Reconfiguration of emergency and urgent care systems in Ireland from 2006: analysis of quantitative performance indicators at a population level

by

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A thesis submitted for the degree of Doctor of Philosophy

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Abbreviations

A&E	**A**ccident and **E**mergency
ACF	**A**uto **C**orrelation **F**unction
AIC	**A**ikake **I**nformation **C**riterion
AMI	**A**cute **M**yocardial **I**nfarction
AMAU	**A**cute **M**edical **A**ssessment **U**nit
AMU	**A**cute **M**edical **U**nit
APC	**A**nnual **P**ercentage **C**hange
BIC	**B**ayesian **I**nformation **C**riterion
CA	**C**ardiac **A**rrest
CFR	**C**ase **F**atality **R**atio
CHO	**C**ommunity **H**ealth **O**ffice
CI	**C**onfidence **I**nterval
COPD	**C**hronic **O**bstructive **P**ulmonary **D**isease
CSO	**C**entral **S**tatistics **O**ffice
ED	**E**mergency **D**epartment
GMS	**G**eneral **M**edical **S**ervices
GP	**G**eneral **P**ractitioner
GPVC	**G**eneral **P**ractitioner **V**isit **C**ard
HIPE	**H**ospital **I**n-**P**atient **E**nquiry
HIQA	**H**ealth and **I**nformation **Q**uality **A**uthority
HP	**H**aase **P**ratschke
HSE	**H**ealth **S**ervice **E**xecutive
ICD	**I**nternational Statistical **C**lassification of **D**isease and Related Health Problems
ICU	**I**ntensive **C**are **U**nit
INMO	**I**rish **N**urses and **M**idwives **O**rganisation

IRR	**I**ncidence **R**ate **R**atio
KPI	**K**ey **P**erformance **I**ndicator
LHO	**L**ocal **H**ealth **O**ffice
LIU	**L**ocal **I**njury **U**nit
LOS	**L**ength **O**f **S**tay
MAU	**M**edical **A**ssessment **U**nit
NAS	**N**ational **A**mbulance **S**ervice
NHS	**N**ational **H**ealth **S**ervice
OECD	**O**rganisation for **E**conomic **C**o-operation and **D**evelopment
PACF	**P**artial **A**uto **C**orrelation **F**unction
PCCC	**P**rimary **C**ommunity and **C**ontinuing **C**are services
PCI	**P**ercutaneous **C**oronary **I**ntervention
PCRS	**P**rimary **C**are **R**eimbursement **S**ervice
SAHRU	**S**mall **A**reas **H**ealth **R**esearch **U**nit
SILC	**S**urvey of **I**ncome and **L**iving **C**onditions
SMR	**S**tandardised **M**ortality **R**atio
SIREN	**S**tudy of the **I**mpact of **R**econfiguration on **E**mergency and Urgent Care **N**etworks
TILDA	**T**he **I**rish **L**ongitu**D**inal study on **A**geing
UCC	**U**rgent **C**are **C**entre
UHI	**U**niversal **H**ealth **I**nsurance
UK	**U**nited **K**ingdom
UN	**U**nited **N**ations
VIF	**V**ariance **I**nflation **F**actor
WHO	**W**orld **H**ealth **O**rganisation
WTE	**W**ork **T**ime **E**quivalents

Declaration of Authorship

This is to certify that the work I, Brenda Lynch, am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism.

Signed:

Date:

Dedicated to my grandmothers, Nora Lynch and Mary Manning;
and to our dearly missed friend, Siobháin O'Doherty.

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Thesis Abstract

Background

Since the mid-2000s, the regional emergency and urgent care systems in Ireland have experienced a period of reconfiguration, with some regions undergoing more significant changes than others. Reasons for these changes include improved safety, efficiency and the pursuit of better outcomes. However, analysis of the impact of these changes at a population level has been under-investigated.

Aims and objectives

The main aim of this thesis is to examine the impact of emergency and urgent care system reconfiguration on regional health system performance using quantitative indicators (structure, process and outcome) at a population level.

This thesis has three objectives:

1. To investigate the impact of changes to emergency department (ED) services in smaller hospitals on the remaining EDs within regional emergency and urgent care systems;

2. To investigate the regional variation in 'potentially avoidable' emergency admissions and identify the drivers of those admissions within regional emergency and urgent care systems;

3. To determine if the case fatality ratios (CFRs) for emergency conditions have improved in line with system reconfiguration carried out at a regional level.

