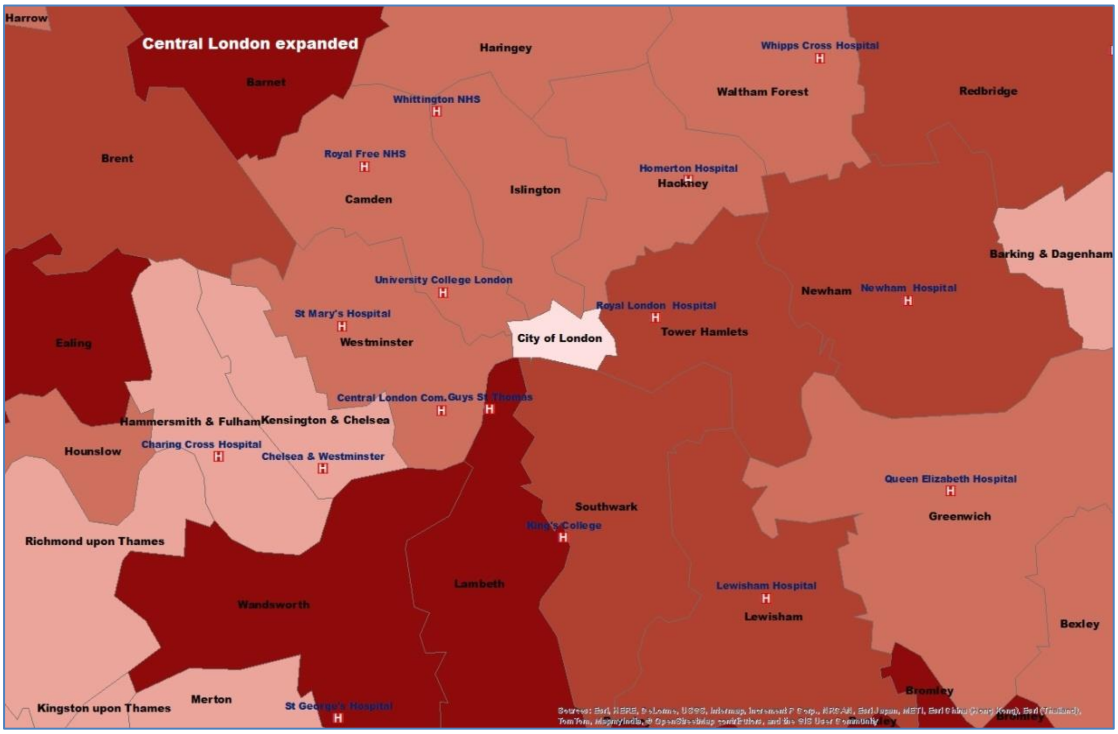


Figure 5-2 Central London boroughs and the City of London

Traditionally, London hospitals have been associated with particular boroughs. However, as shown in Figures 5-1 and 5-2, A&E departments are not evenly distributed between the boroughs, with many being in central London. Healthcare in each London borough is commissioned by a separate CCG, including unscheduled urgent and emergency healthcare (NHS, 2013; NHS England, 2014a). The work of the CCGs, however, does not exhibit overall leadership or management of the care delivery process in London. Therefore, to get a better understanding of how healthcare is delivered in London the borderless structure provided by the super output areas (SOAs) is adopted and used to determine catchment areas of A&E departments.

5.3.2 Descriptive statistics of London A&E attendance

To assess the combination of factors that lead to patients accessing A&E in London, a one-year data set, for 2013/14, is used. First, patterns of A&E attendance, both total and non-admitted, in London are examined and, to see how these attendances vary among the 21 hospital A&E providers, see Table 5-1. Admitted patients are those found to be sick enough to need a hospital bed, while non-admitted patients are able to return home after their time in A&E.

Table 5-1 A&E attendance by provider in London

Providers	Total A&E attendance	Non-admitted patients	Admitted	% admitted	% not admitted
Imperial College Healthcare NHS Trust	437,338	388,345	48,993	11.2	89
Barts Health NHS Trust	326,426	239,343	87,083	26.7	73
King's College Hospital NHS Foundation Trust	240,356	194,387	45,969	19.1	81
North West London Hospitals NHS Trust	218,875	177,401	41,474	18.9	81
Barking, Havering & Redbridge University NHS Trust	210,215	158,855	51,360	24.4	76
North Middlesex University Hospital NHS Trust	161,619	140,948	20,671	12.8	87
Lewisham & Greenwich NHS Trust	158,936	128,703	30,233	19.0	81
Barnet & Chase Farm Hospitals NHS Trust NHS Trust	149,524	119,582	29,942	20.0	80
St George's Healthcare NHS Trust	144,031	107,060	36,971	25.7	74
Ealing Hospital NHS Trust	143,690	122,087	21,603	15.0	85
Epsom & St Helier University Hospitals NHS Trust	142,837	111,968	30,869	21.6	78
Guy's & St Thomas' NHS Foundation Trust	136,731	107,311	29,420	21.5	78
Croydon Health Services NHS Trust	135,769	107,523	28,246	20.8	79
University College London FT	125,277	102,471	22,806	18.2	82
Homerton University Hospital NHS Foundation Trust	117,977	99,150	18,827	16.0	84
Chelsea & Westminster Hospital NHS Foundation Trust	112,480	96,186	16,294	14.5	86
Kingston Hospital NHS Foundation Trust	110,169	93,003	17,166	15.6	84
The Hillingdon Hospitals NHS FT	93,556	71,652	21,904	23.4	77
Royal Free London NHS Foundation Trust	93,387	74,470	18,917	20.3	80
Whittington Hospital NHS Trust	90,992	72,882	18,110	19.9	80
West Middlesex University NHS Trust	58,029	35,976	22,053	38.0	62

Data source: Health and Social Care Information Centre (2015b)

Table 5-1 shows that the highest total A&E attendance and highest percentage (89%) of non-admitted patients were recorded by Imperial College NHS Trust, which is located in the busiest, central part of London. It is possible that many people working in central London, or tourists and other visitors could be accessing healthcare there. It should be noted that data for Central London Community NHS Trust and Imperial College NHS Trust were combined, since the two A&E providers are located in the same MSOA.

Figure 5-3 gives a ranking of total numbers of admitted patients per provider across London. Barts Health NHS Trust had the highest number of admitted patients, followed by Barking Havering and Redbridge NHS Trust, whereas Chelsea and Westminster had the lowest.

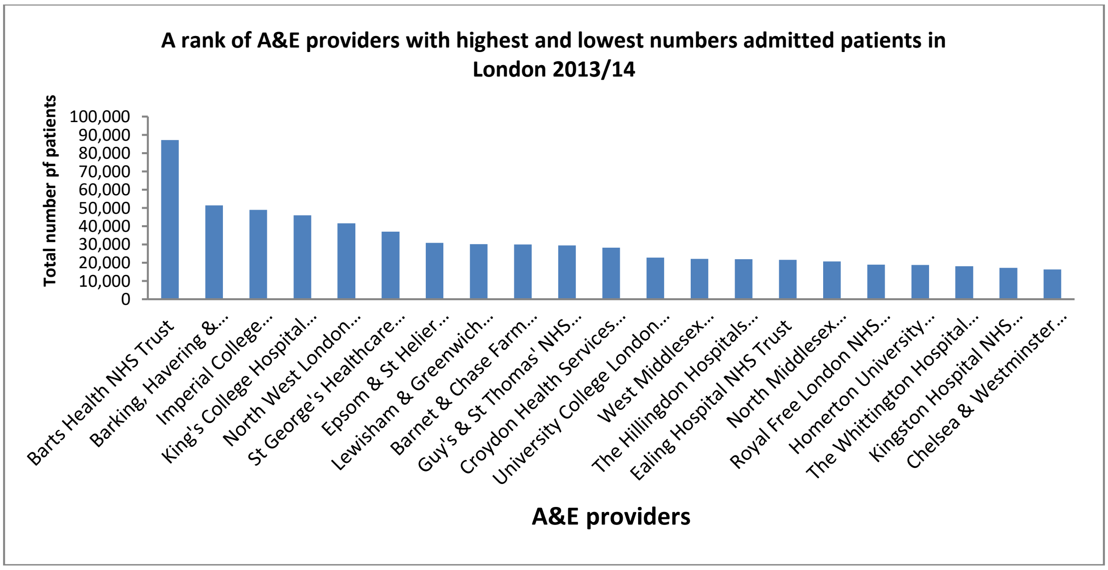


Figure 5-3 Number of A&E patients admitted by provider in London. Data source: Health and Social Care Information Centre (2015b)

Total numbers of non-admitted patients and their final destinations, by A&E provider, are shown in Table 5-2: discharged with or without GP follow-up; referred to other areas of the health care sector or social care system from the A&E.

Table 5-2 Numbers of non-admitted patients according to A&E providers in London. Data source: Health and Social Care Information Centre (2015b).

A&E provider	Discharged - GP follow up	Discharged - no GP follow up	Referred	Others	Total Non-admitted
Imperial College Healthcare NHS Trust	114,830	64,576	28,290	15,250	388,345
Barts Health NHS Trust	66,510	94,403	38,999	39,431	239,343
King's College Hospital NHS Foundation Trust	55,450	87,116	34,641	17,180	194,387
North West London Hospitals NHS Trust	48,808	102,117	18,858	7,618	177,401
Barking, Havering & Redbridge University Hospitals NHS Trust	53,447	72,395	16,457	16,556	158,855
North Middlesex University Hospital NHS Trust	9,920	117,871	2,813	10,344	140,948
Lewisham & Greenwich NHS Trust	37,708	63,042	16,101	11,852	128,703
Ealing Hospital NHS Trust	56,837	34,143	22,892	8,215	122,087
Barnet & Chase Farm Hospitals NHS Trust	71,116	24,910	14,739	8,817	119,582
Epsom & St Helier University Hospitals NHS Trust	6,003	79,906	14,220	11,839	111,968
Croydon Health Services NHS Trust	19,029	68,518	10,415	9,561	107,523
Guy's & St Thomas' NHS Foundation Trust	12,051	71,733	16,567	6,960	107,311
St George's Healthcare NHS Trust	41,339	34,403	19,123	12,195	107,060
University College London Hospitals NHS Foundation Trust	60,381	19,268	13,381	9,441	102,471
Homerton University Hospital NHS Foundation Trust	1,762	70,811	10,385	16,192	99,150
Chelsea & Westminster Hospital NHS Foundation Trust	15,474	12,670	4,815	63,227	96,186
Kingston Hospital NHS Foundation Trust	41,727	32,263	11,766	7,295	93,003
Royal Free London NHS Foundation Trust	28,689	28,125	11,448	6,208	74,470
The Whittington Hospital NHS Trust	33,862	17,751	10,396	10,873	72,882
The Hillingdon Hospitals NHS Foundation Trust	5,534	52,543	7,468	6,107	71,652
West Middlesex University Hospital NHS Trust	12,571	17,079	4,260	2,066	35,976

Total A&E attendances vary by day of the week. Total A&E attendances by day of the week in London over the period 2009/10 to 2013/14 are shown in Figure 5-4. Mondays exhibit the highest demand for A&E care and weekends have the lowest. This could be because GP surgeries are closed over the weekend, and so are congested on Mondays. This challenges GP capacity as demand overwhelms available slots thereby causing more people to attend A&E. In addition, patients accessing out-of-hour services at the weekends may be referred to GPs on Mondays.

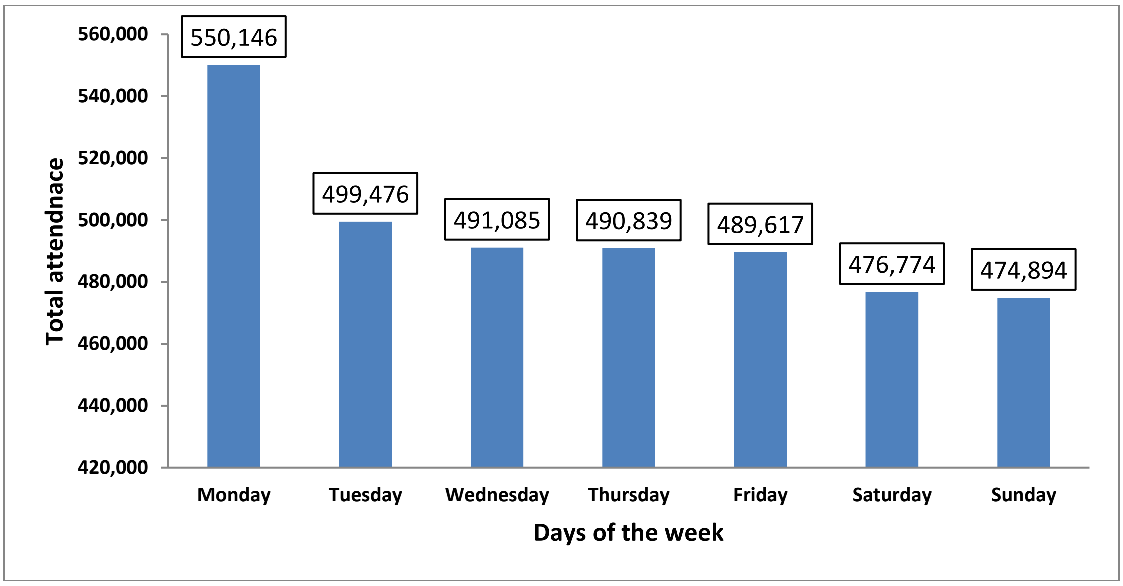


Figure 5-4 Total A&E attendance in London by days of the week for the period 2009/10 to 2013/14. Data source: Health and Social Care Information Centre (2015b)

Self-referred attendances at London A&Es are shown by day of the week, by year from 2009-10 to 2013-14, in Figure 5-5. Growth in these attendances occurred throughout the period and, again, Mondays consistently show the highest totals.

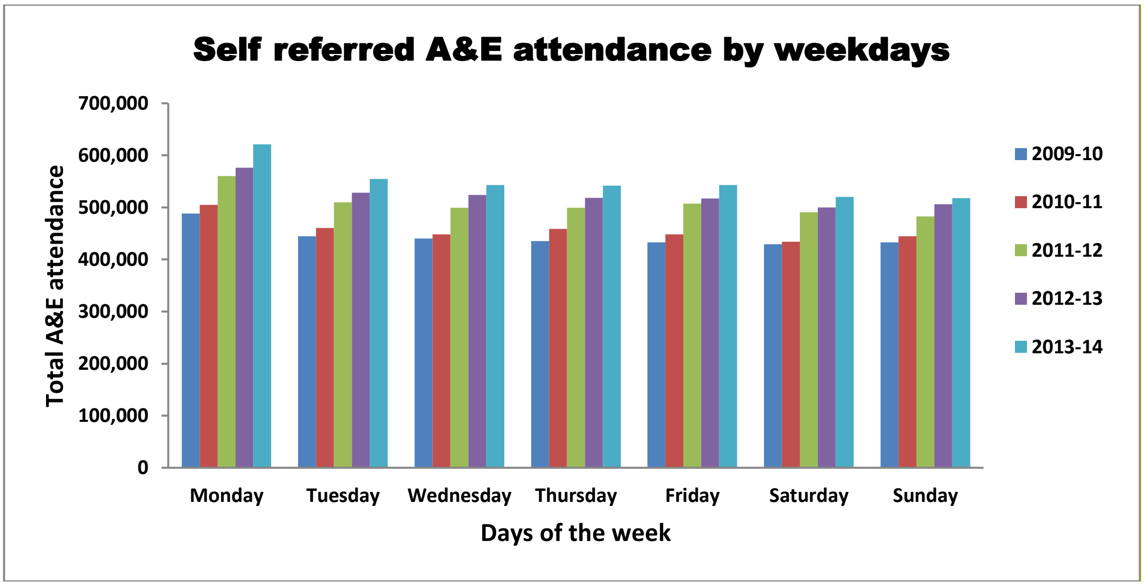


Figure 5-5 A&E attendance (self-referred) in London by days of week, for 2009/10 to 2013/14. Data source: Health and Social Care Information Centre (2015b)

It is also of interest to know which demographic group demands A&E care the most. Figure 5-6 shows total A&E arrivals in London by age group, by year from 2009/10 to 2013/14. A&E demand from the older population (80+) was low at 22%, while the highest growth in healthcare demand was from the age group 20-49 years. However, the older age group may account for more long-stay patients admitted to hospital.

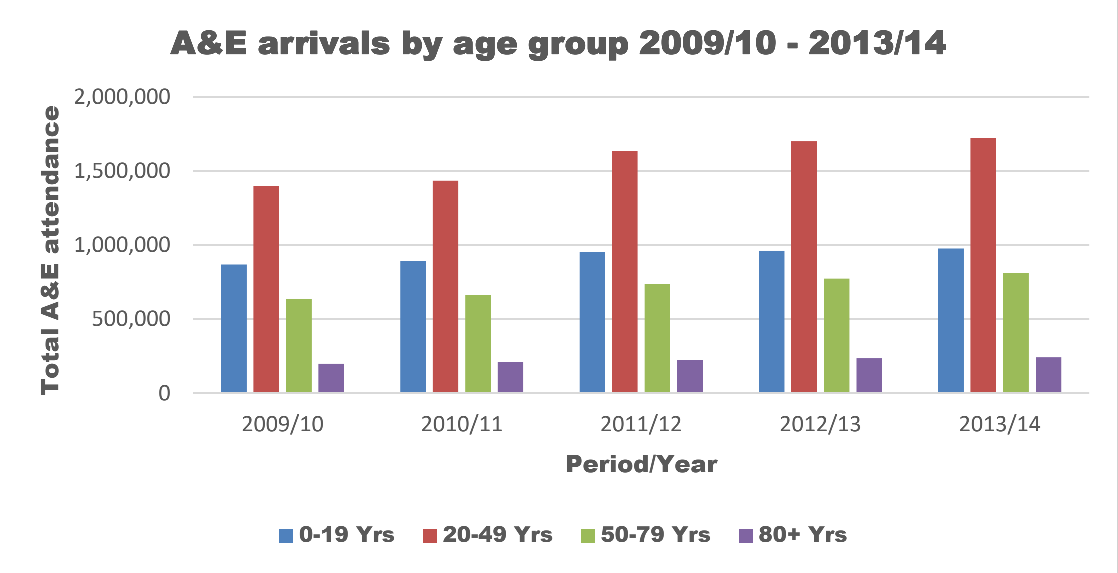


Figure 5-6 Non-emergency A&E attendance by age group for the period 2009/10 and 2013/14. Data source: Health and Social Care Information Centre (2015b)

5.3.3 Meeting the 4-hour targets

Throughput, the ability of the A&E department to process 95% of patients and release them within 4 hours, can highlight hold-ups or bottlenecks (long waiting and queuing) of patients in the process (Eatock *et al.*, 2011). It may also be indicative of excessive numbers of patients accessing A&E. Figure 5-7 shows that 67% or 14 of the 21 providers in the current study did not successfully process 95% of patients within 4 hours. The A&E departments that struggled the most with throughput were Homerton University Hospital NHS Foundation Trust (52%), and Chelsea and Westminster Hospital NHS Foundation Trust (84%). On the other hand, Ealing Hospital NHS Trust (97%), Royal Free London NHS Foundation Trust (96%), Epsom, and St Helier University Hospitals NHS Trust (96%) are providers that had higher throughput than was required by the operational benchmark.

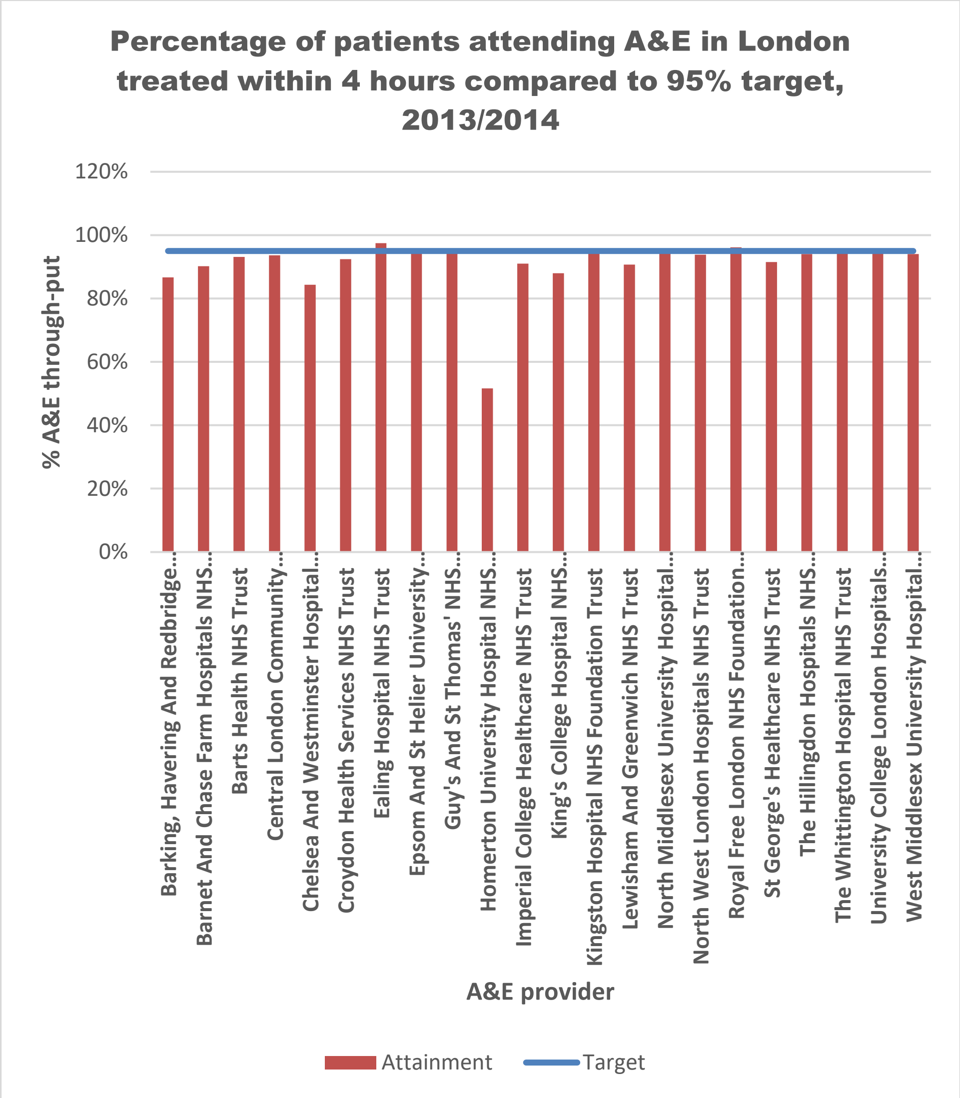


Figure 5-7 A&E performance in terms of throughput – meeting the 95 percent target within 4 hours. Data source: Health and Social Care Information Centre (2015b)

Figure 5-8 shows the overall percentages of achievement of the 4-hour targets in London A&Es between 2010 and 2014. In 2010, 94% throughput was achieved while, in 2014, that level fell to 92%.

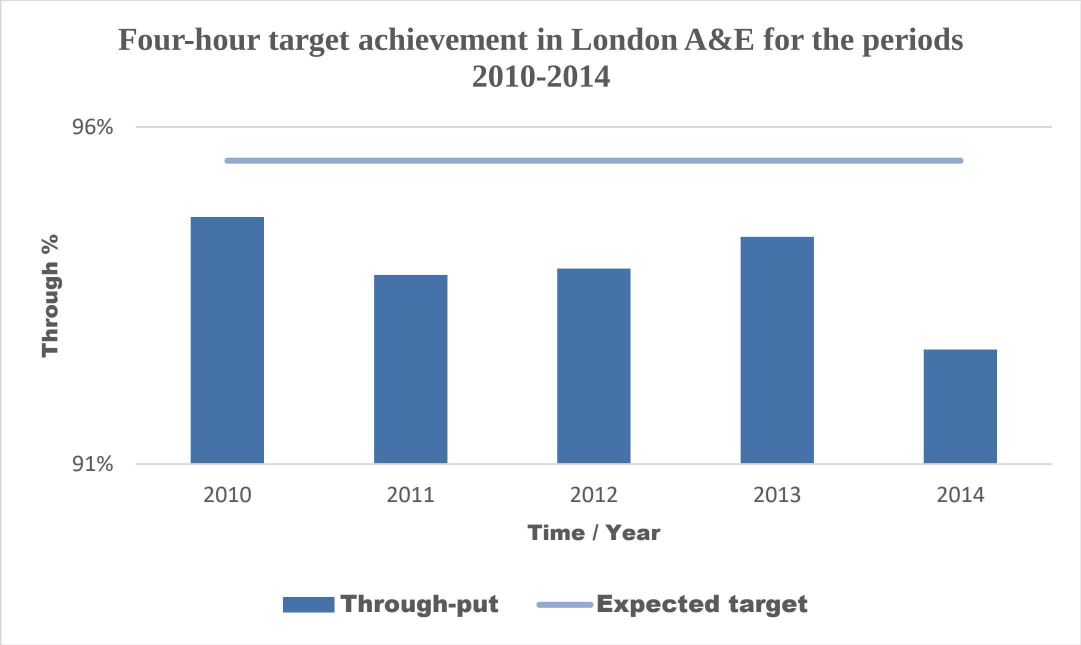


Figure 5-8 Level of patient throughput through London A&Es between 2010 and 2014. Data source: Health and Social Care Information Centre (2015b)

5.3.4 Growth of population and non-admitted A&E attendance in London

Table 5-3 shows changes in the numbers of registered patients and resident population in London between 2009/10 and 2013/14.

Table 5-3 Changes and growth in population, registered patients and number of GPs

	2010	2011	2012	2013	2014	% Change
Registered patients	8,782,435	8,845,605	8,992,795	8,978,299	9,109,833	4%
Resident Population	8,061,495	8,204,407	8,308,369	8,416,535	8,477,400	5%
No. of GPs	5,421	5,552	5,748	5,721	5,566	3%
Patients per GP	1,620	1,593	1,565	1,569	1,637	1%

Data source: Health and Social Care Information Centre (2015a)

It is notable that numbers of registered patients are higher than the estimated resident population. This could be because patients from neighbouring areas outside London can register with a GP inside London. Alternatively, patients might have moved or died but their data continue to be included on GP lists.

Various studies (see Section 4.4.1 and 4.4.2) have pointed to the fact that patients' first point of contact when they need unscheduled non-emergency healthcare is their GP. This means the number of GPs within communities ready to deal with patients' health queries at the most convenient times of demand should be significant. Changes in the numbers of registered patients, in resident population, in the number of GPs and in numbers of patients per GPs in the period 2009/10 and 2013/14 are presented in Table 5-3. The table shows that, within a 5-year period, the population has increased by 5%, and registered patients increased by 4%, while the number of GPs grew by 3%. The number of patients per GP grew by 1%. Given that this is an average over 5 years, it can be observed that, year on year, there seem to be difficulties in increasing the number of GPs so that they become the first point of access for patients.

Table 5-4 and Figure 5-9 show growth in total and non-admitted A&E attendance in London between 2010/11 and 2013/14.

Table 5-4 Table showing total amount of A&E attendance in London over the period 2010/11 to 2013/14

A&E attendance in London	2010-11	2011-12	2012-13	2013-14	% change	Change rate	Std Dev.
Admitted	594,070	649,341	657,697	669,732	11%	3%	33,489
Total Admitted	594,070	649,341	657,697	669,732	11%	3%	33,489
Discharged - GP follow up	644,400	851,969	908,277	892,848	28%	7%	122,312
Discharged - no follow up	1,137,133	1,241,643	1,289,629	1,288,636	12%	3%	71,672
Referred	323,791	351,966	341,187	350,358	8%	2%	12,927
Other	148,220	366,816	424,896	523,429	72%	18%	158,830
Total Non-admitted	2,253,544	2,812,394	2,963,989	3,055,271	26%	7%	359,411

Data source: Health and Social Care Information Centre (2015b)

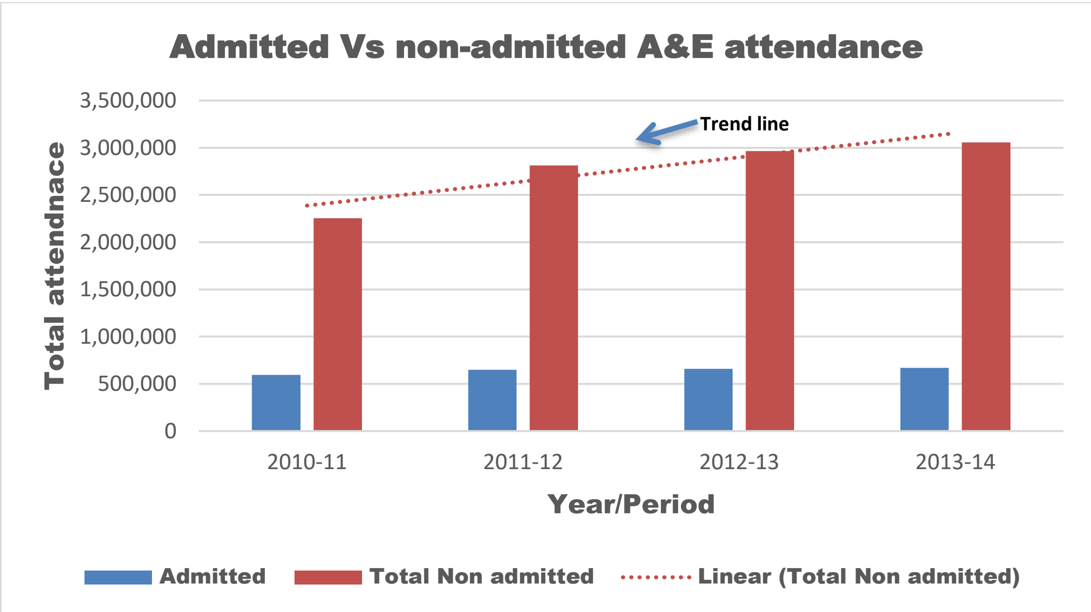


Figure 5-9 Histogram of admitted vs non-admitted patients attending London A&E departments. Data source: Health and Social Care Information Centre (2015b).

5.3.5 Levels of deprivation in London

Index of Multiple Deprivation (IMD) is investigated in this study to explain possible reasons for the nature of access to A&E department in London. A variety of studies (more recently for example, Butler *et al.*, 2013; McHale *et al.*, 2013) suggest that areas with higher deprivation could influence healthcare demand patterns because these areas are found to have fewer primary healthcare access points than more affluent areas. Also the quality of life in more deprived areas could influence attitudes and perceptions about the healthcare delivery process and so affect attitudes of patients towards access points (Gilbert, 2013). Even though a major objective of the NHS is to make healthcare access equitable (Ham, 2004; Department of Health, 2013), in London healthcare delivery is characterised by inequality to access (Gilbert, 2013). For example, Rainsberry *et al.* (2013, p. 14) argued that

"Londoners' health depends too much on where they live. There is too much variation and inequality in the health of the population and in healthcare provision".

Rainsberry et al. (2013) reported, for example, that in Tower Hamlets, one of the most deprived boroughs in London, women have a life expectancy of 54.1 years compared to 72.1 years for women in Richmond-upon-Thames, which is one of the least deprived boroughs.

The IMD is a collection of indices that are analysed to show the extent to which an area could be construed as deprived. The indices are produced and published by the Department for Communities and Local Government (2011); this study uses the version published in 2010. The methodology used in generating and graduating the IMD are reported in seven denominations, namely

- Income Deprivation (what people earn from work and investments),
- Employment Deprivation (chances or people in that area to get employment),
- Education, Skills and Training Deprivation,
- Health Deprivation and Disability,
- Crime (its prevalence),
- Barriers to Housing and Services,
- Living Environment Deprivation (the quality of the local environment namely 'indoors' living environment or the quality of housing and 'outdoors' living environment; contains measures of air quality and road traffic accidents).

Using data for the London LSOAs obtained from Department for Communities and Local Government (2011), Office for National Statistics and Greater London Authority (2015), Figure 5-10 was developed in ArcGIS. It shows that more than 26% of London is found within the most deprived 20% of England. About 19 boroughs in London fall within the top 50 of the 326 ranked most deprived on at least one of the summary indices of deprivation. Hackney, Newham and Tower Hamlets are London Boroughs ranked first, second and third, respectively, as most deprived in 2010, which covered the financial year 2008/09. Figure 5-11 shows the distribution of IMD in London LSOAs, using the 2010 data from the Department for Communities and Local Government (2011).

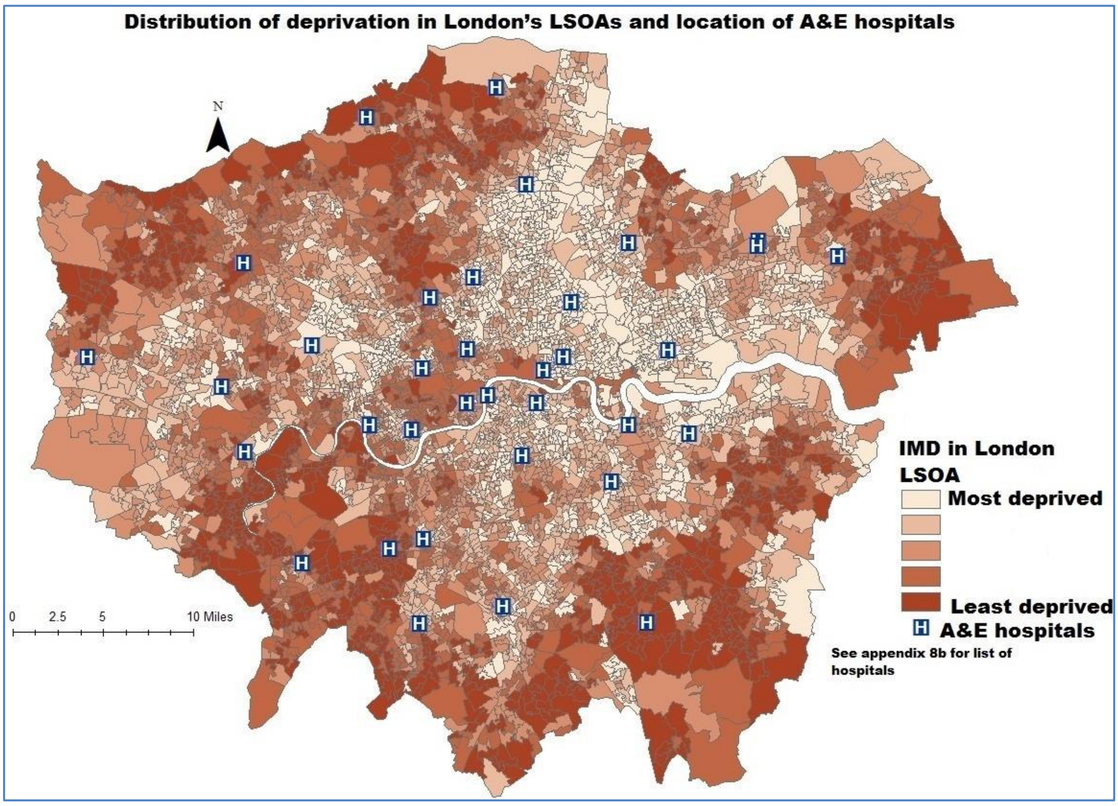


Figure 5-10 IMD ranks of London in 2010, by LSOA, and the locations of A&E departments.

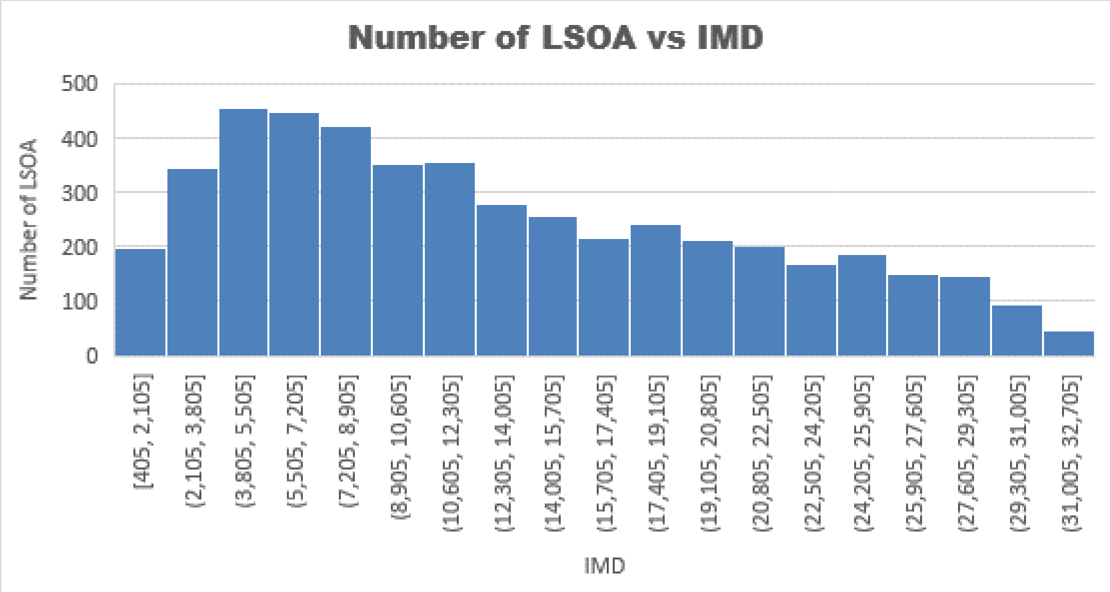


Figure 5-11 Histogram showing the distribution of IMD scores by LSOA in London, based on 2010 data from the Department for Communities and Local Government (2011).

The most deprived LSOA score (see Figure 5-11) is 405 while the least deprived score is 32,705. Appendix 8B presents the IMD per borough. Since IMD has been linked to general healthcare access (for example, McHale *et al.*, 2013; Rainsberry *et al.*, 2013), in which most deprived areas are said to suffer from access inequality compared to least deprived ones, in the following analysis, IMD will constitute a variable to determine if it could explain the nature of A&E demand.

However, the effects of IMD on healthcare access need to be treated with caution since IMD is composed of several variables. As such, it may be unclear which aspects influence demand for A&E.

5.4 Analysis of catchment areas of A&E departments

Catchment area analysis was performed to determine the following for the A&E providers within London:

- The catchment areas of the A&E departments;
- Total population of the catchment areas by MSOAs;
- Details of the local primary healthcare system in the catchment areas. This includes the number of GPs and GP practices; numbers of patients per GP and per GP practice; the number of GP surgeries with just one or two GPs;

- Percentages of patients wanting same-day or next-day GP appointments and their preference for face-to-face contact with a GP at the time of healthcare need.
- Average IMD scores of the catchment areas.

Information on WICs, minor injury unit attendances, numbers of patient-GP consultations, GP workload and numbers of GP referrals to A&E departments were not available for inclusion in the data analysis. As mentioned in Chapter 4, the last official data on GP consultations was published in 2008 (Q-Research, 2009; NHS England, 2013b). Some London NHS Trusts were not included in the analysis, as explained in the following section.

5.4.1 Trusts excluded from the analysis

Table 5-5 shows total attendances at the London providers of A&E services included in this study. A total of 3,408,214 A&E attendances were recorded in these organisations in 2013/14. A total of 403,596 attendances were eliminated from some NHS Trusts for various reasons.

Firstly, data were included only for hospitals providing A&E services. Services provided by CCGs but without location were excluded from the study. Secondly, specialist providers such as mental health, dental care, and eye hospitals were eliminated.

Table 5-5: Total A&E attendance by provider and trusts eliminated from the analysis.

A&E providers in London 2013/2014	Total attendance	Eliminated data	Remark
Barking, Havering & Redbridge University Hospitals NHS Trust	210,215		
Barnet & Chase Farm Hospitals NHS Trust	149,524		
Barts Health NHS Trust	326,426		
Central London Community Healthcare NHS Trust	165,399		Will be added to Imperial
Chelsea And Westminster Hospital NHS Foundation Trust	112,480		
Croydon Health Services NHS Trust	135,769		
Croydon Urgent Care Centre		46,665	Added to Croydon NHS
Ealing Hospital NHS Trust	143,690		
East London NHS Foundation Trust		48,418	Mental health
Epsom And St Helier University Hospitals NHS Trust	142,837		
Guy's And St Thomas' NHS Foundation Trust	136,731		
Homerton University Hospital NHS Foundation Trust	117,977		
Hounslow & Richmond Community Healthcare NHS Trust		79,359	Location
Imperial College Healthcare NHS Trust	271,939		
King's College Hospital NHS Foundation Trust	240,356		
Kingston Hospital NHS Foundation Trust	110,169		
Lewisham And Greenwich NHS Trust	158,936		
Moorfields Eye Hospital NHS Foundation Trust		86,807	Location
NHS Bromley CCG		20,257	Location
NHS Greenwich CCG		42,912	Location
NHS Southwark CCG		19,130	Location
North East London NHS Foundation Trust		55,185	Location
North Middlesex University Hospital NHS Trust	161,619		
North West London Hospitals NHS Trust	218,875		
Royal Free London NHS Foundation Trust	93,387		
South London Healthcare NHS Trust		51528	Location
St George's Healthcare NHS Trust	144,031		
The Hillingdon Hospitals NHS Foundation Trust	93,556		
The Whittington Hospital NHS Trust	90,992		
University College London Hospitals NHS Foundation Trust	125,277		
West Middlesex University Hospital NHS Trust	56,029		
Sum	3,408,214	403,596	

Eliminated

Data in use

Total eliminated data

Data source: Health and Social Care Information Centre (2015b).

Some Trusts were excluded because of changes in location of provision of services. As shown in Figure 5-12, within the period 2009 to 2014 some A&E departments were decommissioned, while others have been absorbed by other NHS Trusts. For example, on October 1st 2013 two main A&E providers within South London Healthcare Trust (SLHT) were fragmented and their services taken over by other NHS Trusts (NHS England, 2014a). Consequently, Princess Royal University Hospital in Bromley with its A&E service came under King's College Hospital NHS Foundation Trust. In addition, Queen Elizabeth Hospital in Woolwich became part of Lewisham and Greenwich NHS Trust. Although A&E attendance data for SLHT was still being generated and published by the HSCIC in 2013/2014, it was unclear how such data could be attributed to particular hospitals since its services had been dispersed. To avoid double counting and other difficulties, data from SLHT was eliminated from the analysis.

In October 2013, Greenwich PCT and Lewisham NHS Trust merged to form today’s Lewisham and Greenwich NHS Trust (NHS Greenwich Clinical Commissioning Group, 2014). Therefore, data on Greenwich PCT/Greenwich CCG was also eliminated from the analysis. A total of 21 NHS provider trusts remain in the analysis, out of the 31 London providers.

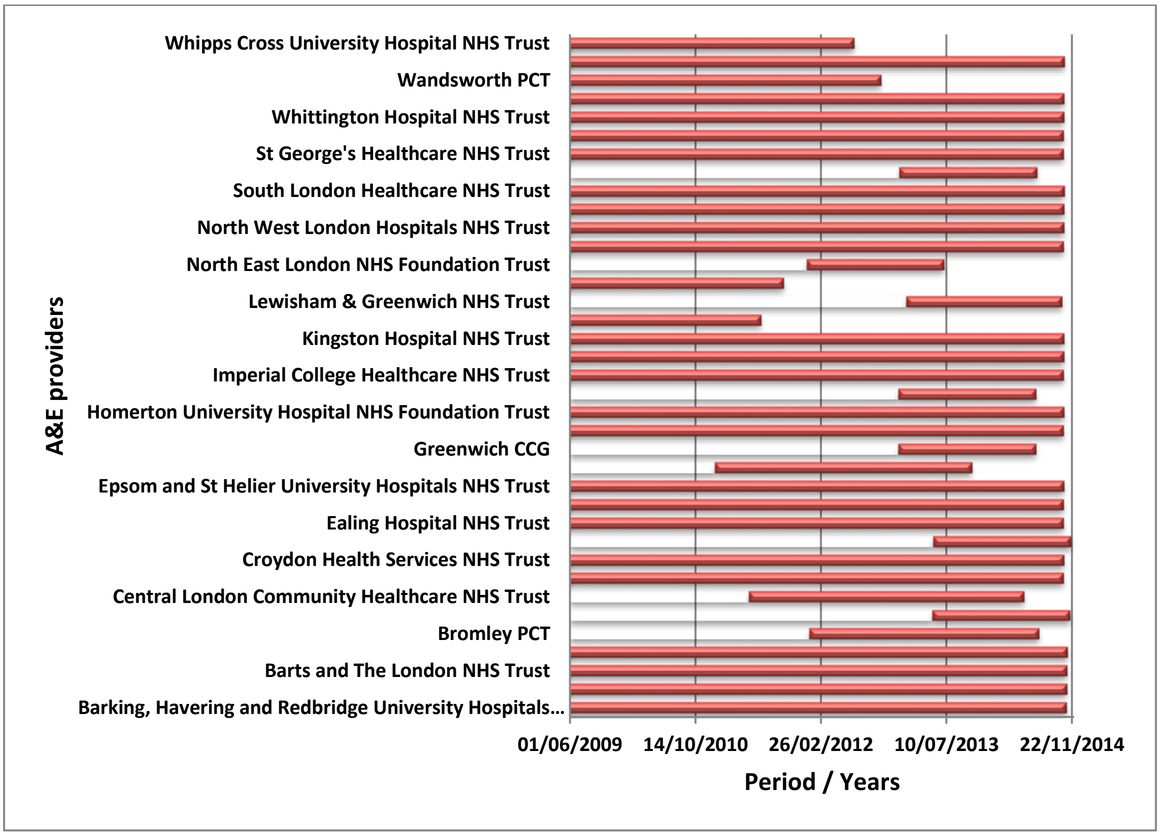


Figure 5-12 Table showing changes over a 5-year period of the organisations providing A&E services in London. Source: Health and Social Care Information Centre (2015b)

5.4.2 Geo-coding of catchment areas by MSOA

As mentioned above, GPs are located in areas where patients can cross borough boundaries to access healthcare. This means that, by looking geographically to determine the components that link resident population and registered patients to healthcare resources, more knowledge will be gained on the process of healthcare delivery. For example, the proximity of patients to GP surgeries, to other primary care services and to A&E departments could have an influence on A&E demand. In Chapter 2, the use of GIS and ArcGIS in this research is explained. In this section, the method of geo-coding used in the catchment areas of A&E departments is further detailed. It is found that most A&E catchment areas in London stretch across borough boundaries.

Table 5-4 shows part of the data assembled in this analysis, as an example of the methodology used to build the catchment areas for the various A&E departments as attributed to each NHS Trust.

ONS data available for administrative or electoral purposes does not necessarily fit with healthcare delivery catchment areas. A mapping by MSOA was therefore undertaken to determine A&E catchment areas. Data were obtained from the ONS Open Geography portal (Office for National Statistics, 2014). The data were made up, firstly, of lists of MSOAs by borough, downloadable as an MS Excel spreadsheet, see for example Figure 5-13, A. Secondly, skeletal base maps (Figure 5-13 B, C) show MSOAs within the borough boundaries.

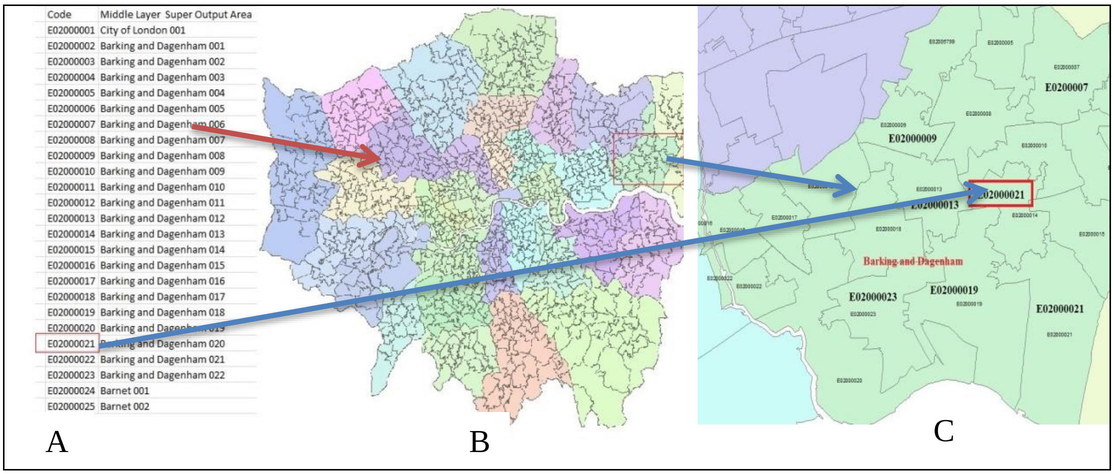


Figure 5-13 MSOAs of boroughs in London, data source: Office for National Statistics (2014)

Studies have suggested that patients have a tendency to access the nearest A&E department in their locality when they need urgent healthcare (Baker and Streatfield, 1995; Baker, 2014). A shortest travel distance approach is therefore used in this study to locate the closest A&E to each MSOA.