Structure and methods

Chapter 2 provides an overview of contextual geographic details such as the degree of regional rurality, deprivation, and differences in demographics and health.

Chapter 3 provides an overview of the Irish health system, including the provision of emergency and urgent care services. A summary of the most significant health policy, clinical programme and reconfiguration reports published in Ireland since 2006 is also provided.

In **Chapter 4** details of frameworks for assessing system performance, used in conjunction with key performance indicators (KPIs), are explored. Ultimately, the Donabedian framework was selected as the most appropriate to investigate the regional changes to emergency and urgent care system performance. Indicators associated with the domains structure, process and outcome were identified. The statistical methods used in each study are also outlined within this chapter.

Under the domain of structure, a time-series analysis is used in **Chapter 5** to investigate changes to ED services and the subsequent impact to the ED trolley numbers within regional hospitals between 2005-2015.

To investigate the domain of process, **Chapter 6** studies the population and health system factors which influence 'potentially avoidable' emergency admissions at a regional level. This is achieved by conducting a cross-sectional analysis of identified factors using negative binomial regression.

The final study in **Chapter 7** addresses the domain of outcome by providing a longitudinal investigation of trends in CFRs for serious emergency conditions over the period 2002-2014 using joinpoint analysis.

In the final chapter, **Chapter 8**, a discussion of the key findings, strengths and limitations of the thesis is provided. Recommendations for future research are also outlined.

Key findings

Regional variations were seen across each framework domain and performance indicator.

Chapter 5 identifies three regions where the immediate impact of ED reconfiguration is either non-significant or associated with a short-term shock to observed ED trolley numbers. This shock was followed by convergence with the pre-reconfiguration trend over the 12-months post ED reconfiguration. Only one region, the North-East, saw a longer term change in the post-reconfiguration trend following changes to the second ED in the region.

In **Chapter 6**, differences were found in the age-adjusted rates of 'potentially avoidable' emergency admissions across regions. The pattern of higher rates of emergency admissions was not consistent across those regions that had, or had not, undertaken significant emergency and urgent care system reconfiguration. The main findings of the study suggest that deprivation is the primary contributor to the variation seen in results across regions. Other factors found to have an impact were the level of short-term lengths of stay in hospital and the rate of private health insurance among the regional populations.

In **Chapter 7**, significant improvements in CFRs were found for the main emergency conditions of stroke and acute myocardial infarction and cardiac arrest (AMI and CA) at a national level between 2002 and 2014, with the rate of improvement slowing from 2007 for stroke. However, the study was unable to attribute improvements seen at a regional level to the degree of reconfiguration within the emergency and urgent care system.

Conclusions

This thesis adds to the evidence regarding the impact of the reconfiguration of emergency and urgent care systems in Ireland on regional populations. The degree of system reconfiguration varied across regions. Numerous other policies, clinical programmes, financial restrictions, changes to staff resources and hospital beds also occurred simultaneously. Ultimately, this research was unable to find a consistent pattern in performance indicators across regions which underwent significant system reconfiguration, meaning it is not possible to attribute indicator results definitively to reconfiguration measures.

Chapter 1

Introduction

1.1 Introduction

Emergency and urgent conditions are those which require a timely intervention of the health system to increase the probability of a positive outcome. Emergency conditions have a higher degree of severity than urgent conditions and require as close to immediate care as possible. There are many different reasons why an emergency event may occur. Such an event could be linked to:

- an underlying chronic condition, e.g. a heart attack or stroke could be linked to an underlying circulatory disease, or an asthma attack could be due to respiratory disease;
- trauma, e.g. a car accident, violent attack or external injury;
- communicable disease episode;
- psychiatric event;
- miscellaneous health episode, e.g. excess alcohol or drug consumption.

Emergency conditions are significant contributors to global mortality. In 2015, stroke was responsible for 11.3% of total global deaths, while external injuries accounted for almost 8.5% of deaths [1]. In Ireland, death from cardiovascular events, including stroke and heart failure, accounted for 31% of all deaths in 2015 [2]. In addition, deaths from respiratory disease accounted for 12.5% and external causes of death accounted for 4.5% of the total 2015 deaths [2].

Emergency and urgent care systems include all the processes and services which contribute to the management of those patients requiring immediate or timely care for a health condition. The processes of care ensure the referral and movement of patients between services within the system. While emergency care is most often received in a hospital setting, during an episode of care a patient may require the use of more than one service. There is some controversy over what is considered to be the most appropriate model of care to ensure the best and most efficient processes and outcomes within an emergency and urgent care system [3]. Ideally, these services would be highly coordinated to ensure the time between the onset of an emergency or urgent event to definitive care is reduced and the use of unnecessary services is avoided. The arrangement and location of emergency services can be referred to as their 'configuration'. Hospital 'configuration' refers to *"the distribution of medical, surgical, diagnostic and ancilliary specialties that are available in each hospital or other secondary or tertiary acute care unit in a locality, region or healthcare administrative area"* [4, p. 13].

Since the mid-2000's, a consensus has emerged that certain very serious conditions, such as stroke [5, 6] and trauma [7], should only be treated in specialty units which have highly trained staff and receive a large volume of cases, thereby ensuring the attainment and retention of skills by those staff. In many situations, these specialty units are placed in larger, urban-based tertiary hospitals [8, 9]. This has created uncertainty regarding the role of smaller, rural hospitals and emergency departments (EDs) [10, 11] within the emergency and urgent care system. In general, smaller hospitals have been positioned as support to the larger hospitals, taking responsibility for less severe, more routine cases, thereby easing the pressures in the tertiary 'hub' hospitals [8]. However, some concerns still exist regarding these services and whether they are fit for purpose due to a lack of experienced nurses, doctors and other limited resources, consequently reducing the possibility of positive outcomes for patients [12–14].

In Ireland, a number of reports have been published since 2006 which address these concerns and recommend changes to the configuration of regional emergency and urgent care systems, see **Chapter 3**. The reconfiguration of hospitals and services can be defined as *"a deliberately induced change of some significance in the configuration by managers and policy makers"* [4, p. 13]. These reports include, *'Transformation Programme, 2007-2010'* [15], *'Report of the National Acute Medicine Programme, 2010'* [16], *'The National Emergency Medicine Programme, 2012'* [17], *'The Establishment of Hospital Groups as a transition to Independent Hospital Trusts, 2013'* [18], and *'Securing the Future of Smaller Hospitals: A Framework for Development, 2013'* [8].

The overall aim of the recommended changes contained within these reports is to create cohesive regional health systems which provide their geographic population base with the optimal combination and location of services for emergency and urgent conditions. As a result, in line with international evidence [5–7], many regional health systems in Ireland have seen a concentration of serious emergency conditions and trauma to larger tertiary 'hub' hospitals, with smaller regional hospitals providing support as off-shoot or 'spoke' hospitals that feed into the larger 'hub' [8, 18, 19].

International studies also contend that certain emergency admissions to hospitals could be avoided if there was a capacity for improved treatment and management of underlying conditions within the community [20–24]. In recognition of these findings, many of the health policy reports in Ireland also acknowledge the need for greater co-ordination between individual components within the wider health system. This approach to the delivery of care would allow for better treatment of certain conditions in the community, thereby increasing the role of primary care to reduce the pressures on secondary care services such as EDs and acute wards.

In order to achieve these aims, a system-wide focus is needed for the implementation and evaluation of changes to the delivery of emergency and urgent care. *"A systems approach improves health by considering the multiple elements involved in caring for patients and the multiple factors influencing health"* [25, p. 1]. This approach can be useful for all levels of the health system including the interactions between patients and clinicians, across different healthcare units, organisations and communities [25, p. 1]. Without a cohesive system approach, which recognises the inter-dependency across services, it is likely that processes and outcomes will suffer. For example, increased waiting times may occur as patients try to access under-resourced or inappropriate services, causing bottlenecks within the system [26] and poorly staffed and co-ordinated services will lead to poorer outcomes [27, 28].

The debate regarding the best design of regional emergency and urgent care systems in Ireland is also being influenced by concerns across the wider health system. These concerns include:

- **Increased ED overcrowding:** Ireland has seen the number of emergency presentations continue to increase year on year [29, 30]. From January to June 2018, there were 728,638 emergency presentations in the year to date compared to 707,716 for the same period last year, an increase of 3% [31].