Figure 5-13 therefore shows a three-step assembly of data used in the GIS modelling. Part A of the figure shows an extract of the MS Excel data giving MSOA codes: for example, Barking and Dagenham (zones 1-22). The map in part B of the figure shows how the map is generated from the codes in part A. Part C of the figure shows part of the borough of Barking and Dagenham, expanded, indicating how the codes are linked to MSOAs in the borough. The red coloured box is used to demonstrate how the code from the spreadsheet is used to locate the specific spot on the map as well as the boundaries. Table 5-6 shows the linkage between postcodes, the relevant MSOA, travel distance to the nearest A&E department and the NHS trust providing the service.

Table 5-6 Matching MSOA code to post code to determine nearest A&E department in area

Post code

Distance to the nearest A&E

Post Code area	MSOA Code	MSOA Areas	Distance to nearest A&E (Miles)	Average IMD score	A&E Hospital	A&E NHS Trust
RM5 2BG	E02000002	Barking and Dagenham 001	1.7	43.02	King George Hospital	Barking, Havering & Redbridge NHS Trust
RM1 1HA	E02000003	Barking and Dagenham 002	1.5	25.61	King George Hospital	Barking, Havering & Redbridge NHS Trust
RM10 7AA	E02000004	Barking and Dagenham 003	1.2	22.70	Queen's NHS	Barking, Havering & Redbridge NHS Trust
RM10 7LJ	E02000005	Barking and Dagenham 004	1.6	32.45	Queen's NHS	Barking, Havering & Redbridge NHS Trust
RM107RB	E02000006	Barking and Dagenham 005	1.5	35.25	King George Hospital	Barking, Havering & Redbridge NHS Trust
RM10 7AE	E02000007	Barking and Dagenham 006	1.4	40.60	Queen's NHS	Barking, Havering & Redbridge NHS Trust
RM10 7DE	E02000008	Barking and Dagenham 007	2	35.56	Queen's NHS	Barking, Havering & Redbridge NHS Trust
IG11 9BY	E02000009	Barking and Dagenham 008	2.1	30.79	King George Hospital	Barking, Havering & Redbridge NHS Trust
RM10 7AN	E02000010	Barking and Dagenham 009	1.7	34.88	Queen's NHS	Barking, Havering & Redbridge NHS Trust
RM10 7EA	E02000011	Barking and Dagenham 010	1.5	25.69	Queen's NHS	Barking, Havering & Redbridge NHS Trust
IG11 9LX	E02000012	Barking and Dagenham 011	2.9	20.24	Newham Hospital	Barts Health NHS Trust
RM8 2AW	E02000013	Barking and Dagenham 012	2.5	36.94	King George Hospital	Barking, Havering & Redbridge NHS Trust
RM10 8DP	E02000014	Barking and Dagenham 013	2.3	36.62	Queen's Hospital	Barking, Havering & Redbridge NHS Trust
RM10 8AD	E02000015	Barking and Dagenham 014	2	44.49	King George Hospital	Barking, Havering & Redbridge NHS Trust
IG11 7AR	E02000016	Barking and Dagenham 015	2	39.76	Newham Hospital	Barts Health NHS Trust
IG11 7QL	E02000017	Barking and Dagenham 016	2.5	25.97	Newham Hospital	Barts Health NHS Trust
IG11 0AT	E02000018	Barking and Dagenham 017	3.1	36.78	Newham Hospital	Barts Health NHS Trust
IG11 0RN	E02000019	Barking and Dagenham 018	3.5	33.56	King George Hospital	Barking, Harvering and Redbridge NHS Trust
IG11 0AL	E02000020	Barking and Dagenham 019	2.4	32.03	Newham Hospital	Barts Health NHS Trust
RM10 9AB	E02000021	Barking and Dagenham 020	2.4	30.28	Newham Hospital	Barts Health NHS Trust
IG11 0BB	E02000022	Barking and Dagenham 021	2.4	48.29	Newham Hospital	Barts Health NHS Trust
IG11 0AB	E02000023	Barking and Dagenham 022	3.2	45.02	Newham Hospital	Barts Health NHS Trust
EN4 0NH	E02000024	Barnet 001	1.4	8.92	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust
EN4 0LY	E02000025	Barnet 002	1.4	16.18	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust
EN4 8HR	E02000026	Barnet 003	2.7	9.59	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust
EN5 2AL	E02000027	Barnet 004	0.5	21.50	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust

Figure 5-9 Matching MSOA code to post code to determine nearest A&E department in area

Data compiled from Office for National Statistics (2014)

The variable "distance" of the A&E to a particular MSOA (Table 5-6) was found by translating all the MSOA postcodes to the central postcode of related MSOA (Table 5-6). Postcodes were then used to manually obtain the road distances from each MSOA to the nearest A&E department. Using the NHS Choices website and cross-referencing with Google Maps for reliability, the distances found are shown in Table 5-6. Figure 5-14 gives an example of how the distance from a postcode to an A&E department was obtained.

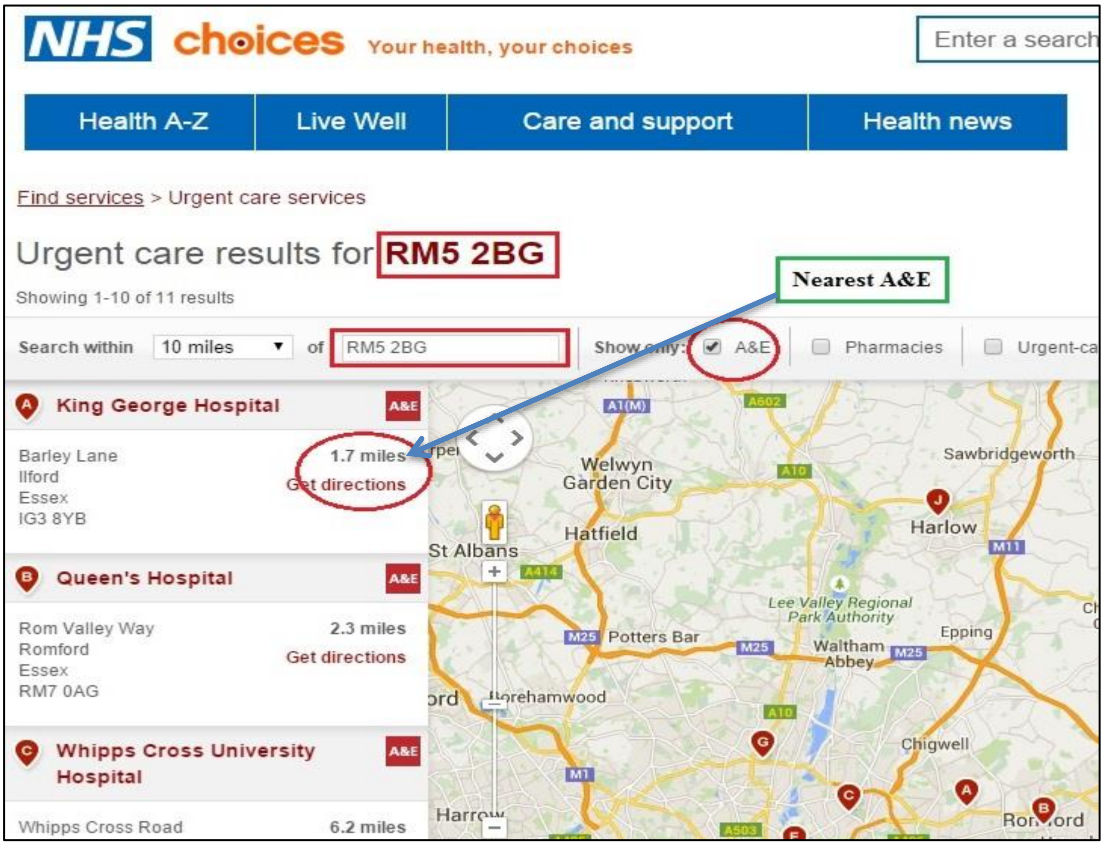


Figure 5-14 How the distances from one A&E department and postcode were determined

By this method, the various maps used in this study were generated, using ArcGIS. Figure 5-15 visualises A&E delivery in London by catchment areas of the 31 hospital A&E providers in London, coloured variously. The catchment areas shown are assumed the basis for patients' interactions with the A&E departments.

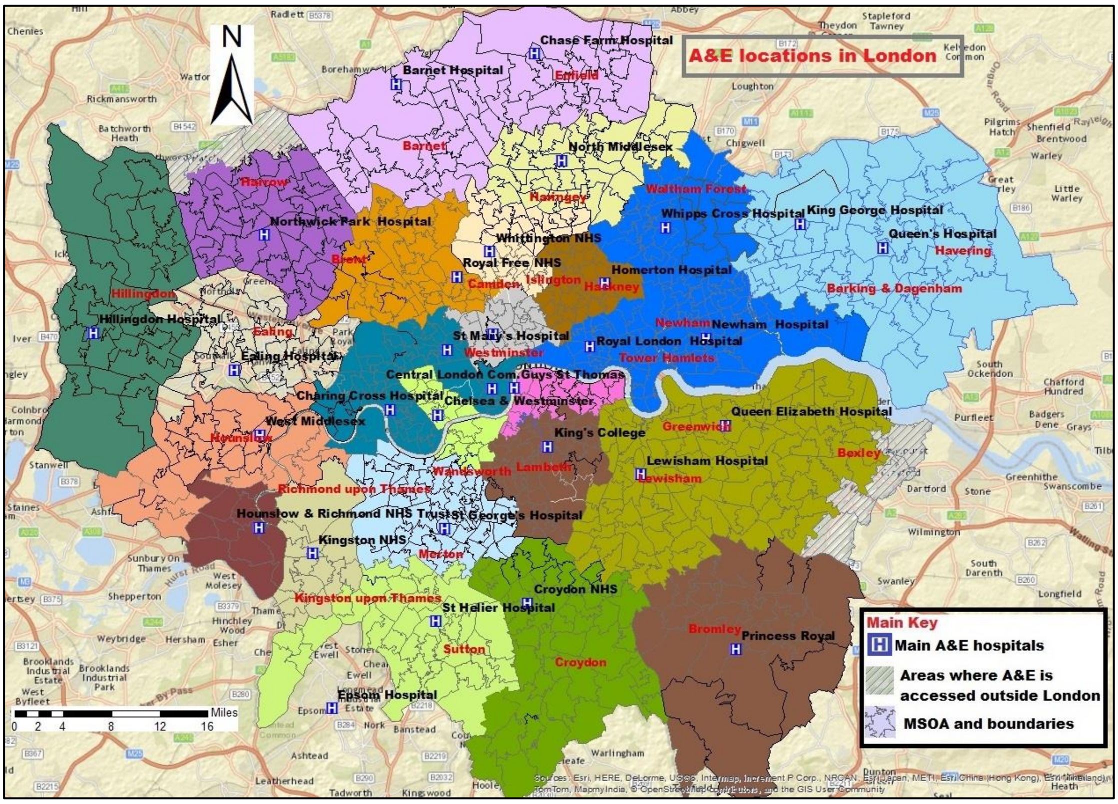


Figure 5-15 Catchment areas of A&E departments within London, by MSOA. Data source: Greater London Authority and Office for National Statistics (2014)

For each of the 983 MSOAs of London, the nearest A&E provider has been determined. Distances were calculated from the nearest A&E department to the centre of each MSOA (see Appendix 5 for an example and Sections 5.3.1 and 5.3.2). These hospitals are managed by 21 NHS Trusts (see for example Appendix 5 and Table 5-5).

It should be noted that some of the A&E providers presented in Table 5-2 operate A&E services in multiple areas. For instance, Barking, Havering & Redbridge University Hospitals NHS Trust operates two A&E departments, one in Queens Hospital in the borough of Havering and the other in King George Hospital in the borough of Redbridge. In addition, Barts Health NHS Trust runs three A&E departments, at Newham Hospital in the borough of Newham, Royal London Hospital in the borough of Tower Hamlets and Whipps Cross Hospital in the borough of Waltham Forest (Figure 5-16). The catchment areas for these different A&E hospitals are combined in this analysis, since data on A&E attendances were available only at the NHS trust level. In Figure 5-16, catchment areas of the A&E departments run by Barts Health NHS Trust and Barking, Havering & Redbridge University Hospitals NHS Trust are shown coloured separately.

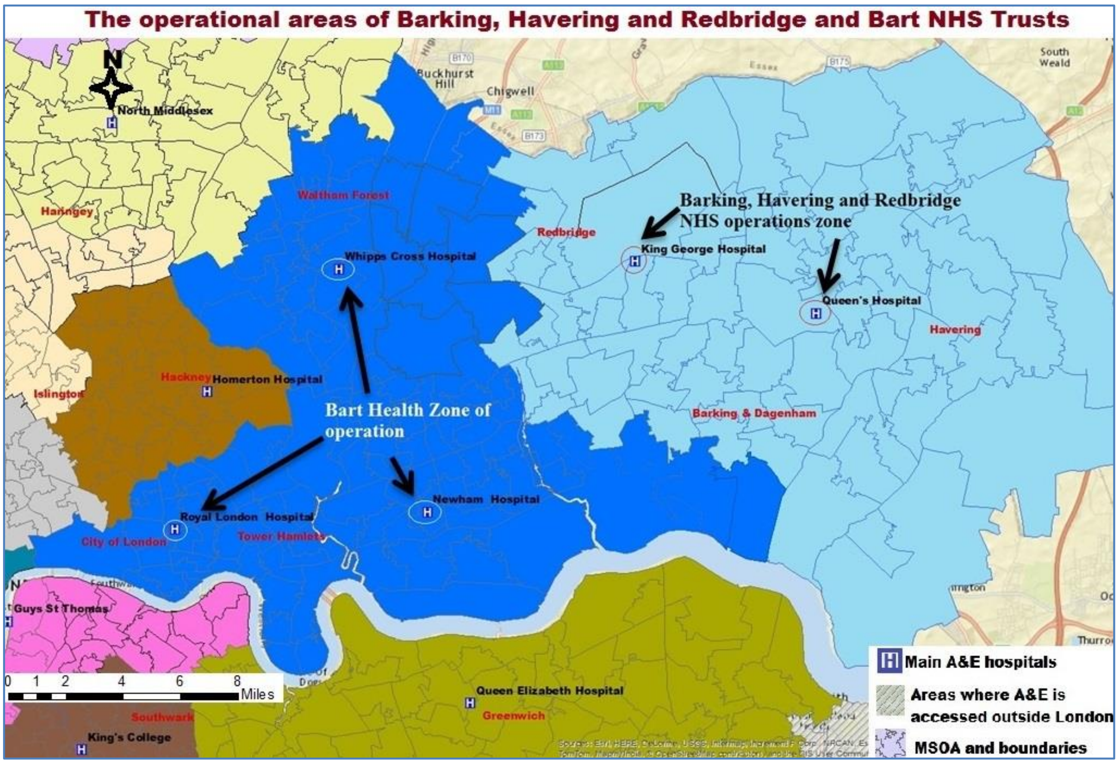


Figure 5-16 Catchment areas of Barking, Havering and Redbridge and Barts Health NHS Trust

The catchment areas used to determine data related to the factors affecting A&E access, such as those related to IMD and GP practices and their availability are now described.

5.4.3 Determining average IMD for catchment areas

IMD scores were averaged over the MSOAs of each A&E provider catchment area. Table 5-7 gives average IMD scores in the catchment areas, calculated using data from the Department for Communities and Local Government (2011) and Health and Social Care Information Centre (2015b). The lowest IMD scores represent the most deprived areas and vice versa.

Table 5-7 London A&E providers and average IMD scores of catchment areas

Providers	***Av. IMD score***
Barking, Havering & Redbridge University NHS Trust	**111**
Barnet & Chase Farm Hospitals NHS Trust NHS Trust	**87**
Croydon Health Services NHS Trust	**107**
Ealing Hospital NHS Trust	**80**
Epsom & St Helier University Hospitals NHS Trust	**208**
King's College Hospital NHS Foundation Trust	**94**
Kingston Hospital NHS Foundation Trust	**255**
Lewisham & Greenwich NHS Trust	**79**
North West London Hospitals NHS Trust	**194**
St George's Healthcare NHS Trust	**121**

The Hillingdon Hospitals NHS FT	**138**
Whittington Hospital NHS Trust	**14**
West Middlesex University NHS Trust	**118**
Barts Health NHS Trust	**20**
Chelsea & Westminster Hospital NHS Foundation Trust	**103**
Guy's & St Thomas' NHS Foundation Trust	**41**
Homerton University Hospital NHS Foundation Trust	**2**
Imperial College Healthcare NHS Trust	**87**
North Middlesex University Hospital NHS Trust	**13**
Royal Free London NHS Foundation Trust	**109**
University College London Hospitals Foundation Trust	**60**

5.4.4 Location of GP surgeries within catchment areas

As discussed in Chapter 4, difficulties in accessing primary care services such as GP surgeries have been cited as drivers for A&E attendances. Official data links GPs and GP surgeries to (formerly) PCTs and (currently) CCGs (Health and Social Care Information Centre, 2015a). However, data are not readily available regarding how GPs and GP practices are distributed within the catchment areas of A&Es. The NHS Choices (2014) website was used to manually determine the GP surgeries within the catchment area of each A&E department. The website was used in conjunction with the MSOA postcodes to locate the GPs in an area. As shown in Figure 5-17, first, the MSOA postcodes were put into the search box to obtain a list of nearby GPs and their location. Then, those GPs in the MSOAs of the catchment area were grouped.

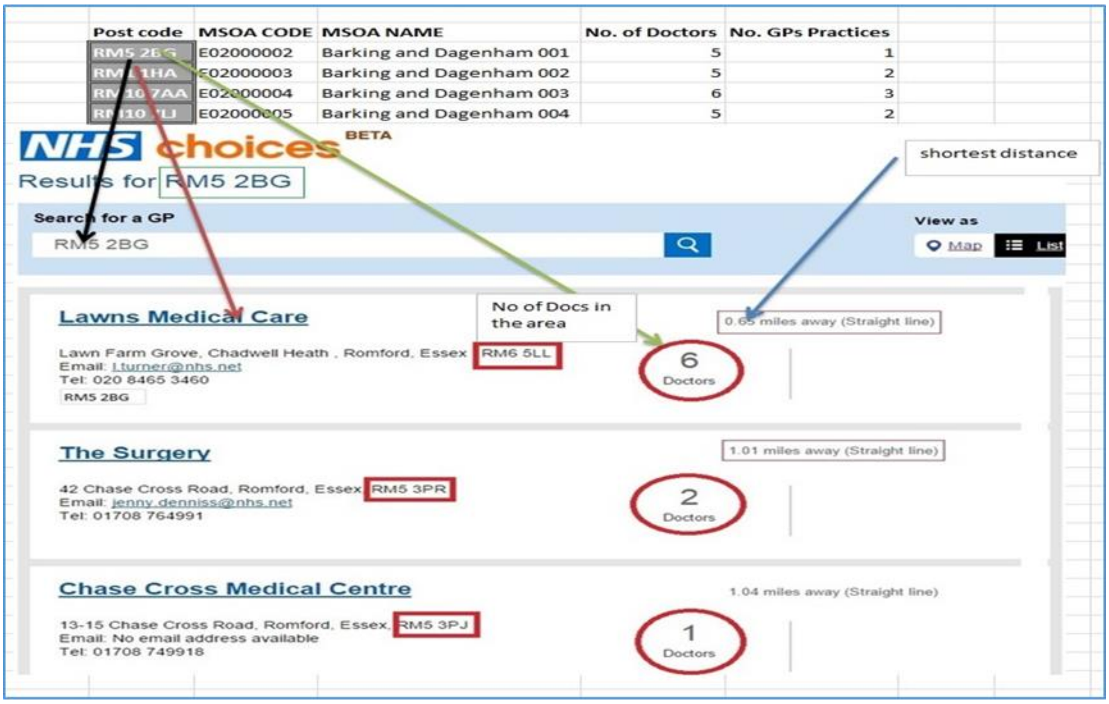


Figure 5-17 How the GPs practices within the catchment areas were located

Once GPs were located within the catchment areas, other GP-based data could be determined, for example numbers of registered patients, average percentages of patients demanding same day and next day access to GPs, patient preferences for face-to-face consultations and patient usage of online technology for making appointments.

5.5 Regression analysis

The aim of this regression analysis is to explain variations of the dependent variable, total numbers of non-admitted attendances at 21 London NHS trusts providing A&E services in 2013/14. Some of these NHS trusts operate A&E departments in several locations (see Section 5.3.3). For these trusts, A&E attendance data were available only on combined attendances at the different A&E departments, and their catchment areas were therefore combined in this analysis.

Having found correlations, linear regression was applied, both in the simple form and as multiple regression, considering all the following variables that have the potential to affect the dependent variable:

- Resident population of the catchment area of A&E department(s)
- The number of registered patients in the catchment area
- Number of GPs in the catchment area
- Number of GP practices in the catchment area

- Average number of patients per GP in the catchment area
- Average patients per GP practice in the catchment area
- Numbers of single/two-headed practices in the catchment area
- Average % ease of phone access to GP surgery
- Average % desire for same day or next day access to GP surgeries, in the catchment area
- Average % patients' preferences for face-to-face contact with GP (in preference to nurse-led or telephone contact) in the catchment area
- Average % patient's appointment booking method (whether online) in the catchment area
- Average IMD score in the catchment area
- Average distance from MSOAs in the catchment area to nearest A&E

5.5.1 Developing the regression variables

The details of the variables used in the regression modelling, carried out using Microsoft Excel, are now given.

1) Dependent variable, total numbers of non-admitted patients in the catchments areas – these are patients who accessed A&E and were not admitted to a bed in hospital. Total numbers of non-admitted patients were used to represent demand at A&E. These were used as the dependent variable rather than total demand, since increases in non-admitted patient numbers have caused the highest growth of demand at A&E, as shown in Figure 5.9.

2) Independent variables – these variables are used to explain individually or collectively why non-admitted patients attend the various providers. The rationale for their use are as follows:

i. Resident population

The total resident population is found for MSOAs within the catchment areas.

ii. Registered patients.

This is the total number of patients registered with GP surgeries within the catchment area. They may not necessarily live in London or within the catchment area.

iii. No of GPs

Here the total number of GPs within a catchment area are counted.

iv. Number of GP practices

It is reasonable to assume that the number of GP practices in a catchment area would affect the level of A&E access.

v. Patients per GP

This measures the average number of patients on a GP's list within a catchment area. It could be expected that the higher the number of patients there are on a GP's list the more the difficulties those patients will have in accessing urgent healthcare.

vi. Patients per GP practice

The calculation is total registered patients divided by number of GP practices in the catchment area. Past studies suggest, for example, Baker *et al.* (2011); Cowling *et al.* (2014), that the more GPs are concentrated in an area, the more patients will access them and reduce A&E attendance.

vii. Single- and two-headed GP practices

These are GP practices with only one or two doctors available. The number of such practices by catchment area are totalled.

viii. Ease of access by phone to GP surgery

This variable was obtained from the GP-patient survey (Ipsos MORI, 2014). Patients were asked how easy it was generally to get through to someone at their GP surgery by phone. Average percentages of those who found it either "very easy" or "fairly easy" were calculated for the catchment areas.

ix. Same day/ Next day access

Again, this variable was obtained from the GP-patient survey (Ipsos MORI, 2014), which surveyed how quickly patients wanted to access their GP surgery, on the last time they "wanted to see or speak to a GP or nurse from their GP surgery." Patients were asked whether they wanted to access GPs the same day, the next working day or later. The average percentages of those wanting access on the same or next day were calculated, in the catchment area GP practices. It could be expected that when a patient wants a contact on the same or next day, and such a contact is not available, some will access care from A&E. A follow-up question asked where patients would go if they did not get a GP appointment at the desired time; 10% responded that they would go to A&E or a walk-in centre.

x. Patient preference

Again from Ipsos MORI (2014), patients were surveyed as to whether they preferred to talk to the GP or a nurse on the phone or to see them face-to-face. Average percentages were found in the catchment area GP practices, of people indicating that they preferred a face-to-face contact with GP to other methods. It could be expected that when a patient prefers to have a face-to-face contact with a doctor and such a contact is not available, some will access care from A&E.

xi. Online booking

Again from Ipsos MORI (2014), patients were surveyed as to how they booked appointments with their GPs. The average percentage of people booking online was found for the catchment areas. It is of interest whether having online access to a GP booking system affects access made to A&E.

xii. Average IMD score

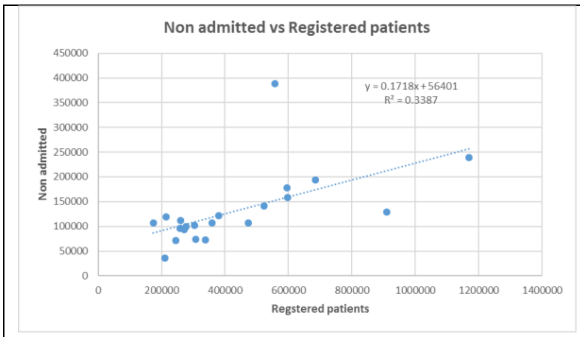
The average IMD score was found for MSOAs within the catchment areas. It is of interest whether the level of deprivation in a catchment area contributes to A&E attendance. However, IMD in relation to London possesses some limitations (See Section 5.3.5) and may not reflect fully the relationship between deprivation and healthcare access in the catchment areas.

xiii. Average distance

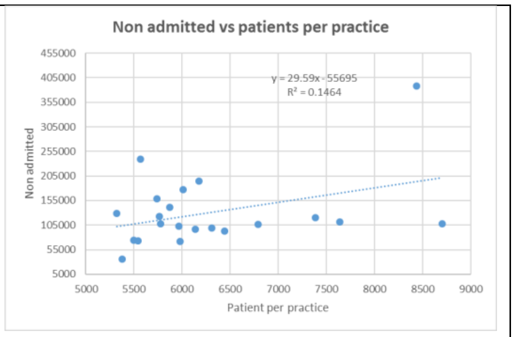
With this variable, the average distance from MSOAs is measured to the nearest A&E department. Some studies (for example, Baker *et al.*, 2011; Ramlakhan *et al.*, 2016) have indicated that when patients live closer to an A&E department, they tend to use it more.

5.5.2 Correlations between variables

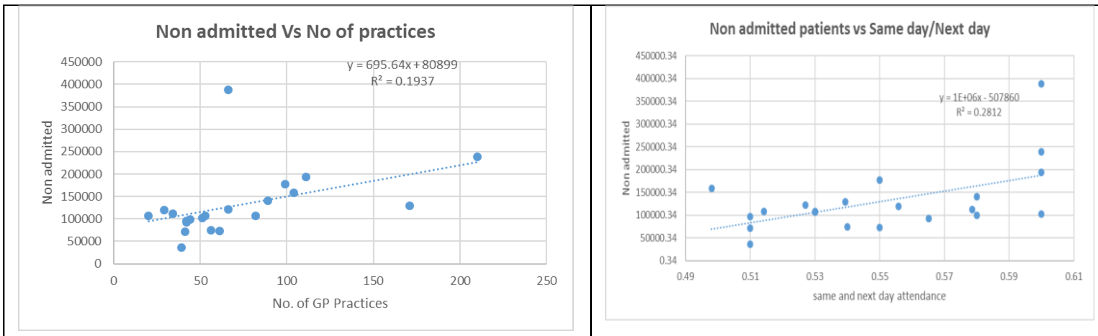
Scatter plots, simple regressions and correlations were used to investigate relationships between variables, two at a time. Examples of the plots are given in Figure 5-10. The figure shows how registered patients (A), patients per practice (B), number of practices (C) and patients' desire for same day or next day appointments(D) correlate with the dependent variable, non-admitted patients.



A) Positive linear relationship, R^2=0.34



B) Positive linear relationship, R^2=0.15



C) Positive linear relationship, R^2= 0.19

D) Positive linear relationship, R^2=0.28

Figure 5-18 Scatter plots and regression lines of some variables with the dependent variable

All these variables show a positive correlation. Table 5-8 gives Pearson correlation coefficients between all variables.

Pearson's correlation coefficient ($-1 \leq r \leq 1$) was used to evaluate the strength of the linear relationship between pairs of the variables, which are all continuous. The linearity of the relationship was observed when a change in one variable was associated with a proportional change in the other variables. As shown in Table 5-8, absolute values of numbers indicate the strength of the relationships, while directions are given by signs, + or - (Draper *et al.*, 1998).

Table 5-8: Pearson correlation coefficients

	Non-admitted patients	*Population*	*Registered patients*	*Patients /practice*	*Patients per GP*	*No. of GPs*	*No. of GP practices*
Non-admitted patients	1.00						
Population	0.57						
Registered patients	0.58	0.99					
Patients /practice	0.38	-0.33	-0.33				
Patients per GP	0.62	0.83	0.86	-0.34			
No. of GPs	0.58	0.99	1.00	-0.33	0.85		
No. of GP practices	0.44	0.97	0.98	-0.46	0.82	0.99	
Ease of access to GP	-0.34	0.09	0.03	-0.30	0.01	0.04	0.10
Same /Next day	0.53	0.33	0.33	0.24	0.37	0.32	0.24
Patients preference	0.45	0.48	0.49	0.15	0.44	0.49	0.46
Single/2 headed Practices	0.56	0.62	0.64	-0.13	0.87	0.62	0.58
Tech Application	-0.11	0.04	0.04	0.01	0.04	0.03	0.05
IMD Av.	-0.11	-0.23	-0.22	0.10	-0.12	-0.23	-0.24
Distance (M)	-0.13	0.12	0.08	-0.41	0.16	0.08	0.12

	Ease of access to GP	*Same /Next day*	*Patients preference*	*Single/2 headed Practices*	*Tech Application*	*IMD Av.*
Non-admitted patients						
Population						
Registered patients						
Patients /practice						
Patients per GP						
No. of GPs						
No. of GP practices						
Ease of access to GP						
Same /Next day	-0.02					
Patients preference	0.30	0.15				
Single/2 headed Practices	-0.04	0.45	0.35			
Tech Application	0.02	0.06	-0.15	0.19		
IMD Av.	0.29	-0.20	0.02	-0.08	-0.14	
Distance (M)	0.35	-0.33	0.21	0.17	-0.02	0.22

Table 5-8 shows that the most significant relationship with non-admitted patients is that of registered patients, with a correlation coefficient of 0.582. This corresponds to an R^2

value of 0.324. High correlations of numbers of registered patients with resident population (0.986), number of GPs (1.000) and number of GP practices (0.985) were found.

There is one apparent outlier in the data: Imperial College Healthcare NHS Trust with 388,345 non-admitted patients. This is a central London trust, where large numbers of temporary visitors to London and those working in central London may access emergency care. However, given the small number of data points (n=21), this variable was not removed.

5.5.3 Multiple regression

Data over-fitting can be a problem with multiple regression, especially given the small number of data points (n=21). It is recommended to have at least 10 data points per independent variable used (Draper *et al.*, 1998). A stepwise process was undertaken, by taking independent variables two at a time, including the variable shown to have the highest correlation with non-admitted patients, GP registered patients. This variable is the most important variable to be included in every regression model, since it indicates the number of people known to be likely to access healthcare in London.

Table 5-9 shows the results of running regression models of non-admitted patients with two independent variables: GP registered patients and one other.

The following models all have p-values which are significant (less than or equal to 0.05): with patients per practice (R^2 = 0.705), with ease of access (R^2 = 0.468) and with same day/next day access required (R^2 = 0.468). The modelling did not include the variables noted in Section 5.5.2 as having high correlation with registered patients, to avoid problems of multicollinearity. All F-statistics gave significant values according to the p-values, indicating overall model fit.

Finally, the stepwise regression is ended by adding a third dependent variable to the regression of non-admitted patients against registered patients and patients per practice. Only the variables without high correlation with registered patients are used. Results are shown in Appendix 5. None of the third dependent variables was significant, according to p-values.

Table 5-9 Regression outcome of non-admitted patients vs registered patients and one other variable

		Registered Patients	Independent variable	Registered patients	Independent variable
Independent variable	**R^2**	**P-value**	**P-value**	**coefficient**	**coefficient**
Population	0.339	0.529	0.899	0.214	-0.046
Patients /practice	0.705	$1.56*10^{-5}$	0.000167	0.233	49.529
Patients per GP	0.389	0.584	0.238	0.06	586
No. of GPs	0.349	0.553	0.594	1.663	-2592.76
No. of GP practices	0.93	$3.94*10^{-1}$	$2.36*10^{-10}$	1.469	-7049.71
Ease of access to GP	0.468	0.003	0.051	0.175	-419999.7
Same /Next day	0.468	0.0214	0.05	0.135	833152.84
Patients preference	0.372	0.0384	0.339	0.141	161774.39
Single/2 headed Practices	0.396	0.124	0.208	0.113	1196
Tech Application	0.357	0.006	0.481	0.173	-515758.5
Distance (M)	0.371	0.005	0.346	0.175	-26133

5.5.4 Discussion of regression results

An R^2 value of 0.705 was achieved with a combination of registered patients and patients per practice, to explain variations in numbers of non-admitted patients. This indicates that 71% of the variation of the dependent variable is explained by the independent variables. In addition, the more conservative adjusted R^2 which takes account of data overfitting, noise in the data, and small sample size, reports a 67% value. Other variables, percentages of patients having ease of telephone access to GPs, and percentages requiring same day/next day access to GPs were shown separately to explain variations in numbers of non-admitted patients in a significant manner. However, it was not possible to show significance of more than two dependent variables in the multiple regression, and, indeed, the small number of data points makes this unsurprising.

5.6 Conclusion

The methodology for understanding the factors that explained why patients access unscheduled urgent healthcare from A&E departments was presented with this London case study. It was suggested that the reasons for accessing A&E departments fall under process design (accessibility), patient-related and population factors.

A catchment area analysis was performed of the A&E departments in London, by the provider trusts. The variables available for this analysis concerned population, GPs and their registered patients, their practices, GP-patient survey results, IMD scores and average distances travelled to A&E departments.

Regression analysis showed the strong influence of population numbers on A&E access, both residents and those registered with GPs, which were highly correlated with each other. It appears that a strong relationship exists between numbers of non-admitted patients and both numbers of registered patients and patients per practice taken together. The survey results on ease of access by phone to GPs and those requiring same day or next day access, taken with numbers of registered patients, also appears to explain some variation.

A major limitation in demonstrating this methodology has been the number of data points available, since only 21 provider catchment areas could be analysed. Moreover, the catchment area analysis carried out using geocoding was time consuming, and to extend this to a larger area of England was beyond the scope of this study.

No data were available on cultural factors, for example regarding the ethnicities of local areas of London. There were also no data on attendances at other UC facilities such as walk-in centres, on use of NHS-111 services or on GP consultations, which could have been relevant to the study.

Variables were categorised as process design, patient behavioural and population related; these were extracted for the catchment areas of London's A&E departments and used in multiple regressions to gain an explanation as to why non-admitted patients access A&Es. According to the categorisation, the numbers of registered patients are of primary importance in numbers accessing A&E departments. It appears that some process design factors affecting accessibility may also be significant in explaining numbers accessing A&E departments: numbers of patients per GP, and ease of phone access to GPs. The patient behavioural factor of requirement for access to healthcare on the same or next day may also be significant. It was not found that an understanding of the process of accessing healthcare, represented by IMD score, was a factor in explaining numbers arriving at A&E.

This chapter has demonstrated use of a novel combination of catchment area analysis and regression analysis to analyse demand at A&E providers across London. A picture emerges of an A&E delivery system that is overloaded with non-admitted patients because of lack of access to GPs in the face of increasing patient and population numbers. In Chapter 6, a second methodology is demonstrated, geo-location analysis combined with simulation to focus on one London borough and model the effects of different proposals for UUEH, including UC hubs, that could improve access to urgent primary care services while speeding up A&E delivery.

Chapter 6 Process modelling and simulation of unscheduled, urgent and emergency care access

6.1 Introduction

This chapter demonstrates a new hybrid method for planning capacity in UUEH. Simulation modelling, informed by Geographic Information System (GIS) location analysis, is used to demonstrate the potential for a process orientated approach to management of urgent and emergency healthcare. Using a case study in the London Borough of Hounslow, first, the current situation of UUEH is analysed; second, the NHS “pyramid” proposal is described and, third, the proposal, detailed in Chapter 4, for urgent healthcare hubs is presented.

The hybrid methodology and case study were introduced in Chapter 2, with a summary of the data sources in Section 2.4.1, the methods in Sections 2.5.4 and 2.6, and the case study in Sections 2.2.2 and 2.7. The methodology is utilised as follows in this chapter. Firstly, simulation modelling is used to support the understanding of the current situation and a recent NHS proposal for UUEH healthcare. GIS modelling is then used to find optimal locations for the proposed UC hubs, linking into discrete event simulation of the operation of the hubs. Several scenarios are analysed in which patients are diverted from A&E to other services, to demonstrate the effects of changes of provision on patient access and queuing efficiency.

In carrying out this analysis of diverting patients from A&E, the findings of Chapters 4 and 5 are drawn upon. These indicate that difficulties accessing GP services may increase A&E attendance for patients not subsequently admitted to hospital. It is thus possible to make the assumption that, given suitably attractive alternative services such as UC hubs, self-referred patients may divert from A&E to services in the primary care sector. Moreover, research detailed in Section 4.8.2 indicates that to succeed in diverting patients A&E, UC hubs should be located away from A&E.

The chapter is organised as follows: Section 6.2 describes the hybrid methodology proposed. Section 6.3 describes the background to the case study on UUEH delivery in

Hounslow. Section 6.4 explains the data used in both the simulation and GIS modelling. Section 6.5 presents the simulation of the current situation of UUEH delivery in Hounslow. The simulation of the NHS “pyramid” proposal is described in Section 6.6. In Section 6.7, optimal locations for the proposed UC hubs are found using GIS modelling, and simulation of UC hub operations is described in Section 6.8 under various scenarios. Section 6.9 provides a summary and conclusion to the chapter.

6.2 Methodology

In this section, the two components of the hybrid technique, simulation modelling and locational analysis, are described.

6.2.1 Simulation in healthcare delivery management

Simulation is defined as the re-creation of a real situation that allows the user to examine different scenarios in the laboratory environment before implementation (Lal and Roh, 2013; Nahmias and Olsen, 2015). In recent years, there has been an increased use of simulation to build models for healthcare delivery improvement to counter the changes occurring in its delivery over time. The background of simulation modelling could be traced to the emergence of scientific management as the quest to improve business processes in factories and industrial production centres became strong (Melão and Pidd, 2000; Kalpic and Bernus, 2002). Then simulation became important in the military (Brailsford *et al.*, 2013), the gaming industry, automobile and other moving equipment manufacturing (Law and Kelton, 1991; Smith, 2003; Jahangirian *et al.*, 2010), architecture, construction and civil engineering (O'Brien *et al.*, 1993; Oloufa, 1993).

From the successes of simulation in these sectors, OM researchers and process designers started seeking to use similar approaches to mimic a better process model for healthcare delivery management. This has ignited interests and researchers, for example, Jun *et al.* (1999) found over 100 articles and related papers published on simulation in healthcare within just one year. As such, leading healthcare modelling researchers, for example, Brailsford *et al.* (2010) believed that simulation could be the route to improving the ways healthcare processes are defined, designed and implemented. With the improvement of computers and software, simulation software packages such as ProcessModel, ProModel, Arena, Simul8, and others have made the modern day’s business process simulations easier and possible (Mendling *et al.*, 2010).

Some popular simulation approaches used in healthcare modelling include discrete-event simulation (DES), Agent Based Modelling, Monte Carlo modelling and System Dynamics (SD) (Brailsford, 2007; Royston, 2009). These approaches may be applied in a mixed, hybrid fashion. This research focuses on DES for its modelling of individual patients queuing for service, and limits on available resources such as clinicians.

Despite the widespread acceptance of simulation modelling in healthcare, there is scarcity of the implementation of the results of running these models in practice (Jun *et al.*, 1999; Barjis, 2011; Brailsford *et al.*, 2013). However, Rohleder *et al.* (2011) presented a study of successful application of DES to support process improvements in an orthopaedic outpatient clinic. Lal and Roh (2013) listed areas, as shown in Table 6-1, where simulation has been used or applied to healthcare. Notably, there is a lack of application of simulation models to UUEH.

Table 6-1 List of sectors with examples of simulation practices in healthcare

Section	**Area affected by simulation modelling**
Hospital operation	➢ Bed occupancy and utilisation ➢ Staffing analysis ➢ Occupation room scheduling
Emergency department	➢ Patient triage and its impact on resources ➢ Number of beds needed ➢ Patient flow from emergency departments to hospital input unit ➢ Staffing analysis
Outpatient clinics	➢ Patient scheduling policies ➢ Work load balancing ➢ Facility analysis of lobby size, number and design of exam room space ➢ Equipment utilisation
Healthcare supply chain	➢ Blood platelets usage and optimal inventory levels ➢ Pharmaceutical need demand and inventory levels
Call centres	➢ Patient appointment ➢ scheduling staffing need

Source: Lal and Roh (2013).

6.2.2 Understanding Optimal Location

Location-allocation theories were needed to reduce the number of hubs to realistic levels and to locate them optimally.

The definition of optimal location is broad and varies depending on the context. Nahmias and Olsen (2015) suggested that optimal location relates to the least cost geographical location where a production unit is best sited. Obtaining the right location to establish a public service such as a healthcare facility is complex. Factors such as convenience, connectivity and visibility are important. The use of *p*-Median and Maximal Cover, as available with ArcGIS to select optimal locations, is investigated.

6.2.3 P-Median location of UC hubs

The *p*-Median problem, also referred to as the Minimise Impedance Problem (Daskin and Maass, 2015) finds locations for *p* (in number) facilities in such a way that the demand weighted average distance between demand points and the nearest of the selected facilities is minimised. The heuristic algorithm contained in ArcGIS has been used to find feasible solutions for various candidate locations and identify the best locations for the number of hubs to be located. In this model, there are no capacity problems at the facilities. Similarly, the Minimise Impedance Problem aims to determine the optimal locations where facilities can be located such that the total sum of weighted impedances is minimised (Pratt *et al.*, 2014). Impedance represents anything that hinders the flow of traffic and is usually measured as travel distance, time or speed obstacles. Examples of impedance include one-way streets, high traffic volumes and stop signs (ArcGIS, 2014). A cut-off distance may be imposed in these models, to recognise the drop-off in demand outside the area where a facility is located.

The mathematical formulation of the *p*-Median Problem is as follows (for example, Marianov and Serra, 2002, p. 141)

$$\text{Minimise } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} a_i \, d_{ij} \, x_{ij} \qquad (1)$$

subject to

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad i = 1, \ldots, \quad m \qquad (2)$$

$$x_{ij} \leq x_{jj} \qquad i = 1,2,\ldots, \quad m \qquad j = 1,2,\ldots, \quad n \tag{3}$$

$$\sum_{j=1}^{n} x_{jj} = P \tag{4}$$

$$x_{ij} \in \{0, 1\} \qquad i = 1,2,\ldots, \quad m \qquad j = 1,2,\ldots, \quad n \tag{5}$$

Where:

$$x_{ij} = \begin{cases} 1 & if\ demand\ point\ i\ is\ asigned\ \ to\ facility\ j \\ 0 & otherwise \end{cases}$$

i= Index of demand points

m=Total number of demand points in the area of interest

j=Index of potential facility sites

n=Total number of potential facility locations

a_i=Weight related to demand point i

d_{ij}= Distance between demand node i and potential facility j

P= Number of facilities to be located

In the above model, equation (1) minimises the total demand-weighted distance between population and facilities. Constraints (2) ensure that all demand is assigned to a facility site. Constraints (3) ensure that demand is assigned only to an open facility. Constraint (4) limits the number of facilities to be located.

6.2.4 Maximal Covering Location of UC hubs

The Maximal Covering Location Problem (MCLP), also known as the Maximum Coverage Problem, is an approach used to find the optimal locations among different places so that as many demand points as possible are covered within a certain distance. Public services such as schools and hospitals, which are essential, must be made available to everybody. Despite this, economic and geographic factors can constrict the distance that people are prepared to travel. This is why for practical reasons, a cut-off distance or travel time is defined for this model (Marianov and Serra, 2002). Given the quest for maximum coverage with public services such as healthcare, this is suitable for locating a UC service as it will find locations that patients can quickly access (Daskin and Maass, 2015). In developing maximum coverage, the essence, however, is not to cover all demand; the objective is to locate a fixed number of facilities so that demand covered by those services is maximised. The mathematical programming formulation is expressed as follows, see Marianov and Serra (2002, p. 126).

$$\text{Maximise } Z = \sum_{i \in I} a_i \, y_i \tag{6}$$

$$\text{Subject to: } y_i \leq \sum_{j \in N_i} x_j \qquad \forall i \in I \tag{7}$$

$$\sum_{j \in J} x_j = P \tag{8}$$

$$x_j, y_i \in \{0, 1\} \qquad \forall j \in J, i \in I \tag{9}$$

where

$$y_i = \begin{cases} 1 & if\ node\ i\ is\ covered \\ 0 & otherwise \end{cases}$$

$$x_j = \begin{cases} 1 & if\ \ a\ facility\ is\ sited\ at\ j \\ 0 & otherwise \end{cases}$$

I = Set of demand locations,

J = Set of candidate facility sites,

P= The number of facilities to be located,

S = Standard time or distance for coverage,

N_i = The set of all candidate sites which can cover demand nodes *I* within time *S*,

a_i = The population at demand node *i*.

In the above model, equation (6) maximises the population-weighted demand that is covered. Constraints (7) define that demand at node *i* is covered when at least one facility is located within coverage distance or standard time S. Constraint (8) provides the total number of facilities that can be located.

6.3 Case study on UUEH delivery: the London Borough of Hounslow

The London Borough of Hounslow was selected to exhibit the performance of the process of unscheduled urgent and emergency health care. Hounslow is one of the 32 boroughs that make up Greater London. Being an outer borough, it possesses different characteristics from boroughs in the inner part of London. For example, its population concentration is mostly dense and compact in some areas such as Chiswick and Brentford while areas such as Feltham and Hanworth are mixed suburban/rural in character. The 2014 population estimate of Hounslow of 270,330 people is the one used in this study (Greater London Authority and Office for National Statistics, 2014). The population registered with GP practices in 2014 was 291,038, served by 153 GPs. By 2030, estimates are that 4% of Hounslow’s population will be over the age of 80, about one-quarter will be under 18 years while 15% will be over the age of 65 years old.

The Hounslow CCG commissions healthcare in the borough, with GPs structured according to five GP zones, shown coloured in Figure 6-1. Crosses mark the GP practices, with double crosses indicating more than one practice at one location. There are no WICs within the borough, but one is located just outside the borough in Ashford Hospital (See Figure 6-1). There is an A&E department located at West Middlesex NHS Hospital Trust, which also houses a UCC, also shown in Figure 6-1.

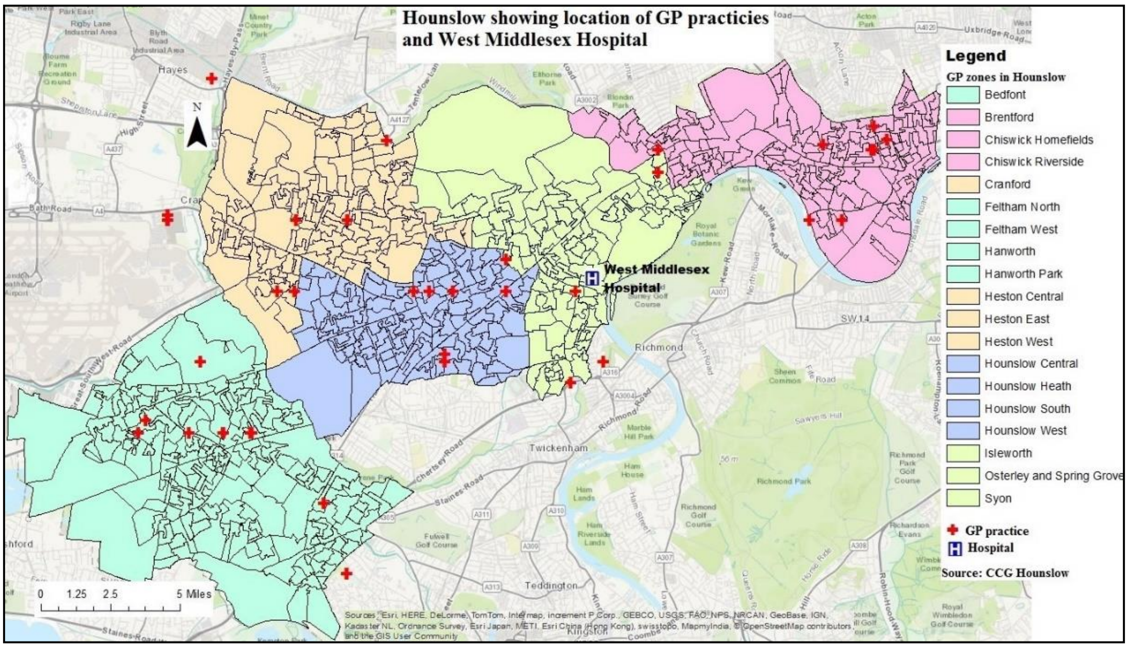


Figure 6-1 London Borough of Hounslow showing West Middlesex Hospital A&E department and the five GP zones (coloured).

The West Middlesex University Hospital NHS Trust is an acute NHS healthcare delivery facility located in Isleworth in the London Borough of Hounslow. It is operated and managed by Chelsea and Westminster NHS Foundation Trust. Given its location, West Middlesex’s catchment area tends to include patients living within the Borough of Hounslow and from neighbouring boroughs such as Richmond upon Thames and the Borough of Ealing. GP-registered patients residing in these boroughs and Hounslow also access A&E services from other A&E departments such as Ealing, Kingston, Hillingdon and Charing Cross.

According to the Joint Strategic Needs Assessment (JSNA) of patients registered with GPs in the borough in 2014, about 12% of the patients come from outside the borough (London Borough of Hounslow, 2014 p. 4). However, it was not clear how many people accessed healthcare outside the borough despite registering with GPs here.

In designing the modelling in this chapter, it is assumed that demand for healthcare comes entirely from with the Borough of Hounslow, as shown in Figure 6-2. The grounds for this are that the majority of patients come from Hounslow, and since data for patients accessing healthcare outside the borough are not available, it is assumed that the number accessing care elsewhere is approximately equal to those coming into the borough for care. The modelling is done at the LSOA level, which provides data according to the small areas in the borough, a level appropriate for developing the scenarios.

Figure 6-2 presents the distribution of GP practices and the population concentration of the borough. The arrows show the direction of patient movement to their nearest GP surgeries, assuming that patients attend the closest GP to where they live (official data on such relationships are not available). The premise follows that patients would also conveniently access UC from the nearest points to where they live or work. The modelling in this chapter builds on these patterns of access.

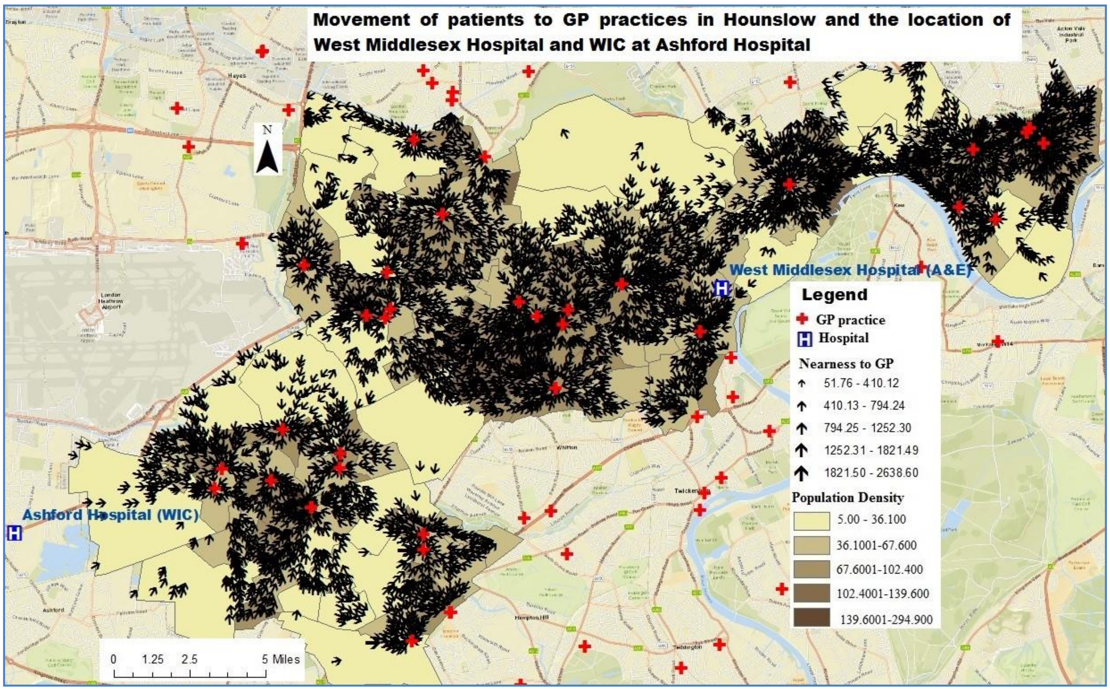


Figure 6-2 Patient access to nearest GP practices in Hounslow borough.

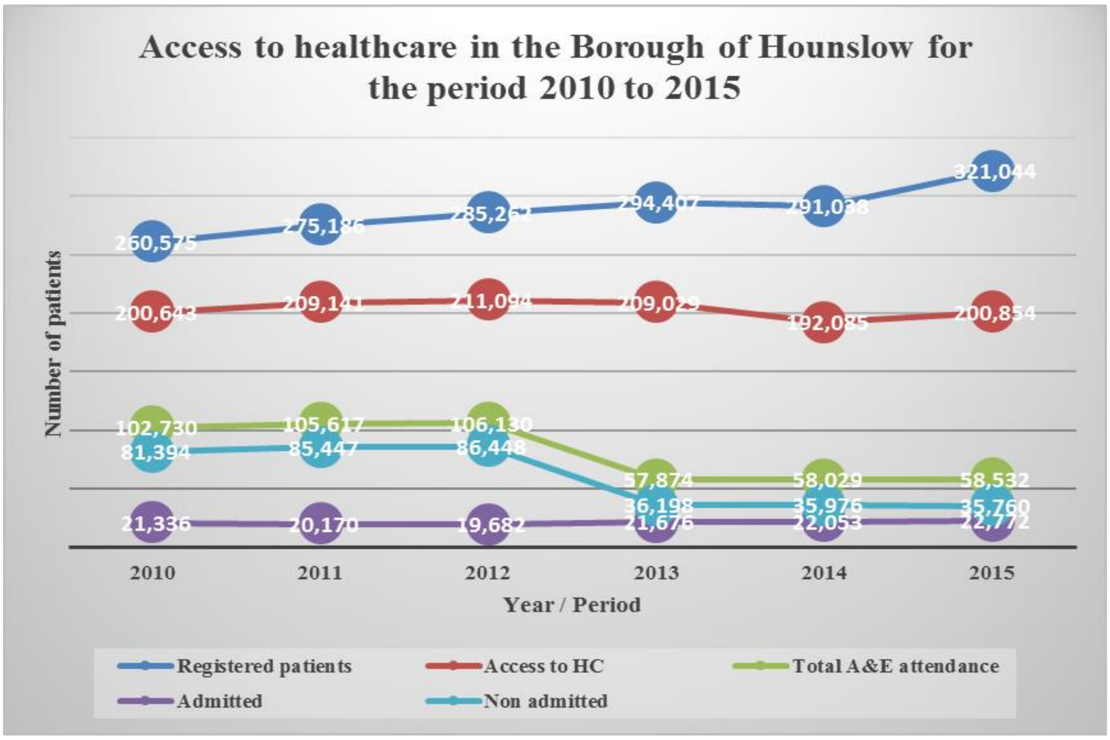


Figure 6-3 Admitted and non-admitted patients at West Middlesex Hospital, Data source: Health and Social Care Information Centre (2015b)

Figures 6-3 summarises the access made to West Middlesex A&E Department for the period 2010 to 2015, and all access to unscheduled healthcare at all facilities in the borough. A drop in recorded A&E access can be noted from the year 2013 and continuing to 2015, while the number of registered patients increased during the same period. Since the majority of the data used comes from the Health and Social Care Information Centre (2015b), it is suggested that this drop in recorded access from 2013/14 could have been caused by changes in the management of the hospital which went to Chelsea and Westminster Hospital. The numbers of admitted patients have, however, remained stable and are consistent with population growth.

Data have not been available on numbers of GP consultations. As Figure 6-4 shows, the number of GP practices has been falling since 2010. At that time, there were 57 practices, but in 2015, there were only 53. Even though the number of GPs has been increasing, it cannot be determined how they have been distributed in the borough, given that more practices have not been created. Also, there has been a strong change in the number of patients per practice, or list size, between 2011 and 2012. However, list size fell in 2013 and 2014 and then rose in 2015.

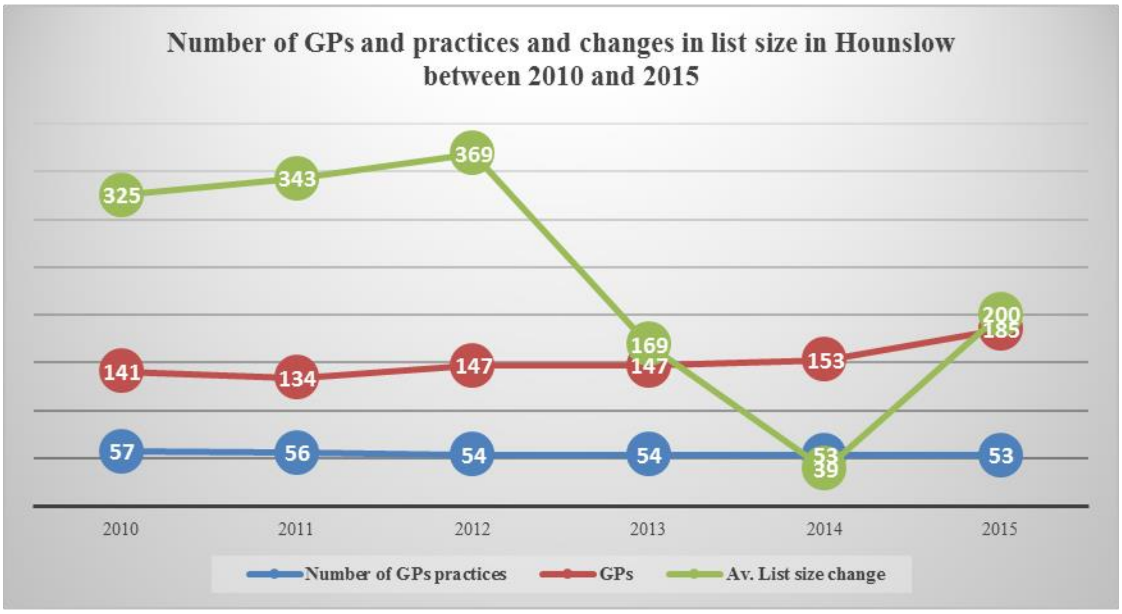


Figure 6-4 Number of GPs and practices, with changes in the average list size in the London Borough of Hounslow between 2010 and 2015

The performance of West Middlesex Hospital A&E Department from 2010 to 2015 is summarised in Figure 6-5. Briefly, it is expected that 95% of patients attending A&E departments in England should be treated, admitted or discharged within 4 hours. Similar to most A&E departments in England, as described in Section 4.5, performance at West Middlesex Hospital has dropped according to this indicator. In 2014, 89% of patients who accessed A&E were treated, hospitalised or discharged within 4 hours, thereby failing to meet the expected target.

Figure 6-5 also shows that the proportion of A&E patients who were not admitted dropped from 81% in 2010 to 62% in 2014. This has occurred alongside a drop in A&E attendances from 106,130 in 2012 to 57,874 in 2013, with a slight increase to 58,029 in 2014.

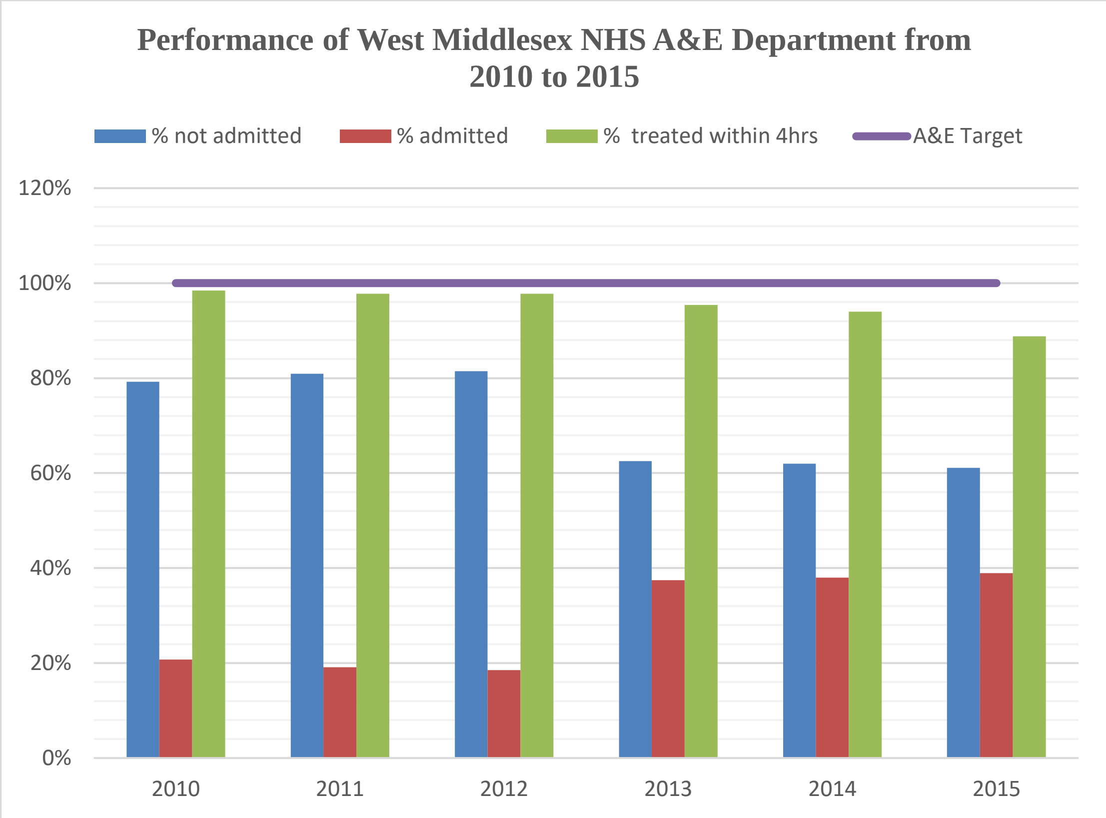


Figure 6-5 Performance of West Middlesex Hospital A&E from 2010 to 2015

6.4 UUEH delivery in Hounslow: data description

In the modelling, data for patient health care access in the London Borough of Hounslow, by LSOA, came from the website (http://www.data.gov.uk) of Greater London Authority and Office for National Statistics (2014). This includes patients who accessed unscheduled healthcare from the following NHS sources: telehealth phone system (NHS 111), GP practices, WICs, A&E department and GP out-of-hour services. A breakdown by time of day for general access to unscheduled health care was also available from this source.

From the Department of Health (2014a), aggregated data were used on the number of people who made calls to NHS 111 telehealth (from the file called NHS 111 Minimum data). Data by LSOA on NHS 111 phone calls were not available. An assumed break-down of the NHS 111 data according to the time of day is based on estimates from NHS England (2015).

Postcodes were used to link population density by LSOAs to services; only active postcodes were used. This gave a picture of areas with no, or very limited, resident population, such as industrial zones. It provided information about numbers of registered patients and numbers of GPs in the area. Postcodes enabled the calculation of nearness to facilities, and the direction patients could take to access healthcare (see Figure 6-2). However, with about 12% of patients coming from outside the borough (as explained in Section 6.2), it was not possible to include these people in the modelling.

Other data used include the number of GP practices within Hounslow CCG (NHS England, 2014b) and A&E attendance by providers (Health and Social Care Information Centre, 2015b). Table 6-1 shows the referral methods through which patients attended A&E in Hounslow.

Table 6-1 A&E attendances by patient group for 2014-15

Referral method	**Percentage**
Self-referral	*63%*
Other	*12%*
Emergency services	*11%*
General medical practitioner	*5%*
Health care provider: same or other	*4%*
Not known	*4%*
Work	*1%*
Police	*0%*
Educational establishment	*0%*
Local authority social services	*0%*
General dental practitioner	*0%*
Community dental service	*0%*
Total	100%

Data source: Health and Social Care Information Centre (2015b)

Of the 200,344 patients who accessed unscheduled and emergency healthcare in 2014/15 from various healthcare access points in the London Borough of Hounslow, 58,532 went to the A&E department. As shown in Table 6-1, 63% of them were self-referred, that is they accessed A&E without any referral from a care deliverer or social care body. Eleven per cent arrived through emergency services such as ambulance whereas GPs referred about 5%.

Table 6-2 Patients admitted and not admitted from West Middlesex NHS A&E department

Disposal method	***Percentage***
Admitted patients	39%
Total admitted patients	**39%**
Not admitted	
Discharged - GP follow up	21%
Discharged - no follow-up	28%
Referred	8%
Others	4%
Total non-admitted patients	**61%**

Source: Health and Social Care Information Centre (2015b)

Table 6-2 shows that 39% of A&E attendances at West Middlesex were admitted to the hospital while 61% were not admitted, i.e. they were discharged elsewhere. Some of the healthcare access data are attributed to organisations without hospital locations. For example, patient data from Hounslow and Richmond Community Healthcare NHS Trust could not be utilised because it is not known where these patients were treated. In particular, it could not be determined whether patients in the borough were sent to Chelsea and Westminster Hospital A&E department. Therefore, the data from the HSCIC were used whilst being aware of these inconsistencies.

Microsoft Excel was used for statistical analysis of data, and to obtain various parameters for the simulations such as totals or averages of distances, patient wait times, and the number of patients accessing a particular access point. Excel spreadsheets were translated into comma separated values (CSV) files for input to the GIS software, ArcGIS. ArcGIS was used to input data and compose links to places on grid references, as well as create sums and averages of the population, numbers of patients and so on.

In 2014/15, 58,532 patients accessed the West Middlesex A&E Department or, on average, 160.36 people per day. In Hounslow borough in 2014/15, the total number of patients who accessed UUEH was 200,854. This includes access to all the GP practices, WICs, GP out-of-hours, those who made calls to NHS 111 and those who went to the A&E department. Per day, this amounted to 550 people. An hour-by-hour breakdown of attendance was applied, as can be seen in Appendix 10.

6.5 Simulation of current UUEH delivery in Hounslow: the base model

In this case study of UUEH delivery in Hounslow, simulation is used firstly to investigate the current process design. The role played by various UUEH access points on demand at the A&E department is examined. In this strategic level simulation, what happens within the A&E department is not simulated in detail; the focus is on activities external to the A&E.

6.5.1 Developing the base model

Patients accessing unscheduled UUEH delivered by the NHS currently have two separate routes: the emergency route and the UC route. The emergency route is via 999 calls and ambulance to the A&E department; the UC or non-emergency route is via other access points such as GPs, WICs, the NHS 111 telehealth system and GP out-of-hours, as shown in Figure 6-6.

Current unscheduled UUEH delivery was simulated using the example of the West Middlesex Hospital NHS A&E department and other services in the Borough of Hounslow. In this base model, the following assumptions are made:

- The A&E department is meant for critically sick patients
- The A&E department will also treat patients who are not facing emergency health situations
- The A&E department is an entry point for hospital admission
- A&E department operates 24 hours per day, 7 days per week
- Patients can be referred to the A&E department by GPs or from other access points

Figure 6-6 shows the simulation model of the current process of UUEH access. This is the base model to which what-if scenarios are applied in Section 6.6. The different routes through the base model are marked and described as follows:

1. **Self-referred** – the red route, is used by patients who refer themselves to the A&E department. They are assumed to be made up of a mix of very seriously ill patients and those who are less ill.

2. **999 or ambulance –** the green route**,** is used by patients brought in by ambulance, who are seriously ill. About 90% of them are assumed to be admitted and a bed provided in a hospital ward.

3. **NHS 111** is a non-emergency access point where patients can telephone the healthcare system at any time, 24 hours a day, 365 days a year if they feel that they need health care. In this study, the NHS 111 access is split into day and night. However, detailed information concerning the work patterns of staff and number of staff per shift was not available.

a. **111-day** From this access point, daytime callers are either provided with healthcare advice, and they stay at home, or are referred to their GPs, or to a WIC for further treatment or are sent to the A&E department.

b. **111-night** Callers are either advised at home or referred to the GP out-of-hours service or to the A&E department.

4. **GP out-of-hours** is an access point for patients in need of GP services when GPs have closed for the day (See Section 4.5.4). When patients access this point they are either advised at home, referred to the A&E, or referred to their own GP.

5. **GP practice and walk-in-centre** refer to physical access points where patients seek healthcare from their GPs or WIC, mostly during normal working hours. In this model, the two arrival points are combined since separate arrival data on them were not available. However, in the simulation itself, these activities are separate.

6.5.2 Simulating the Base Model

Simul8 software was used for all simulations in this case study. For the base model and all following simulations, an average of 550 patients (see Section 6.3) were assumed to access UUEH per day in Hounslow. In the base model, these were distributed across the six access points according to the following assumptions, with exponential distributions.

- 40% accessed A&E as follows:
  - ✓ 65% of them were self-referred
  - ✓ 35% used ambulance or other emergency access
- 8% accessed healthcare through the telephone system NHS 111 during the day
- 13% accessed NHS 111 during the night
- 23% accessed GP out-of-hours

- 16% accessed GPs and WIC of which
  - ✓ 80% used GP practices
  - ✓ 20% used WIC

Service times at the different activity stations were assumed to be exponential, with averages as follows: A&E, 37 minutes; NHS 111 day, 10 minutes; NHS 111 night, 5 minutes; GP and GP out-of-hour, 10 minutes and WICs 15 minutes.

The following shift pattern was used:

- day (9 am-5 pm), when 999, NHS 111, GP and WIC services are available;
- night (5 pm-1 am) when 999, NHS 111, and GP out-of-hours are functioning;
- early morning (1am-9am) when 999, NHS 111, and GP out-of-hours are functioning.

All services, including A&E, are represented by a single "activity" with multiple replications according to numbers of personnel (or treatment stations) assumed to be available.

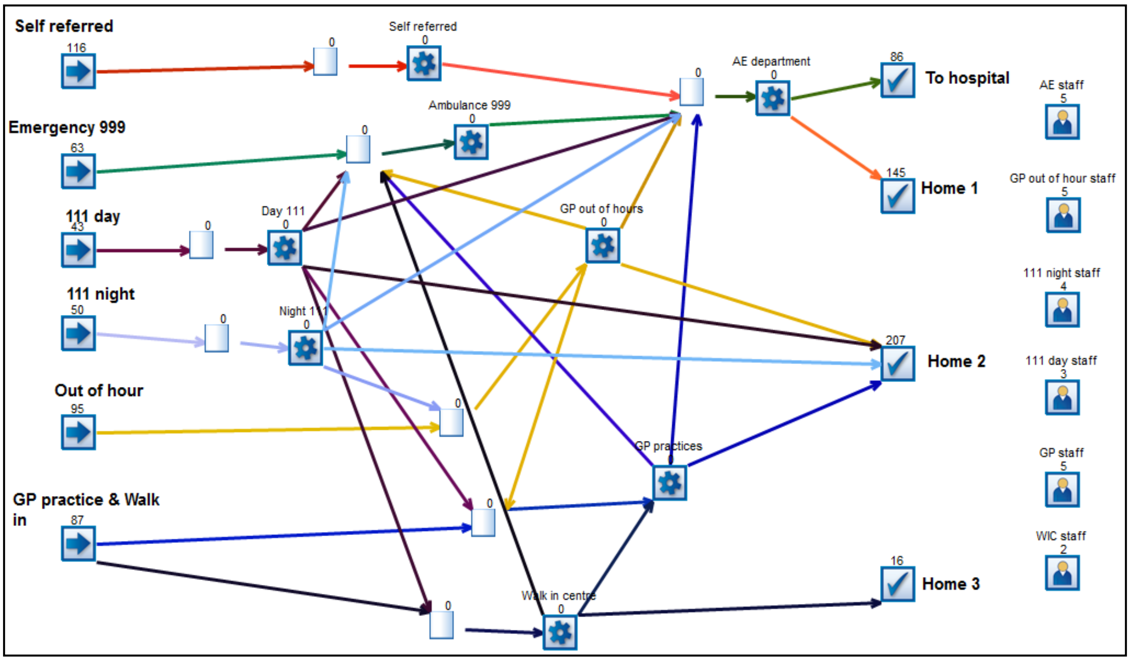


Figure 6-6 Base model showing points of healthcare access

Figure 6-6 represents the model that was run in Simul8 with trials of 100 runs, where one run represents one day. Seasonal changes were discounted from this model; it was assumed that access was the same throughout the year.

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	236.00	248.12	260.25	
Queue for Day 111	Average Queuing Time	1.22	1.30	1.37	
Queue for Night 111	Average Queuing Time	1.89	2.02	2.15	
Queue for GP out of hours	Average Queuing Time	3.83	4.03	4.23	
Queue for GP practices	Average Queuing Time	0.96	1.05	1.15	
Queue for Walk in centre	Average Queuing Time	1.68	2.24	2.79	
Queue for Ambulance 999	Average Queuing Time	0.15	0.18	0.22	
AE department	Number Completed Jobs	226.69	228.00	229.31	
Day 111	Number Completed Jobs	43.00	43.00	43.00	
Night 111	Number Completed Jobs	50.00	50.00	50.00	
GP out of hours	Number Completed Jobs	107.55	108.12	108.69	
GP practices	Number Completed Jobs	121.83	123.06	124.29	
Walk in centre	Number Completed Jobs	18.74	19.47	20.20	
Self referred	Number Completed Jobs	116.00	116.00	116.00	
Ambulance 999	Number Completed Jobs	74.50	75.22	75.94	
AE staff	Utilization %	70.71	71.77	72.83	
111 day resources	Utilization %	5.90	6.06	6.23	
111 night resource	Utilization %	7.40	7.58	7.75	
GP out of hour	Utilization %	8.81	8.97	9.14	
GP resources	Utilization %	15.13	15.46	15.78	
WIC resources	Utilization %	6.97	7.33	7.69	

Base model

Figure 6-7 Simulation results of the base model

Results of the base model simulation are given in Figure 6-7, showing 95% confidence intervals for trial results. The results indicate that there are high waiting times at the A&E department, similar to what is observed today. Average waiting time here was 248.12 minutes, which is comparable to the 240-minute target expected for patients to be processed in the A&E department. In this model, it was observed that a large volume of patients (on average 228) was treated in the A&E per day. Of these patients, on average 75 came in by ambulance while 116 were self-referred (others were referred from other access points). Table 6-3 presents a summary of outcomes from the simulation as it concerns other sectors of the care delivery points

The simulation results are summarised in Table 6-1. Long queues were evident for A&E while there were short queues at the other delivery points. With long queues in the A&E department, utilisation of staff resources stood at 71.77% whereas at GP practices it was 15.46%.

Table 6-2 Summary outcomes from simulation of the base model showing average performance from all care delivery points.

Access point source	Average queues (minutes)	Average numbers of patients processed	Average utilisation (%)

A&E	248.12	228	71.77
111 day	1.3	43	6.06
111 nights	2.02	50	7.58
GP Out-of- hour	4.03	108	8.97
GP practice	1.05	123	15.46
WIC	2.24	20	7.33
999 Ambulance	0.18	75	0
Self –referred	0	116	0

The base model describing the current situation of UUEH access in a realistic manner is used as the basis for a number of what-if scenarios, which are described in Section 6.6.

6.6 Simulation of NHS proposal for UEC delivery: what-if scenarios

In this section the base model is modified to determine the effects on the delivery process should patients access UUEH according to the NHS "pyramid" proposal for UUEH (NHS England (2013b), described in Section 4.6 (see Figure 4-12). The following shorthand was used for patients who access care according to the NHS proposal. "Right" access means only very sick patients access the A&E department while other patients use the other UC access points. The assumption was that patients self-referring to A&E are "right" when they use other UC access points according to this delivery model. The base model was varied to find out what effects will occur in the care delivery process according to scenarios where self-referring patients access UUEH 100%, 75%, 50% and 25% "right" according to the NHS process design.

The approach used is similar to that of the NHS England Channel Shift model (NECS, 2017). The Channel Shift model enables CCGs and other authorities to calculate cost savings from redirection of demand from one UEC provider such as A&E to another. It assumes that proportions of non-admitted, 'minor' demand at A&E can be diverted elsewhere.

6.6.1 Where self-referring patients access healthcare 100% "right"

In this scenario, it is assumed that 100% of self-referring patients access healthcare according to the NHS design. This eliminates the self-referred (red route) of the base model. Emergency patients arrive at the A&E by ambulance; also, patients are referred to A&E from the other routes. The self-referred (65%) patients are redistributed to the other access points as follows.

- 111-day access point received 5% of the day part of self-referrals
- 111-night access point received 20% of the night part of self-referrals
- Out of hours GP practice received 70%
- GP practices and walk-in centres received 5%

Figure 6-8 shows the Simul8 model for UUEH access when patients access care 100% "right".

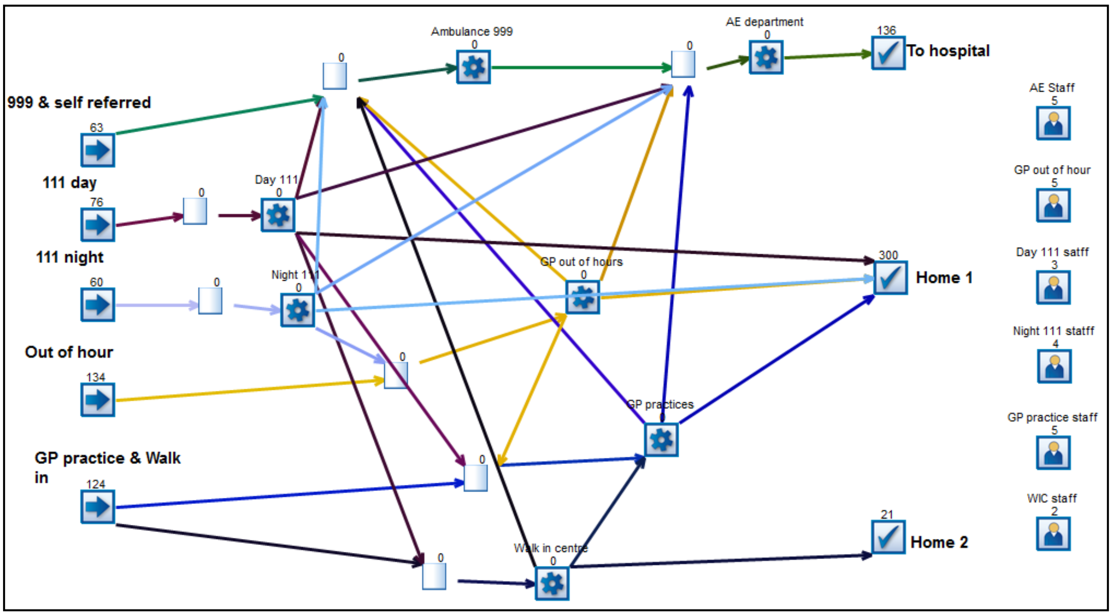


Figure 6-8 Simulation model where patient access is 100% right

Simulations were carried out as for the base model, with the same staff numbers and service times at all activity stations. The results, as shown in Figure 6-9, show that when patients access A&E and other care delivery points 100% right, average A&E queuing times dropped to 22.67 minutes from 248.12.

		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	18.87	22.67	26.48	
Queue for Day 111	Average Queuing Time	4.81	4.97	5.13	
Queue for Night 111	Average Queuing Time	2.69	2.85	3.00	
Queue for GP out of hours	Average Queuing Time	9.03	9.40	9.77	
Queue for GP practices	Average Queuing Time	3.32	3.50	3.68	
Queue for Walk in centre	Average Queuing Time	3.14	3.65	4.15	
Queue for Ambulance 999	Average Queuing Time	0.13	0.16	0.19	
AE department	Number Completed Jobs	133.05	134.73	136.41	
Ambulance 999	Number Completed Jobs	78.54	79.32	80.10	
Day 111	Number Completed Jobs	76.00	76.00	76.00	
Night 111	Number Completed Jobs	60.00	60.00	60.00	
GP out of hours	Number Completed Jobs	150.00	150.61	151.22	
GP practices	Number Completed Jobs	174.41	175.84	177.27	
Walk in centre	Number Completed Jobs	27.70	28.65	29.60	
To hospital	Number Completed	133.05	134.73	136.41	
Home 1	Number Completed	301.86	303.58	305.30	
Home 2	Number Completed	17.90	18.69	19.48	
AE Resources	Utilization %	41.24	42.08	42.92	
Day 111 Resources	Utilization %	10.41	10.63	10.85	
Night 111 Resources	Utilization %	3.78	3.87	3.96	
WIC Resources	Utilization %	8.61	9.00	9.39	
GP practice Resources	Utilization %	21.63	21.99	22.36	
GP out of hour	Utilization %	12.31	12.52	12.73	

Figure 6-9 Simulation result from the model where 100% access is right

6.6.2 Patients accessing healthcare 75%, 50% and 25% "right"

Further models were run for scenarios where 75%, 50% and 35% of patients accessed healthcare the "right" way. The base model was adapted in a similar way, but in this case retaining a remainder of patients self-referring to A&E directly. Appendix 11 A-F gives the simulation models and results. Figures 6-10 and 6-11 summarise the results, which are described as follows.

i) A&E Queue

Figure 6-10 gives the average queuing times by percentage right. Queuing times drop from the base model, 0% right, at 248.12 minutes, to 22.67 minutes when it was assumed that they attended the A&E 100% correctly. It was found that even a small improvement in percentage right (25%) could lead to a reduction in queuing time of 181.64 minutes.

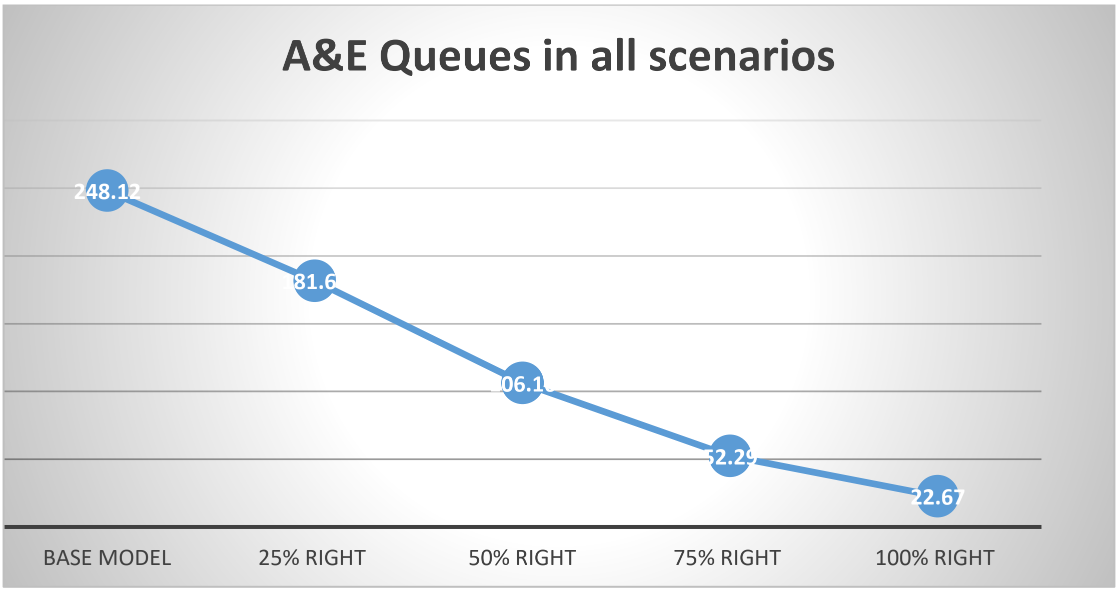


Figure 6-10 Falls in average A&E queuing times as patients access UEC by different percentages “right”

ii) Queues at the other access points

As expected, when patients accessed unscheduled UUEH at A&E by various percentages “right”, the simulation results for other access points shown in Figure 6-11 reflect increasing queuing times.

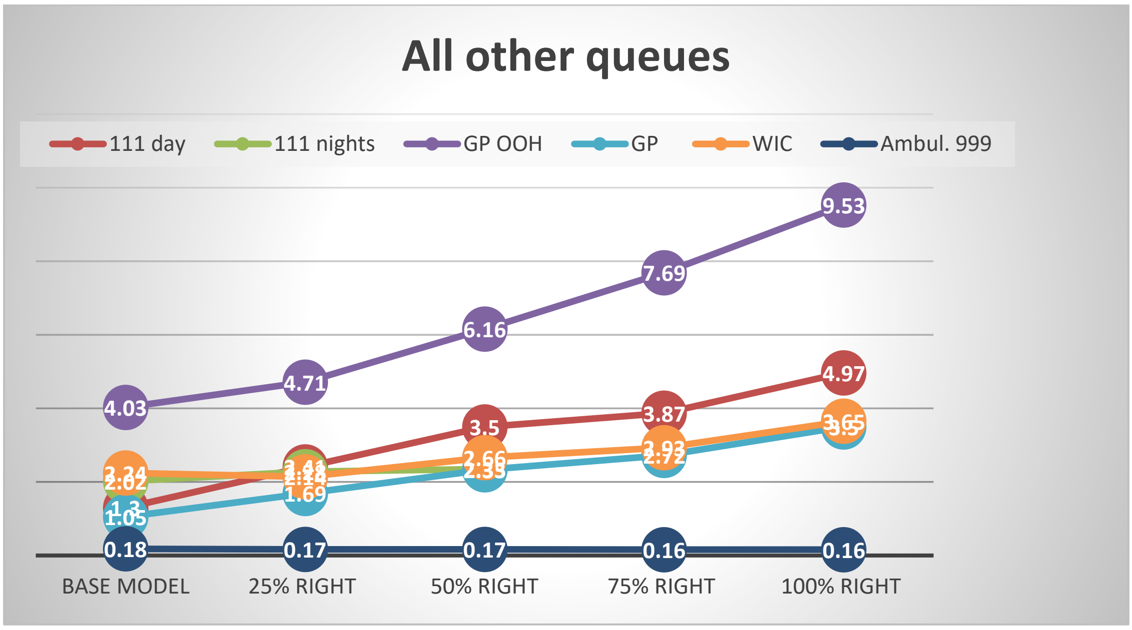


Figure 6-11 Average queuing times at non-A&E access points by percentages “right” in UEC access

In general, queues in the other care delivery points increased gradually with improvement in the "rightness" of access. However, with referrals between services, there are some reductions in queuing times.

iii) Effects on numbers of patients served and staff utilisation

The effect of accessing healthcare "right" on access points regarding average numbers of patients served, and average utilisation of staff is shown in Figure 6-12.

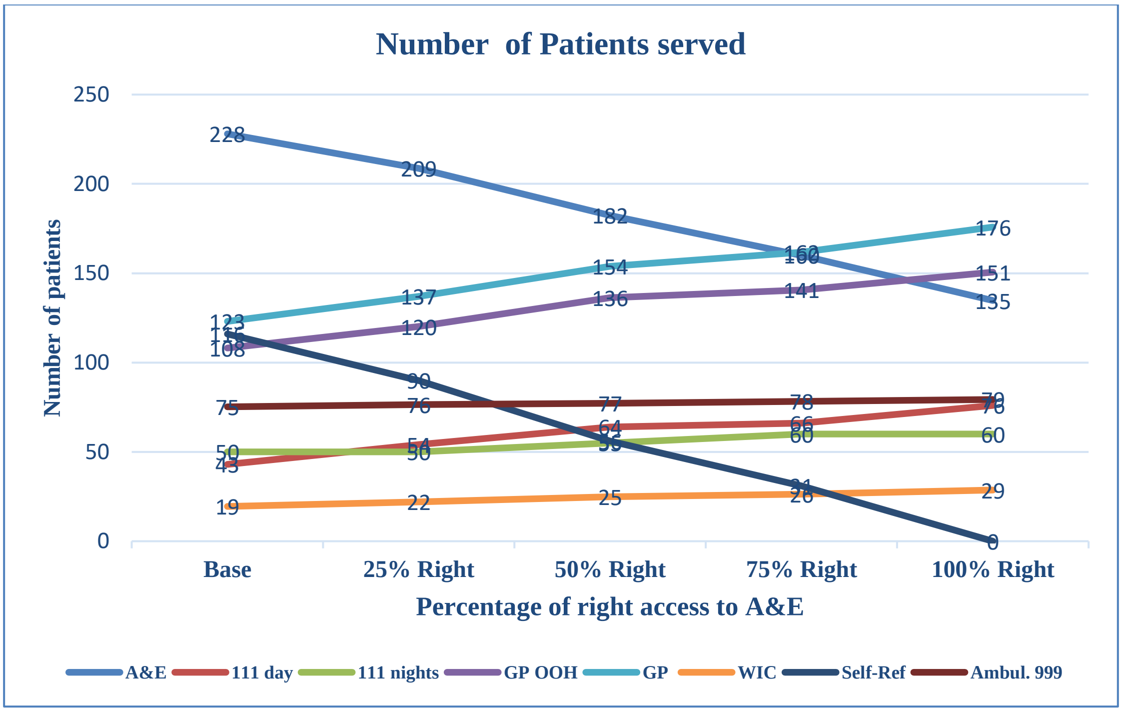


Figure 6-12 Numbers of patients served at every stage of UEC delivery by percentage "right"

It can be seen that the numbers of patients served vary depending on percentages of self-referred patients accessing UUEH in the "right" manner. For example, at the Base level (0% "right") 228 patients were processed on average at A&E, with a steady reduction to 135 patients at 100% "right". For the same scenarios, 151 patients used GP out-of-hours, rising to 151 at 100% "right".

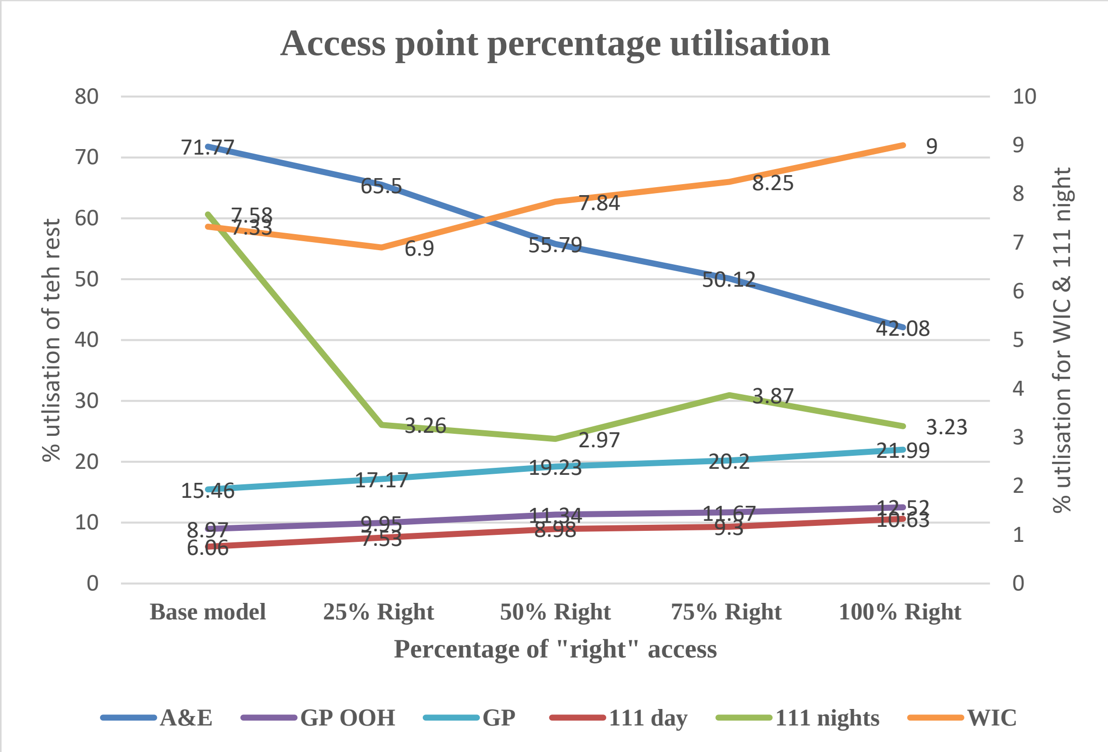


Figure 6-13 Access point utilisation (%) at every stage care is accessed "right"

Average staff utilisation (as a percentage of time busy) at the different UUEH access points is shown in Figure 6-13. There were variations in the level of utilisation at the various access points with changing degrees of access "rightness." At 100% "right", utilisation at the A&E was 42% compared to 71.8% at the Base level. Also, utilisation at GP practices was 15.5% while at WIC it was 7.3% at the Base level but increased to 22% and 9% when patients accessed healthcare 100% "right".

6.6.3 Resource change and effects on each access point compared to base

Further simulation experiments were conducted with reductions in the resources provided (personnel or numbers of activity centres) at each percentage "right". Table 6-3 shows how changes in the resources provided at A&E affect average queuing times at A&E and resource utilisation. The base model measures are included for comparison.

Table 6-3 Resource changes at A&E and effects on care delivery

Process access behaviour	Number of Resources	Queuing (minutes)	Utilisation %
100% Right	5	22.67	42.08
100% Right	4	87.99	52.6
100% Right	3	257.19	70.13

Process access behaviour	Number of Resources	Queuing (minutes)	Utilisation %
50% Right	5	106.16	57.3
50% Right	4	243.6	71.63
50% Right	3	508.41	93.84
Process access behaviour	Number of Resources	Queuing (minutes)	Utilisation %
75% Right	5	52.29	50.12
75% Right	4	160.43	62.65
75% Right	3	378.51	83.46
Process access behaviour	Number of Resources	Queuing (minutes)	Utilisation %
25% Right	5	181.64	65.5
25% Right	4	352.82	81.87
25% Right	3	655.89	99.19
Process access	Number of Resources	Queuing (minutes)	Utilisation %
Base	5	248.12	71.46

It can be observed from Table 6-2 that the Base model with 5 units of resources (activity centres) in the A&E department had average queuing times of 248.12 minutes and 71% utilisation. If patients accessed UUEH 100% "right", with 5 resources an average queuing time of 22.67 minutes is achieved, with utilisation of 42.1%. When resources are reduced to 4, utilisation was 52.6% with an increased queuing time of 89 minutes. A further reduction to 3 units of resources led to utilisation of 70.13% and queue of 257.19 minutes, which is longer than with the base model.

In most of the cases except 25% "right", a reduction of one unit of resources from the Base model could still provide improvements in queuing time, and hence savings on staff costs. However, any further reduction makes the service process inefficient. With 25% "right", it makes no economic sense to reduce personnel. With 5 units of resources, queuing time fell (181.68 minutes), but utilisation (65.5%) is lower than with the Base model.

In the above simulation scenarios and subsequent experiments, the current UUEH access and the effects of degrees to which the "pyramid" NHS proposal for UUEH could improve UUEH demand, delivery and A&E capacity were examined. It has been demonstrated that rerouting patients demanding UUEH could be a solution for reducing the pressure on A&E departments. This analysis shows that congestion in A&E departments could be driven largely by factors outside the department such as non-responsiveness of the other access points, which would have dealt with UUEH. However, the NHS “pyramid” proposal depends on the willingness of the public to make behavioural changes to current usage. In the following sections, a proposal for UUEH access according to process-oriented considerations, rooted in patient oriented designs, is explored.