- **Increased financial stress on the health system:** Due to the global financial crisis, financing of the Health Service Executive (HSE) in Ireland fell by 22% from 2009 to 2013, amounting to a decrease of almost €3·3 billion [32, 33]. It is only in the most recent budgets that there have been increases in the allocation to the health service. In 2018, a budget of €14.5 billion represents an overall increase of €608 million (4.4% from 2017) [34]. However, despite this increase, there are still very significant financial challenges in maintaining the existing level of overall activity [34, p. 1].

- **An increasing aging population:** Between 2015 and 2030 the share of the population aged 65 and over is projected to increase from one in eight, to one in six. The number of people aged 85 and over is projected to almost double [35]. As the number of older people increases, the burden of chronic disease will grow by an estimated 20% by 2020 [36], resulting in an increased demand for health services.

- **Increased expense for new technologies and pharmaceutical drugs:** In 2014, Ireland ranked among the highest in the Organisation for Economic Co-operation and Development (OECD) in terms of pharmaceutical spend per capita. Expenditure on high-tech drugs increased by €250m, or 76%, over the period 2009-2016 [37]. It is also expected that future investment in new medicines and health technology will be associated with significant costs [37].

- **Difficulties with workforce recruitment and retention:** Between 2007 and 2013, staff levels were reduced by over 11,268 work time equivalents (WTEs) since peak employment levels in September 2007 [33, p. 2]. There was an overall reduction in numbers of nurses and midwives from a high of 39,006 WTE in 2007 to a low of 33,768 WTE in 2013, despite no corresponding fall in service demand [38, p. 69]. In 2017, there was some improvement seen among this group, with reported numbers of 36,777 WTEs by the end of that year [38, p. 5]. Ireland also continues to have a low number of doctors per capita compared to other OECD countries. In 2015, Ireland had a relatively high ratio of nurses to doctors, 3.8 in 2015 compared to the OECD average of 2.8 [39, p. 15]. It has also been especially difficult to ensure adequate staff in smaller rural hospitals [40, p. 40] [8, 18].

- **A greater focus on quality and safety due to various high profile incidents:** Recent high profile incidents regarding cervical cancer screening [41] have increased demand for greater transparency, and improved quality and safety within the health system.

- **Rising demands for greater public and patient involvement in health planning:** It is believed that greater public and patient involvement in health planning will result in more appropriate services of higher quality, which will lead to higher levels of service user compliance and satisfaction [42, p. 7].

The desire to address all of these concerns, while also improving the general performance of the health system, has given rise to seemingly irreconcilable conflicts in policy formation. For example, the need to provide high quality care to patients as close as possible to their place of residence, while at the same time ensuring affordability and sustainability, are potentially at odds with each other. Even in the aftermath of the publication of numerous health policy and reconfiguration reports, outlined in **Chapter 3**, uncertainty remains regarding the ability of system reconfiguration to resolve these conflicts. Few studies have been conducted to assess the overall effect of emergency and urgent care system reconfiguration on population outcomes, which is what they are ultimately designed to improve [43]. This is despite the fact that there are a number of natural experiments which have been undertaken in other countries around similar system changes [44–46].

The ability to find appropriate resolutions to these conflicts is restricted by a lack of good system-level indicators of performance. Such indicators have not been identified or reported. The majority of the debate uses hospital or service specific data and in general tends to refer to specific conditions. Reports which include, the *'National Healthcare Quality Reporting System: 2015, 2016, 2017, 2018'* [47–50] have generally found improvements nationally in mortality for many serious emergency conditions. The findings also confirm that patients are more likely than previously to be treated in appropriate settings [47–50], particularly for conditions such as stroke [51]. However, the majority of this analysis has been conducted at a hospital level. To date these reports continue to focus on specific service users i.e. those who attend acute hospitals. They do not provide a detailed analysis of the total populations served by the regional emergency and urgent care systems.

Therefore, the following is unknown from an Irish health system perspective:

- Have changes to acute services, such as EDs, placed increased pressures on remaining regional services?
- Have changes to acute services resulted in patients attending the most appropriate service given their condition? If they do not, what is driving specific acute service use?

- Has the reconfiguration of regional emergency and urgent care systems improved outcomes for populations? For example, are those who experience an emergency condition more likely to survive in regions which have experienced significant system reconfiguration?

1.2 Aims

The main aim of this thesis is to examine the impact of reconfiguration on regional emergency and urgent care system performance using quantitative indicators (structure, process and outcome) at a population level.

To address this aim, the feasibility of different system level quantitative indicators to compare the performance of different emergency and urgent care systems will be tested. These indicators will be used to examine the impact of a specific policy (reconfiguration), which aims to improve emergency and urgent care system function, by using the natural experiment that has occurred in Ireland.

1.3 Objectives

This thesis has three objectives:

1. To investigate the impact of changes to ED services on the remaining EDs within the regional emergency and urgent care system;

2. To investigate the regional variation in 'potentially avoidable' emergency admissions and identify the drivers of those admissions within regional emergency and urgent care systems;

3. To determine if the CFRs for emergency conditions have been affected by the reconfiguration of regional emergency and urgent care systems.

1.4 Thesis outline

This thesis is comprised of three papers, which describe structure, process and outcome indicators of emergency and urgent care systems since reconfiguration measures have been undertaken. Figure 1.1 illustrates the aim, objectives and studies included in this thesis.

Chapter 2 provides a general overview of the regional characteristics of Ireland. Contextual issues such as rurality, deprivation, demographics and health are addressed in this chapter.

Chapter 3 provides a background to the Irish health system, as well as an overview of emergency and urgent care provision. This chapter also provides a summary of the most significant health reports and policy papers which relate to health system reconfiguration published in Ireland since 2006.

Chapter 4 outlines the possible frameworks for assessing system performance, and identifies the most appropriate framework to achieve the aim of this thesis. It also provides a detailed description of the statistical methods used in each study.

Chapter 5 addresses changes to the structural elements of the regional emergency and urgent care systems. Time-series analysis investigates the changes to ED services and the subsequent changes to ED trolley numbers within regional hospitals between 2005-2015.

Chapter 6 focuses on a process element associated with emergency and urgent care systems. This study describes the regional variation in ‘potentially avoidable’ emergency admissions and investigates the factors which influence those emergency admissions at a regional level.

Chapter 7 focuses on outcome measures associated with emergency and urgent care, and investigates whether improvements are seen in the CFRs for serious emergency conditions in Ireland, specifically in those regions which have undergone system reconfiguration.

Finally, **Chapter 8** provides an overall discussion of the main findings from each study, the implications for health policy, the strengths and limitations of the thesis, and suggestions for future research.

In addition, appendices are included which provide supplementary material to support several of the chapters.

1.5 Overview of the Study of the Impact of Reconfiguration on Emergency and Urgent Care Networks (SIREN)

The Study of the Impact of Reconfiguration on Emergency and Urgent Care Networks (SIREN) is a collaborative research project between University College Cork, Trinity College Dublin, the Royal College of Surgeons Ireland and the Health Service Executive, led by Professor John Browne, School of Public Health, University College Cork. Beginning in 2013, the study adopted a mixed methods approach to understanding the impacts of the reconfiguration of emergency and urgent care networks on regional populations. The study was guided substantially by the Medical Care Research Unit of the

University of Sheffield research programme, which focused on the emergency and urgent care system in the UK [52]. Within SIREN, six work packages were established:

- **Work Package 1 - Qualitative study of stakeholder views on emergency and urgent care system configuration.** This work package included a documentary analysis of planning documents such as published reconfiguration plans, published service plans, the minutes of meetings of reconfiguration steering groups and other executive bodies, and media reports. This analysis produced a detailed description of the emergency and urgent care system models in development and operational in each region [53]. Interviews with a range of regional stakeholders were also conducted including general practitioner representatives, local politicians, local media representatives, patient representatives and representatives of hospital campaign groups. All interviewees were asked about the extent of changes to emergency and urgent care systems, and what they perceived to be the main drivers of system changes in their region [54].

- **Work Package 2 - Consensus development study on quantitative indicators.** A systematic review of the literature on population focused indicators used in international emergency and urgent care systems evaluation was performed [55]. A group of experts, including senior clinicians and researchers and 'indicator users' from a wide range of specialties and disciplines, subsequently participated in a delphi exercise [56] to identify the most relevant *population-based indicators* to assess changes to regional emergency and urgent care systems.