6.7 Finding optimal locations for UC hubs: GIS modelling

The findings regarding optimal locations for UC hubs, with the case study in Hounslow borough, are now presented. In the borough, apart from GP practices of various sizes, a UCC located at West Middlesex Hospital and a walk-in centre at Ashford Hospital (outside Hounslow), there are no other UCUs/UCCs (see Figure 6-2).

6.7.1 Qualitative selection of candidate UC hub locations

The analysis of travel of patients to GP practices (Figure 6-2) has been used to find locations for UC hubs that are suitably distant from the A&E to ensure a distinct identity to the service. Eleven potential locations within the London Borough of Hounslow, which were deemed best for locating UC hubs according to current patient travel patterns, were selected These are referred to as candidate locations and were central points within the LSOAs, and were chosen with larger populations close by. Table 6-4 shows these selected points within the borough, and, for their catchment areas, the resident population sizes, numbers of registered patients, and numbers of A&E attendances, admitted and non-admitted. The selected locations are all distant from the A&E department itself, in accordance with research findings (see Section 4.8.2) that co-location of primary care services with A&E may not reduce demand at A&E.

Table 6-4 Population of the catchment areas of candidate UC hub sites in Hounslow showing levels of A&E attendance

Location	Population	Registered patients	A&E attendance	Non-admitted	Admitted
Chiswick	31,210	39,682	4,528	3,079	1,449
Clayponds Hospital	2,521	5,892	3,617	2,460	1,157
Brentford and Isleworth	42,340	45,711	4,927	3,350	1,577
Summer Wood Road	5,101	2,972	3,727	2,534	1,193
Feltham	51,150	58,669	5,227	3,554	1,673
Beachwood	3,298	1,022	6,346	4,316	2,030
Heart of Hounslow	59,967	62,338	6,338	4,310	2,030
Great West Road	50,917	54,288	6,458	4,391	2,067
Ashford Hospital	6,125	1,000	799	544	259
The Cygnets	10,651	14,022	12,829	8,726	4,103
Kew	7,051	10,422	3,729	2,536	1,193
Sum	270,330	291,038	58,525	39,800	18,731

Source: DOH and NHS (2014)

Individual grid references for these candidate locations were obtained and projected onto the British National Grid, as shown in Figure 6-14, using ArcGIS.

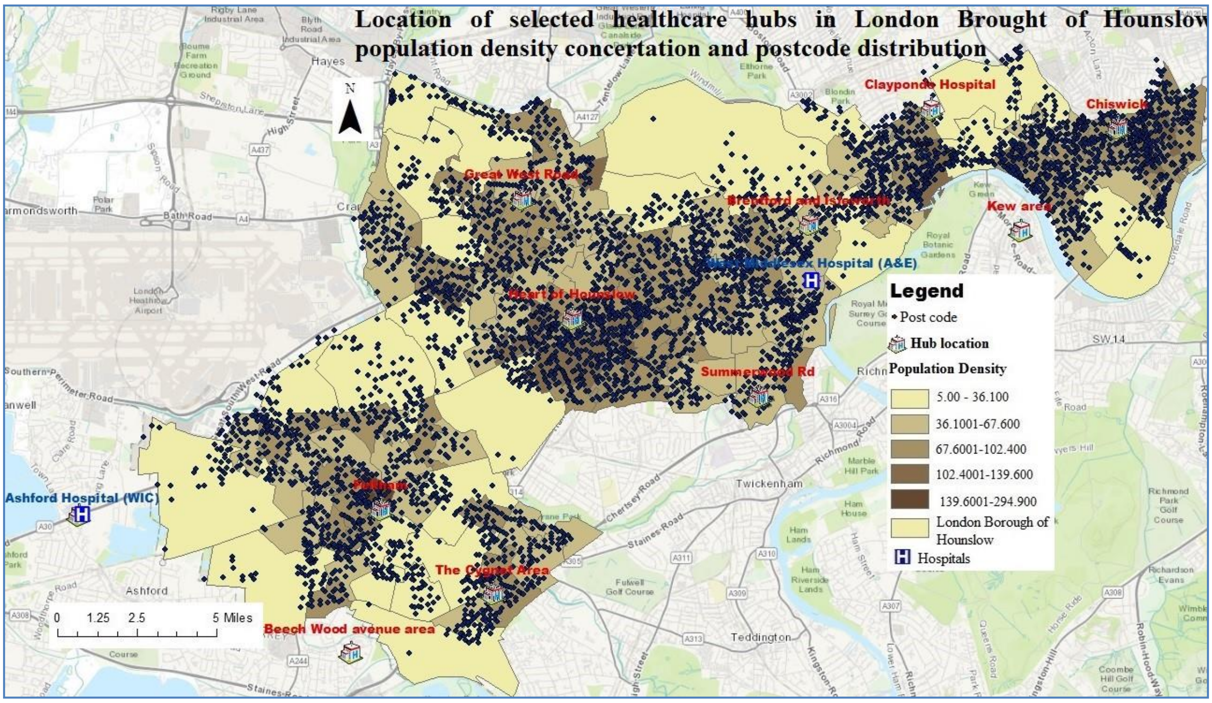


Figure 6-14 Access to candidate locations for UC hubs and direction of patient access

Firstly the *p*-Median model (minimising impedance) was used to determine the optimal location of UC hubs within the London Borough of Hounslow. With 11 candidate locations, optimal solutions for four, two and one hubs are compared.

Data were input concerning population density, road network and candidate hub locations into the ArcGIS platform, and runs were carried out with the use of the location allocation extension. Results were obtained as shown in Figure 6-15.

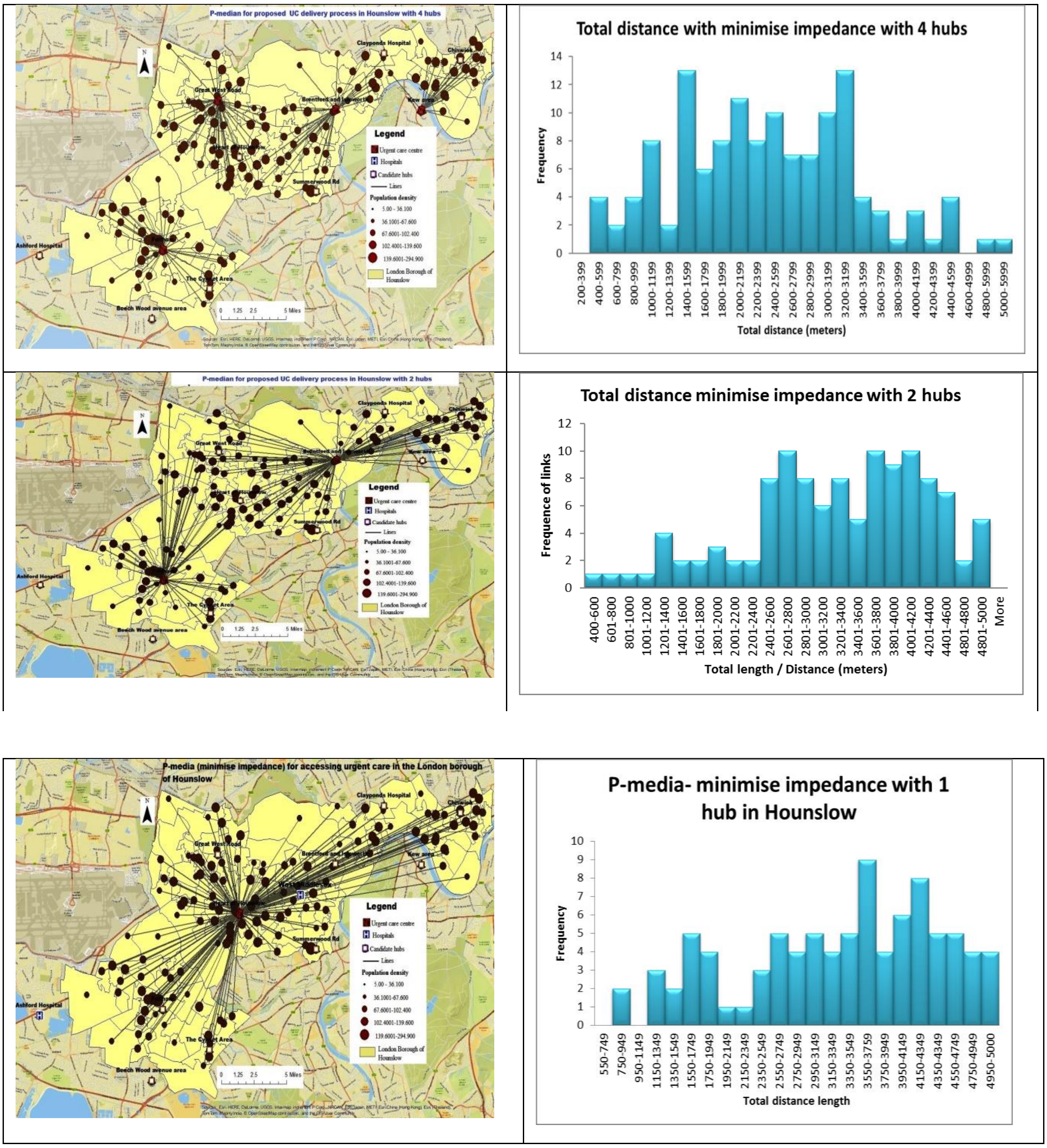


Figure 6-15 Minimise impedance for location of 4/2/1 UC hubs in the London Borough of Hounslow

The results show optimal locations for 4, 2 or 1 hubs according to the model. Distances from population locations to hubs are presented in the adjacent histograms. It is notable that there are increased distances travelled with 2 hubs or 1 hub, in comparison to 4 hubs. However, some patients will have to travel longer distances than others in all configurations.

Secondly, the Maximal Coverage model was used to find optimal locations for UC hubs. The model was run for location of four, two and one UC hub(s) in Hounslow; the results shown in Figure 6-16 were obtained.

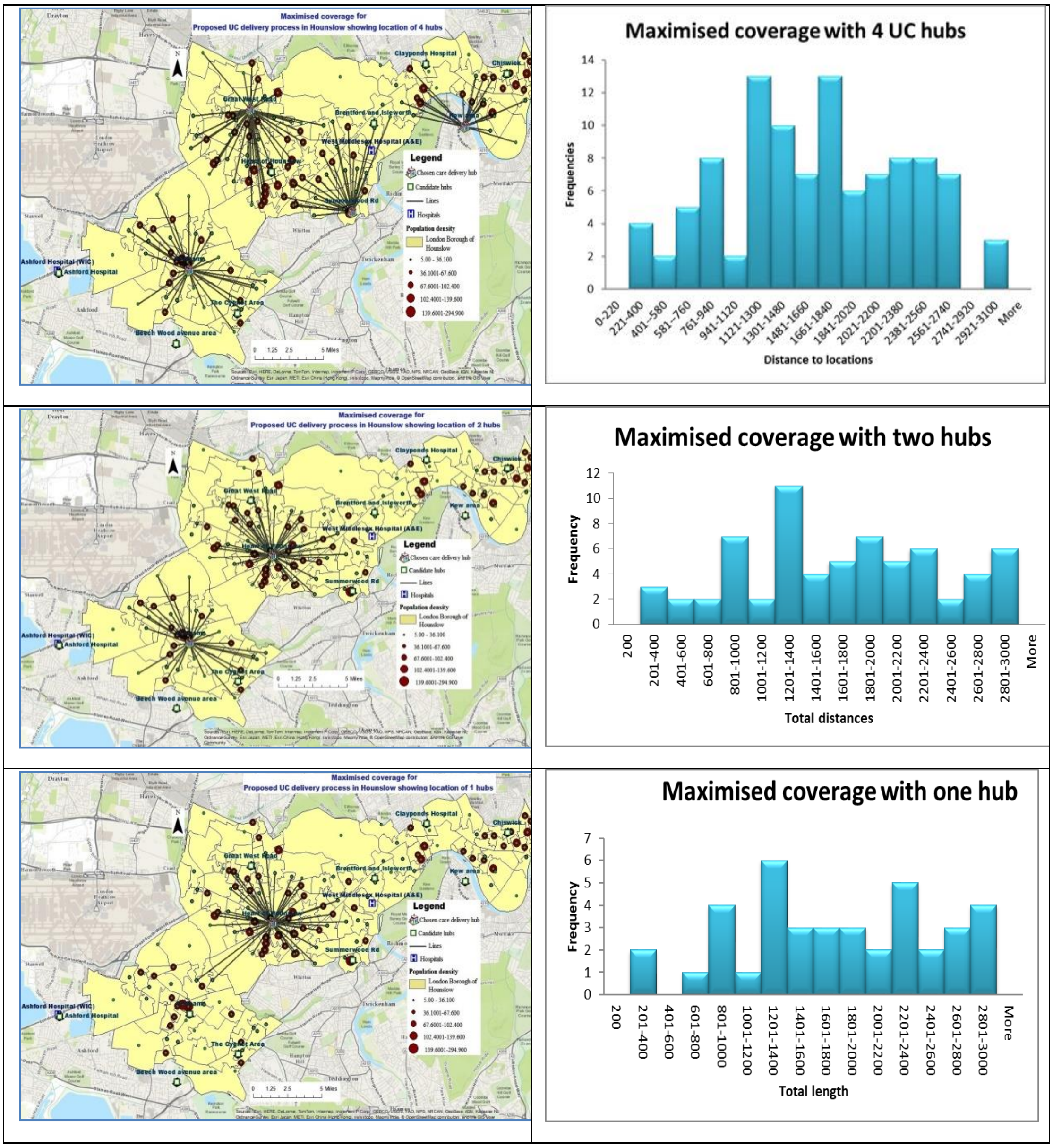


Figure 6-16 Maximised coverage of UC hubs in Hounslow ranging from 4 to 1

Figure 6-16 demonstrates that four UC hubs naturally provide better coverage as they spread out to more demand points and at shorter distances. However, with only two hubs or one hub with impedance cut-off of 3,000 metres (1.9 miles), some demand is left uncovered, especially in areas where there is lower population. To get better coverage, the impedance cut-off can be increased, but this will mean that residents have more difficulty getting access. In cases where one demand point lies within the impedance cut-off of more than one facility, the closest facility will be assigned (Pratt *et al.*, 2014).

Simulation of the operation of UC hubs then proceeded using results of both Maximum Coverage modelling with cut-off distances and *p*-Median modelling with no cut-offs.

6.8 Simulation of UC hubs

The following assumptions about UC hubs are made in simulations of their operation.

i) UC hubs provide unscheduled urgent healthcare to patients who can access it without prior booking.

ii) UC hubs are independent and away from A&E departments and capable of treating all minor health concerns and also give birth control, health prevention, and nutritional advice (see Appendix 2). Cases that are more serious are quickly referred to the A&E department.

iii) The A&E department can refer to the UC hubs any patients who are primary care treatable.

iv) UC hubs are accessible and visible. They are open 24 hours per day, 7 days per week, to all registered patients, irrespective of who their GPs may be.

v) The hubs receive and respond to all NHS 111 calls that are made in the catchment of the hub location.

Simulations with 4/2/1 hub(s) were carried out according to the following “what if” scenarios:

a. With a cut-off travel distance of 3,000 meters (1.9 miles) between residential areas and hubs, representing a likely travel distance that residents can easily undertake.

b. With no cut-off, assuming that the hubs must serve all postcodes within the catchment.

With all simulations, effects on queuing times at hubs, A&E and other services are analysed.

6.8.1 4 Hub location and simulation

i) Four hubs with cut-off

From the 11 candidate locations, the optimal locations selected using the Maximum Coverage algorithm within the ArcGIS platform were Chiswick, Brentford and Isleworth, Great West Road and Feltham, as shown in Figure 6-18.

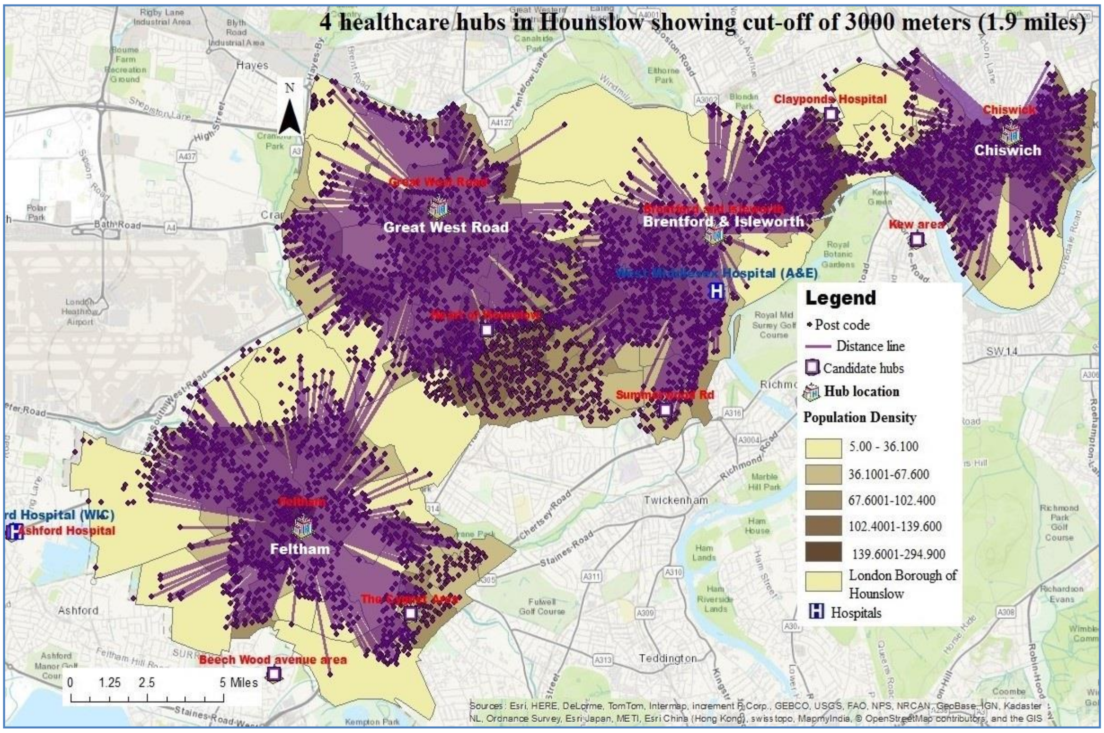


Figure 6-17 London Borough of Hounslow showing a 4-hub model with a cut-off distance 1.9 miles

With 4 hubs, only 81% of the postcodes were served due to a cut-off of 5,000 meters (1.9 miles). Table 6-5 provides details of the distance distribution.

Table 6-5 Areas (postcodes) served and those not served

All demand points in Hounslow (postcodes)	**4,929**
Total points (postcodes) served by this model	3,985
Total points (postcodes) unserved due to cut-off (5,000 meters or 1.9 miles)	944
Percentage served	81%

Percentage unserved	19%

With 19% of the region remaining unserved, it is possible that those patients would access healthcare from the A&E department, something that is desirable to eliminate.

ii) 4-hub model with no cut-off

Optimal locations with 4 hubs were found using the *p*-Median algorithm of ArcGIS with no cut-off. As shown in Figure 6-18, almost all postcodes in the borough (99.95%) were covered. However, the average distances vary from hubs to postcodes as shown in Figure 6-19. The hub locations found are the same as with cut-off.

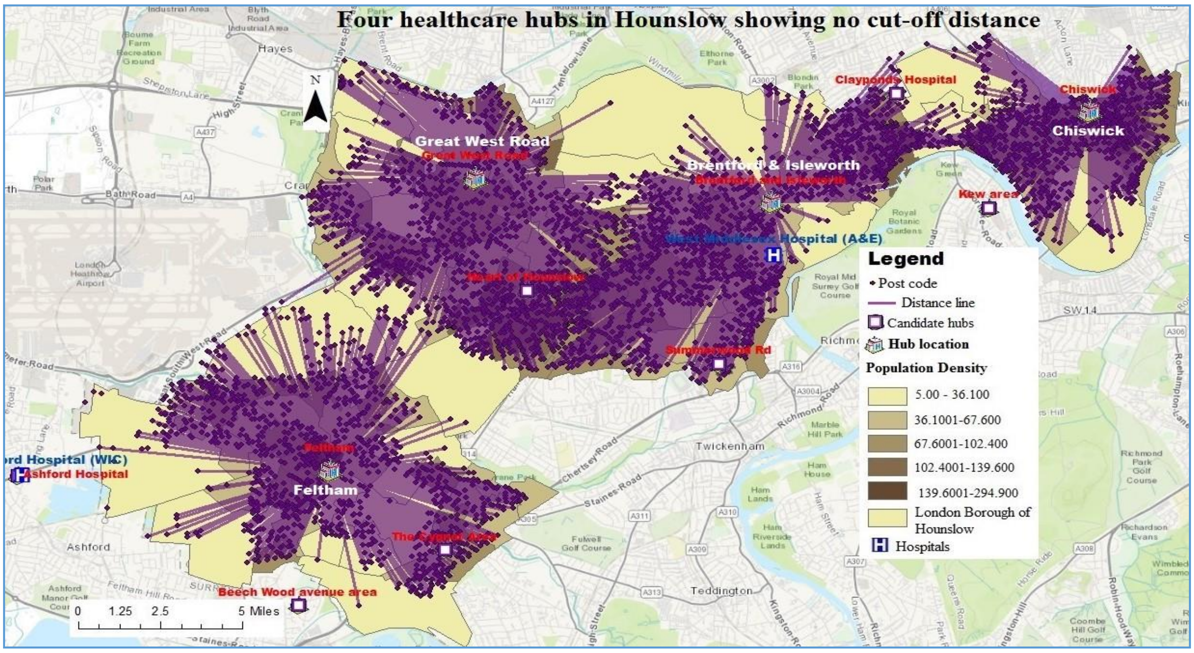


Figure 6-18 London of Hounslow showing 4 care delivery hubs

Average distance to healthcare hubs with cut-off is 1,602 meters (0.99 miles). With no cut-off average distance becomes 1,831 meters or 1.14 miles. Figure 6-20 compares the average distances travelled to each hub location with and without the assumption of cut-off. As expected, mean distance travelled increases if no cut-off is assumed.

Figure 6-19 Mean distance to 4 Hubs with and without cut-off

Five percent of postcodes according to Figure 6-20 could not be covered despite no cut-off. This could be due to the fact that these postcodes are located at the edge or slightly outside the borough, which is the area of measurement. Also, these postcodes could have been changed at the time of this study and the route to them might have been redirected to pass through a different borough or district. As such, the ArcGIS "spider" could not identify the route network to these postcodes within the Borough of Hounslow.

The model designed for the simulation of 4-hub operation is presented in Figure 6-21.

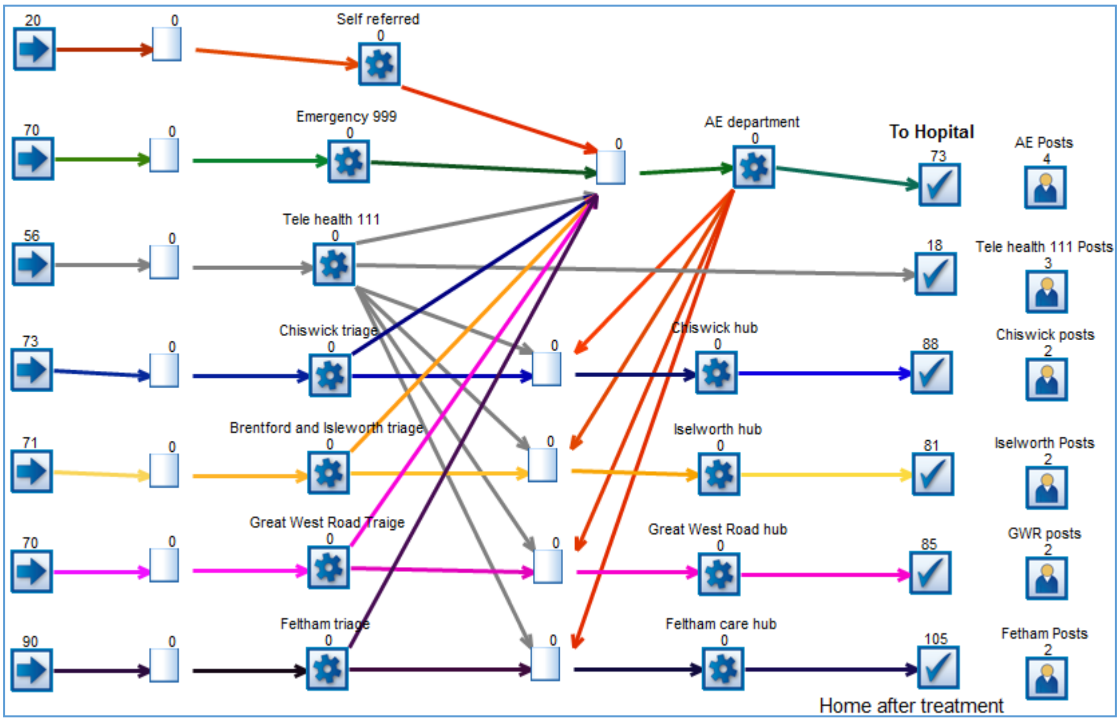


Figure 6-20 Four-hub care delivery simulation model

Similar data were used as in the Base model simulation presented in Section 6.4. In this case, however, it is suggested that 20% of patients went to A&E department. Of this group, 25% were self-referred, and 75% used emergency (999 or ambulance) access; all self-referring patients are referred from A&E to a UC hub nearest to their place of residence. Then, of the remaining 80% who accessed unscheduled healthcare elsewhere, 13% made telehealth contact by calling NHS 111. For the hubs accessed the distribution was as follows:

- Chiswick (17%),
- Brentford (16%),
- Great West Road (15%)
- Feltham (19%).

The hub distribution was based on weights of regional population concentration according to London Borough of Hounslow (2013). The assumption is that the areas with a larger population will have more patients accessing the hubs.

As with the Base model, the data available concerned daily healthcare attendance for unscheduled healthcare to all healthcare facilities in Hounslow over a period of 24 hours. In each hub, two work cubicles were assumed to be available to provide healthcare 24 hours per day, 7 days per week. Shift work patterns were applied.

In the simulation model, those who access A&E through the self-referred (red route) are referred back to a hub (red route from A&E). Patients who arrive at hubs via the emergency services are admitted to hospital.

Simulation results for a 4-hub system are presented in Figure 6-22. With 4 hubs it is found that average queues at the A&E fell from 248.12 minutes (Base model) to 36.48 minutes, since A&E is now dealing only with the very sickest patients. Other queues, utilisation and average numbers of patients treated are summarised in Figure 6-23.

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

4 hubs		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	31.74	36.54	41.33	
Queue for Tele health 111	Average Queuing Time	0.15	0.17	0.19	
Queue for Chiswick hub	Average Queuing Time	9.88	10.99	12.10	
Queue for Iselworth hub	Average Queuing Time	9.09	10.54	11.98	
Queue for Great West Road hul	Average Queuing Time	8.64	9.52	10.41	
Queue for Feltham care hub	Average Queuing Time	17.02	19.06	21.10	
AE Posts	Utilization %	46.35	47.34	48.32	
Tele health 111 Posts	Utilization %	3.81	3.91	4.02	
Chiswick posts	Utilization %	31.81	32.48	33.14	
Iselworth Posts	Utilization %	31.27	32.10	32.94	
GWR posts	Utilization %	30.69	31.39	32.08	
Fetham Posts	Utilization %	37.80	38.61	39.41	
Self referred	Number Completed Jobs	20.00	20.00	20.00	
Tele health 111 home	Number Completed	18.71	19.39	20.07	
Chiswick home	Number Completed	85.69	86.54	87.39	
Isleworth home	Number Completed	83.83	84.81	85.79	
Great West RD home	Number Completed	82.68	83.64	84.60	
Feltham home	Number Completed	100.65	101.68	102.71	
Hopsital entry	Number Completed	72.61	73.94	75.27	

Figure 6-21 Simulation results from the 4-hub model

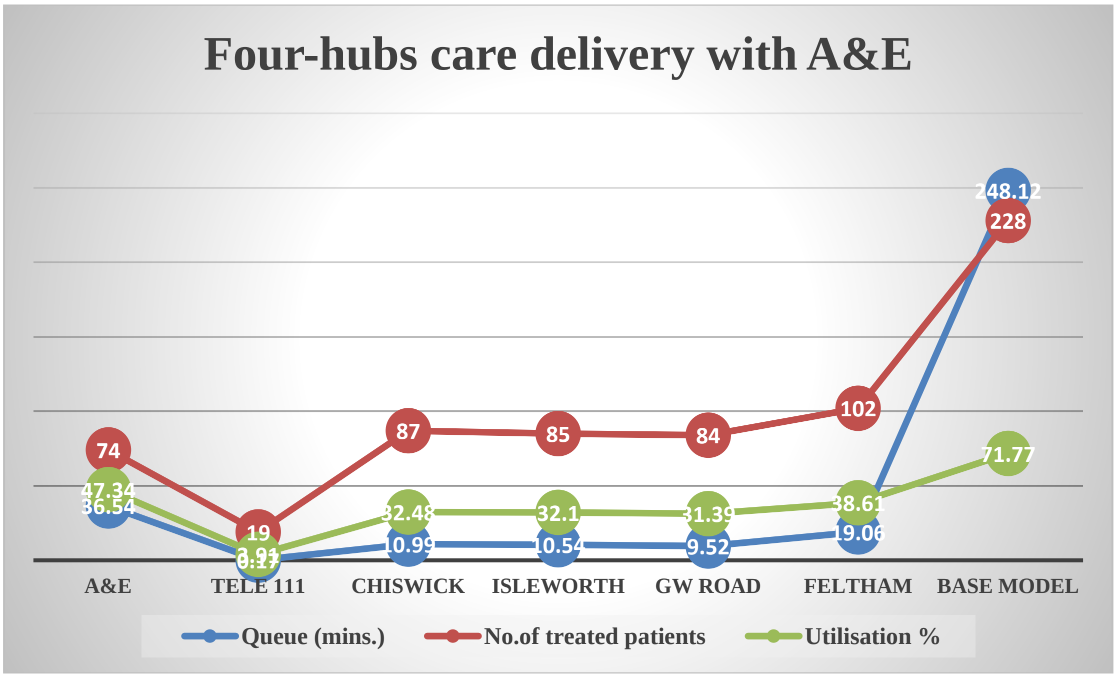


Figure 6-22 Four hub model comparing performance of the various hubs to the A&E Base model

Overall, with more unscheduled patients treated at the hubs, the number of patients going to A&E was reduced. While 74 patients overall were admitted, 451 patients were treated by the hubs, NHS 111 telehealth system and discharged home.

6.8.2 Two hubs location and simulation

Regarding economic factors, for example, healthcare planners could be interested in supporting only two hubs in the area instead of four. The challenge now becomes where best to locate the care delivery points.

Figure 6-24 shows a GIS optimal location of two hubs with cut-off, namely Feltham and Brentford-Isleworth.

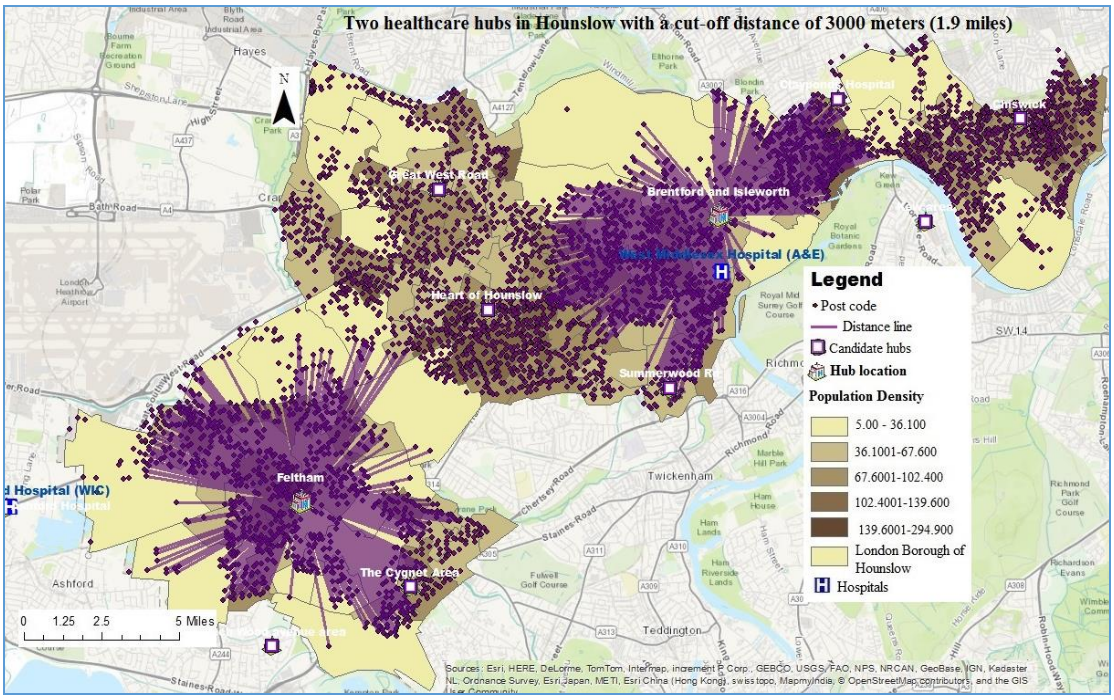


Figure 6-23 Two UC hub locations in Hounslow with demand cut-off

The immediate observation from the Figure 6-24 is that the cut-off causes many areas (postcodes) to remain unserved by the hubs. Table 6-6 demonstrates that 54% of the borough remains unserved as a result.

Table 6-6 Areas (postcodes) served and those not served as a result of cut-off

All demand points in borough (postcodes)	**4,929**
Total postcodes served in Brentford-Isleworth and Feltham	2,246
Postcodes unserved	2,683
Percentage postcodes served	46%
Percentage postcodes unserved	54%

The 2-hub location with no cut-off assumed is shown in Figure 6-25. Average distances travelled by patients were as follows:

a. Brentford and Isleworth, without cut-off 3,414 meters (2.1 miles) compared with 1.13 miles with cut-off

b. Feltham, without cut-off 2,712 meters (1.7 miles) compared with 1.02 miles with cut-off.

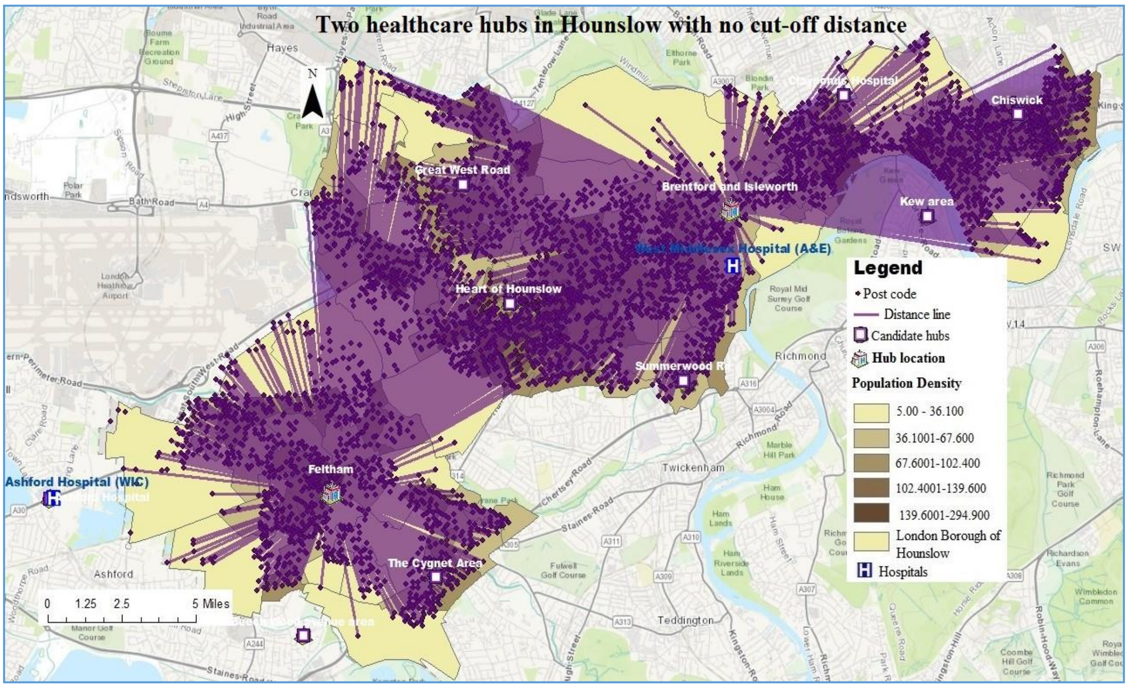


Figure 6-24 Two hub access with no cut-off

To simulate the two-hub model, it was approached in two ways in view of the large proportion of the population uncovered when cut-off is assumed. First, the model was simulated assuming a scenario of 13% usage of the NHS 111 telehealth system as in the base model. This follows the assumption that there was no cut-off distance and that patients preferred to visit the hubs rather than make phone healthcare contacts. A second “what if” scenario for two hubs with cut-off assumed increased telehealth access at 20%.

In the 2-hub simulation models, access to A&E remained at 20%. Patient arrivals at the hubs were distributed as follows, according to population in the catchment area:

- Brentford and Isleworth access was 27% with no cut-off and 35% with cut-off
- Feltham access was 25% with no cut-off and 30% with cut-off.

With two hubs, in comparison with the 4-hub simulation model, the additional population was redistributed to the two hubs. The number of units of resources at each of the two hubs was increased accordingly; shifts were maintained as defined earlier.

The 2-hub simulation model and results can be found in Appendix 12 (A-P). Table 6-8 summarises the results from each hub, A&E and the effects on access when more patients access NHS 111 telehealth rather than the hubs, assuming a cut-off in the distance travelled.

Table 6-7 Two-hub model where 13% and 20% accessed NHS 111 telehealth

	13%	**20%**	**13%**	**20%**	**13%**	**20%**
UEC access points	**Queue (mins)**	**Queue (mins)**	**No. of completed treatments**	**No. of completed treatments**	**Utilisation (%)**	**Utilisation (%)**
A&E	42.65	43.06	76	76	48.61	48.51
Brentford & Isleworth hub	8.58	3.04	185	170	35	26.42
Feltham hub	4.12	1.14	159	128	29.8	20.1
NHS 111	0.17	1.01	34	82	3.91	6.28

From Table 6-7, the A&E queue remains low compared to the base model. Average queuing times at the two hubs with the 13% NHS 111 (no cut-off) model are decreased in comparison with the 4-hub model (between 9.52 mins and 19.06 mins); this is to be expected since the same level of resources are now concentrated in two locations to serve the same demand. Again as expected, queues and utilisation at NHS 111 increase with the 20% usage and the same number of servers; similarly, queues and utilisation at the hubs decrease with 20% NHS 111 usage.

6.8.3 One hub location and simulation

Due to limited economic resources or lack of enough space and planning challenges, for example, it could be the case that only one hub is developed in the Borough of Hounslow. A one-hub only simulation model was run in a similar way to two hubs.

With a cut-off of 3,000 meters (1.9 miles), Brentford and Isleworth was selected as the optimal location for the hub (Figure 6-26). However, with this selection, coverage was much reduced from 2- or 4-hub models as shown in Table 6-10.

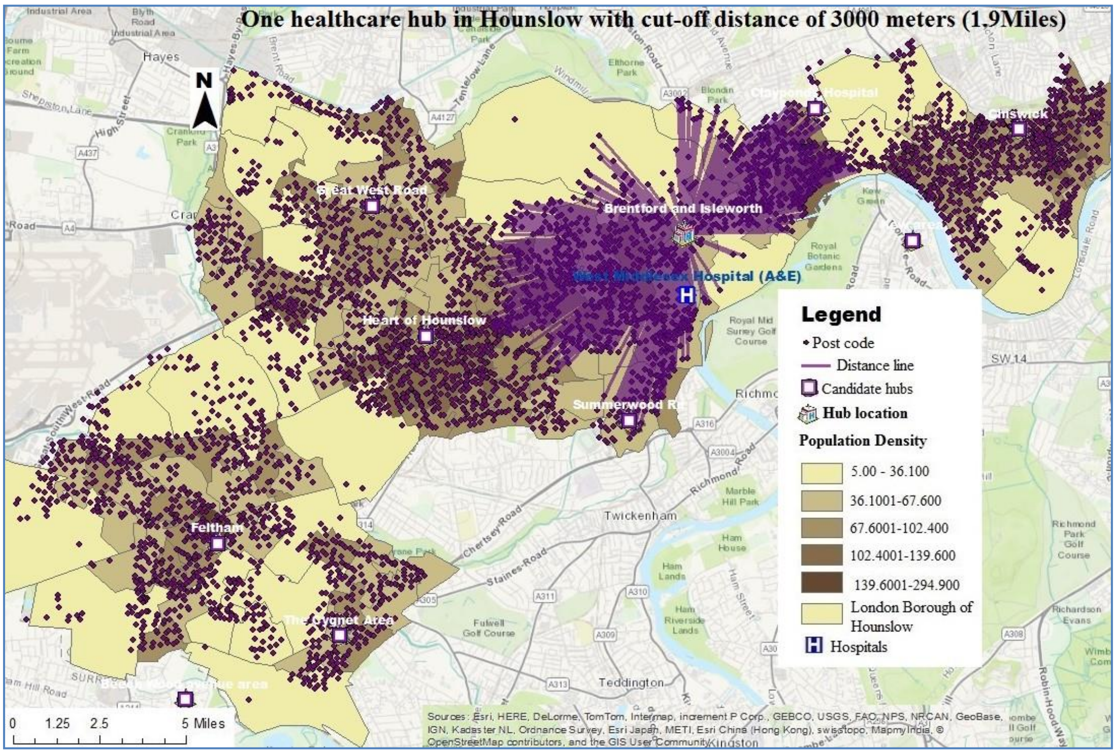


Figure 6-25 Location of one UC hub with a cut-off of 1.9 miles

According to Table 6-8, only 25% of the borough was covered assuming cut-off. The average distance travelled to the hub was 1,815 meters (1.13miles).

Table 6-8 Areas (postcodes) in the Borough of Hounslow served and not served due to cut-off distance with one hub

Total demand points of postcodes in the borough of Hounslow	4,929
Total areas (postcodes) in the borough of Hounslow served with hub	1,238
Areas (postcodes) in the borough of Hounslow covered	**25%**
Unserved areas (postcodes) in the borough of Hounslow	3,691
Percentage unserved	**75%**

Figure 6-27 presents the geographic selection of a hub where no cut-off is assumed.

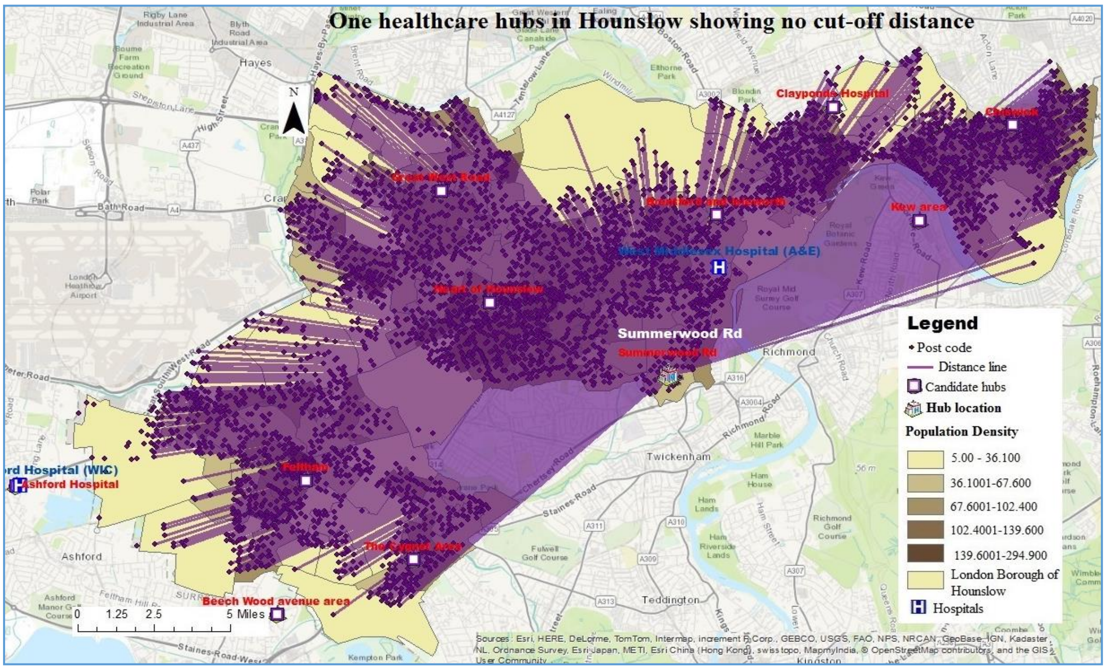


Figure 6-26 One hub with no cut-off. Average distance 5,45 meters (3.4miles).

In this case, Summerwood Road was selected as optimal for the hub location if there is no cut-off assumed. Average distance travelled increased to 5,445 meters (3.4 miles) in comparison to 1.13 miles to Brentworth and Isleworth if cut-off is assumed.

In simulating the healthcare process for one UC hub, as with the base model, 20% accessed the A&E department. Of those who attended A&E, 83 (75%) were brought in as emergencies while 26 (27%) accessed as self-referred. This access number remains the same irrespective of cut-off or no cut-off. It is assumed that 13% will utilise NHS 111 when there is no cut-off. However, when cut-off is assumed, it is simulated with an increase of NHS 111 usage to 20% and 25%. Simulation models are shown in Appendix 15K (1, 2 and 3).

With one hub, it is assumed that all resources are concentrated there, with eight cubicles as activity centres. Table 6-9 reports the summary of the main outcomes at the care delivery points. Average A&E queuing times remain low but varied with the number of patients who used the telehealth system. It should be noted that “Not applicable” in the table refers to the candidate location not selected by the one-hub model.

Table 6-9 Performance of the one-hub model with and with no cut-off and changes in use of telehealth

Access point for unscheduled urgent and emergency health care	A&E	NHS 111	Summerwood Road (no cut-off)	Brentford & Isleworth (Cut-off)
Queuing (minutes) (13%)	57.36	0.18	Not applicable	4.13
Queuing (minutes) (20%)	69.05	1.01	1.9	Not applicable
Queuing (minutes) (25%)	77.55	1.9	1.57	Not applicable
No. of patients seen (13%)	93	22	Not applicable	338
No. of patients seen (20%)	97	36	321	Not applicable
No. of patients seen (25%)	99	45	309	Not applicable
Resource utilisation % (13%)	51.48	3.8	Not applicable	31.54
Resource utilisation % (20%)	53.59	6.43	25.06	Not applicable
Resource utilisation % (25%)	55	8.02	24.17	Not applicable

Figure 6-28 shows the effect of changes in access to NHS 111 on A&E attendance. The numbers of patients treated at A&E increased due to increased referrals from the NHS 111.

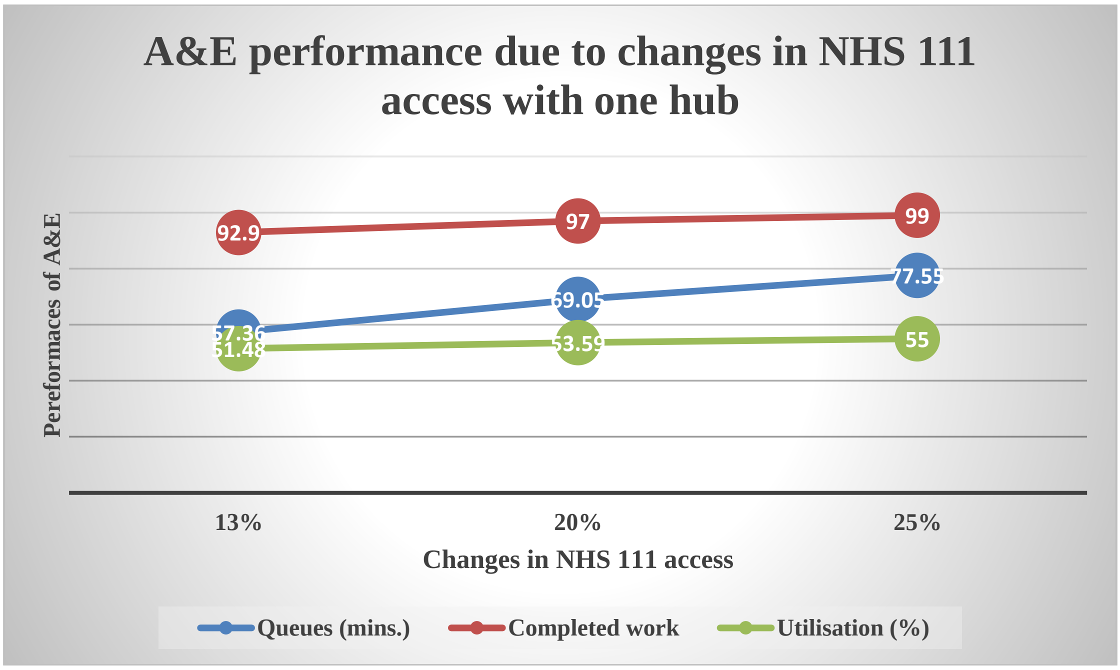


Figure 6-27 The effect of changes in NHS 111 access on A&E performance

With utilisation, as shown in Table 6-10, in Brentford and Isleworth, which has cut-off, the number of patients treated was 338. However, at Summerwood Road where NHS 111 usage was 20%, 321 patients were treated and, when telehealth usage increased to 25%, 309 patients were treated. The effects of distance could be seen playing a strong role in increased healthcare access especially in association with Summerwood Road.