- **Work package 3 - Analysis of quantitative indicators of emergency and urgent care system performance.** This work package was divided into two separate components. The final set of indicators from work package 2 were assessed for viability given data availability. These selected indicators were constructed to compare the performance of the regional networks identified in work package 1. This analysis consisted of cross-sectional and longitudinal comparisons. This part of the work package encompasses the studies outlined within this thesis, specifically the analysis described in **Chapter 6** and **Chapter 7**. Analysis conducted in **Chapter 5**, though not directly identified by the delphi exercise, was undertaken to complement the other studies and provide an insight into the structural changes to the emergency and urgent care system.

The second component of this work package assesses the equity of resource allocation and staffing across regions and services. This work is still ongoing and is being conducted by the Centre for Health Policy and Management in Trinity College Dublin.

- **Work package 4 - Patient experience surveys.** The Urgent Care System Questionnaire developed by the University of Sheffield was used to measure patient experience addressing three domains: entry into the system; progress through the system; and convenience of the system [57].

- **Work package 5 - Synthesis of qualitative and quantitative findings and final consultation with stakeholders.** This work package is currently being completed and is working to synthesise the qualitative evidence from work package 1, with the quantitative evidence collected in work packages 3 and 4.

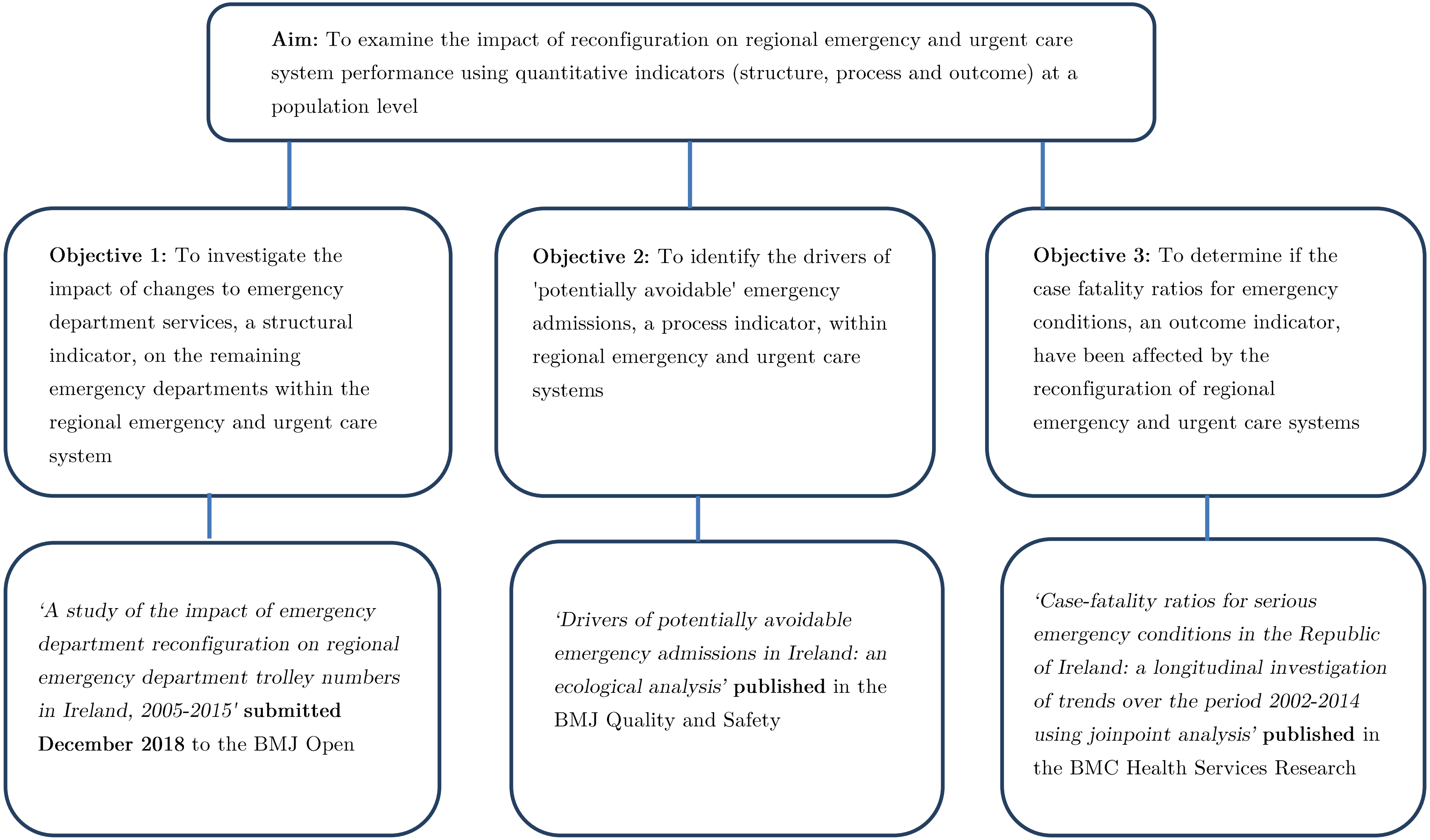
- **Work package 6 - Report writing and dissemination.** This work package is a culmination of the previous work packages and includes the final report writing and dissemination of findings. The dissemination of findings from each individual work package has been a continuous process throughout the study. Multiple papers have been published [54, 57–59] and several regional public meetings have been conducted to present findings to stakeholders who contributed to the original qualitative interviews.