6.9 Summary of GIS/simulation modelling and conclusion

This chapter started with an investigation of the current situation of UEC in Hounslow, using simulation. The base model was then modified according to scenarios where patients self-referring to A&E behaved 100%, 75%, 50% and 25% “right” according to the NHS “pyramid” proposal for UEC (Figure 4-11). With even only 25% patients behaving “right”, it is demonstrated that considerable reductions in queuing times at A&E could be achieved and, with higher percentages, there could be cost efficiencies in numbers of staff resources provided. The proposal for UC hubs was then analysed. Using a novel combination of GIS modelling and simulation, a demonstration was made of modelling for scenarios involving the location of 4/2/1 UC hub(s) in the case study area of Hounslow borough.

From the various locations selected and modelled with ArcGIS, simulation models have been built to demonstrate UC delivery in Hounslow borough with 4/2/1 UC hub(s) and NHS 111 usage of 13% (Base model, no cut-off distance assumed), 20% (assuming cut-off) and 25% (one hub only). A summary of the simulation results is presented in Table 6-10, showing a comparison with the Base model A&E results.

Table 6-10 Summary of all hub performance

4 hubs	**Queuing (mins)**	**No. of patients treated**	**Utilisation %**
A&E	36.54	74	47.34
Tele 111	0.17	19	3.91
Chiswick	10.99	87	32.48
Brentford and Isleworth	10.54	85	32.1
GW Road	9354	84	31.39
Feltham	19.06	102	38.61
Base A&E	**248.12**	**228**	**71.77**
2 hubs	**Queuing (mins)**	**No. of patients treated**	**Utilisation %**
A&E	42.65	76	48.61
Tele 111 (13%)	0.17	34	3.91
Brentford and Isleworth	8.58	185	35
Feltham	4.12	159	29.8
1 hub			
	Queuing (mins)	**No. of patients treated**	**Utilisation %**
A&E	57.36	93	51.48
Tele 111 (13%)	0.18	22	3.8
Isleworth	4.13	338	31.54

2 hubs	**Queuing (mins)**	**No. of patients treated**	**Utilisation %**
A&E	43.06	76	48.51
Tele 111 (20%)	1.01	82	6.28
Brentford and Isleworth	3.04	170	26.42
Feltham	1.14	128	20.1
1 hub	**Queuing (mins)**	**No. of patients treated**	**Utilisation %**
A&E	69.05	97	53.59
Tele 111 (20%)	1.01	36	6.43
Summerwood Rd	1.9	321	25.06
1 hub	**Queuing (mins)**	**No. of patients treated**	**Utilisation %**
A&E	77.55	99	55
Tele 111 (25%)	1.9	45	8.02
Summerwood Rd	1.57	309	24.17

In Table 6-10, the Base model reflects the operational situation in the A&E department today. With 4 UC hubs, the lowest A&E queue and modest queues in the hubs are found. As the number of hubs is reduced, hub queues also reduced; A&E queues increased although not to the level of the base model.

The average distances travelled between postcode clusters and locations of healthcare hubs with the different scenarios are summarised in Table 6-11. With four hubs, distances to the hubs, irrespective of whether there was cut-off assumed or not, were generally shorter. With two hubs, increased average distance travelled is demonstrated, and similarly for one hub only.

Table 6-11 Distance summary

4 hub	Distances (With cut-off in miles)	Distances (No cut-off miles)
Chiswick	0.73	0.73
Brentford and Isleworth	1.07	1.33
Great West Road	1.16	1.35
Feltham	1.01	1.14
Mean	**0.99**	**1.14**
2 hubs		
Brentford and Isleworth	1.13	2.10
Feltham	1.02	1.70
Mean	**1.08**	**1.90**
1 hub		
Brentford and Isleworth	1.13	-
Summerwood Rd	-	3.40

Figure 6-29 brings together the effects of the use of 4/2/1 hubs on both queuing times and distances travelled. With decreasing numbers of hubs, queues lengths at the hubs tend to reduce while distances increase, although with increased distances fewer people were assumed to access the hubs when cut-off is assumed.

The hybrid locational analysis/simulation methodology has been used to demonstrate the effects of re-provisioning of health services. This methodology has enabled trade-offs to be shown that can be made with the establishment of UC hubs in the case study area. Locating four hubs rather than two or one means closer access to residents, and hence a greater likelihood of hub access rather than visiting A&E. However, spreading resources between four hubs means longer queuing times, and the overheads of running four facilities. With two or one UC hub(s), it has been shown that increased use of the NHS 111 telehealth service could compensate for those not willing to travel the extra distances to the reduced number of hubs.

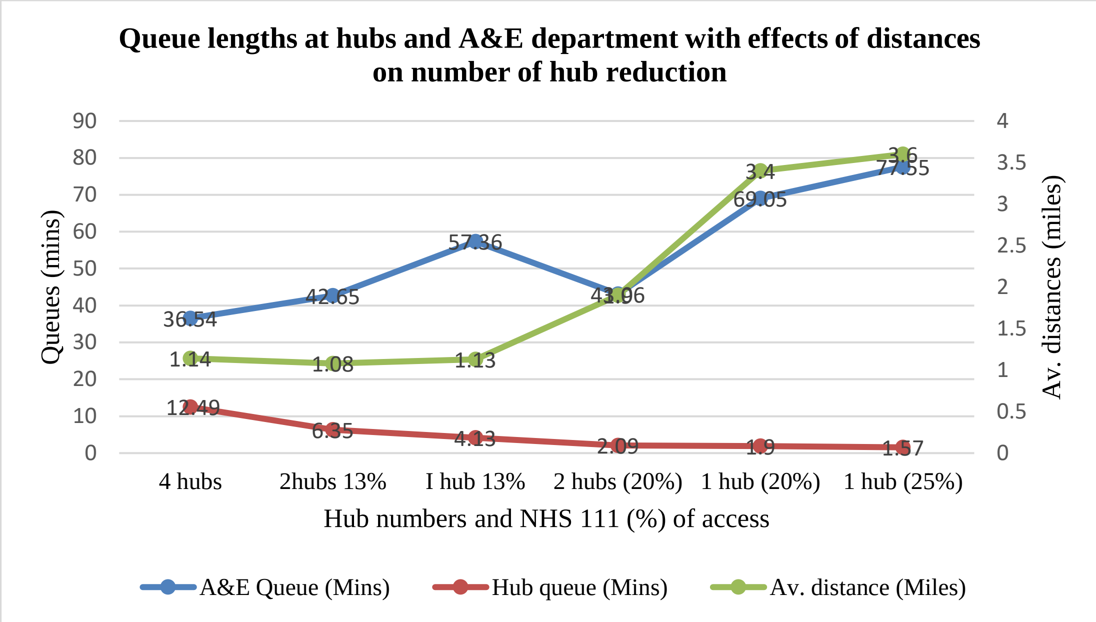


Figure 6-28 Queue length at hubs and A&E, and distance travelled to hubs by scenario.

Chapter 7 Conclusions

7.1 Introduction

This chapter draws conclusions from the research. It summarises, provides the outcomes, and reflects on how the research questions have been answered and research objectives met. It also presents the main findings and contributions this research has made to OM, process management and healthcare delivery management. It outlines some of the limitations of the research and future research opportunities.

The chapter starts by recalling the research objectives and questions in the research overview in Section 7.2, before a summary of the research in Section 7.3 and an evaluation of answers to research questions in Section 7.4.2. The chapter then proceeds to report on the research contributions in Section 7.5 and limitations of the research in Section 7.6. Section 7.7 presents further research opportunities arising from this research.

7.2 Research overview

Before providing a summary of this research, a recall of the research objectives and questions follows.

7.2.1 Recall of the research objectives

The objectives of this research have been threefold. Given the process nature of healthcare delivery, in which healthcare is delivered in stages, referrals, handovers and transfers, it was expected that there would be a formal process model which shows the ways in which healthcare delivery was guided by a form of process orientation (see Section 3.1.6) or some hybrid process models. Looking at the persistent capacity problems in the A&E department, the first objective was to assess the extent to which process management has been researched, designed and adopted in the healthcare sector and its level of efficacy.

The second objective was to investigate the role of process management in influencing A&E demand. That is, it examines whether process design rather than, or as well as, patient behaviour influences patient choice of the access point to unscheduled urgent and emergency healthcare in the A&E department. The third objective was to develop a conceptual model that can improve and support the grounds for a better urgent and emergency care delivery process.

7.2.2 Recall of the research questions

From the research objectives presented, the following questions were conceived to guide the development of the research:

1. How has the process management approach been researched and implemented to support healthcare delivery management?

2. a) In what ways has this research improved patients' choice of appropriate access points when in need of urgent and emergency health care and what impact has it had on the demand in the A&E department?

2. b) What factors explain demand in the A&E department?

3. In what ways can process management support the design of an optimal process-driven urgent and emergency health care delivery model?

7.3 Research summary

Three main factors led to the development of this research. The first was the proliferation of negative reporting about the performance of the A&E department of the NHS. Discussions in the British media and communities gave the impression that the healthcare system was not working well and required re-design (Ham *et al.*, 2016). The second driver came from the representatives of the Foundation Trust Network (2013) who called for a redesign of the process of urgent, and emergency care delivery of the NHS. They suggested that due to higher than expected demand for urgent and emergency healthcare (UUEH), the A&E department has persistently, over the years, struggled to provide healthcare that covered the demand given its limited resources. The third driver was the curiosity about the theoretical formulation guiding process management research in healthcare delivery management. Past research within the OR domain, for example, Rais and Viana (2011); Saghafian *et al.* (2015) has shown various methods and approaches developed and used to improve the management of the A&E department. These past research studies have focused on the internal workings of the A&E department, to tackle challenges such as congestion, in-patients' flow, bed management, among others. Despite this, little has been done to regulate sources and types of demand to A&E.

The first stage of the research was to examine the growing body of literature that explored process management in the service sectors to understand whether healthcare management was benefiting from these developing approaches. It was found that those process methods were mostly applied in silos and subsections of the healthcare system. Such applications did not adhere to a Process Orientation (PO) approach, which calls for end-to-end application in the whole system. From the literature, therefore, the efficacy of process management in healthcare delivery as a whole was not justified.

To gain a practical perspective on this and determine the nature of current process design, its relationship to UUEH management as well as capacity problems of the A&E department, the relationship between the role of A&E, demand for UUEH and the capacity problems of the NHS in England were examined in Chapter 4. The focus was on type 1 A&E units, which provide 24-hour consultant-led service with full resuscitation facilities (for example, Blunt, 2014). The chapter examines the nature of A&E operations in England over the period 2010 to 2015. One main finding was that the biggest increases in demand for healthcare in the A&E department came from patients who could have been treated elsewhere, in the primary care sector. This occurs despite the presence of many primary care access points such as GP surgeries, walk-in centres (WICs), and tele-health NHS 111, among others. While primary care treatable patients were demanding healthcare in the A&E in larger numbers, the role of primary care access points was unclear. There has been a growing trend to diverting urgent care (UC) patients away from A&E departments, see (Crawford *et al.*, 2017). In response to this, Chapter 4 ends with a proposal for UC hubs, proposed and developed along PO lines.

To understand the relationship between demand for A&E and UUEH access points, a catchment area analysis of factors possibly influencing A&E attendance was investigated, using London as a case study, as reported in Chapter 5. The grounds for this case study was that London fared poorer in A&E performance and the provision of UUEH compared to other regions of the country, such as the south west. The catchment area analysis used 2014 data to gain an understanding of factors influencing attendance. Using the factors determined in the catchment analysis, regression analysis was performed to find various factors, individually and in combination, that contributed to A&E demand.

A second case study, described in Chapter 6, turned the attention to one London borough, that of Hounslow, to investigate several schemes for improved delivery of UUEH. GIS was used to support the investigation, with mapping to reflect the structure of the current process design. Moreover, location-allocation modelling within GIS was used to optimise locations for UC hubs, as proposed in Chapter 4. Simulation modelling followed, as presented in Sections 6.5 to 6.8, to enable an analysis of the current UUEH delivery process design in comparison with other schemes.

7.4 Addressing the research objectives and questions

7.4.1 Addressing the research objectives

The first research objective was *to assess the extent to which the process management approach has been researched and used to develop models for effective healthcare delivery management*. *In doing so, it determines the extent to which these models, methods and approaches have been efficacious.*

Chapter 3 shows from a comprehensive literature review the ways that process management research in healthcare delivery has been undertaken. Various perspectives are presented, namely PO and a variety of process methods. The chapter concludes that, given the end-to-end nature of healthcare, most process method approaches, which have tended to be popular in healthcare delivery research, have been inefficacious. Also, PO, which is deemed a good approach for healthcare delivery, is not generally applied (see, for example Kohlbacher, 2010; Nilsson and Sandoff, 2015).

The second research objective was *to investigate the role of process management in influencing A&E demand*. This meant examining *whether process design rather than (or as well as) patient behaviour influences patient choice of access point to non-emergency healthcare and the A&E department.*

In Chapter 4, the seriousness of A&E capacity problems is related and evidence is given that the UUEH process design could influence patients' behaviour in accessing care. Patients follow the system in place as a means of eliminating their pain. From regression analysis in Chapter 5, it appears that some process design factors affecting accessibility may be significant in explaining numbers accessing A&E departments, numbers of patients per GP, and ease of phone access to GPs.

The third research objective was to *develop a conceptual model that can improve and support the grounds for a better urgent and emergency care delivery process*. In Chapter 4, it was shown that high usage of the A&E department by primary care treatable patients could be due to inconsistent availability of access to primary care services at the time of demand. Other factors include the proximity and convenience of primary care services, perceived urgency of care requirements and levels of self-diagnosis skills, among other factors. To answer calls for a redesign of urgent and emergency care pathways, a UC hubs model is developed, where there is a separation of urgent and emergency care pathways, and accessibility by location and time of day is paramount.

7.4.2 Answering the research questions

1. *How has the process management approach been researched and implemented to support healthcare delivery management?*

This question is answered in Chapter 3. Here process management is defined and the various ways it has been researched and applied to healthcare delivery are detailed. A difference between PO and individual process methods is noted.

2. *a) In what ways has this research improved patients' choice of appropriate access points when in need of urgent and emergency health care and what impact has it had on the demand in the A&E department?*

The literature review reported in Chapter 3 finds that process management research in healthcare delivery has largely been inefficacious, especially in the area of UUEH. Chapter 4 highlights the confusion of access points to UUEH, lack of process ownership and inconvenience to patients of the current UUEH system. The conclusion is thus made that process management methods, or research therein, have failed to affect the high usage of the A&E department by primary care treatable patients.

2. b) What factors explain demand in the A&E department?

This question is answered in Chapter 5, which analyses the catchment areas of A&E providers in London to find factors that could affect demand in A&E, combined with regression analysis to assess their influence.

3. In what ways can process management support the design of an optimal process-driven urgent and emergency health care delivery model?

Chapter 3 (Section 3.1) finds that process management is properly defined and guided by a PO approach; such an approach is used to develop the UC hub design for UUEH proposed in Chapter 4 and analysed in Chapter 6.

7.5 Research Contributions

The main contributions this research has made are as follows:

7.5.1 Determining the efficacy of process management research in relation to healthcare delivery

The first contribution is an examination of the extent to which process management has been researched in healthcare delivery management, and an assessment of its efficacy.

This contribution is detailed in Chapter 3. The initial approach in Chapter 3 is to review the field of process management and determine how it has influenced the design of process models for healthcare delivery management. Chapter 3 describes a number of different process management methods, and reviews and assesses the literature relating to their application to healthcare delivery management. It concludes by assessing the efficacy of process management methods to healthcare delivery management.

This review is novel in its application and assessment of efficacy and implementation. There are reviews of process management methods in business (vom Brocke and Rosemann, 2015; Alotaibi and Liu, 2017), which includes several examples related to healthcare, and similarly in particular areas such as IT systems (for example, Meidan *et al.*, 2017). However, these reviews do not focus on healthcare delivery. Some previous studies have found that organisations that adopt process rather than functional operations tend to be effective (Maddern *et al.*, 2013; vom Brocke and Rosemann, 2015). In the related field of simulation modelling, (Jahangirian *et al.*, 2012) found that the healthcare sector lags behind defence and commerce in implementation of the results of simulation modelling. Similarly, several authors report a lack of implementation of the results of running Operational Research and simulation models in practice in healthcare (Jun *et al.*, 1999; Barjis, 2011; Brailsford *et al.*, 2013). However, no previous study has shown how and with what efficacy the approaches of process management have been adopted in health care.

Examining process management as applied to healthcare and checking for its efficacy has been an unexplored area. By analysing it in this study, therefore, it contributes to the debates about the usefulness of process management in healthcare delivery.

7.5.2 A focus on process for unscheduled urgent and emergency healthcare access design

This research has provided an assessment of process management in access to A&E and urgent care health facilities. Furthermore, a process-orientated design for urgent care is proposed, in the form of UC hubs.

Given the demand for long-term solutions to the capacity problems of A&E, this research has contributed by exploring the design of a process model where UC is delivered away from the A&E department within communities. The proposal for UC hubs could provide long term improvement to the process of UUEH delivery, with effective access points and diversion of patients away from A&E.
The benefits of the hubs can be identified as follows:

1. Access to UUEC is properly defined and patients understand the appropriate route to take when in need of such healthcare.
2. There is a reduction in confusion and ambiguity by eliminating the current plethora of access points.
3. The care delivery system is supported in reducing the cost of healthcare delivery, bringing health care closer to the community and reducing reliance on hospital treatments.

This contribution is described in Chapter 4, which explores the various ways in which UUEH is designed and the way in which access points are visible to patients when they need healthcare. In particular, Section 4.2 examines why demand for A&E services persistently causes capacity problems. Section 4.6 describes the role of various UC health facilities. Section 4.7 assesses access to A&E from the viewpoints of patient sources, referrals and clinical need for attendance. Section 4.8 provides an assessment of previous and current initiatives for diverting patients away from A&E services. The UC hubs proposal is described in Sections 4.8.4 and 4.8.5.

This research is novel in applying PO principles to UUEH. There have been many previous studies suggesting operational improvements to the A&E department (see, for example, McHale *et al.*, 2013; Cowling *et al.*, 2014; Saghafian *et al.*, 2015). Moreover, there is the broad recognition that UC access in the A&E department is driven by the nature of the current care delivery process rather than the specific services that A&E provides (McHale *et al.*, 2013; Crawford *et al.*, 2017). More recent studies, for example, Nilsson and Sandoff (2015); Crawford *et al.* (2017) also confirm that the process design for UC delivery is unclear and so the tendency is for patients to continually seek UC from the A&E department. Richardson and Mountain (2009); Crawford *et al.* (2017) recommended that solutions for A&E congestion be sought outside the department. However, in this research it was found that source and types of demand for healthcare in the A&E department and the nature of the process relationship between communities, primary care delivery access points and the A&E department have not been properly presented in previous research. Moreover, there is sparse evidence in the literature regarding the development of alternative UC access points, such as GP cooperatives, or strengthening of existing UC access points, such as WICs, in order to reduce A&E presentation by primary care treatable patients. This is confirmed in some recent research, by Nilsson and Sandoff (2015); Crawford *et al.* (2017), who point out that there is limited research showing the importance of alternative access points to UUEH.

This research study contributes to research into alternative UUEH access points such as GP cooperatives and WICs. Such research would apply generally in national health systems that are organised along similar lines to that of England. With increased demand for community-based access points for UC delivery, this research could provide a generalised idea and direction for designing such community-based approaches for UC delivery.

7.5.3 Methodological developments in operations management research

This research contributes two methodological developments to OM research. Firstly, a combined use of GIS catchment area analysis and regression is presented to analyse factors influencing the current situation of A&E attendance. Secondly, a hybrid methodology of GIS location-allocation modelling combined with simulation is demonstrated to analyse different scenarios for future configurations of UUEH.

The first methodological contribution is found in Chapter 5, which demonstrates the use of the catchment area analysis and regression with a case study in London. Details are given in Section 5.4 of the manner in which factors in the catchment areas of London A&E providers were determined using ArcGIS. Section 5.5 presents the regression variables used, and discusses results of correlations and multiple regression.

Chapter 6 presents the combined use of locational analysis and simulation in a case study of UUEH in the London Borough of Hounslow. Firstly, a base simulation model is developed and run in Section 6.5. A simulation of the NHS "pyramid" proposal is built and run with various scenarios in Section 6.6. The new UC hub proposal is analysed in Sections 6.7 and 6.8; optimal locations for different configurations of UC hubs are found in Section 6.7 and these locations are used to inform simulation modelling in Section 6.8.

In designing these methodologies, since many previous studies have focused on the internal operations of departments such as A&E (as pointed out in Section 3.1.6), it was decided that more attention should be given to examining access to UUEH, and demand for A&E services, as well as its capacity problems. In particular, as evidenced by the review of Lal and Roh (2013), see Section 6.2.1, there has been a lack of application of simulation models in UUEH.

In a study described in Section 4.5.2, Cowling *et al.* (2013) used regression analysis to analyse numbers of visits made to A&E by GP-registered patients, taking into account characteristics of the accessibility of their GP practices. This study was conducted at a GP practice level, however, rather than at A&E catchment area level.

The combination of location-allocation modelling with simulation has been rare. With an application in elective rather than unscheduled health care, Harper *et al.* (2005) used simulation modelling with a geographical basis for regional planning of oral and maxillofacial surgery across London. This study did not, however, involve the use of GIS or location-allocation modelling to optimise service locations.

The combined methodology of catchment area analysis and regression proved successful in analysing factors influencing A&E attendance. However, the non-availability of data such as numbers of GP consultations and WIC attendances meant that the complete picture of factors affecting demand in A&E could not be gained. Validation of the multiple regression models built was also not possible, since the small number of data points, corresponding to the A&E providers with consistent data availability, meant that the dataset could not be divided into training and testing sets.

In the combined methodology of GIS location analysis with simulation, it was ensured that candidate sites for UC hubs corresponded to current patterns of access to GP surgeries, using GIS mapping. In building the base simulation model, results for wait times at A&E were calibrated against expected wait time distributions, given the four-hour target for maximum A&E waiting times. However, the limitations of the data available for the study meant that some aspects of the modelling could not be verified.

The methodology of catchment area analysis combined with regression was applied to A&E providers in the London area. This methodology could equally well be applied to A&E providers in a larger area of England, especially if data on catchment areas are readily available. Moreover, the methodology could be applied to different types of health facility accessible to the public or other public or business service locations.

The hybrid methodology of GIS location analysis and simulation was applied to future scenarios for UC hubs in one locality. Local planners could use a similar methodology to plan geographical developments that could affect demand at other facilities, where there is known variability. Such a method could be used when planning new businesses or public services.

7.6 Research limitations

While this research has contributed to knowledge in the domains of OM, process management and healthcare delivery, simulation and GIS, benefitting academics and practitioners alike, some limitations encountered need to be identified.

7.6.1 Study scope

A growing number of works on process management have emerged in recent years, encouraging its application for healthcare delivery management. While there are signs that adopting them for healthcare delivery management could be useful, it has been hard to tell how process methods have been efficacious in healthcare delivery. This research followed the PO line of thinking which is a systemic posture described as end-to-end (Maddern *et al.*, 2013; vom Brocke and Rosemann, 2015). From the OM perspective, end-to-end relates to the fact that activities begin where production starts, and end with the consumer. Since an end-to-end process safeguards the comprehensive completion of work, naturally managed within a specified timeframe, it is a shortcoming that most research into UC and A&E delivery has focused on achieving improvements in the internal procedures of A&E. Moreover, since much research on A&E has been localised within the A&E department (Lane *et al.*, 2000; Dewar *et al.*, 2014; Saghafian *et al.*, 2015), this research considered that internal improvements have been extensively examined. Therefore, this study limited its analysis by focusing on the relationship between the processes that lead patients to the right UUEH access points when demanding healthcare. A full end-to-end study of UUEH was not therefore appropriate.

7.6.2 Data collection and data sources

The data used in this study were secondary publicly-available data obtained from official sites and databases. The possible problems associated with use of secondary data have been presented in Section 2.4.2.

This research had to deal with the non-availability of some key data, for example, data on GP-patient consultations, usage of the NHS 111 system and WICs. The lack of publicly-available data on these issues has meant that in some cases estimates from the official databases were used. These data estimates may be questionable. Official data on GP-patient consultations, for example, are available up to 2008. From 2009 to 2015, the data used were an extrapolation, calculated using a similar approach to that provided by the NHS (see Figure 4-2).

7.6.3 GIS and simulation modelling

Formulating ArcGIS and simulation models from the academic perspective was straightforward. However, it would have been beneficial to have access to healthcare organisations for more practical, observational studies. This was hard to attain because a healthcare body did not commission this research. Therefore, access to raw data and practical contact was constrained. Health and social care research approval would have been required from the Integrated Research Application System (IRAS). This application takes months for approval and the fact that this PhD research was a time-limited operation meant that this research had to rely on descriptions, secondary reports from the NHS itself, DOH and various affiliated organisations such as the Kings Fund.

The simulation presented here is an approximation of the real care delivery processes. Therefore, gaining independent validation is desirable so that confidence can be placed in the results of what-if scenario modelling. The various characteristics of the system modelled were designed following knowledge of the system gained from many publications and reports. As highlighted in Section 2.4.1, data for the simulation and GIS modelling were secondary data obtained from various sources.

7.7 Further research opportunities

The findings presented in this research suggest areas for further research. This research was conducted within the UK context and, therefore, generalisability beyond the UK could be limited, given that the UK healthcare delivery philosophy is different from that of many countries. Healthcare delivery in England is mostly provided to all permanent residents, is free at the point of use and financed by taxes (Department of Health, 2013). This is different from, for example, the USA, where capitalistic philosophy prevails and most European countries where there is a mixture of insurance and free delivery (OECD, 2013a).The methodology of this research can be generalised for application in similar environments elsewhere. Nevertheless, it can be argued that the design approach and the operationalisation of healthcare systems should be similar, irrespective of philosophy of delivery.

As the healthcare sector continues to seek solutions to streamline its operations, this research has indicated that the inclination towards process methods has not been efficacious, despite the expressed importance of process management. This is because process methods have been applied in individual situations, rather than acknowledging the systemic nature of healthcare delivery. Therefore, further research should look at ways of making end-to-end process in healthcare a reality. Within this context, there is an opportunity to examine how the healthcare delivery system is or could be integrated further and operationalised from the source of demand to the discharge destination. This could be done by system mapping of current delivery models and then conducting simulation experiments to test initiatives that could be deemed beneficial to the system.

One contentious problem raised in this research in that of appropriate and inappropriate A&E attendance. Many studies have defined people who attended A&E for minor ailments as inappropriate attenders. Such classifications have been made by, for example, The Nuffield Provincial Hospitals Trust (1960); Dale *et al.* (1995); Dale and Dolan (1996). Different estimations have been made of inappropriate attendance at A&E, using a variety of metrics (see for example, McHale *et al.*, 2013). The proposals for a solution to this type of problem have concentrated on the A&E department where actions have been developed to intercept patients thought to be treatable elsewhere. There is the need for the NHS to provide an authoritative definition of the role of the A&E department and its functions. In addition, defining the roles of GP practices and other primary care services and communicating them so that patients understand the care delivery process presents an opportunity in research.

Improving management and the role of management in healthcare delivery is a related area for further study. To research the behaviours of healthcare managers and their knowledge of process management could provide information as to whether process managers adhere to a process orientation viewpoint, as presented in Section 3.1.5., and could point to ways in which managers can contribute to the design of processes. A methodology such as agent-based simulation modelling (Railsback *et al.*, 2006; Brailsford *et al.*, 2010; Kiesling *et al.*, 2012), interactions between patients and NHS staff, could be used to highlight the positive impact that managers can have in improving day-to-day operations. Since the economic crisis of 2008, public and media commentators in England have openly questioned the role of management in healthcare organisations such as the NHS. While managers plays a leading role to improve, manage and maintain the care delivery process, the NHS does not appear to have properly defined and mapped the roles of managers. The idea of modelling management behaviours has been raised by authors such as (Nahmias and Olsen, 2015). However, limited research has been undertaken on this subject. Given the important role management plays in process management, in relation to process measurement, ownership, redefinition, modification and other aspects of process design presented in Section 3.1.4 of this study, this could be a fruitful area for further research.

The use of Information Technology and application software in enabling, shaping and improving process management has been identified as a strong driver for process improvement. Information systems (IS), defined as the means of combining software, hardware, various forms of infrastructure and personnel to aid planning, coordination and decision making, have been successfully used in various industries and organisations to improved process design and relationships with customers (Nahmias and Olsen, 2015). Today many industries such as travel, hotel management, and logistics among others, have reduced queue lengths due to the adoption of information systems in process management. So far, this research has attempted to show how telephone systems could reduce A&E queues, especially where distances to healthcare access points are a limiting factor. Further research could examine the expanding strength of IS in connecting patients to the right UUEH access points for their convenience. This could, moreover, reduce variability within the care delivery process as well as costs.

This study has examined the possible application of process management within healthcare delivery. It has focussed on demand for urgent and emergency health care, both in primary care settings and in A&E. It has established the difficulties in attaining efficacy from the process management perspective. The research points forward to further studies both in process management and in health care delivery to enhance operational effectiveness.

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Appendices

Appendix 1Evidence for efficacy of process management methods

Table A1Efficacy of process management methods as demonstrated in research

Process model	Researcher (s)	Reasons for study and context	Evidence of Efficacy
BPR	Elkhuizen *et al.* (2006)	➢ Literature review investigating evidence of BPR conception, development, adoption and application in healthcare (Hospitals). ➢ Review conducted among 86 studies in BPR in healthcare. Study was to show the extent of BPR application healthcare management. ➢ Shows that BPR has been developed more for hospital and not very healthcare system-wide application.	➢ Show that BPR is increasing researched for healthcare process management but efficacy is mixed. There are reports of reduction in resource use, costs, length of stay, increased quality. ➢ But doubts were presented on successes reported and those realised.
BPR	Bertolini *et al.* (2011a)	➢ To improve the efficiency of operations in a Neurosurgery Ward in Parma Hospital in Italy with the application of BPR. ➢ They applied simulation method in order get a better picture of how to apply the re-engineering method. ➢ Major weakness here is that focus is placed on a silo.	By applying the Delphi method with simulation, areas of improvement were identified, modelled and design thus improved, quality, outcomes and reduced costs.
BPR	Coulson-Thomas (1997),	➢ How to improve process in healthcare delivery with the use of IT systems. ➢ Supported by the British NHS via Luton and Dunstable NHS Trust and Spanish healthcare system via the Manresa General Hospital as well as the European Commission (EC). ➢ The project HOCAPRIT (Hospital Care Assistance Process Re-engineering requiring integrated Information Technologies) saw the design of a process model.	➢ Concurrent relationship management (CRM) enabled human issues to be dealt with in a timely and efficient manner enabling stakeholders to move forward together. ➢ People of process and ownership were improved. ➢ Improve coordination and fostered process improvement with IT. ➢ More institutions adopted the re-engineering approach in full or part.
BPR	Kwak and Lee (2002)	➢ To develop a multi-criterion mathematical programming (MCMP) approach designed to aid strategic planning in association with BPR planning in a health-care system. ➢ MCDM is popular in OR and financial studies.	➢ No evidence of applicability. It became more of a methodological development and remains to be tried in healthcare.
BPR	McNulty and Ferlie (2004a))	➢ Examined the implementation of BPR in NHS hospitals to improve patient focus. ➢ They observed challenges in meeting such a task especially how a new form of process model in a large and complex public service establishment is received. ➢ However challenges remain to make BPR a proper process model.	➢ Various departments transformed to become more patient centred. ➢ Emergency services, elective inpatient surgery and outpatient services all benefited from redesign. ➢ There was reduction in hand-offs within clinical processes, better clinical coordination and cash saving from cost reduction to the amount of between £500,000–600,000 per annum from 1994–98.
PPR	Probert *et al.* (1999)	➢ Applied PPR at the Peterborough Hospitals NHS Trust and particularly within the departments of Patient Admissions and the Dermatology Referral. ➢ Also to develop a better relationship between primary and secondary care and also to develop a collaborative approach to patient care between groups mainly the Health Authority, GPs, Patients and Hospitals.	➢ Achieved reduction of inappropriate admission as patients were directed to the appropriate clinic. ➢ Reduce length of stay (LOS) in hospitals resulting to the of £400,000/year ➢ Only more serious cases are being admitted thereby reduction in waiting time and more empty beds (low bed blocking rates). ➢ Improve process and connection between the GPs and patients in the Dermatology Diagnostic Patient Process about their condition, reduces unnecessary hospitals visits and improve the IT and IS system to ease process links in departments.

			➢ Patient centred by putting patients in the centre of process design.
Patient-focused care with BPR	Newman (1997)	➢ To adopt Patient Focus Care in the Kingston NHS Foundation trust with the aid of BPR in which patients would be treated as "the customer" just as observed in the private sector.	➢ Improvement in quality of care as nurses spent more time on the wards. ➢ Fall in readmission rates, reduction in "ready for action time" from 16% to ~3-9%. Patient complaints fell by 34%. ➢ These changes and improvement were observed across all the re-engineered departments.
BPM – Information system	Poulymenopoulou *et al.* (2003)	➢ To use BPM approach and improve Emergency healthcare process in Athens, Greece by using workflow technology and web services.	➢ Improved contact between A&E departments docking and ambulances in the field. ➢ Improved redirections between hospitals in a more appropriate manner. The adoption of internet methods improved process management and exhibited the power of IT in healthcare delivery management.
BPM	Snyder *et al.* (2005)	➢ Part of a larger study in which through the adoption of BPM a process mapping approach was conducted for two medical clinics to improve design, implement, and maintain an integrated information system with two other health-care entities.	➢ Process mapping helped linked the various clinics into one unit and thus reduced resources and costs wastage usually driven by poor integration. ➢ It was easy for patients to access services at both clinics as boundaries were reduced due to the high application of IT. Hence patients' data could be accessed anywhere after it was inputted into the central computer system. ➢ Service quality improved as work flow gains were achieved with the various integration methods leading to higher moral of workers. The clinic became more competitive against the bigger ones.
BPM	Becker *et al.* (2007)	➢ Potential for process optimisation by improving existing medical IS with the knowledge from BPM. ➢ This will reduce cost, ease the routine work of staff and improve patient safety without a de facto re-engineering the organisation.	➢ Greatly increased efficiency and patient safety. ➢ Cost reduction, relief for health workers in matters of routine tasks. ➢ Automating co-ordination and evaluation tasks.
BPM	Helfert (2009)	➢ Was to use the idea behind BPM to develop the implementation of standardise Personnel Payroll Attendance and Recruitment System (PPARS) within the healthcare human resource and payroll department for the Irish healthcare sector.	➢ Identified specific challenges in healthcare sector that can hold back BPM and IT application, for example, time management in healthcare is identified as the leading reason why most errors and challenges occurred. ➢ They present a model developed to enforce ways of applying BPM on process improvement.
Process mining	Mans *et al.* (2009)	➢ Seeking to apply a process mining model in a healthcare organisation in the Netherlands. Since the healthcare sector is very labour intensive getting precise and good quality data on the working of processes as well as feedbacks was very necessary.	➢ Provided on the spot data so hospital process is easily monitored, errors identified in real time manner. ➢ Improved pathway in hospital and reduced confusion. ➢ The live data provision proved more accurate than data collected by humans. ➢ Show the proper employment of IT and its usefulness.
Lean Management	Womack et al. (2005)	➢ "Going lean" in healthcare was their attempt to use the principles of lean to improve patents flows and eliminate wastes.	➢ Applied to the Virginia Mason Medical Centre in Seattle, Washington, USA where main delivery process was

			improved, costs reduced and waste limited.
Lean management	Radnor (2011)	➢ Public organisations in the UK were pressed to adopt models popular in the private sector, therefore healthcare sector organisation were compelled to adhere. This work was to examine findings from three studies - two Hospitals and a Mental Health Trust in England, on the implementation of the Lean model in healthcare management.	➢ Some claims of efficacy but doubts still lingered, see table 3(p. 4) ➢ Author concludes that Lean might present the remedy for efficiency in healthcare delivery effectiveness but its adoption could be open for negotiation.
Lean management	Fillingham (2007)	➢ Opinion on how over a period of 18 months Bolton Hospitals NHS Trust explored whether or not lean methodologies, could be applied to improve and manage healthcare delivery.	➢ Lean could be applied in healthcare delivery by learning lessons from its structure rather than direct translation from manufacturing design
Lean management	Spear (2005)	➢ Relating to hospitals in the USA, the author examines if various problems identified and blamed on system design and management culture could be improved in the application of TPM.	➢ Author posits that with TPM, making small changes as prescribed by the model means that efficiency and cost targets were met.
Lean/ TPS	Fine *et al.* (2009)	➢ Narrates the application of lean in 5 Canadian healthcare organisations	➢ Patients advised at point of care on availability of tests quick reports on result. ➢ A&E physicians report and enter orders electronically within 15 minutes of patient arrival ➢ Improved throughput and reduced cost. More benefits are presented on table 1p. 28
TQM	Khorramshahgol *et al.* (1995)	➢ While many hospitals in the USA where adopting TQM to help improve quality, reduce costs, and improve delivery processes, this study examined the role of information systems in making TQM implementation a success. ➢ Study did not show that the new HIS model developed was implemented	➢ Integrated hospital information system (HIS) was developed to improve processes that go beyond patient data and billing to improvement in care delivery across different departments. ➢ HIS was to serve and coordinate operations between external (patients, customers, and suppliers) and internal (nurses and doctors), improving communication among them.
TQM	Nwabueze (2011); (2014)	➢ Explained the emergence of TQM in the NHS and reasons behind its fall. ➢ Provides on table 1 (Nwabueze, 2011 p. 502) four approaches to TQM in the NHS. ➢ Presented perspectives for the failure of TQM in NHS such as the lack of leadership and poor management structures.	➢ Provided possible benefits of TQM such as strengthening process structure and improve outcomes. ➢ Reported on failures of TQM and persistent problems in NHS care delivery processes as a consequence.
TQM	Shortell *et al.* (1995)	➢ Examined among 61 hospitals in the USA to determine if there were any relationships among organisational culture, quality, processes improvement and outcomes.	➢ Of 3,303 hospitals, 69% indicated to implementing the basics of TQM, some already for a period of two years. ➢ Gains in outcomes such in areas of clinical efficiency and human resources. ➢ TQM more prominent among hospitals with a participative, flexible, risk-taking culture. ➢ Bigger hospitals also struggled with TQM implementation.
Capacity management	Richardson and Mountain (2009)	➢ Examined what congestion, overcrowding and capacity problems in the A&E are and their sources, drawing from the Australian perspective.	➢ Poor process design contributed to more A&E problems emanating from sources outside the A&E.

Simulation	Shim and Siegel (1998)	➢ Examined computer simulation applied to emergency care process in a hospital and to evaluate the effects of some proposed changes to improve patient wait times in the process.	➢ From the model there was demonstrable possibility for shorten patient wait times in the emergency care process. ➢ Improvement in costs and diversifying of access points which could increase flows.

Appendix 1B

Other attributes of Business process re-engineering (BPR). Some publications and research have termed BPR as follows

- ➢ business process change (Armistead *et al.*, 1995; Al-Mashari *et al.*, 2003),
- ➢ business process redesign (see for example, Jansen-Vullers and Reijers, 2005b; Elkhuizen *et al.*, 2006),
- ➢ Business Process Renewal (for example, Armistead *et al.*, 1999),
- ➢ Process innovation (Davenport, 1992; Pisano, 1997),
- ➢ Business Process Improvement (Harrington and Harrington, 1995),
- ➢ Business Process Management (for example, Al-Mashari and Zairi, 1999; Weske, 2007),
- ➢ Structured analysis and improvement (for example, Zairi, 1997).

Appendix 1CB

Value of IT to BPM

The literature suggests that the use of IT could help the healthcare delivery processes in the following ways

➢ Reduce operation cost for the healthcare delivery whether in a GP surgery or the wider healthcare system or subsystem. It also helps the healthcare system communicate with patients for example IT usage by GP surgeries in London has expanded faster than in other parts of the country (Veena *et al.*, 2012).

➢ IT can assist in the storage and retrieval of data, storage of test results and plan operations. Here electronically, GPs, departments and sectors can easily disseminate and share data with each other. It also provides quick check-in for patients such as self-services platforms for patients especially outpatients (Anyanwu *et al.*, 2003).

➢ It can help the healthcare system easily collect data from patients and carry out surveys to gauge the effectiveness of processes and their perception about service delivery. It can also help GPs, consultants and healthcare management to communicate and share ideas on new development in the field (White, 2006).

➢ Improve public health educating patients on healthy living thereby reducing the quest to seek hospital treatment. Development in mobile technology has led to the emergence of devices such as smartphones and tablets with “apps” which can be used to communicate directly with patients (Wu *et al.*, 2007)

Appendix 2 Regression analysis showing the relationship between consultation and care delivery process

To determine the amount of patients per GP we divided the total amount of registered patients by the amount GPs per year. Also for list size we divided the amount of registered patients by the number of practices for that year. Patient who needed access within 12 to 24 hours was obtained from GP-patients survey for each year between 2009 and 2014 and extracted data of patients who said they needed 24-hour accesses to GP surgeries. Have a preferred GP refer to patients who indicated in the survey that they have a preferred at the practice. Ease of getting to GP practice refer to how patients could access their GP without any hindrance. Hindrances here include distance, size, hidden from sight or hard to find, located in busy area and such factors. These impedances make it discouraging for patients to access. Also how comfortable and welcoming the practice is for the patients was answered in the survey which was summed up to make ease of getting to GPs. Frequency of seeing preferred GP refers to the fact that patients needed to access their GPs regularly. This means those patients surely had an illness, which required regular GP follow-up. When patients need regular access and cannot get they tend go to the A&E department. GP recommendation relates to the fact that registered patients will recommend their GP to other patients to register. Low percentage of recommendation means GP practice performance is poor and not a good indication for the said GP practice. A description of Ipsos-Mori can be found in the appendix 4B.

In order to get the relationships of these variables and determine how they can support access defined in GP consultation, A&E capacity and provide direction for understanding current delivery process. The multiple regression analysis produced the following results presented on table below

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	1.000					
R Square	1.000					
Adjusted R Square	1.000					
Standard Error	7847.95					
Observations	9					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	7	5.08952E+15	7.27074E+14	11805008.54	0.00	
Residual	1	61590293.8	61590293.8			
Total	8	5.08952E+15				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	197172130.4	5397495.24	36.53030186	0.02	128590450.8	265753810
Patients/ practice	55286.62651	53.37058751	1035.900654	0.00	54608.4889	55964.76412
Patients / Doct	1580144.603	2649.370843	596.4225835	0.00	1546481.155	1613808.051
Have a pre. GP	-300275.5415	257.9463578	-1164.100723	0.00	-303553.0608	-296998.0223
12/24hrs access	-234.5761832	0.398864801	-588.1095111	0.00	-239.6442411	-229.5081254
Ease of getting to practice	208.2317978	0.836782493	248.8481768	0.00	197.5994681	218.8641275
freq.see.pre.GP	709110.9225	609.0524727	1164.285434	0.00	701372.1771	716849.6679
Recommed GP	-3884358433	3218187.326	-1207.001967	0.00	-3925249380	-3843467486

Calculated with data from HSCIC (2014b)

The multiple regression models with seven independent variables produced an R^2 of 0.997, an adjusted R^2 of 0.992. It means that 99% of changes in consultations will be explained by the independent variables or the model. R^2 is defined as the coefficient of determination. Its role is to evaluate the fitness of the data to the model. For this result it shows the value of consultation to the healthcare delivery process and explains that if measures are taken to adjust patients per GP, patients per practice, and 24-hours healthcare need, there would be a balance in GP consultations and therefore a reduction in A&E attendance, as such improving the care delivery process.

Also observed is the difference between the R^2 and the adjusted R^2 which is very small and can be interpreted that that none of the independent variables is redundant. All of them contribute to consultation variability. The significance of the analysis is shown with the F statistics (F-significance) which is 0.001 meaning that the results are statistically significant and reliable. Also the p-value measures how compelling statistically the results were obtained. This means the results observed in a study could have or not occurred by chance. Thus a higher the P-value, that is, a value above 0.05 will be interpreted to fall below statistical significance.

On the regression on table 4-3, all variables produced P-Values far below 0.05.

Generally, it is said that the amount of patient consultation in GP surgeries is on the increase (NHS England, 2014c) but it is not specifically clear if the consultation is evenly spread out across the country and reasons for the increased consultation and effects. From the regression analysis, it can be argued that where patient per GP is high, GP work load will increase thereby making it hard for openings in scheduling to occur especially as more patients want to access GPs within 24 hours. The number of patients per practices or list size means that the larger the size the smaller the time GPs will spend with patients and satisfaction rates will fall. The list size might also be compromised by the fact GP surgeries might have 1 or 2 headed practices. In London, for example, many practices are headed by single or 2 GPs (Veena *et al.*, 2012). In our London analysis in chapter 5, we expand on the role of 1 &2 headed GP surgeries and determine their relationship with non-admitted patients.

Appendix 3 First A&E diagnosis

First A&E diagnosis	2009	2010	2011	2012	2013	2014	Mean
Allergy (inc anaphylaxis)	2%	0.36%	0.36%	0.37%	0.37%	0%	0.71%
Bites/stings	2%	0.47%	0.47%	0.49%	0.48%	0%	0.81%
Burns and scalds	3%	0.58%	0.60%	0.61%	0.60%	1%	0.93%
Cardiac conditions	4%	2.15%	2.23%	2.15%	2.25%	2%	2.59%
Central nervous system conditions (exc stroke)	3%	1.38%	1.37%	1.22%	1.26%	1%	1.65%
Cerebro-vascular conditions	3%	0.61%	0.66%	0.56%	0.58%	1%	0.92%
Contusion/abrasion	5%	3.03%	2.93%	2.89%	2.60%	3%	3.12%
Dermatological conditions	3%	0.49%	0.52%	0.62%	0.67%	0.67%	0.94%
Diabetes and other endocrinological conditions	2%	0.28%	0.24%	0.26%	0.28%	0%	0.60%
Diagnosis not classifiable	16%	10.05%	12.37%	13.37%	13.85%	14.24%	13.35%
Dislocation/fracture/joint injury/amputation	7%	4.86%	4.66%	4.71%	4.43%	5%	4.96%
Electric shock	2%	0.02%	0.02%	0.06%	0.05%	0%	0.38%
ENT conditions	4%	1.10%	1.13%	1.36%	1.55%	2%	1.70%
Facio-maxillary conditions	2%	0.27%	0.23%	0.26%	0.26%	0%	0.60%
Foreign body	3%	0.74%	0.75%	0.80%	0.73%	1%	1.10%
Gastrointestinal conditions	6%	3.29%	3.31%	3.52%	3.71%	4%	3.92%
Gynaecological conditions	3%	0.68%	0.66%	0.77%	0.77%	1%	1.08%
Haematological conditions	2%	0.17%	0.24%	0.18%	0.19%	0%	0.54%
Head injury	4%	2.16%	2.24%	2.39%	2.31%	2%	2.66%
Infectious disease	3%	0.66%	0.61%	0.66%	0.77%	1%	1.06%
Laceration	6%	4.50%	3.85%	4.23%	3.68%	4%	4.30%
Local infection	4%	1.42%	1.41%	1.43%	1.52%	2%	1.80%
Muscle/tendon injury	3%	1.46%	1.38%	1.36%	1.34%	1%	1.70%
Near drowning	2%	0.01%	0.01%	0.01%	0.01%	0%	0.34%
Nerve injury	2%	0.07%	0.08%	0.13%	0.12%	0%	0.44%
Nothing abnormal detected	4%	2.01%	1.87%	1.90%	1.79%	2.00%	2.26%
Obstetric conditions	2%	0.27%	0.28%	0.29%	0.27%	0%	0.60%
Ophthalmological conditions	4%	1.90%	1.78%	1.96%	1.91%	2%	2.23%
Other vascular conditions	2%	0.30%	0.31%	0.35%	0.38%	0%	0.68%
Poisoning (inc overdose)	3%	0.82%	0.84%	0.87%	0.84%	1%	1.20%
Psychiatric conditions	3%	0.58%	0.58%	0.64%	0.68%	1%	1.00%
Respiratory conditions	5%	2.64%	2.85%	2.79%	3.16%	3%	3.23%
Septicaemia	2%	0.06%	0.08%	0.11%	0.14%	0%	0.46%
Social problems (inc chronic alcoholism and homelessness)	2%	0.19%	0.19%	0.19%	0.21%	0%	0.53%
Soft tissue inflammation	6%	3.37%	3.40%	3.60%	3.52%	4%	3.83%
Sprain/ligament injury	6%	3.76%	3.68%	3.92%	3.74%	4%	4.09%
Urological conditions (inc cystitis)	4%	1.27%	1.30%	1.52%	1.62%	2%	1.87%
Vascular injury	2%	0.06%	0.05%	0.05%	0.06%	0%	0.39%
Visceral injury	2%	0.04%	0.05%	0.05%	0.04%	0%	0.37%

Compiled from Health and Social Care Information Centre (2015b)

Data presented on Appendix 3 is made up of percentages of all records, meaning all the null and unmatched record has been eliminated. It should also be noted that for the period covered (2009-10 and 2013-14) not all NHS trusts provided data submissions to A&E. As such HES and data quality can be poor for some fields (Health and Social Care Information Centre, 2015b).

Appendix 4First A&E Treatment

First A&E treatment						
	2009	2010	2011	2012	2013	2014
Active rewarming of the hypothermic patient		0.01%	0.01%	0.01%	0.01%	0%
Anaesthesia		0.42%	0.41%	0.36%	0.35%	0%
Arterial line		0.01%	0.02%	0.02%	0.02%	0%
Bandage/support		1.27%	1.34%	1.38%	0.90%	1%
Blood product transfusion		0.05%	0.30%	0.04%	0.02%	0%
Burns review		0.03%	0.04%	0.04%	0.03%	0%
Central line		0.14%	0.14%	0.01%	0.01%	0%
Chest drain		0.01%	0.01%	0.01%	0.01%	0%
Continuous positive airways pressure/nasal intermittent positive pressure ventilation/bag valve mask		0.01%	0.02%	0.03%	0.03%	0%
Cooling - control body temperature		0.03%	0.09%	0.01%	0.00%	0%
Defibrillation/pacing		0.01%	0.01%	0.01%	0.01%	0%
Dental treatment		0.01%	0.02%	0.10%	0.08%	0%
Dressing	3.50%	2.19%	2.34%	2.42%	2.20%	2%
Dressing/wound review		0.13%	0.22%	0.27%	0.33%	0%
Epistaxis control		0.02%	0.04%	0.05%	0.04%	0%
Eye		0.20%	0.21%	0.10%	0.03%	0%
Fracture review		0.03%	0.03%	0.05%	0.05%	0%
Guidance/advice only	37.70%	25.04%	27.05%	34.38%	34.35%	34%
Incision and drainage		0.09%	0.10%	0.16%	0.14%	0%
Infusion fluids		0.37%	0.43%	0.72%	0.84%	1%
Intravenous cannula	4.50%	3.29%	3.78%	4.21%	4.09%	4%
Intubation & Endotracheal tubes/laryngeal mask airways/rapid sequence induction		0.06%	0.08%	0.08%	0.03%	0%
Joint aspiration		0.01%	0.01%	0.01%	0.01%	0%
Lavage/emesis/charcoal/eye irrigation		0.04%	0.04%	0.06%	0.05%	0%
Loan of walking aid (crutches)		0.21%	0.29%	0.38%	0.38%	0%
Lumbar puncture		0.00%	0.00%	0.00%	0.00%	0%
Manipulation		0.14%	0.15%	0.19%	0.19%	0%
Medication administered	4.50%	3.26%	4.11%	6.04%	6.78%	7%
Minor plastic procedure/splint skin graft		0.00%	0.01%	0.00%	0.00%	0%
Minor surgery		0.07%	0.07%	0.08%	0.07%	0%
Nasal airway		0.18%	0.19%	0.18%	0.01%	0%
Nebulise/spacer		0.29%	0.31%	0.37%	0.47%	0%
None (consider guidance/advice option)	12.10%	7.94%	10.67%	13.23%	12.74%	12%
Observation/electrocardiogram, pulse oximetry/head injury/trends	6.40%	4.95%	5.14%	6.71%	7.17%	7%
Occupational therapy		0.02%	0.03%	0.03%	0.03%	0%
Oral airway		0.00%	0.01%	0.01%	0.00%	0%
Other (consider alternatives)	6.90%	3.47%	3.09%	2.75%	2.27%	2%
Other parenteral drugs		0.76%	0.87%	1.66%	2.48%	3%
Parenteral thrombolysis		0.08%	0.05%	0.01%	0.01%	0%
Pericardiocentesis		0.00%	0.01%	0.00%	0.00%	0%
Physiotherapy		0.10%	0.11%	0.08%	0.08%	0%
Plaster of Paris		1.05%	1.14%	1.18%	1.06%	1%
Prescription/medicines prepared to take away	2.90%	2.08%	2.80%	3.51%	3.57%	0%
Prescription (retired 2006)	3.30%	1.42%	0.53%	0.04%	0.00%	3%
Recall/x-ray review		0.11%	0.11%	0.14%	0.11%	0%
Recording vital signs	2.60%	1.85%	3.58%	6.40%	7.86%	9%
Removal foreign body		0.30%	0.31%	0.37%	0.34%	0%
Resuscitation/cardiopulmonary resuscitation		0.06%	0.06%	0.09%	0.12%	0%
Sling/collar cuff/broad arm sling		0.42%	0.49%	0.61%	0.56%	1%
Social worker intervention		0.01%	0.01%	0.01%	0.02%	0%
Splint		1.01%	1.10%	1.24%	1.17%	1%
Supplemental oxygen		0.20%	0.19%	0.22%	0.23%	0%
Sutures		0.52%	0.49%	0.55%	0.50%	0%
Tetanus		0.42%	0.16%	0.14%	0.14%	0%
Urinary catheter/suprapubic		0.13%	0.13%	0.16%	0.16%	0%
Wound cleaning		0.57%	0.79%	0.91%	0.79%	1%
Wound closure (exc sutures)		1.03%	1.02%	1.10%	1.00%	1%

Data source: compiled from Health and Social Care Information Centre (2015b).

Appendix 4 presents the treatments that patients, who accessed A&E departments, first received. The aim was to determine from the first treatments if patients where facing emergencies which require resuscitation. Other were to determine if patients know how to self-diagnose and choose the right access points. The table also support the agreement mad in the research that when patients are in pain, they consider it as an emergency. Note treatments such as guidance/ advice, medication administered among others.

Appendix 5 A Multiple regression analysis for London A&E access

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.85049966
R Square	0.72334967
Adjusted R Square	0.67452902
Standard Error	42478.8036
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	3	80206685822	26735561941	14.8164706	5.37E-05
Residual	17	30675628843	1804448755		
Total	20	1.10882E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-430707.18	158,421.79	-2.718736911	0.014592502	-764948	-96466.41049
Registered patients	0.21268469	0.04439416	4.790825954	0.000170126	0.119021	0.306348185
Patients /practice	44.8592757	11.33475221	3.957675906	0.001016283	20.94504	68.77351252
Same /Next day	338467.553	320458.2048	1.056198743	0.305656855	-337640	1014575.265

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.86
R Square	0.74
Adjusted R Square	0.69
Standard Error	41,329.12
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	81,844,681,072.78	27,281,560,357.59	15.97	0.00
Residual	17	29,037,633,592.45	1,708,096,093.67		
Total	20	110,882,314,665.24			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	- 121,901.44	131,388.29	- 0.93	0.37	- 399,106.50	155,303.62
Registered patients	0.23	0.04	5.90	0.00	0.15	0.31
Patients /practice	44.72	10.67	4.19	0.00	22.20	67.24
Ease of access to GP	- 222,986.95	152,521.88	- 1.46	0.16	- 544,780.00	98,806.09

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.84
R Square	0.71
Adjusted R Square	0.66
Standard Error	43,662.36
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	78,473,486,018	26,157,828,673	13.72	0.00
Residual	17	32,408,828,647	1,906,401,685		
Total	20	110,882,314,665			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	- 268,031.45	85,040.39	- 3.15	0.01	- 447,450.99	- 88,611.91
Registered patients	0.24	0.05	4.87	0.00	0.14	0.35
Patients /practice	51.22	11.60	4.42	0.00	26.75	75.68
Patients preference	- 47,869.13	124,958.92	- 0.38	0.71	- 311,509.41	215,771.15

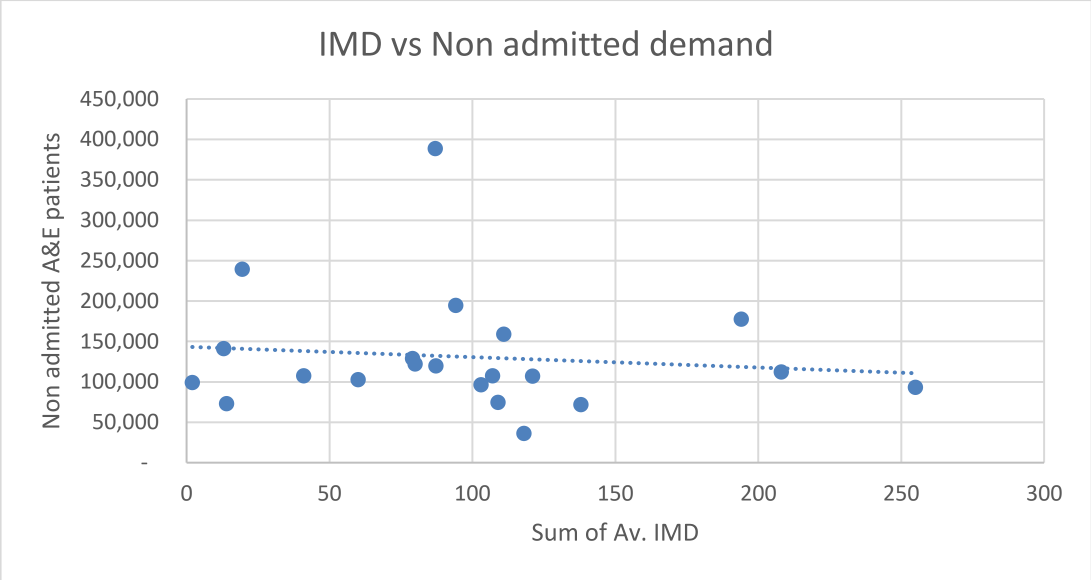
SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.86					
R Square	0.74					
Adjusted R Square	0.69					
Standard Error	41,512.67					
Observations	21.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3.00	81,586,180,893	27,195,393,631	15.78	0.00	
Residual	17.00	29,296,133,772	1,723,301,987			
Total	20.00	110,882,314,665				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	- 275,548.704	72,381.553	- 3.807	0.001	- 428,260.432	- 122,836.975
Registered patients	0.189	0.050	3.742	0.002	0.082	0.295
Patients /practice	47.970	10.260	4.676	0.000	26.324	69.617
Single/2 headed Practice	879.414	626.782	1.403	0.179	- 442.981	2,201.808

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.853					
R Square	0.727					
Adjusted R Square	0.679					
Standard Error	42,161.286					
Observations	21					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	80,663,555,923	26,887,851,974	15.13	0.00	
Residual	17	30,218,758,742	1,777,574,044			
Total	20	110,882,314,665				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	- 184,489.04	110,987.71	- 1.66	0.11	- 418,652.64	49,674.56
Registered patients	0.24	0.04	5.95	0.00	0.15	0.32
Patients /practice	49.80	10.36	4.81	0.00	27.93	71.66
Tech Application	- 566,101.08	480,257.34	- 1.18	0.25	- 1,579,355.49	447,153.33

Data sources: Greater London Authority and Office for National Statistics (2014); HSCIC (2014b); Health and Social Care Information Centre (2015b)

This multiple regression supports the results presented on section 5.4. It is extension of that analysis and is explained in the chapter.

Appendix 5B IMD vs none admitted patients at A&E department in London



Appendix 5 B GP patient survey

GP-patient survey is survey conducted by polling organisation Ipsos-Mori on behave of the NHS in which over one million patients in England are consulted and questioned about their assessment of the GP surgeries they consult. Responses since 2009 to 2014 are stored in a database (Ipsos MORI, 2014). We extracted some of the survey results to support our regression analysis.

Appendix 5 C Regression analysis and assessment of its usefulness in our research

R-squared, also known as coefficient of multiple determination for the case of our study, which is multiple regression, is a statistical measure of how close the data are to the fitted regression line. The rule is that R-squared is always assessed between the values 0 and 100% and the higher the R-squared, the better the model fits for the data. However, we can simplify our understanding of it by reporting that the R-square obtained in this analysis indicates that 93% of the independent variables explain the reason for the occurrence of variations on the dependent variable (non-admitted A&E attendance).

The p-value for each term tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) indicates that you can reject the null hypothesis. In other words, a predictor that has a low p-value is likely to be a meaningful addition to your model because changes in the predictor's value are related to changes in the response variable.

Problems with regression approach

Although regression analysis is widely used and accepted in management research, there are some drawbacks of using it.

While multiple regressions are great, it does not necessarily mean that increased numbers of independent variables will lead to the development of a better regression model (Sykes, 1993). This research just like many in social science studies is heavy with variables that must be made visible (for example, Wang and Jain, 2003). The fact that there are boundaries in the areas of interest (healthcare delivery) and the fact that MR requires variables to be treated as invisible sources of a set of empirical observations on dependent and independent variables, it means that comparative aspects in our study become limited in number. The fact that actors in the healthcare operations (patients and care deliverers) put strong value on specific cases it becomes necessary to care for such interests and thus make the variables more visible.

Multi-collinearity is a very strong problem in a study of this magnitude. Multi-collinearity is a situation where independent variables tend to correlate with each other rather than with the independent correlating only with the dependent variable. This makes it hard to select the right amount of variables, which can show a broad perspective as to how a particular phenomenon affects the dependent variable. We tried to keep our study as natural as possible and did less to over fit the data. To check for multi-collinearity, we used the following two approaches to select the best independent variables to explain our dependent variable

i. Scatter X,Y plots

Scatter diagrams or scatter plots are used to probe the possibility that there exist a relationship or association between two variables. This relationship is shown in a way that a non-random structure develops in the plots (Draper *et al.*, 1998). A straight line, known as the best-fit line is usually added. The straight line follows the least squares method. As shown on figure 20, we examined among the variables to assess which one correlated with the dependent variable and which ones correlated with each other. We can see that there are one dependent variable non-admitted patients correlating positively with registered population on figure 19 (a) and population 19(b) and patients per GP 19 (C).

However, it had a weak relationship with IMD (c). Our drive has been that all the selected independent variables correlate only with the dependent variable.

However, the scatter plots as shown on figure 19 have the shortcoming in that statistically, it might not show how strong the relationships between the two variables are. For example, the relationship between non-admitted patients and registered patients shows a positive relationship but how strong this relationship is hard to determine. To solve this problem, we used the Pearson coefficient.

ii. The Pearson's coefficient evaluates the strength of the linear relationship between two continuous variables (Draper *et al.*, 1998). The linearity of the relationship is observed when a change in one variable is associated with a proportional change in the other variable. Numerically the strength, positive or negative direction of the linear relationship between two variables is denoted with values between −1 and +1. This merely show the sign of the direction while the numbers either +/- will indicate the strength (Draper *et al.*, 1998). For this study, we have demonstrated this type of relationship on table 16.

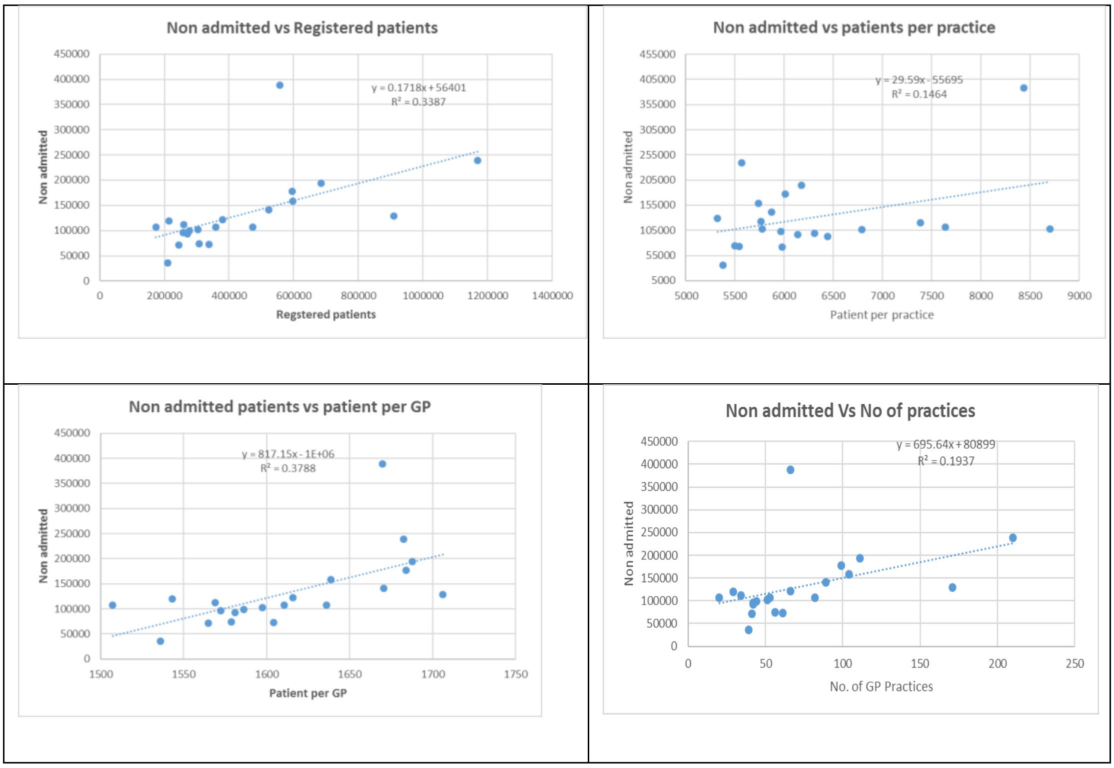
The usefulness of the correlation table presented on table 14 are that it helps us improve on the variables and understand which ones would correlated with the dependent variable and which ones will not during the design of regression analysis.

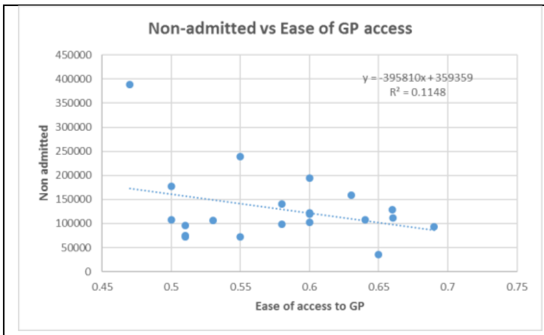
Generally, correlation has been found not to mean causality. Therefore, the finding on the correlation which may reflect an existence of relationship does in reality mean that such can be proven (Draper *et al.*, 1998). In this way it would mean that there could be a third factor involved that caused variations such as process or systemic factors.

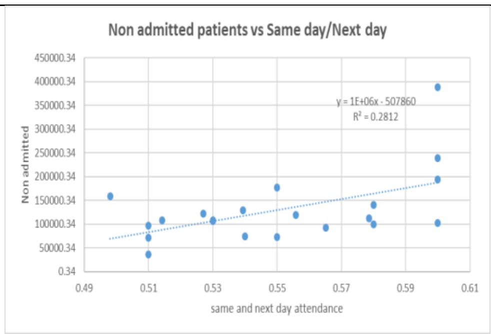
Other problems, which warranted avoidance in the regression design was the problems of data over-fitting. Over-fitting can be described as the drive to make the data to fit a statistical model by adjusting the data such that it possesses too many degrees of freedom during the modelling process (Draper *et al.*, 1998). One effect of this is lack of generalisability and future application. The most plausible solution for this is the use of larger data sample (Velu and Reinsel, 2013).

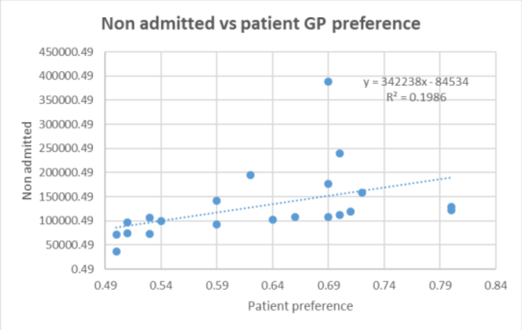
Another challenge in using the regression was how to deal with the outliers that presented themselves in the model. Outlier are described as the observation(s) that present themselves abnormally outside the other values within the random sample from a population (Draper *et al.*, 1998). On the scatter graph presented on figure 20, those points that are distinctly separate from the rest of the data are examples of outliers.

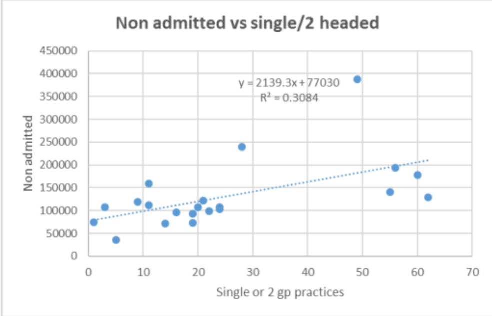
The reasons for the existence of outliers in this study are variation in activities in inners London and lighter activities in outer London, figure 11 for example. Also generating the variables through MSOA could have skewed the data somewhat. To solve this problem, we had two options – to eliminate the data points or to perform the regression and see how it affects the results. Since eliminating data point can also be dangerous for the model as a whole, we decided first to perform the regression with these outliers in place and determine their specific influence on the results. The expectation was that if the influence of the outliers were to be minor, then eliminating them may not matter that much. Should their influence tended to be substantial we would have devised to possibly eliminate the data points with the outliers.

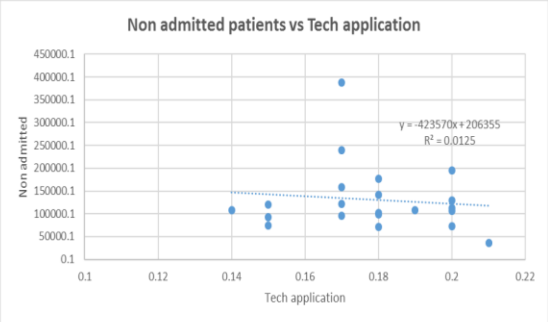


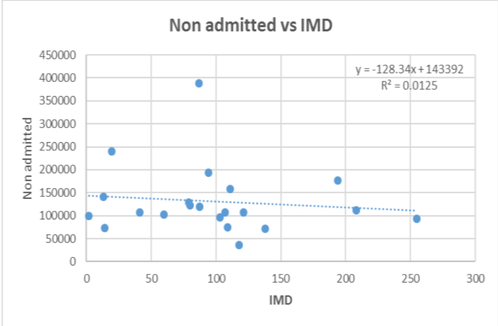


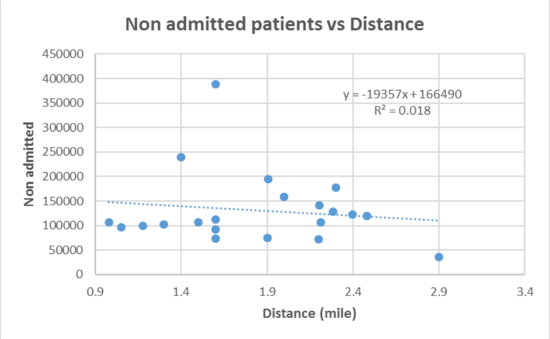


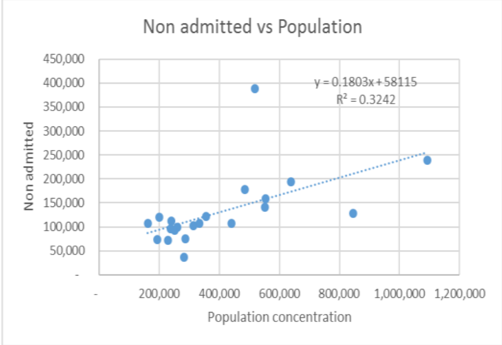












Appendix 5 B GP patient survey

GP-patient survey is survey conducted by polling organisation Ipsos-Mori on behave of the NHS in which over one million patients in England are consulted and questioned about their assessment of the GP surgeries they consult. Responses since 2009 to 2014 are stored in a database (Ipsos MORI, 2014).

Appendices

Appendix 6Final regression variables

Step 1

Providers	Non-admitted patients	Population	Registered patients	Patients /practice	Patients per GP	No. of GPs	No. of GP practices
Barking, Havering & Redbridge University NHS Trust	158,855	554,676	596,475	5,735	1,639	364	104
Barnet & Chase Farm Hospitals NHS Trust NHS Trust	119,582	199,981	214,128	7,384	1,543	139	29
Barts Health NHS Trust	239,343	1,092,522	1,169,690	5,570	1,683	695	210
Chelsea & Westminster Hospital NHS Foundation Trust	96,186	239,158	257,806	6,138	1,572	164	42
Croydon Health Services NHS Trust	107,523	440,331	473,771	5,778	1,636	290	82
Ealing Hospital NHS Trust	122,087	355,379	380,458	5,765	1,616	235	66
Epsom & St Helier University Hospitals NHS Trust	111,968	240,522	259,814	7,642	1,569	166	34
Guy's & St Thomas' NHS Foundation Trust	107,311	162,430	174,006	8,700	1,507	115	20
Homerton University Hospital NHS Foundation Trust	99,150	259,657	277,663	6,311	1,586	175	44
Imperial College Healthcare NHS Trust	388,345	519,075	557,016	8,440	1,670	334	66
King's College Hospital NHS Foundation Trust	194,387	638,404	685,348	6,174	1,688	406	111
Kingston Hospital NHS Foundation Trust	93,003	251,334	270,626	6,443	1,581	171	42
Lewisham & Greenwich NHS Trust	128,703	844,558	910,150	5,323	1,706	533	171
North Middlesex University Hospital NHS Trust	140,948	552,751	522,671	5,873	1,671	313	89
North West London Hospitals NHS Trust	177,401	485,373	595,193	6,012	1,684	353	99
Royal Free London NHS Foundation Trust	74,470	287,265	307,843	5,497	1,579	195	56
St George's Healthcare NHS Trust	107,060	334,238	359,961	6,792	1,611	223	53
The Hillingdon Hospitals NHS FT	71,652	229,160	245,236	5,981	1,565	157	41
University College London FT	102,471	313,549	304,283	5,966	1,597	190	51
West Middlesex University NHS Trust	35,976	282,418	209,710	5,377	1,536	137	39
Whittington Hospital NHS Trust	72,882	194,920	337,985	5,541	1,604	211	61

Step 2

Providers	Ease of access to GP	Same /Next	Patients preference	Single/2 headed P	Tech Application	IMD Av.	Distance (M)
Barking, Havering & Redbridge University NHS Trust	63%	50%	72%	11	17%	111	2.0
Barnet & Chase Farm Hospitals NHS Trust NHS Trust	60%	56%	71%	9	15%	87	2.5
Barts Health NHS Trust	55%	60%	70%	28	17%	20	1.4
Chelsea & Westminster Hospital NHS Foundation Trust	51%	51%	51%	16	17%	103	1.1
Croydon Health Services NHS Trust	64%	51%	69%	24	14%	107	2.2
Ealing Hospital NHS Trust	60%	53%	80%	21	17%	80	2.4
Epsom & St Helier University Hospitals NHS Trust	66%	58%	70%	11	20%	208	1.6
Guy's & St Thomas' NHS Foundation Trust	50%	53%	66%	3	19%	41	1.0
Homerton University Hospital NHS Foundation Trust	58%	58%	54%	22	18%	2	1.2
Imperial College Healthcare NHS Trust	47%	60%	69%	49	17%	87	1.6
King's College Hospital NHS Foundation Trust	60%	60%	62%	56	20%	94	1.9
Kingston Hospital NHS Foundation Trust	69%	57%	59%	19	15%	255	1.6
Lewisham & Greenwich NHS Trust	66%	54%	80%	62	20%	79	2.3
North Middlesex University Hospital NHS Trust	58%	58%	59%	55	18%	13	2.2
North West London Hospitals NHS Trust	50%	55%	69%	60	18%	194	2.3
Royal Free London NHS Foundation Trust	51%	54%	51%	1	15%	109	1.9
St George's Healthcare NHS Trust	53%	53%	53%	20	20%	121	1.5
The Hillingdon Hospitals NHS FT	51%	51%	50%	14	18%	138	2.2
University College London FT	60%	60%	64%	24	18%	60	1.3
West Middlesex University NHS Trust	65%	51%	50%	5	21%	118	2.9
Whittington Hospital NHS Trust	55%	55%	53%	19	20%	14	1.6

Appendix 6 presents the variables used to analyse the multiple regression and various scatter plots and spearman correlation presented in Chapter 5.

Appendix 7(A) Registered patients and resident population

Registered patients or GP-registered patients are patients whose personal and medical details are recorded and held in the register of GPs. These patients are registered as people who can access healthcare from any healthcare facility in England but are affiliated to a particular practice usually near their residence. However, they may not reside in the particular borough or town where their GP or hospital is located (HSCIC, 2014b).

On the other hand, resident population relates to the actual number of people who normally live in a region, town, borough or SOA. In a MSOA for example, the numbers of registered patients there are usually more than the resident population (Office for National Statistics, 2014b).

In this study, we use GP registered patients in preference to resident population in our analysis. The grounds for this is that GP registered patients provide a proper picture of possible healthcare demand based on actual people living in an area. Many registered patients could reside outside the area but access healthcare in the area and vice versa. Also with increased mobility of people, it is easier to track origins of patients when they are registered rather than in the resident population. Non-registered patients can also be easily identified and classified. For example 2005 it was found that more than 150,000 patients who presented at A&E department in London were not registered with a GP (Savage, 2015). This show the challenges posed where trying to account for sources of demand.

We also note that there have been various instances where practices had inflated patients numbers, that is, where there were more patients than existed in reality (Harper and Rai, 2014; Savage, 2015)

Appendix 8 B) LSOAs for London Borough of Hounslow showing 191 of 714 LSOAs

FID	OA11CD	LSOA11CD	WD11NM_BF	LAD11NM	LSOA11NM	USUALRES	HHOLDRES	POPDEN	HHOLDS
0	E00013096	E01002634	Heston West	Hounslow	Hounslow 005B	463	463	35	153
1	E00013017	E01002612	Hanworth Park	Hounslow	Hounslow 024E	293	293	47.5	120
2	E00013014	E01002612	Hanworth Park	Hounslow	Hounslow 024E	343	343	73	126
3	E00013095	E01002632	Heston West	Hounslow	Hounslow 010C	430	430	69.7	129
4	E00012856	E01002580	Chiswick Riverside	Hounslow	Hounslow 008C	248	248	154	142
5	E00012857	E01002581	Chiswick Riverside	Hounslow	Hounslow 008D	301	301	76.2	140
6	E00012850	E01002578	Chiswick Riverside	Hounslow	Hounslow 007D	306	306	13.7	127
7	E00012974	E01002606	Hanworth	Hounslow	Hounslow 026C	310	310	36.6	128
8	E00012972	E01002605	Hanworth	Hounslow	Hounslow 026B	383	383	149	156
9	E00012973	E01002607	Hanworth	Hounslow	Hounslow 026D	358	358	60.6	134
10	E00013266	E01002668	Isleworth	Hounslow	Hounslow 014A	342	280	71.1	133
11	E00012787	E01002571	Chiswick Homefields	Hounslow	Hounslow 007A	228	228	39.2	113
12	E00013177	E01002647	Hounslow Heath	Hounslow	Hounslow 021A	325	325	148.4	122
13	E00013174	E01002646	Hounslow Heath	Hounslow	Hounslow 017B	300	300	191.1	134
14	E00013171	E01002648	Hounslow Heath	Hounslow	Hounslow 018C	608	608	149.8	218
15	E00013015	E01002611	Hanworth Park	Hounslow	Hounslow 024D	384	384	14.5	136
16	E00013094	E01002632	Heston West	Hounslow	Hounslow 010C	469	469	35.8	132
17	E00013010	E01002611	Hanworth Park	Hounslow	Hounslow 024D	292	292	62	108
18	E00013091	E01002633	Heston West	Hounslow	Hounslow 005A	335	335	100.6	129
19	E00013011	E01002612	Hanworth Park	Hounslow	Hounslow 024E	271	271	57.9	155
20	E00013090	E01002633	Heston West	Hounslow	Hounslow 005A	379	379	26.9	137
21	E00013274	E01002667	Isleworth	Hounslow	Hounslow 020A	419	419	93.1	164
22	E00012717	E01002561	Bedfont	Hounslow	Hounslow 023E	301	301	115.8	127
23	E00012796	E01002572	Chiswick Homefields	Hounslow	Hounslow 007B	318	318	59.9	124
24	E00012793	E01002572	Chiswick Homefields	Hounslow	Hounslow 007B	359	359	57.8	131
25	E00012790	E01002571	Chiswick Homefields	Hounslow	Hounslow 007A	273	273	123.5	126
26	E00012799	E01002574	Chiswick Homefields	Hounslow	Hounslow 001D	302	302	69.3	122
27	E00012986	E01002609	Hanworth	Hounslow	Hounslow 028B	311	311	75.3	117
28	E00012907	E01002594	Feltham North	Hounslow	Hounslow 024C	437	437	80.8	138
29	E00012982	E01002606	Hanworth	Hounslow	Hounslow 026C	381	381	106.4	127
30	E00012903	E01002592	Feltham North	Hounslow	Hounslow 022D	268	268	4	103
31	E00013336	E01002686	Syon	Hounslow	Hounslow 006E	306	306	4	139
32	E00013337	E01002682	Syon	Hounslow	Hounslow 014D	416	416	103	129
33	E00013338	E01002682	Syon	Hounslow	Hounslow 014D	324	324	71.7	126
34	E00168187	E01033081	Syon	Hounslow	Hounslow 003F	206	206	74.6	122
35	E00168189	E01033082	Syon	Hounslow	Hounslow 003G	196	196	38.7	111
36	E00013154	E01002651	Hounslow Heath	Hounslow	Hounslow 021C	491	491	118.9	165
37	E00013152	E01002650	Hounslow Heath	Hounslow	Hounslow 021B	450	450	120.3	130
38	E00168873	E01002558	Bedfont	Hounslow	Hounslow 023B	333	333	229.7	134
39	E00012917	E01002594	Feltham North	Hounslow	Hounslow 024C	411	411	75.4	135
40	E00012996	E01002616	Hanworth Park	Hounslow	Hounslow 027E	344	344	73.7	127
41	E00168875	E01033083	Hounslow Central	Hounslow	Hounslow 018F	858	858	746.1	318
42	E00013257	E01002673	Isleworth	Hounslow	Hounslow 020E	273	273	525	124
43	E00013255	E01002673	Isleworth	Hounslow	Hounslow 020E	303	303	203.4	108
44	E00012834	E01002581	Chiswick Riverside	Hounslow	Hounslow 008D	367	367	81.9	158
45	E00013065	E01002628	Heston East	Hounslow	Hounslow 011D	422	422	91.3	132
46	E00012827	E01002581	Chiswick Riverside	Hounslow	Hounslow 008D	317	317	193.3	144
47	E00012820	E01002578	Chiswick Riverside	Hounslow	Hounslow 007D	212	212	70.7	104
48	E00012829	E01002581	Chiswick Riverside	Hounslow	Hounslow 008D	260	260	72.2	126
49	E00168192	E01002565	Brentford	Hounslow	Hounslow 006B	961	185	37.2	92
50	E00168190	E01033081	Syon	Hounslow	Hounslow 003F	231	231	121.6	122
51	E00013122	E01002643	Hounslow Central	Hounslow	Hounslow 015B	267	267	77.4	117
52	E00013120	E01002640	Hounslow Central	Hounslow	Hounslow 012C	429	429	83	134
53	E00013121	E01002639	Hounslow Central	Hounslow	Hounslow 012B	411	403	73.8	130
54	E00013314	E01002686	Syon	Hounslow	Hounslow 006E	386	383	86.5	137
55	E00012960	E01002610	Hanworth	Hounslow	Hounslow 028C	383	383	13.1	136
56	E00013136	E01002641	Hounslow Central	Hounslow	Hounslow 018A	477	477	71.3	155
57	E00168852	E01002648	Hounslow Heath	Hounslow	Hounslow 018C	361	361	125.3	129
58	E00168850	E01002648	Hounslow Heath	Hounslow	Hounslow 018C	447	447	114.3	138
59	E00166032	E01033000	Feltham West	Hounslow	Hounslow 025F	371	371	447	119
60	E00168859	E01002643	Hounslow Central	Hounslow	Hounslow 015B	184	184	28.3	81
61	E00012807	E01002575	Chiswick Homefields	Hounslow	Hounslow 001E	308	308	145.3	139
62	E00012886	E01002584	Cranford	Hounslow	Hounslow 013B	452	452	74.6	124
63	E00012882	E01002585	Cranford	Hounslow	Hounslow 013C	404	404	80.2	128
64	E00012803	E01002573	Chiswick Homefields	Hounslow	Hounslow 001C	354	354	66.3	147
65	E00012809	E01002570	Chiswick Homefields	Hounslow	Hounslow 001B	332	332	94.9	134
66	E00012888	E01002583	Cranford	Hounslow	Hounslow 013A	472	472	81	128
67	E00013232	E01002661	Hounslow West	Hounslow	Hounslow 016D	399	399	82.6	111
68	E00013230	E01002666	Hounslow West	Hounslow	Hounslow 021E	462	462	42.6	143
69	E00013238	E01002660	Hounslow West	Hounslow	Hounslow 016C	453	453	102.7	132
70	E00012744	E01002557	Bedfont	Hounslow	Hounslow 023A	214	214	30.9	120
71	E00012742	E01002559	Bedfont	Hounslow	Hounslow 023C	429	429	3.9	153
72	E00012740	E01002558	Bedfont	Hounslow	Hounslow 023B	243	243	34.8	127
73	E00013184	E01002655	Hounslow South	Hounslow	Hounslow 019C	360	360	71.7	119
74	E00013105	E01002636	Heston West	Hounslow	Hounslow 010E	366	366	101.9	108
75	E00013108	E01002635	Heston West	Hounslow	Hounslow 010D	447	447	74.5	141
76	E00013189	E01002653	Hounslow South	Hounslow	Hounslow 019A	491	491	104	145
77	E00013188	E01002653	Hounslow South	Hounslow	Hounslow 019A	406	406	63	121
78	E00013109	E01002637	Heston West	Hounslow	Hounslow 005C	382	382	6.2	132
79	E00013056	E01002626	Heston East	Hounslow	Hounslow 004C	373	373	22.4	122
80	E00013057	E01002627	Heston East	Hounslow	Hounslow 004D	347	347	559.7	132
81	E00013366	E01002689	Turnham Green	Hounslow	Hounslow 007E	274	274	130.5	137
82	E00013364	E01002687	Turnham Green	Hounslow	Hounslow 029A	268	268	76.8	133
83	E00013362	E01002690	Turnham Green	Hounslow	Hounslow 007F	301	301	75.6	120
84	E00013286	E01002680	Osterley and Spring Grove	Hounslow	Hounslow 009D	381	381	30.2	138
85	E00013207	E01002656	Hounslow South	Hounslow	Hounslow 019D	390	390	89.7	117
86	E00013284	E01002676	Osterley and Spring Grove	Hounslow	Hounslow 012E	417	417	11.6	139
87	E00013205	E01002656	Hounslow South	Hounslow	Hounslow 019D	324	324	47.7	127
88	E00013283	E01002679	Osterley and Spring Grove	Hounslow	Hounslow 009C	329	329	88	120
89	E00013202	E01002657	Hounslow South	Hounslow	Hounslow 018E	368	368	97.1	137
90	E00012946	E01002600	Feltham West	Hounslow	Hounslow 025D	373	373	103	126
91	E00013110	E01002637	Heston West	Hounslow	Hounslow 005C	398	398	176.1	134
92	E00013191	E01002653	Hounslow South	Hounslow	Hounslow 019A	495	495	84.5	143
93	E00013199	E01002654	Hounslow South	Hounslow	Hounslow 019B	352	352	75.9	140
94	E00013371	E01002687	Turnham Green	Hounslow	Hounslow 029A	330	330	105.4	166
95	E00013296	E01002675	Osterley and Spring Grove	Hounslow	Hounslow 009A	365	365	47.5	124
96	E00013217	E01002663	Hounslow	Hounslow	Hounslow	459	459	128.6	139
97	E00013295	E01002674	Osterley a	Hounslow	Hounslow	376	376	129.2	160
98	E00013214	E01002665	Hounslow	Hounslow	Hounslow	351	351	120.2	116
99	E00013210	E01002658	Hounslow	Hounslow	Hounslow	326	326	85.1	125
100	E00013306	E01002678	Osterley a	Hounslow	Hounslow	356	356	5.4	122
101	E00013307	E01002678	Osterley a	Hounslow	Hounslow	315	315	89.2	126
102	E00013304	E01002678	Osterley a	Hounslow	Hounslow	366	366	16.5	134
103	E00013305	E01002678	Osterley a	Hounslow	Hounslow	356	356	21.6	138
104	E00013384	E01032573	Turnham (	Hounslow	Hounslow	195	195	117.5	107
105	E00013302	E01002677	Osterley a	Hounslow	Hounslow	320	320	64.4	126
106	E00013383	E01002691	Turnham (	Hounslow	Hounslow	267	267	9.4	114
107	E00013226	E01002665	Hounslow	Hounslow	Hounslow	538	538	111.9	139
108	E00013227	E01002665	Hounslow	Hounslow	Hounslow	314	314	138.9	136
109	E00013224	E01002666	Hounslow	Hounslow	Hounslow	470	470	63.3	139
110	E00013225	E01002665	Hounslow	Hounslow	Hounslow	415	408	106.4	133
111	E00013267	E01002668	Isleworth	Hounslow	Hounslow	374	365	52.3	168
112	E00013264	E01002668	Isleworth	Hounslow	Hounslow	257	257	130.5	116
113	E00013265	E01002667	Isleworth	Hounslow	Hounslow	238	238	63.8	113
114	E00012955	E01002610	Hanworth	Hounslow	Hounslow	290	290	64.9	139
115	E00012953	E01002598	Feltham V	Hounslow	Hounslow	356	356	97	114
116	E00168887	E01033030	Feltham V	Hounslow	Hounslow	265	265	373.2	129
117	E00168884	E01033000	Feltham V	Hounslow	Hounslow	277	277	503.6	105
118	E00012864	E01002586	Cranford	Hounslow	Hounslow	453	453	115	123
119	E00013348	E01002693	Turnham (	Hounslow	Hounslow	270	270	131.7	169
120	E00013334	E01033082	Syon	Hounslow	Hounslow	232	232	279.5	131
121	E00013335	E01033082	Syon	Hounslow	Hounslow	214	214	24.9	107
122	E00013332	E01002684	Syon	Hounslow	Hounslow	257	257	94.1	130
123	E00013333	E01033082	Syon	Hounslow	Hounslow	242	242	75.9	132
124	E00013330	E01002686	Syon	Hounslow	Hounslow	309	309	51	145
125	E00013331	E01002686	Syon	Hounslow	Hounslow	367	367	73.5	129
126	E00013229	E01002666	Hounslow	Hounslow	Hounslow	626	444	87.4	125
127	E00166037	E01002662	Hounslow	Hounslow	Hounslow	194	194	112.8	68
128	E00166034	E01002559	Bedfont	Hounslow	Hounslow	291	291	77.8	126
129	E00168858	E01002566	Brentford	Hounslow	Hounslow	260	260	117.1	126
130	E00166039	E01002684	Syon	Hounslow	Hounslow	275	275	79.9	131
131	E00013183	E01002654	Hounslow	Hounslow	Hounslow	277	277	10.5	136
132	E00013102	E01002634	Heston W	Hounslow	Hounslow	442	442	200	154
133	E00013103	E01002636	Heston W	Hounslow	Hounslow	438	438	118.4	133
134	E00013182	E01002649	Hounslow	Hounslow	Hounslow	301	289	96.2	119
135	E00013100	E01002636	Heston W	Hounslow	Hounslow	392	392	112.6	121
136	E00013181	E01002648	Hounslow	Hounslow	Hounslow	448	448	112.3	143
137	E00013101	E01002633	Heston W	Hounslow	Hounslow	378	378	71.1	128
138	E00013180	E01002650	Hounslow	Hounslow	Hounslow	515	515	111.2	142
139	E00012735	E01002558	Bedfont	Hounslow	Hounslow	347	347	86.3	128
140	E00013166	E01002652	Hounslow	Hounslow	Hounslow	468	468	135.7	122
141	E00013162	E01002650	Hounslow	Hounslow	Hounslow	381	381	101.6	142
142	E00013168	E01002649	Hounslow	Hounslow	Hounslow	368	357	72.7	128
143	E00012927	E01002602	Feltham V	Hounslow	Hounslow	430	430	74.9	155
144	E00168894	E01002558	Bedfont	Hounslow	Hounslow	340	340	177.1	119
145	E00012874	E01002589	Cranford	Hounslow	Hounslow	359	359	43.1	117
146	E00012873	E01002588	Cranford	Hounslow	Hounslow	375	375	225.9	149
147	E00012871	E01002588	Cranford	Hounslow	Hounslow	344	344	185.9	119
148	E00012878	E01002589	Cranford	Hounslow	Hounslow	204	204	13.6	76
149	E00013004	E01002617	Hanworth	Hounslow	Hounslow	298	298	21.7	129
150	E00013085	E01002636	Heston W	Hounslow	Hounslow	413	413	67.6	132
151	E00013005	E01002617	Hanworth	Hounslow	Hounslow	365	365	50.1	145
152	E00013084	E01002627	Heston Ea	Hounslow	Hounslow	251	251	94.4	86
153	E00013356	E01032573	Turnham (	Hounslow	Hounslow	278	278	74.3	118
154	E00013355	E01032573	Turnham (	Hounslow	Hounslow	199	199	68.4	122
155	E00013353	E01002693	Turnham (	Hounslow	Hounslow	258	258	62.5	106
156	E00013262	E01002672	Isleworth	Hounslow	Hounslow	491	491	46.3	151
157	E00013263	E01002667	Isleworth	Hounslow	Hounslow	392	348	46	129
158	E00013260	E01002672	Isleworth	Hounslow	Hounslow	276	276	492.9	138
159	E00013261	E01002672	Isleworth	Hounslow	Hounslow	228	228	30.3	137
160	E00013268	E01002668	Isleworth	Hounslow	Hounslow	223	223	78.8	101
161	E00013269	E01002669	Isleworth	Hounslow	Hounslow	405	405	92.9	154
162	E00012786	E01002571	Chiswick H	Hounslow	Hounslow	276	276	45.2	125
163	E00012785	E01002569	Chiswick H	Hounslow	Hounslow	256	256	173	128
164	E00012784	E01002569	Chiswick H	Hounslow	Hounslow	277	277	168.9	119
165	E00012783	E01002569	Chiswick H	Hounslow	Hounslow	318	318	71.6	136
166	E00012782	E01002564	Brentford	Hounslow	Hounslow	236	236	130.4	103
167	E00012781	E01002564	Brentford	Hounslow	Hounslow	267	267	126.5	123
168	E00012780	E01002562	Brentford	Hounslow	Hounslow	338	338	89.4	139
169	E00012789	E01002571	Chiswick H	Hounslow	Hounslow	328	328	96.5	129
170	E00012788	E01002569	Chiswick H	Hounslow	Hounslow	296	229	33	115
171	E00013176	E01002646	Hounslow	Hounslow	Hounslow	573	573	105.9	192
172	E00013175	E01002649	Hounslow	Hounslow	Hounslow	417	402	82.6	161
173	E00013172	E01002646	Hounslow	Hounslow	Hounslow	454	454	126.8	138
174	E00013170	E01002646	Hounslow	Hounslow	Hounslow	355	355	232	123
175	E00013178	E01002649	Hounslow	Hounslow	Hounslow	344	344	112.4	148
176	E00012936	E01002599	Feltham V	Hounslow	Hounslow	381	381	86.8	115
177	E00013179	E01002648	Hounslow	Hounslow	Hounslow	429	429	141.6	138
178	E00012937	E01002596	Feltham V	Hounslow	Hounslow	324	324	104.2	128
179	E00012934	E01002599	Feltham V	Hounslow	Hounslow	267	267	153.4	104
180	E00012932	E01033000	Feltham V	Hounslow	Hounslow	263	263	131.5	94
181	E00012933	E01033000	Feltham V	Hounslow	Hounslow	302	302	135.4	116
182	E00012930	E01002603	Feltham V	Hounslow	Hounslow	612	612	97.6	186
183	E00012931	E01002603	Feltham V	Hounslow	Hounslow	340	340	82.5	122
184	E00012939	E01002598	Feltham V	Hounslow	Hounslow	521	521	85.8	182
185	E00012846	E01002576	Chiswick F	Hounslow	Hounslow	301	301	71.3	140
186	E00012847	E01002578	Chiswick F	Hounslow	Hounslow	299	299	39.2	129
187	E00012844	E01002578	Chiswick F	Hounslow	Hounslow	329	329	55.6	123
188	E00012845	E01002582	Chiswick F	Hounslow	Hounslow	290	290	105.1	126
189	E00012842	E01002578	Chiswick F	Hounslow	Hounslow	356	356	30.7	129
190	E00012843	E01002576	Chiswick F	Hounslow	Hounslow	312	312	86.4	124
191	E00012840	E01002576	Chiswick F	Hounslow	Hounslow	252	252	107.2	116

Source: Greater London Authority and Office for National Statistics (2014)

Appendix 8 C More on GIS data analysis and use

Applying GIS to research in healthcare management is not a new phenomenon. While mapping and GIS is considered valuable in epidemiology, its use in healthcare delivery management has not been wide ranging as would have expected (Luo, 2014). Epidemiology refers to the science of studying the health of the populations, learning about the possible causes, effects and the patterns of disease conditions within defined populations and areas (Youngson, 2006). In 1854, John Snow, an English physician, showed how the use of spatial data and mapping can be useful for epidemiological research (Dever, 2006, p. 501). While investigating the causes of cholera outbreak in London in the 1854s John Snow used the GIS mapping techniques to pinpoint the affected areas and link them to the specific water sources that caused the cholera outbreak. By eliminating the various agents that spread the diseases right from the water source, cholera, a deadly disease that killed many people was resolved (Dever, 2006). The ability to visibly identify disease hot spots and also resources (quality and quantity) needed to resolve them has meant that using spatial data approach such as the GIS has increasingly become valuable in public health epidemiology (Dever, 2006; Luo, 2014). By gaining this knowledge, it is possible to effectively respond to the health of the population and disease management.