In completing my thesis, I contributed to the overall SIREN study as a project committee member. While the studies described within the thesis contribute to the wider project, a significant degree of autonomy was incorporated into the research conducted to allow the final thesis to be a cohesive piece of research, one which is meaningful and contributes to the literature independent of the final SIREN findings.

1.6 Author contribution

I was the lead author of the research papers in **Chapters 5**, **6**, **7**. This involved the formulation of the research question for each study in conjunction with my supervisors Dr. Tony Fitzgerald and Professor John Browne, sourcing, extracting and cleaning the relevant data, conducting data analysis and drafting each manuscript. Each manuscript draft was assessed by both supervisors, Dr. Tony Fitzgerald and Professor John Browne, as well as my advisors Dr. Claire Buckley, Dr. Paul Corcoran and Dr. Orla Healy.

FIGURE 1.1: Overview of thesis including aims and objectives



Chapter 2

Background - regional characteristics

2.1 Introduction

This chapter provides an overview of the demographic and social structures of the regions of the Republic of Ireland.

2.2 Defining a region

The Republic of Ireland, Ireland hereafter, is a country of 70.2 thousand km^2 on the west of Europe with a population of 4.7 million [60]. It can be divided into 4 provinces (Ulster, Leinster, Munster and Connacht), 8 Nomenclature of territorial units for statistics 3 (NUTS 3) regions, 26 counties, 40 constituencies, 3,409 Electoral Divisions and 18,488 Small Areas [60, p. 5].

The purpose of this study is to understand the regions within which emergency and urgent care systems operate within Ireland. The emphasis is placed on the regional populations of interest, rather than on the individual. When conducting systems research, using the individual as the unit of analysis may obscure insights that are better understood at the community or regional level. Ecological analysis allows the study of the regional or area level impact of changes to systems [61]. The level at which this ecological analysis is conducted can vary. Some associations are best studied at a smaller regional level to ensure that areas have relatively homogeneous health and social structures. However, there are certain factors that are best viewed over larger areas as effects might not be apparent when viewed at a small area level. Such factors include climate, water, air quality [61] and arguably health systems [62].