Another reason for using the geographic information system was to provide a more practical visual outlook to the research. One outcome from my research funding was the expectation that my findings should create an impact. Although the description of impact by my funding body has been was vague, we posit that impact refers to the ability to 'making a direct effect on an aspect being studied.' In operation management, researchers are increasing encouraging research fining to be made available to the non-academic parties, industries and policy makers (Steenkamp, 2010; Stevenson, 2012). One of the best ways to do so was to present such materials on the maps. This will improve visualisation, make the study look real as it affect the areas where people live and also engage policy makers, healthcare deliverers and patients (Dever, 2006).

Appendix 8 Part of London's Middle Super Output Areas (MSOAs) and some key variables

A)

Post Code area	MSOA code	MSOA Areas	Nearest Distance to A&E (miles)	Av. MSOA IMD score	A&E hospital	A&E NHS Trust	No. of GPs in MSOA	MSOA Population	Registered patients	No. of GP practices
RM5 2BG	E02000002	Barking and Dagenham 001	1.7	43.0	King George Hospital	Barking, Havering & Redbridge NHS Trust	5	7,900	8,543	1
RM1 1HA	E02000003	Barking and Dagenham 002	1.5	25.6	King George Hospital	Barking, Havering & Redbridge NHS Trust	5	8,775	9,418	2
RM10 7AA	E02000004	Barking and Dagenham 003	1.2	22.7	Queen's NHS	Barking, Havering & Redbridge NHS Trust	6	10,045	10,688	3
RM10 7LJ	E02000005	Barking and Dagenham 004	1.6	32.5	Queen's NHS	Barking, Havering & Redbridge NHS Trust	5	8,282	8,925	2
RM107RB	E02000006	Barking and Dagenham 005	1.5	35.2	King George Hospital	Barking, Havering & Redbridge NHS Trust	5	8,739	9,382	3
RM10 7AE	E02000007	Barking and Dagenham 006	1.4	40.6	Queen's NHS	Barking, Havering & Redbridge NHS Trust	5	8,791	9,434	1
RM10 7DE	E02000008	Barking and Dagenham 007	2	35.6	Queen's NHS	Barking, Havering & Redbridge NHS Trust	7	11,569	12,212	3
IG11 9BY	E02000009	Barking and Dagenham 008	2.1	30.8	King George Hospital	Barking, Havering & Redbridge NHS Trust	6	10,395	11,038	1
RM10 7AN	E02000010	Barking and Dagenham 009	1.7	34.9	Queen's NHS	Barking, Havering & Redbridge NHS Trust	6	10,615	11,258	2
RM10 7EA	E02000011	Barking and Dagenham 010	1.5	25.7	Queen's NHS	Barking, Havering & Redbridge NHS Trust	6	9,887	10,530	3
IG11 9LX	E02000012	Barking and Dagenham 011	2.9	20.2	Newham Hospital	Barts Health NHS Trust	5	9,000	9,643	2
RM8 2AW	E02000013	Barking and Dagenham 012	2.5	36.9	King George Hospital	Barking, Havering & Redbridge NHS Trust	5	8,402	9,045	2
RM10 8DP	E02000014	Barking and Dagenham 013	2.3	36.6	Queen's Hospital	Barking, Havering & Redbridge NHS Trust	6	9,402	10,045	2
RM10 8AD	E02000015	Barking and Dagenham 014	2	44.5	King George Hospital	Barking, Havering & Redbridge NHS Trust	5	7,563	8,206	1
IG11 7AR	E02000016	Barking and Dagenham 015	2	39.8	Newham Hospital	Barts Health NHS Trust	5	8,676	9,319	2
IG11 7QL	E02000017	Barking and Dagenham 016	2.5	26.0	Newham Hospital	Barts Health NHS Trust	5	8,498	9,141	1
IG11 0AT	E02000018	Barking and Dagenham 017	3.1	36.8	Newham Hospital	Barts Health NHS Trust	5	8,890	9,533	2
IG11 0RN	E02000019	Barking and Dagenham 018	3.5	33.6	King George Hospital	Barking, Harvering and Redbridge NHS Trust	7	9,276	9,919	2
IG11 0AL	E02000020	Barking and Dagenham 019	2.4	32.0	Newham Hospital	Barts Health NHS Trust	6	9,276	9,919	2
RM10 9AB	E02000021	Barking and Dagenham 020	2.4	30.3	Newham Hospital	Barts Health NHS Trust	5	7,904	8,547	1
IG11 0BB	E02000022	Barking and Dagenham 021	2.4	48.3	Newham Hospital	Barts Health NHS Trust	5	8,777	9,420	2
IG11 0AB	E02000023	Barking and Dagenham 022	3.2	45.0	Newham Hospital	Barts Health NHS Trust	5	8,482	9,125	0
EN4 0NH	E02000024	Barnet 001	1.4	8.9	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,756	10,399	2
EN4 0LY	E02000025	Barnet 002	1.4	16.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	10,156	10,799	2
EN4 8HR	E02000026	Barnet 003	2.7	9.6	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,956	10,599	2
EN5 2AL	E02000027	Barnet 004	0.5	21.5	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	4	7,313	7,956	0
EN4 0AD	E02000028	Barnet 005	2	13.1	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,598	10,241	3
EN4 8AA	E02000029	Barnet 006	2	13.7	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	8,166	8,809	0
EN5 2AA	E02000030	Barnet 007	1.2	12.9	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	8,517	9,160	2
EN5 1BJ	E02000031	Barnet 008	1.7	10.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,130	9,773	0
EN4 8JR	E02000032	Barnet 009	3.1	8.0	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	4	7,294	7,937	1
EN4 8ER	E02000033	Barnet 010	2.7	18.6	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	7,857	8,500	2
N12 8QR	E02000034	Barnet 011	2.6	15.0	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	8,537	9,180	2
N12 0DX	E02000035	Barnet 012	2.8	14.1	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	8,508	9,151	2
HA8 8BY	E02000036	Barnet 013	2.9	17.0	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,313	9,956	2
HA7 4LS	E02000037	Barnet 014	3.6	15.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	7	10,743	11,386	3
N11 1PX	E02000038	Barnet 015	2.9	15.4	North Middlesex	North Middlesex NHS Trust	5	9,741	10,384	1
NW7 0AA	E02000039	Barnet 016	2.7	10.9	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	10,514	11,157	3
N12 7BN	E02000040	Barnet 017	2.6	18.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	5	7,675	8,318	1
HA8 0BD	E02000041	Barnet 018	3.3	17.7	Northwick Park	North West London NHS Trust	5	8,297	8,940	1
N12 0AA	E02000042	Barnet 019	3.3	16.3	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,811	10,454	1
N12 7AA	E02000043	Barnet 020	2.5	8.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	7	10,639	11,282	3
HA8 0DZ	E02000044	Barnet 021	3.5	23.1	Northwick Park	North West London NHS Trust	6	9,896	10,539	1
N10 1AA	E02000045	Barnet 022	2.4	22.2	Whittington hospital	Whittington Hospital NHS Trust	4	9,071	9,714	1
N3 1AA	E02000046	Barnet 023	3.2	14.2	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	10,237	10,880	2
HA8 0AA	E02000047	Barnet 024	3.1	26.4	Northwick Park	North West London NHS Trust	6	10,163	10,806	2
N3 1AY	E02000048	Barnet 025	3.4	12.5	Whittington hospital	Whittington Hospital NHS Trust	7	11,373	12,016	1
NW7 2LA	E02000049	Barnet 026	3.3	37.0	Barnet Hospital	Barnet & Chase Farm Hospitals NHS Trust NHS Trust	6	9,817	10,460	2
N10 1JW	E02000050	Barnet 027	2.8	21.6	Whittington hospital	Whittington Hospital NHS Trust	5	8,503	9,146	1
N3 1BF	E02000051	Barnet 028	3.4	13.1	Whittington hospital	Whittington Hospital NHS Trust	6	10,064	10,707	3
N2 0AU	E02000052	Barnet 029	2.1	16.8	Whittington hospital	Whittington Hospital NHS Trust	5	8,647	9,290	2
NW4 4SF	E02000053	Barnet 030	2.8	19.3	Northwick Park	North West London NHS Trust	6	9,698	10,341	2
NW4 1AA	E02000054	Barnet 031	3.6	15.2	Royal Free	Roya Free NHS Trust London	5	8,697	9,340	2
NW4 1AB	E02000055	Barnet 032	3.7	18.5	Royal Free	Roya Free NHS Trust London	5	8,206	8,849	1
N2 0AA	E02000056	Barnet 033	1.9	9.0	Whittington hospital	Whittington Hospital NHS Trust	4	11,130	11,773	2
NW11 9JQ	E02000057	Barnet 034	2.8	16.1	Royal Free	Roya Free NHS Trust London	6	9,212	9,855	1
N3 3JR	E02000058	Barnet 035	2.8	10.3	Royal Free	Roya Free NHS Trust London	6	10,484	11,127	2
NW2 1LY	E02000059	Barnet 036	3.2	24.7	Royal Free	Roya Free NHS Trust London	6	10,220	10,863	2
NW11 0AG	E02000060	Barnet 037	2.8	12.5	Royal Free	Roya Free NHS Trust London	6	10,459	11,102	3
NW11 0NX	E02000061	Barnet 038	2.1	11.8	Royal Free	Roya Free NHS Trust London	7	10,920	11,563	2
NW11 9EH	E02000062	Barnet 039	2.4	29.7	Royal Free	Roya Free NHS Trust London	5	8,013	8,656	1
NW11 8HZ	E02000063	Barnet 040	2.2	20.5	Royal Free	Roya Free NHS Trust London	6	9,940	10,583	1
NW11 8DE	E02000064	Barnet 041	1.6	23.5	Royal Free	Roya Free NHS Trust London	5	7,971	8,614	0
DA18 4AA	E02000065	Bexley 001	4.5	23.4	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	10,114	10,757	1
DA17 5DH	E02000066	Bexley 002	3.5	32.4	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	7,773	8,416	0
DA17 5AA	E02000067	Bexley 003	4.3	27.7	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	9,748	10,391	1
DA17 6AA	E02000068	Bexley 004	4.9	29.4	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	8,857	9,500	1
DA17 5BW	E02000069	Bexley 005	4.3	20.3	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	7,495	8,138	1
SE2 0AA	E02000070	Bexley 006	3.2	13.7	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	6,301	6,944	0
DA17 6LL	E02000071	Bexley 007	4.4	17.3	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	7,982	8,625	1
DA1 5QJ	E02000072	Bexley 008	2.9	34.2	Darent Valley Hospital	Outside London	6	7,407	8,050	1
DA16 1AR	E02000073	Bexley 009	3	8.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	10,341	10,984	2
DA1 4FB	E02000074	Bexley 010	3.9	31.0	Darent Valley Hospital	Outside London	4	10,831	11,474	1
DA7 4DS	E02000075	Bexley 011	4	9.3	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	7,762	8,405	1
DA16 1DE	E02000076	Bexley 012	3	18.6	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	8,055	8,698	0
DA1 4RA	E02000077	Bexley 013	2.9	14.6	Darent Valley Hospital	Outside London	4	7,930	8,573	1
DA16 1AN	E02000078	Bexley 014	3.9	11.0	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	7,772	8,415	1
DA15 8PF	E02000079	Bexley 015	2.7	13.0	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	7,972	8,615	1
DA1 4DL	E02000080	Bexley 016	4.7	12.1	Darent Valley Hospital	Outside London	5	9,537	10,180	2
DA15 8PA	E02000081	Bexley 017	2.9	14.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	7,620	8,263	1
DA1 3LD	E02000082	Bexley 018	3.3	9.4	Darent Valley Hospital	Outside London	4	8,983	9,626	1
DA16 1AA	E02000083	Bexley 019	3.6	21.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	9,878	10,521	2
DA15 8LN	E02000084	Bexley 020	3.2	8.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	10,748	11,391	2
DA15 8AZ	E02000085	Bexley 021	2.8	11.7	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	6	8,000	8,643	1
DA5 1AA	E02000086	Bexley 022	4.7	7.2	Darent Valley Hospital	Outside London	3	7,435	8,078	1
DA14 4JB	E02000087	Bexley 023	4.1	7.0	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	2	7,686	8,329	1
DA14 6QG	E02000088	Bexley 024	3.6	9.1	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	7,844	8,487	1
DA14 4AG	E02000089	Bexley 025	4	7.4	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	7,890	8,533	1
DA14 4AA	E02000090	Bexley 026	4.4	11.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	5	8,833	9,476	1
DA14 4PH	E02000091	Bexley 027	4.6	12.7	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	4	9,789	10,432	1
DA144PH	E02000092	Bexley 028	4.6	30.8	Queen Elizabeth Hospital	Lewisham and Greenwich NHS Trust	3	6,530	7,173	0
HA7 1EF	E02000093	Brent 001	1.9	21.1	Northwick Park Hospital A&E	North West London NHS Trust	5	6,491	7,134	0
NW9 0AA	E02000094	Brent 002	2.8	24.1	Northwick Park Hospital A&E	North West London NHS Trust	8	11,106	11,749	3
HA3 0SH	E02000095	Brent 003	1.2	23.6	Northwick Park Hospital A&E	North West London NHS Trust	7	8,969	9,612	2
HA3 0AJ	E02000096	Brent 004	1	14.7	Northwick Park Hospital A&E	North West London NHS Trust	6	10,144	10,787	3
NW9 0XD	E02000097	Brent 005	2.7	23.3	Northwick Park Hospital A&E	North West London NHS Trust	5	7,821	8,464	2
HA3 0PS	E02000098	Brent 006	1.2	25.1	Northwick Park Hospital A&E	North West London NHS Trust	4	9,181	9,824	2
HA3 0PT	E02000099	Brent 007	1.2	23.8	Northwick Park Hospital A&E	North West London NHS Trust	5	8,167	8,810	2

Sources: Greater London Authority and Office for National Statistics (2014)

B) Locations of A&E departments in London

A&E department	Address	PostCode	City	Longitude	Latitudes
Barnet Hospital	Wellhouse Lane, Barnet	EN5 3DJ	London	-0.215544	51.6509897
Central London Com.	64 Victoria Street, London	SW1E 6QP	London	-0.1375024	51.49766
Charing Cross Hospital	Fulham Palace Road, London	W6 8RF	London	-0.219935	51.487054
Chelsea & Westminster	369 Fulham Road, London	SW10 9NH	London	-0.1814587	51.4842605
Croydon NHS	530 London Road, Croydon	CR7 7YE	London	-0.1087831	51.3891287
Ealing Hospital	Uxbridge Road, Southall, Middlesex	UB1 3HW	London	-0.346339	51.506988
Epsom Hospital	Wrythe Lane, Carshalton, Surrey	SM5 1AA	London	-0.267382	51.336036
Guys St Thomas	Westminster Bridge Road, London	SE1 7EH	London	-0.1196707	51.4979079
Hillingdon Hospital	Pield Heath Road, Uxbridge, Middlesex	UB8 3NN	London	-0.4609053	51.5255156
Homerton Hospital	Homerton Row, London	E9 6SR	London	-0.0460987	51.5506338
King George Hospital	Barley Lane, Goodmayes, Essex	IG3 8YB	London	0.1121069	51.5805448
King's College	Denmark Hill, London	SE5 9RS	London	-0.0923059	51.4683569
Kingston NHS	Galsworthy Road, Kingston upon Thames	KT2 7QB	London	-0.2830899	51.4142847
Lewisham Hospital	High Street Lewisham	SE13 6LH	London	-0.0170508	51.4543295
Newham Hospital	Glen Road, Plaistow, London	E13 8SL	London	0.0353906	51.5230076
North Middlesex	Wilbury Way, London	N18 1BX	London	-0.0810894	51.6123512
Northwick Park Hospital	Watford Road, Harrow	HA1 3UJ	London	-0.3224814	51.5750985
Queen Elizabeth Hospital	Stadium Road, London	SE18 4QH	London	0.0511479	51.4790733
Queen's Hospital	Rom Valley Way, Romford, Essex	RM7 0AG	London	0.178914	51.5686218
Royal Free NHS	Pond Street, London	NW3 2QG	London	-0.1661535	51.55387
Royal London Hospital	Whitechapel Road, Whitechapel, London	E1 1BB	London	-0.058075	51.5190259
Princess Royal	Princess Royal University Hospital, Farnborough Common	BR6 8ND	London	0.0596255	51.3657134
St George's Hospital	Blackshaw Road, London	SW17 0QT	London	-0.1757459	51.4267274
St Mary's Hospital	Praed Street, Paddington London	W2 1NY	London	-0.1742119	51.5171233
University College London	235 Euston Road, Fitzrovia, London	NW1 2BU	London	-0.1370125	51.5248655
West Middlesex	Twickenham Road, Isleworth, Middlesex	TW7 6AF	London	-0.326169	51.47408
Whipps Cross Hospital	Whipps Cross Road, Leytonstone, London	E11 1NR	London	0.0026384	51.5788311
Whittington NHS	Magdala Avenue, London	N19 5NF	London	-0.1394029	51.5665141
Chase Farm Hospital	The Ridgeway, Enfield	EN2 8JL	London	-0.1036391	51.6663122
St Helier Hospital	Wrythe Lane, Carshalton, Surrey	SM5 1AA	London	-0.1831914	51.3800725
Hounslow & Richmond NHS Trust	Thames House, 180 High Street, Teddington	TW118HU	London	-0.3266145	51.4274317

Data source: Greater London Authority (2014)

Appendix 9 MSOA/Borough CCGs, population and IMD ranks. 1- Most **deprived** and 300 least deprived.

MSOA Health Care Commissioning Group	EST. MSOA population	Av rank IMD Rank
Barking and Dagenham CCG	201,000	22
Barnet CCG	384,600	176
Bexley CCG	233,500	174
Brent CCG	318,800	35
Bromley CCG	315,800	203
Camden CCG	226,000	74
City and Hackney CCG	262,400	2
Croydon CCG	373,400	107
Ealing CCG	345,800	80
Enfield CCG	314,000	64
Greenwich CCG	275,100	28
Hammersmith and Fulham CCG	188,200	55
Haringey CCG	263,700	13
Harrow CCG	242,600	194
Havering CCG	247,500	177
Hillingdon CCG	283,700	138
Hounslow CCG	258,000	118
Islington CCG	217,000	14
Kensington & Chelsea /W. London CCG	160,900	103
Kingston upon Thames CCG	164,700	255
Lambeth CCG	315,400	29
Lewisham CCG	287,400	31
Merton CCG	203,200	208
Newham CCG	331,400	3
Redbridge CCG	288,200	134
Richmond CCG	190,700	285
Southwark CCG	304,100	41
Sutton CCG	193,100	196
Tower Hamlets CCG	273,100	7
Waltham Forest CCG	266,900	15
Wandsworth CCG	319,300	121
Westminster CCG	228,200	87

Level of CCGs based on boroughs in London and their respective levels of deprivation and population. Data compiled from Greater London Authority (2014)

Appendix 10 Healthcare access in Hounslow per year, week and day

Yearly, weekly and daily access to healthcare in Hounslow

Time	Annual	Weekly	daily
00:00:00	7,769	149	21.29
01:00:00	7,404	142	20.29
02:00:00	7,091	136	19.43
03:00:00	6,987	134	19.14
04:00:00	6,831	131	18.71
05:00:00	6,883	132	18.86
06:00:00	6,726	129	18.43
07:00:00	7,039	135	19.29
08:00:00	7,456	143	20.43
09:00:00	8,291	159	22.71
10:00:00	9,021	173	24.71
11:00:00	9,594	184	26.29
12:00:00	9,699	186	26.57
13:00:00	9,542	183	26.14
14:00:00	9,438	181	25.86
15:00:00	9,073	174	24.86
16:00:00	9,334	179	25.57
17:00:00	9,386	180	25.71
18:00:00	9,334	179	25.57
19:00:00	9,125	175	25.00
20:00:00	9,229	177	25.29
21:00:00	8,916	171	24.43
22:00:00	8,656	166	23.71
23:00:00	8,030	154	22.00
Sum	200,854	3,852	550.29

Data compiled from (Health and Social Care Information Centre, 2015b)

Appendix 11 GP practices in the London borough of Hounslow

- 303 Bath Road Surgery
- Albany Practice
- Bath Road Surgery
- Blue Wing Family Doctor Unit
- Brentford Family Practice
- Brentford Group Practice
- Carlton Surgery
- Chestnut Practice
- Chiswick Family Practice
- Chiswick Health Practice
- Clifford House Medical Centre
- Clifford Road Surgery
- Cole Park Surgery
- Cranford Medical Centre
- Crosslands Surgery
- Dr Sood
- Firstcare Practice
- Gill Medical Practice
- Glebe Street
- Green Practice
- Greenbrook Bedfont
- Greenbrook Great West
- Greenbrook Heston
- Greenbrook Isleworth
- Greenbrook Manor
- Grove Park
- Grove Park Terrace
- Grove Village Medical Centre
- Hatton Medical Practice
- Holly Road
- Hounslow Family Practice
- Hounslow Medical Practice
- Jersey Practice
- Kingfisher Practice
- Little Park Surgery
- Manor House Practice
- Mount Medical Centre
- North Hyde Medical Practice
- Pentelow Practice
- Queens Park Medical Practice
- Redwood Practice
- Skyways Medical Centre?
- Spring Grove Medical
- St David? s Practice
- St Margaret? s Medical Practice
- The Practice Feltham
- The Practice HOH
- Thornbury Centre for Health
- Twickenham Park Medical Practice
- Wellesley Road
- West4GP
- Willow Practice

Appendix 12 Regional population distribution of Hounslow

Region	Population
Bedfont	13,280
Brentford	16,143
Chiswick Homefields	11,976
Chiswick Riverside	12,056
Cranford	13,077
Feltham North	12,198
Feltham West	16,154
Hanworth	12,743
Hanworth Park	12,587
Heston Central	12,958
Heston East	13,025
Heston West	13,071
Hounslow Central	16,535
Hounslow Heath	15,576
Hounslow South	12,015
Hounslow West	14,088
Isleworth	12,489
Osterley and Spring Grove	13,683
Syon	14,529
Turnham Green	12,147
Total	270,330

Source: Hounslow Ward Atlas 2014.

Appendix 13 Summary of structural and patients' factors affecting process in unscheduled urgent and emergency healthcare

1. **Structural**

➢ Where GP practices sizes are smaller patient access is low because GP practices have no room to manoeuvre.

➢ WIC are either not very visible, popular, viewed as important or their functions are confusing. Also WIC may not be economically viable

➢ Location of GPs in A&E departments have been identified as a good reason for patients to access A&E department more while making the other access point more obscure

➢ GP-patient size or GP list size has shown to reduce access to GPs.

➢ Free access to A&E where process is not respected

➢ Many access points with patient left still seeking healthcare

2. **Patients**

➢ Patient need to visibly see doctor or a medic to gain assurance of their ailment

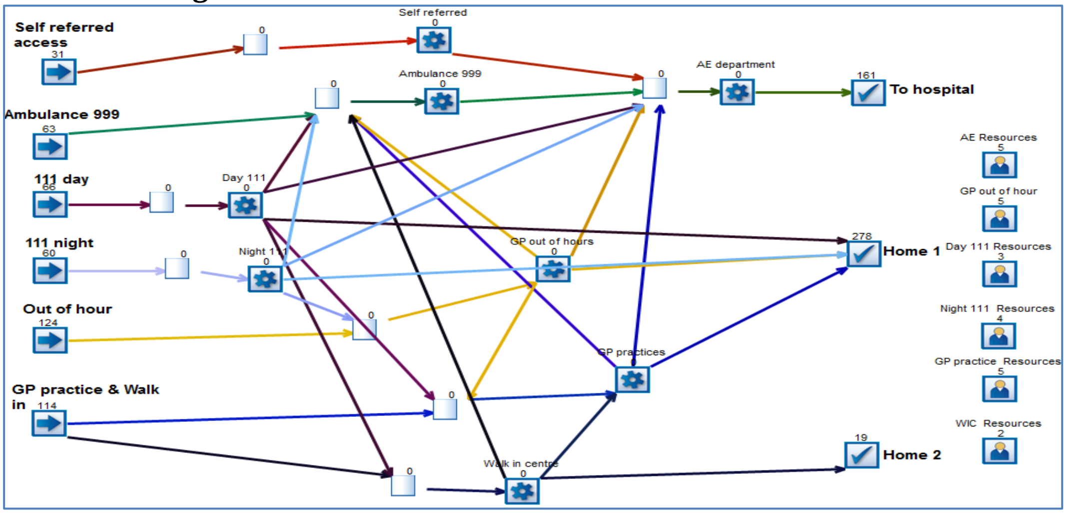
➢ Trust-patients are seeking a trusted medical professional in a proper medical environment.

➢ Time–economic pressure means that patients have limited times to juggle with schedules of GP booking systems

➢ Low knowledge of self – diagnosis. The expectation that patients have to know where to attend healthcare based on the seriousness of their illness has been debunked. These and other factors raised in this study cannot be resolved with current system. This why we have proposed as recommendation for solution developing hub models.

Appendix 14 Simulation Models

A- 75% right



Notice that with 75% correct access, 25% of patients access A&E as self-referred unlike with 100% right where no person attended A&E as self-referred.

B- Simulation results 75% right

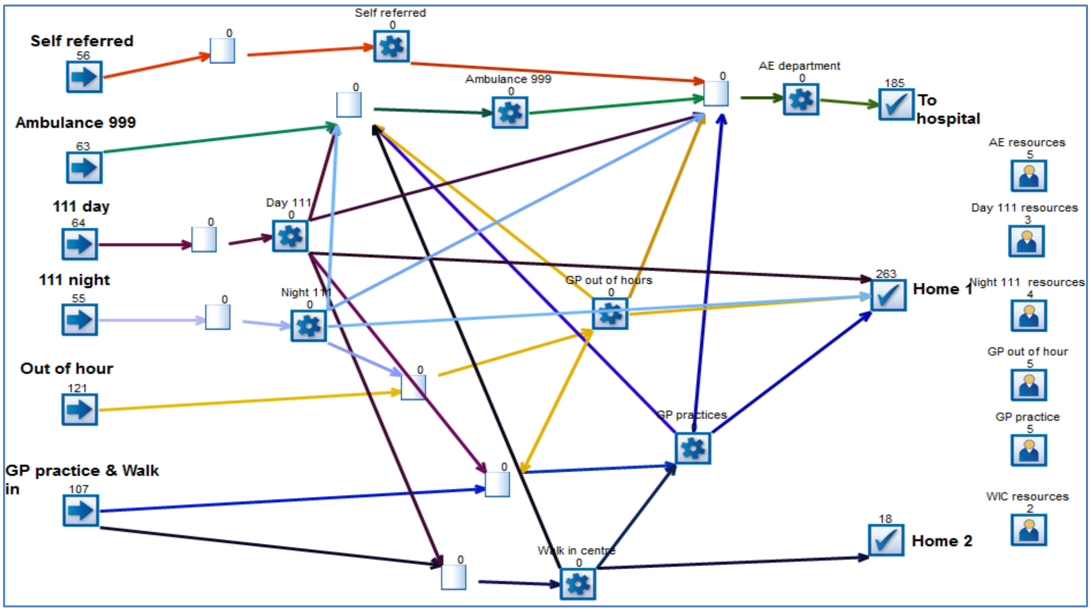
SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	45.21	52.29	59.37	
Queue for Day 111	Average Queuing Time	3.71	3.87	4.02	
Queue for Night 111	Average Queuing Time	2.69	2.85	3.00	
Queue for GP out of hours	Average Queuing Time	7.40	7.69	7.98	
Queue for GP practices	Average Queuing Time	2.58	2.72	2.87	
Queue for Walk in centre	Average Queuing Time	2.47	2.93	3.38	
Queue for Ambulance 999	Average Queuing Time	0.13	0.16	0.19	
AE department	Number Completed Jobs	158.37	159.97	161.57	
Day 111	Number Completed Jobs	66.00	66.00	66.00	
Night 111	Number Completed Jobs	60.00	60.00	60.00	
GP out of hours	Number Completed Jobs	140.00	140.61	141.22	
GP practices	Number Completed Jobs	160.35	161.73	163.11	75% right
Walk in centre	Number Completed Jobs	25.43	26.33	27.23	
Self referred	Number Completed Jobs	31.00	31.00	31.00	
Ambulance 999	Number Completed Jobs	77.45	78.22	78.99	
AE Resources	Utilization %	49.18	50.12	51.06	
Day 111 Resources	Utilization %	9.08	9.30	9.51	
Night 111 Resources	Utilization %	3.78	3.87	3.96	
GP out of hour	Utilization %	11.47	11.67	11.87	
GP practice Resources	Utilization %	19.86	20.20	20.54	
WIC Resources	Utilization %	7.89	8.25	8.62	
Queue for Self referred	Average Queuing Time	0.00	0.00	0.00	

C- 50% right

Model



Simulation model of how patient access unscheduled urgent and emergency care 50% right

D- 50% right Simulation results

SIMUL8 CORPORATION Results Manager

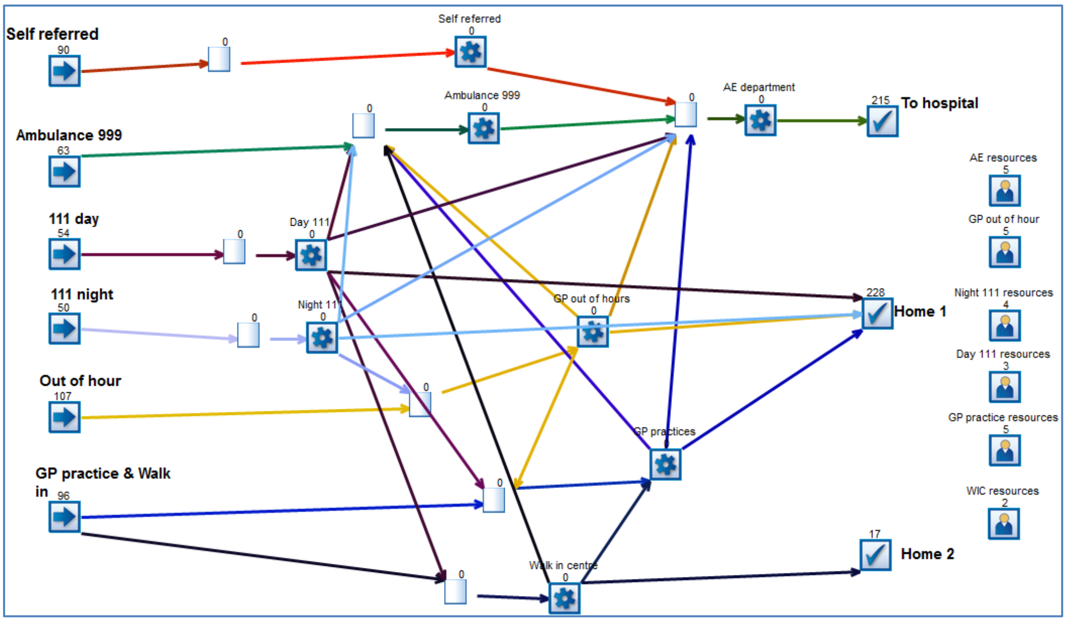
KPIs | KPI History | Scenarios | All Object Results | Custom Reports

		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	96.73	106.16	115.59	
Queue for Day 111	Average Queuing Time	3.37	3.50	3.63	
Queue for Night 111	Average Queuing Time	2.21	2.35	2.49	
Queue for GP out of hours	Average Queuing Time	5.90	6.16	6.41	
Queue for GP practices	Average Queuing Time	2.21	2.33	2.44	
Queue for Walk in centre	Average Queuing Time	2.22	2.66	3.10	
Queue for Ambulance 999	Average Queuing Time	0.13	0.17	0.20	
AE department	Number Completed Jobs	180.78	182.36	183.94	
Day 111	Number Completed Jobs	64.00	64.00	64.00	
Night 111	Number Completed Jobs	55.00	55.00	55.00	
GP out of hours	Number Completed Jobs	135.71	136.28	136.85	50% right
GP practices	Number Completed Jobs	152.53	153.87	155.21	
Walk in centre	Number Completed Jobs	24.02	24.89	25.76	
Self referred	Number Completed Jobs	56.00	56.00	56.00	
Ambulance 999	Number Completed Jobs	76.84	77.61	78.38	
AE resources	Utilization %	56.33	57.30	58.27	
Day 111 resources	Utilization %	8.76	8.98	9.19	
Night 111 resources	Utilization %	2.90	2.97	3.05	
GP out of hour	Utilization %	11.14	11.34	11.54	
GP practice	Utilization %	18.89	19.23	19.58	
WIC resources	Utilization %	7.48	7.84	8.19	

Simulation results when patient access unscheduled urgent and emergency care 50% right

E- 25% right

Model



Simulation model of how patient access unscheduled urgent and emergency care 25% right

F- Simulation results

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

25% right

		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	170.46	181.64	192.82	
Queue for Day 111	Average Queuing Time	2.30	2.41	2.52	
Queue for Night 111	Average Queuing Time	2.13	2.28	2.43	
Queue for GP out of hours	Average Queuing Time	4.49	4.71	4.93	
Queue for GP practices	Average Queuing Time	1.56	1.69	1.81	
Queue for Walk in centre	Average Queuing Time	1.72	2.14	2.56	
Queue for Ambulance 999	Average Queuing Time	0.14	0.17	0.21	
AE department	Number Completed Jobs	207.27	208.66	210.05	
Day 111	Number Completed Jobs	54.00	54.00	54.00	
Night 111	Number Completed Jobs	50.00	50.00	50.00	
GP out of hours	Number Completed Jobs	119.55	120.12	120.69	
GP practices	Number Completed Jobs	135.76	137.10	138.44	
Walk in centre	Number Completed Jobs	21.18	21.98	22.78	
Self referred	Number Completed Jobs	90.00	90.00	90.00	
Ambulance 999	Number Completed Jobs	75.69	76.45	77.21	
AE resources	Utilization %	64.50	65.50	66.50	
Day 111 resources	Utilization %	7.35	7.53	7.71	
Night 111 resources	Utilization %	3.18	3.26	3.35	
GP out of hour	Utilization %	9.77	9.95	10.13	
GP practice resources	Utilization %	16.84	17.17	17.51	
WIC resources	Utilization %	6.58	6.90	7.22	

Simulation results when patient access unscheduled urgent and emergency care 25% right

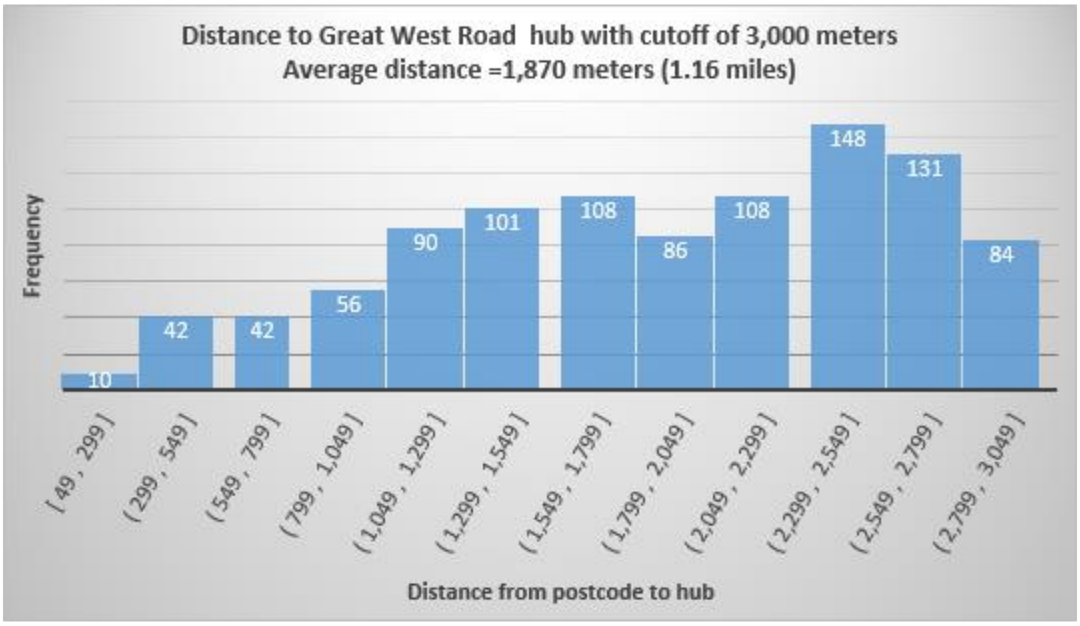
Appendices

Appendix 15 The hub models and simulation results

A) 4 hubs

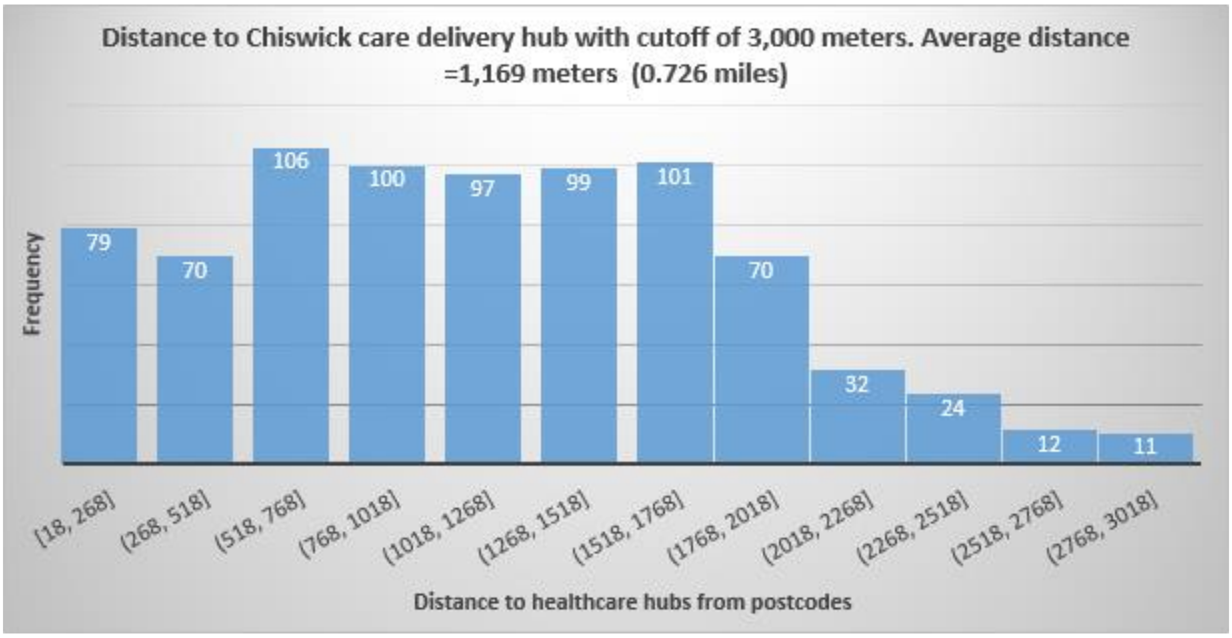
a. Distant Results and compilation

1. Great West Road



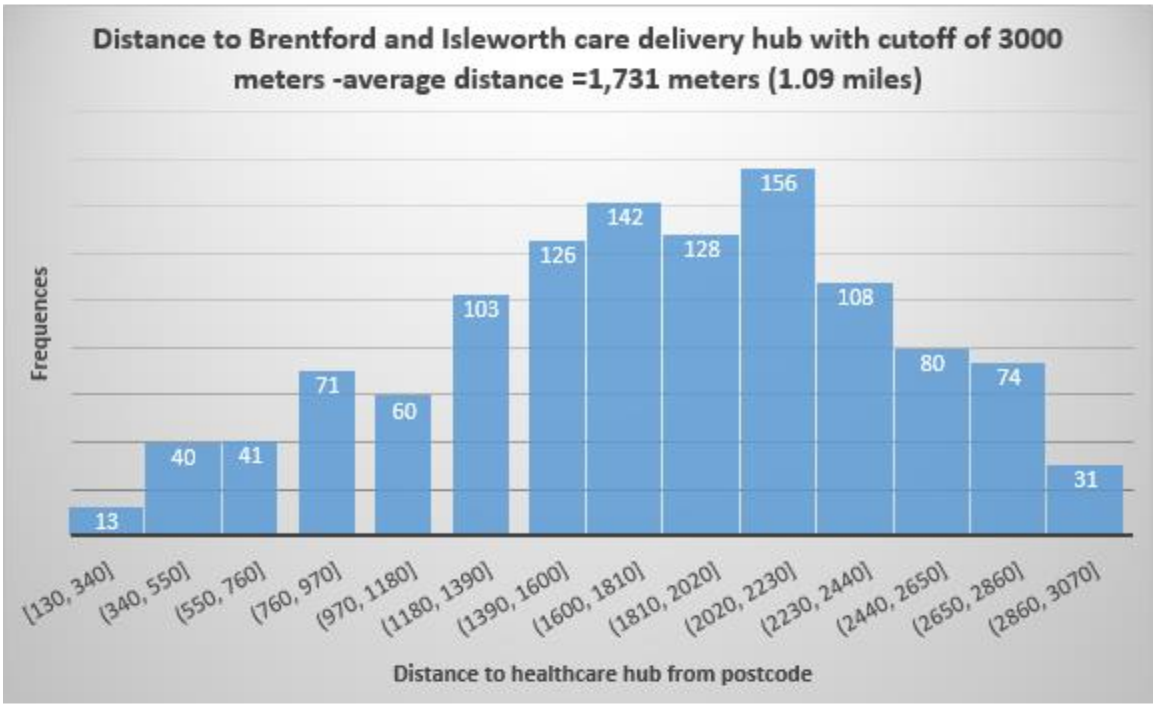
Histogram of distance from distance from postcodes to care delivery hub Great West Road care delivery hub

2. **Chiswick:** The patients in the region of Chiswick as shown on the map travelled on average 0.73 miles to access their healthcare hub.



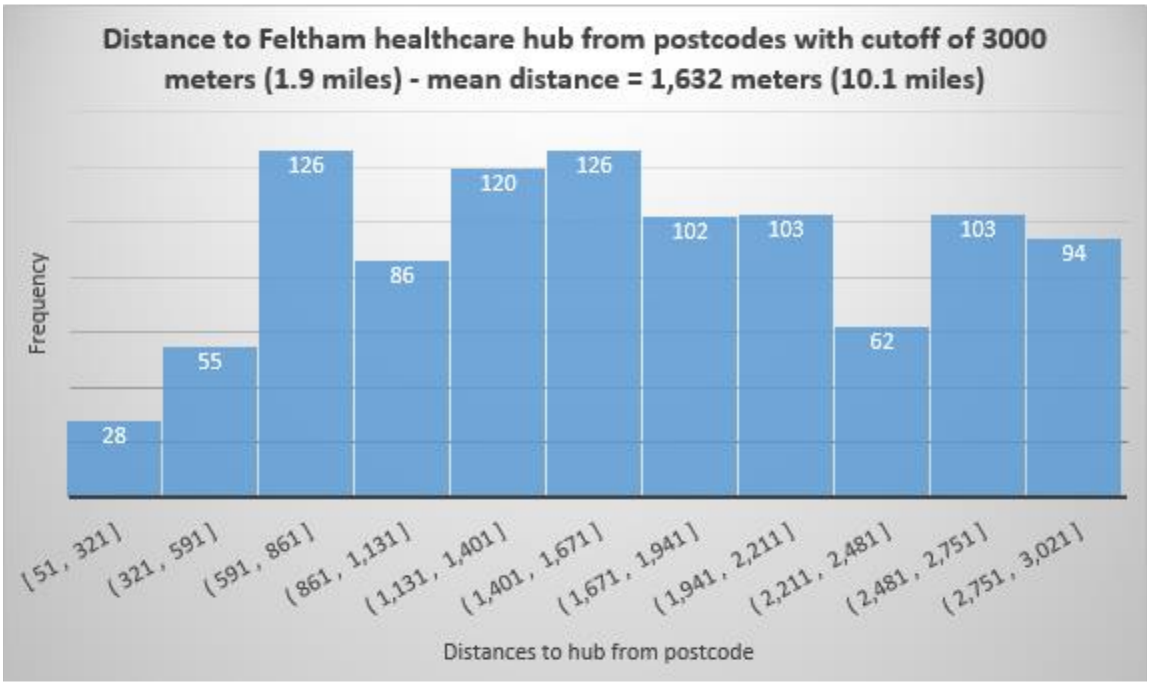
Distance from demand ID points (postcode) to Chiswick health care delivery hub

3. **Brentford and Isleworth:** With a cut-off points, the patients in this part of the brought travelled 1.09 miles to the healthcare hub as shown on this histogram.



Histogram distance from postcodes to care delivery hub in Brentford and Isleworth care delivery hub

4. **Feltham:** We posit that the patients in Feltham travelled 10.1 miles to access a healthcare hub as shown on the data presented on this histogram.

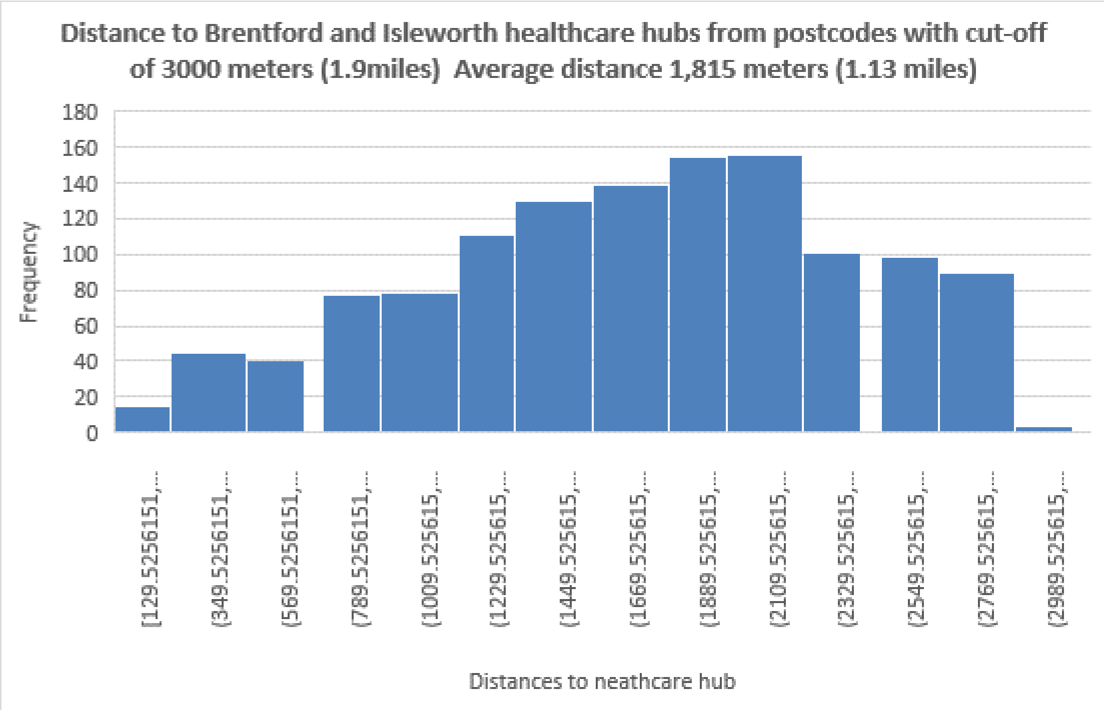


Appendices

Histogram of distance from distance from postcodes to care delivery hub Feltham health care delivery hub

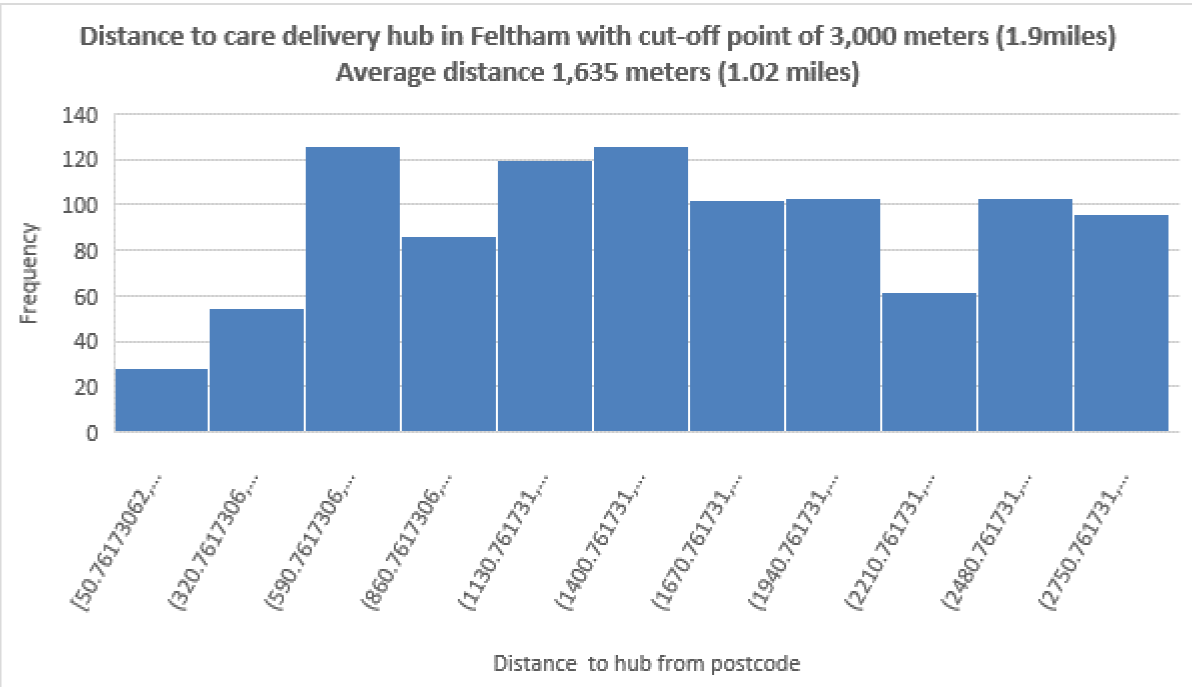
B) Comparison of the performance of the various hubs

a.



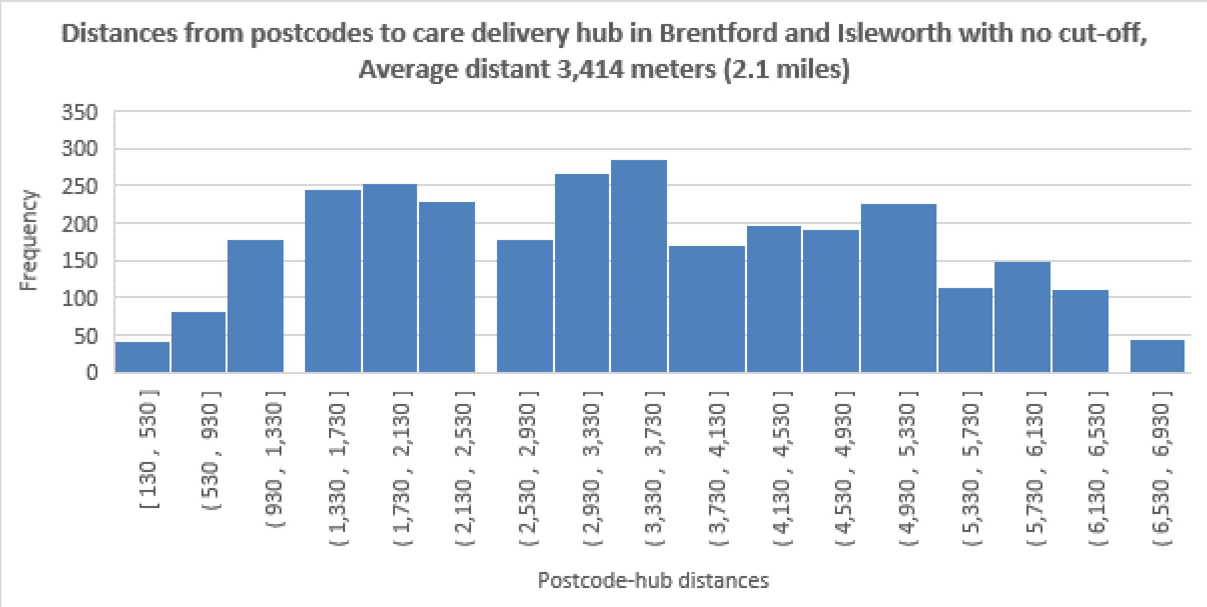
Histogram of distance from distance from postcodes to care delivery hub in Brentford and Isleworth

b.



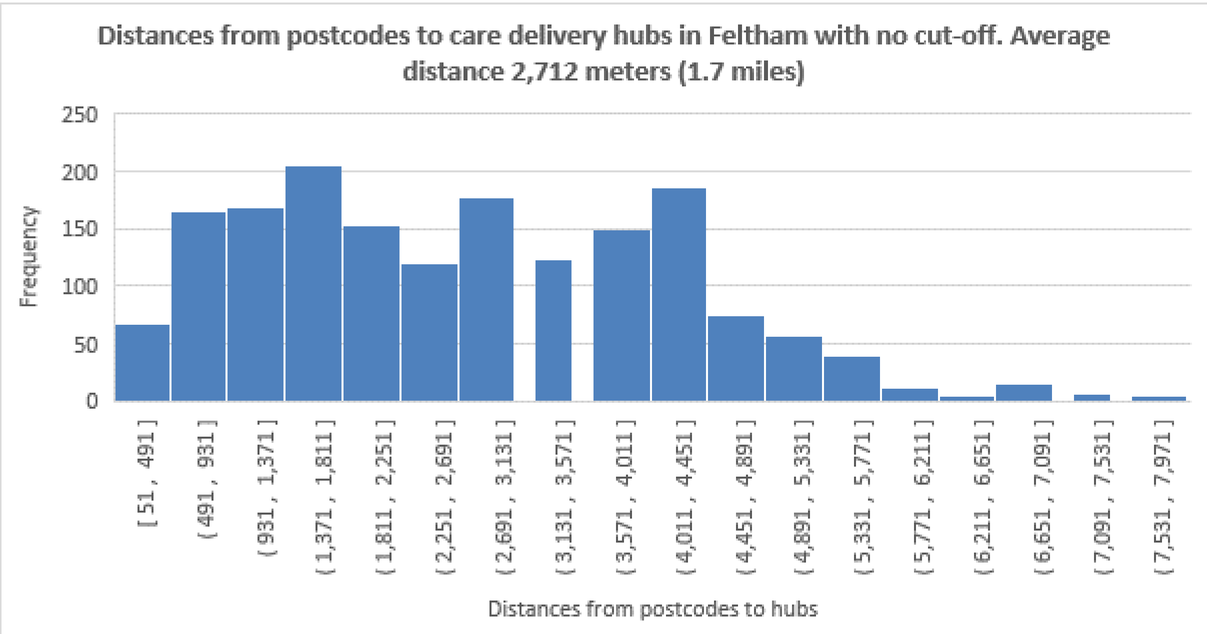
Histogram of distance from postcodes to care delivery hub in Feltham

c.



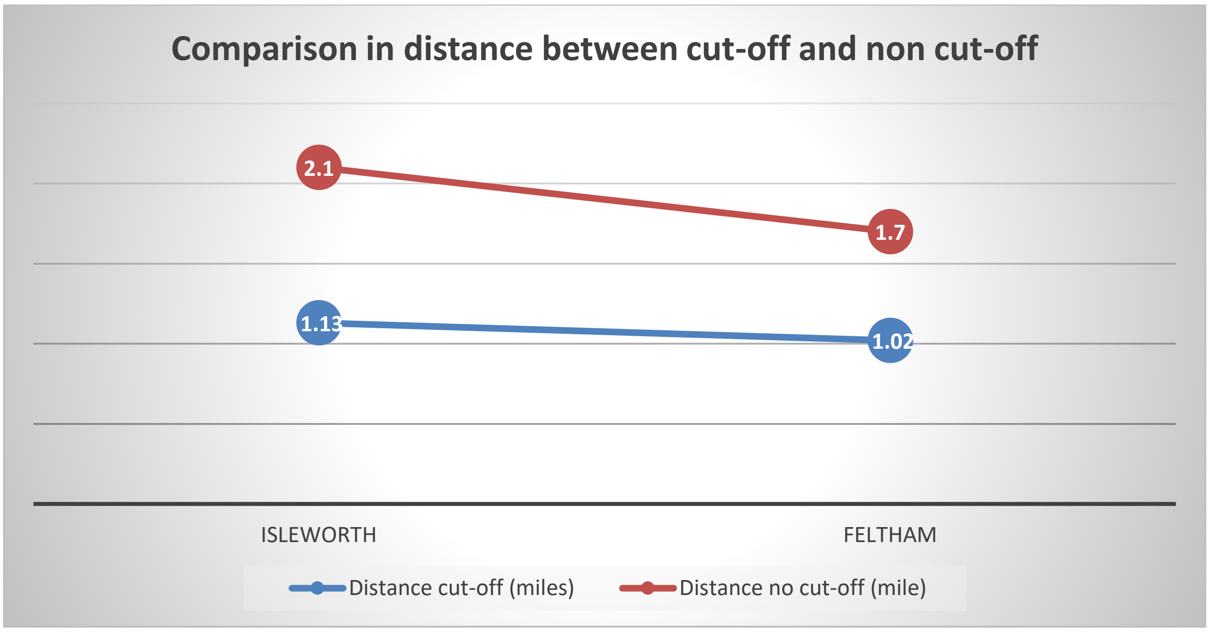
Histogram of distance from postcodes to care delivery hub in Isleworth and Brentford there is no cut-off

d.



Histogram of distance from postcodes to care delivery hub in Feltham where there is not cut off

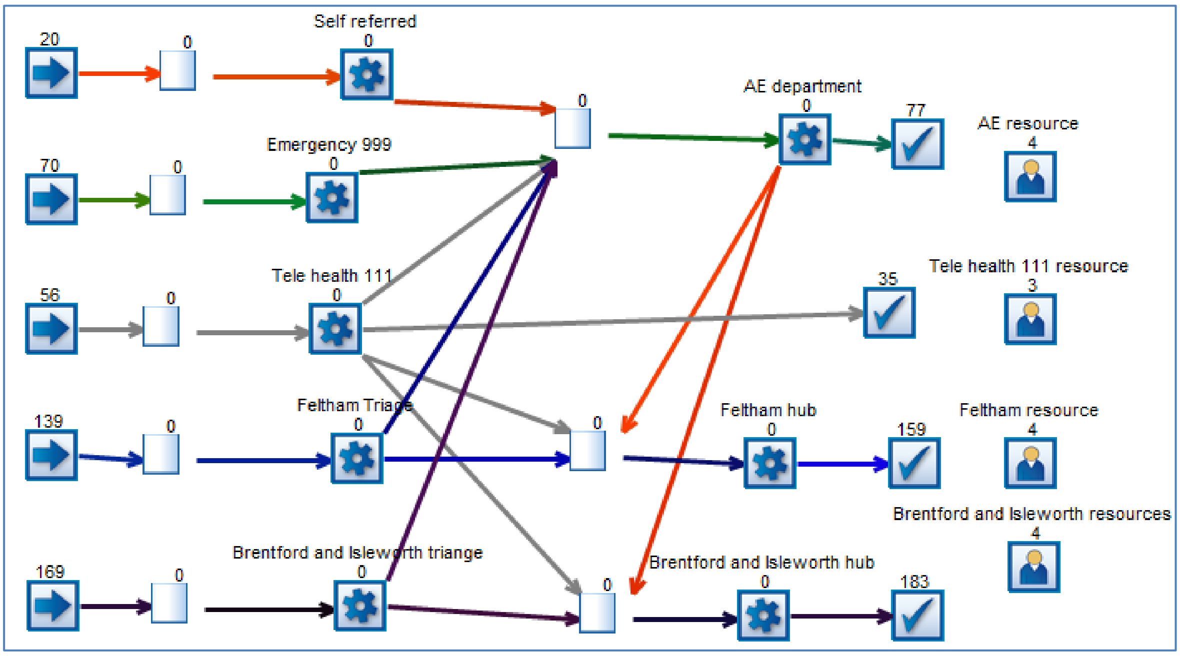
e. Summary of the distance comparison between cut-off and no cut-off



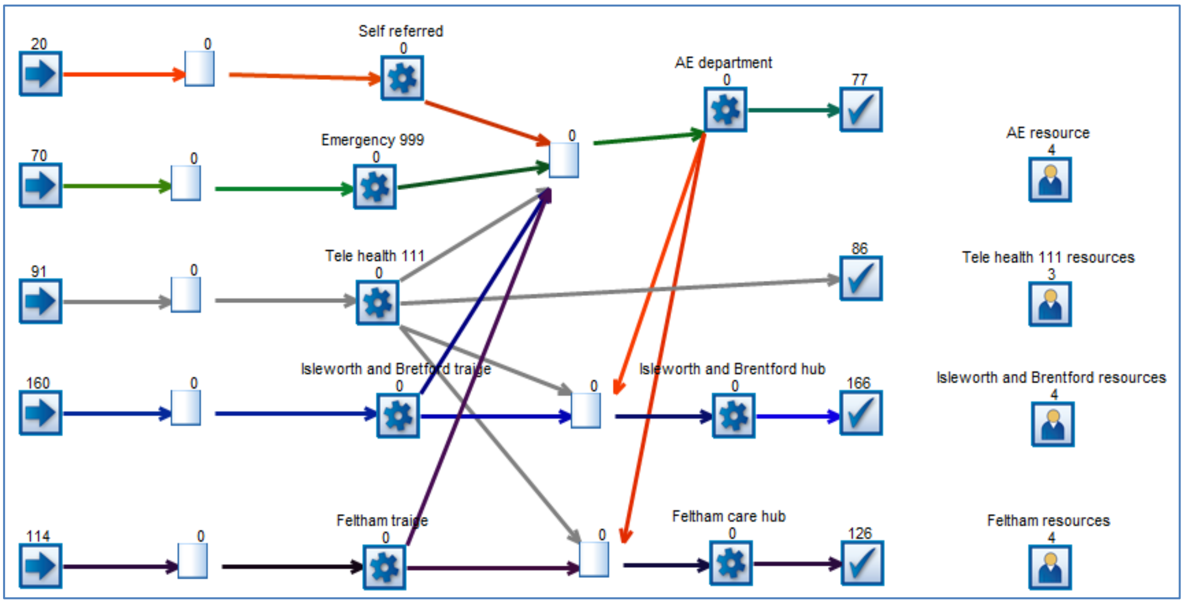
Comparing the difference between access where there was cut-off and non-cut-off

C) 2 hub Simulation model

a. The model



2-hub model where 13% accessed telephone system 111



2-hub model where 20% accessed telephone system 111

b. Simulation Results

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KPIs | KPI History | Scenarios | All Object Results | Custom Reports

2 hubs 13% 111		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	37.01	42.65	48.28	
Queue for Tele health 111	Average Queuing Time	0.15	0.17	0.19	
Queue for Feltham hub	Average Queuing Time	3.87	4.21	4.55	
Queue for Brentford and Islew	Average Queuing Time	7.82	8.58	9.35	
Tele health 111 resource	Utilization %	3.81	3.91	4.02	
Brentford and Isleworth resou	Utilization %	34.47	35.02	35.57	
Feltham resource	Utilization %	29.28	29.75	30.21	
AE resource	Utilization %	47.60	48.61	49.61	
Hopsital entry	Number Completed	74.70	76.00	77.30	
Tele health home	Number Completed	32.74	33.52	34.30	
Feltham Home	Number Completed	158.06	159.17	160.28	
Brentford and Iselworth home	Number Completed	184.09	185.31	186.53	

Outcomes from 2-hubs simulation where 13% accessed telephone system 111

Appendices

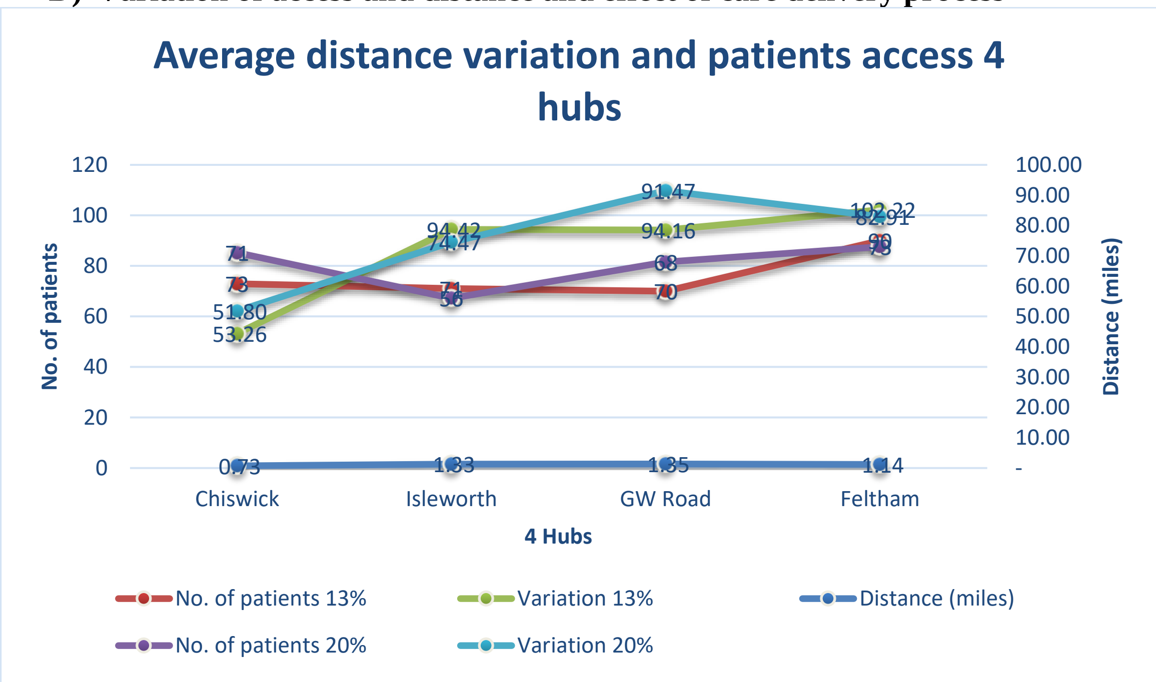
SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

2 hub 20% 111 access		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	37.33	43.06	48.79	
Queue for Isleworth and Brent	Average Queuing Time	2.86	3.04	3.23	
Queue for Feltham care hub	Average Queuing Time	1.02	1.14	1.26	
Queue for Tele health 111	Average Queuing Time	0.98	1.01	1.05	
AE resource	Utilization %	47.48	48.51	49.54	
Isleworth and Brentford resou	Utilization %	26.00	26.42	26.83	
Feltham resources	Utilization %	19.72	20.10	20.48	
Tele health 111 resources	Utilization %	6.16	6.28	6.40	
Hopsital entry	Number Completed	74.46	75.82	77.18	
Tele health 111 home	Number Completed	81.36	81.90	82.44	
Islworth home	Number Completed	168.62	169.67	170.72	
Feltham Home	Number Completed	126.47	127.61	128.75	

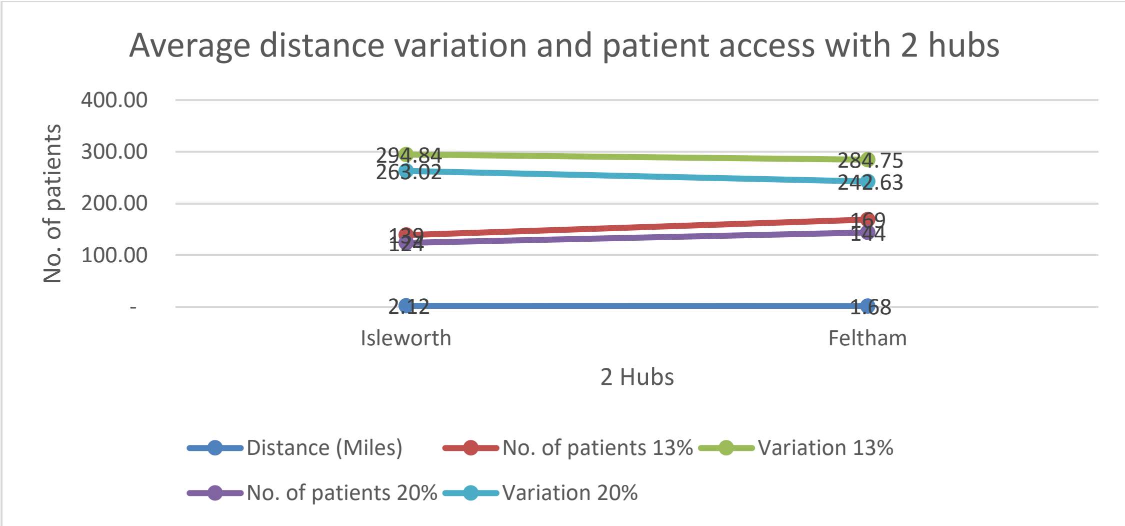
Outcomes from 2-hubs simulation where 20% accessed telephone system 111

D) Variation of access and distance and effect of care delivery process



Distances and changes in patient access to 4 care delivery hubs

E) distances and changes in patient access to 2 care delivery hubs



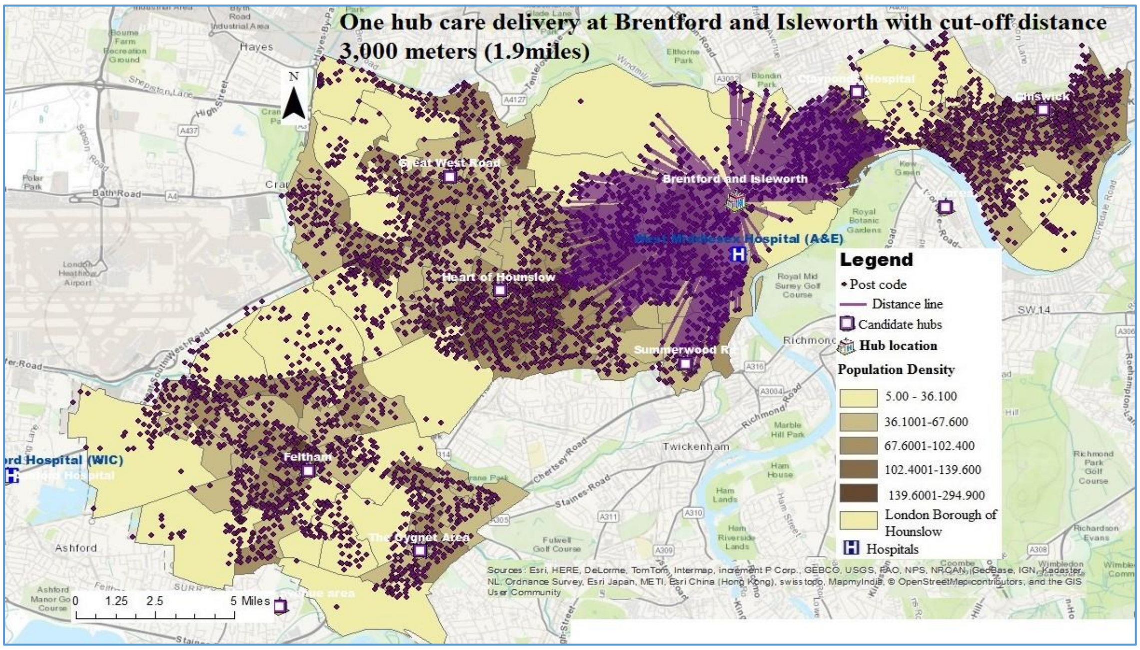
Distances and changes in patient access to two healthcare delivery hubs

Distance variation calculated with formula = Distance x number of patient attended at hubs

F) 1 hub

ArcGIS geographic selection

a. With cut-off



One hub model with cut-off of 3,000 meters

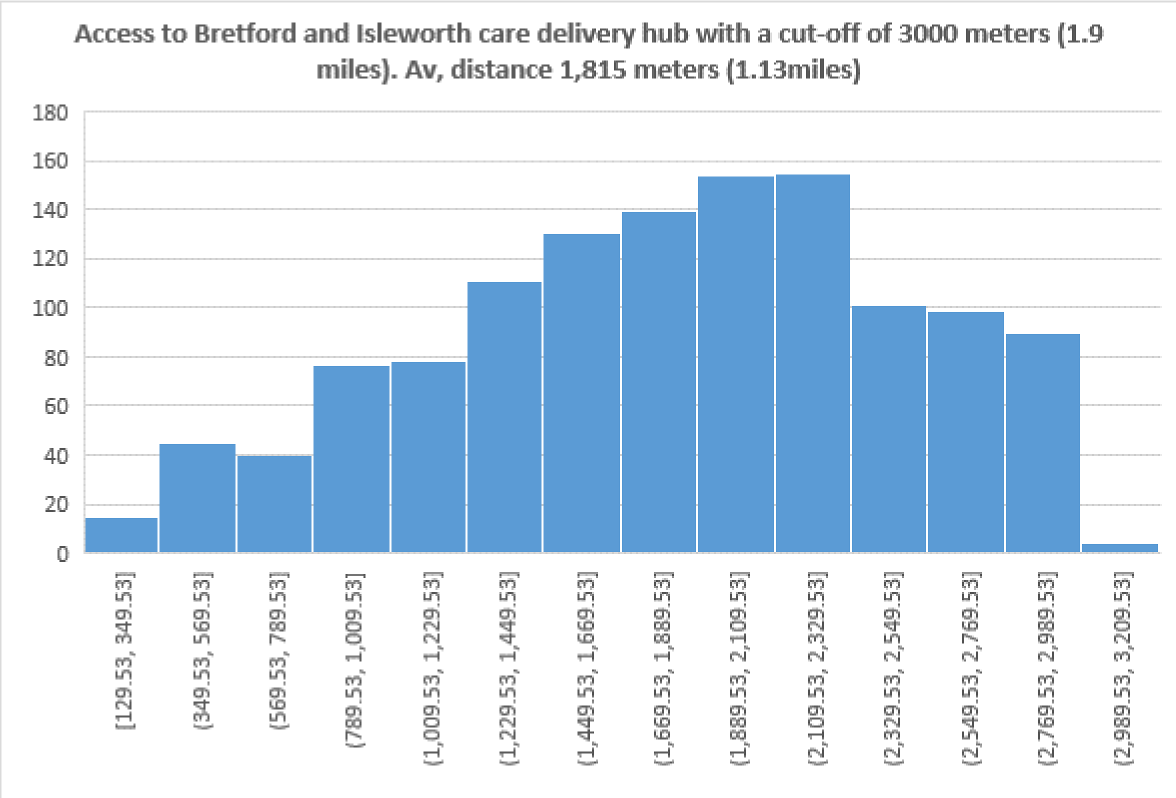
b. From the map, on figure 24 we calculated the parts of the borough that have been served and the percentage that is not served due to cut-off

Areas (postcodes) in the Borough of Hounslow served and those not served because of cut-off with one hub

Total demand points of postcodes in the borough of Hounslow	4,929
Total areas (postcodes) in the borough of Hounslow served with hub	1,238

Areas (postcodes) in the borough of Hounslow covered	**25%**
Unserved areas (postcodes) in the borough of Hounslow	3,691
Percentage unserved	**75%**

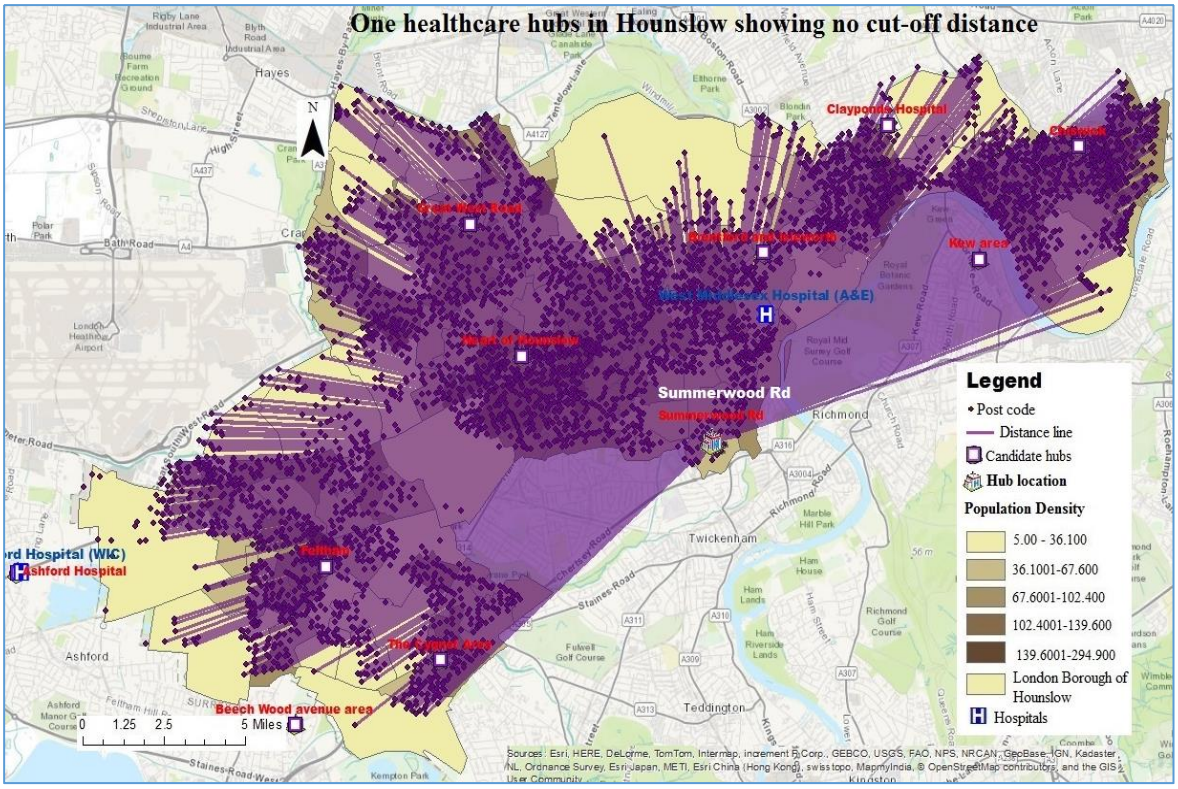
G) Histogram showing distance to Brentford and Isleworth care delivery hub with cut-off of 3,000 meters



Histogram showing distance to Brentford and Isleworth care delivery hub with cut-off of 3,000 meters

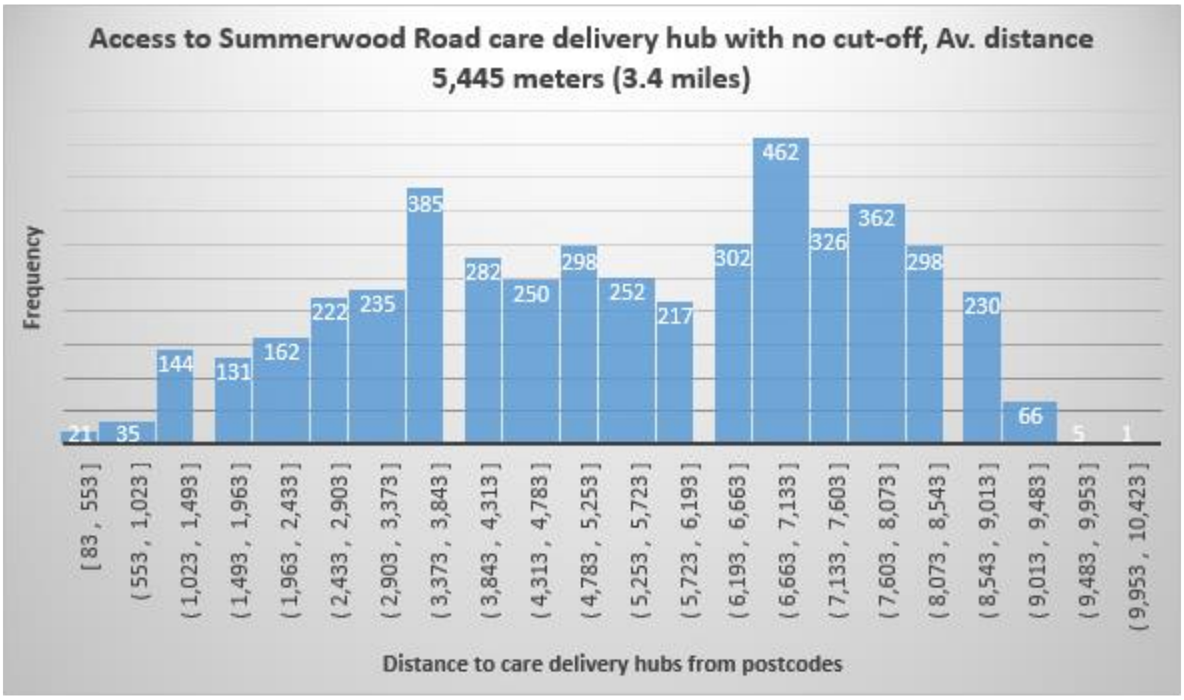
H) With no cut-off

Geographic selection where there is no cut-off



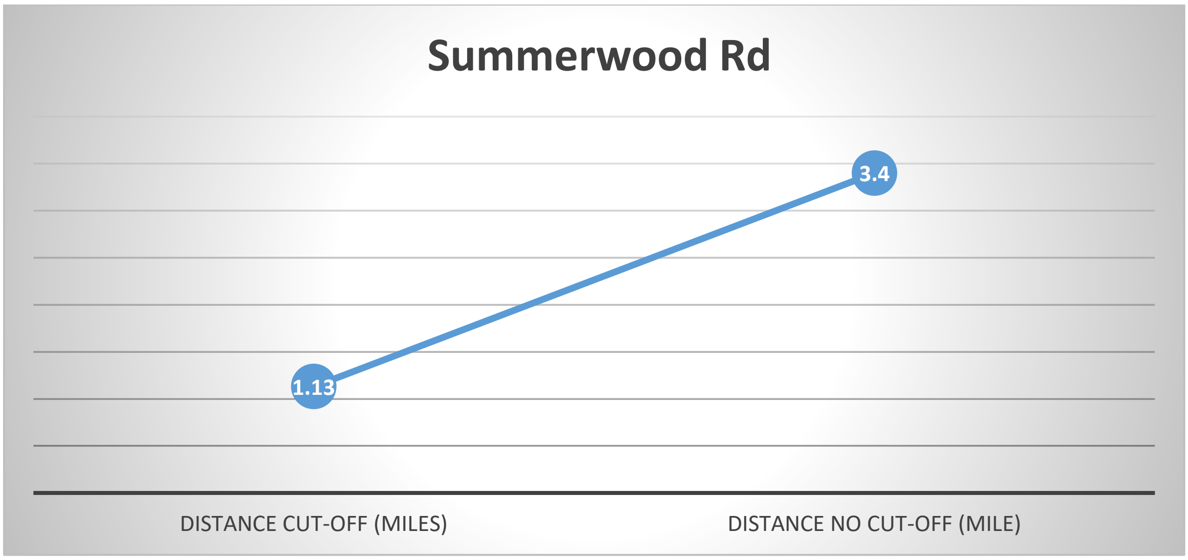
One hub with no cut-off . Average distance 5,45 meters (3.4miles).

I) Distance to Summerwood Road care delivery hub with no cut-off



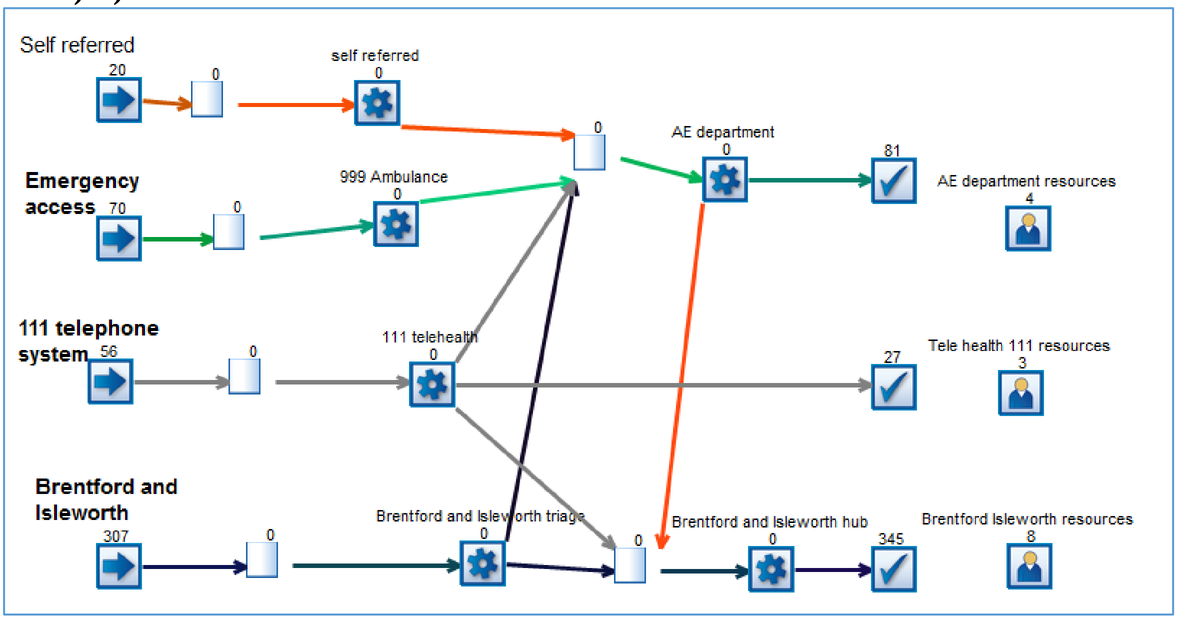
Distance to Summerwood Road care delivery hub with no cut-off

J) Hub model where with changes in distance due to cut-off and non-cut-off



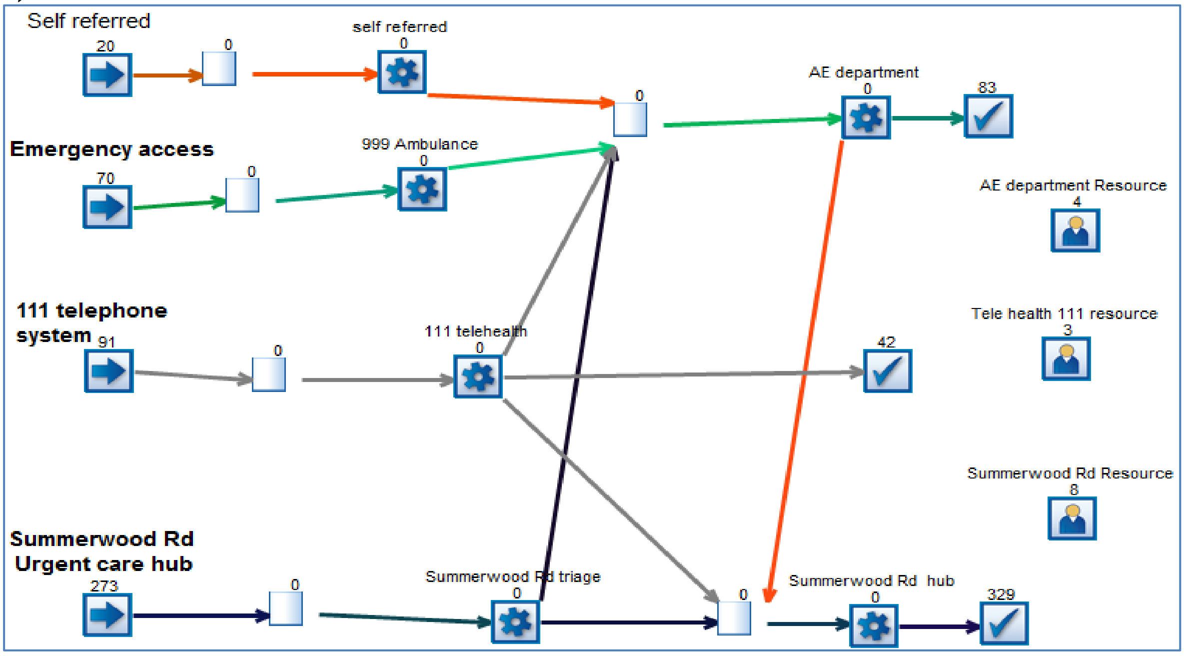
1-hub model where with changes in distance due to cut-off and non-cut-off

K) 1) Simulation model of One hub model



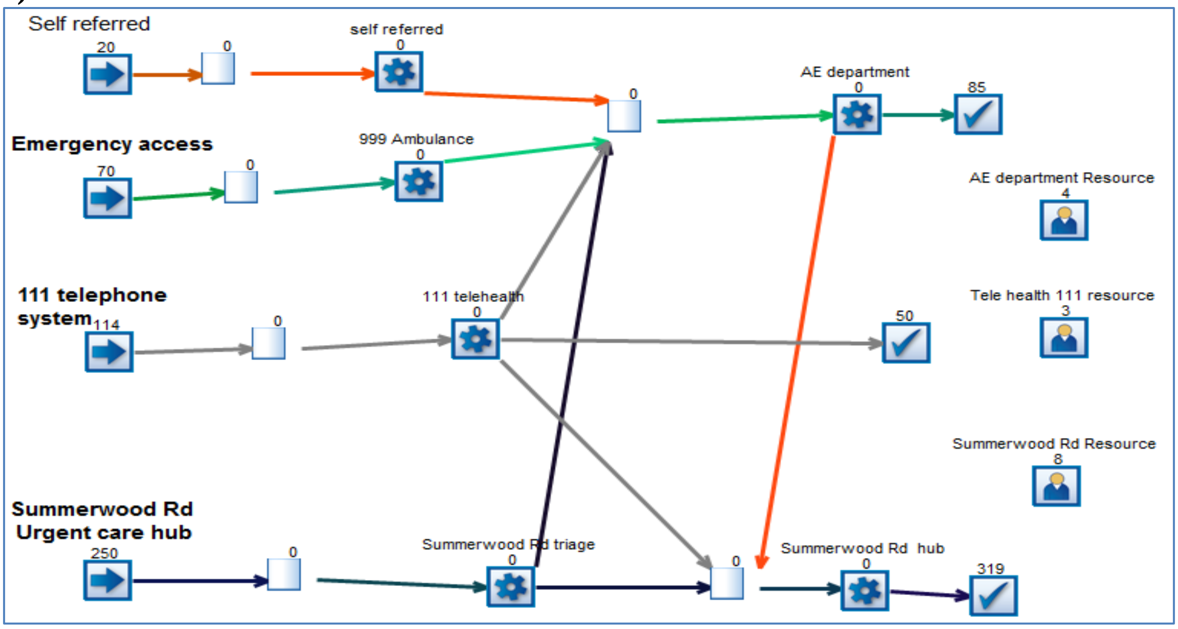
1-hub model where 13% access telephone system 111

2)



1-hub model where 20% access telephone system 111

3)



1-hub model where 25% access telephone system 111

L) 1 Simulation results for one hub model

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

1 hub model-13% 111		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	50.37	57.36	64.34	
Queue for Brentford and islew	Average Queuing Time	3.90	4.13	4.36	
Queue for 111 telehealth	Average Queuing Time	0.16	0.18	0.21	
Tele health 111 resources	Utilization %	3.71	3.80	3.90	
Brentford Isleworth resources	Utilization %	31.19	31.54	31.89	
AE department resources	Utilization %	50.47	51.48	52.48	
To Hospital	Number Completed	91.52	92.90	94.28	
Tele health home	Number Completed	21.53	22.27	23.01	
Brentford and Isleworth home	Number Completed	336.29	337.83	339.37	

1 simulation results for one hub model with 13% telephone system 111 access.

2)

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

1 hub 20% 111 access		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	60.97	69.04	77.11	
Queue for Summerwood Rd h	Average Queuing Time	1.78	1.90	2.01	
Queue for 111 telehealth	Average Queuing Time	0.97	1.01	1.05	
AE department Resource	Utilization %	52.53	53.59	54.64	
Tele health 111 resource	Utilization %	6.30	6.43	6.55	
Summerwood Rd Resource	Utilization %	24.78	25.06	25.34	
Hospital	Number Completed	95.22	96.59	97.96	
Home	Number Completed	35.32	36.36	37.40	
End 3	Number Completed	319.44	321.05	322.66	

Simulation results for one hub model with 20% telephone system 111 access

3)

SIMUL8 CORPORATION Results Manager

KPIs | KPI History | Scenarios | All Object Results | Custom Reports

1 hubs 25% 111 access		Low 95% Range	Average Result	High 95% Range	Risk
Queue for AE department	Average Queuing Time	68.75	77.55	86.35	
Queue for Summerwood Rd h	Average Queuing Time	1.46	1.57	1.68	
Queue for 111 telehealth	Average Queuing Time	1.84	1.90	1.96	
AE department Resource	Utilization %	53.94	55.01	56.08	
Tele health 111 resource	Utilization %	7.88	8.02	8.15	
Summerwood Rd Resource	Utilization %	23.87	24.17	24.46	
Hospital	Number Completed	97.88	99.33	100.78	
Tele health home	Number Completed	44.36	45.44	46.52	
Summerwood RD home	Number Completed	307.50	309.23	310.96	

Simulation results for one hub model with 25% telephone system 111 access