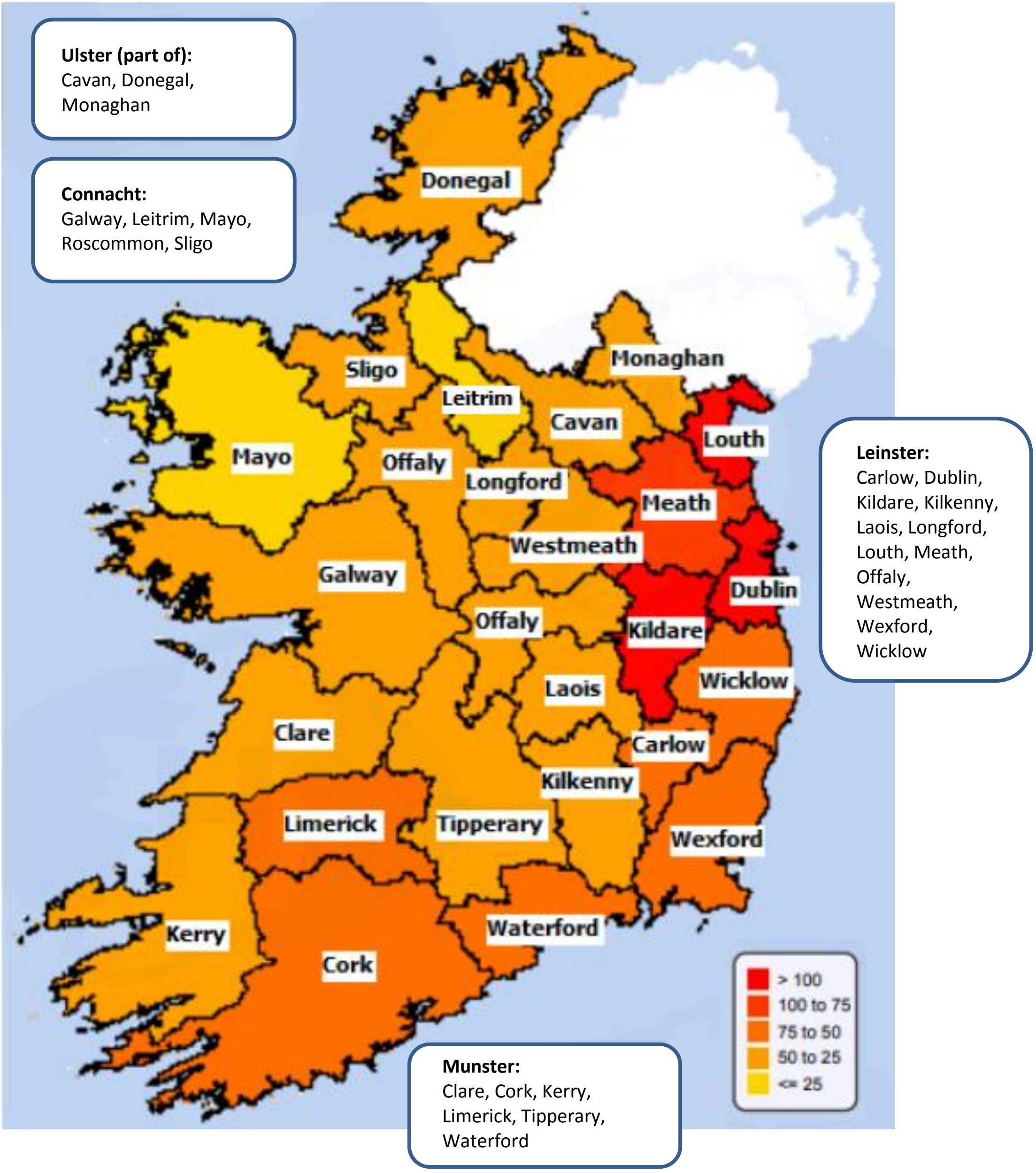
It is important that when investigating the functioning of health systems, regions are defined in such a way that it allows for a meaningful analysis of geographical variation. Chosen regions should allow for linkages between existing data sources, such as the census and health services administrative data [63]. However, the use of existing secondary administrative data may require compromises. In many cases, to avoid the difficulties, cost and inconvenience of collecting data that already exists in some form, health service planners, practitioners and researchers may have to rely on existing definitions of a region [64]. The regional levels associated with the specific purposes that administrative data is collected for, e.g. understanding demographic distributions, unemployment, etc., may not accurately reflect, or be adapted to, how people attend and use health services and engage with health systems [63]. At the same time, recognisable regions may increase stakeholder buy-in through greater public support and commitment to the subsequent findings, outcomes and policy recommendations. Such support is vital for recommendations which address the use of resources and the restructuring of services [63].

In Ireland, county of residence is the unit of geography which is most recognisable and most frequently used in public discourse. It is also the level at which a significant amount of administrative data, across many different areas including education, health and deprivation, is collected. Therefore, as this study is concerned with the impact of reconfiguration at a population level, county is taken as the principal regional unit. In addition to county, where relevant and where data will permit, other health service networks or regions will be referenced. These networks/regions are further outlined in **Chapter 3**.

Counties in Ireland vary in terms of ecological characteristics such as their urban-rural divide, their demographics and the health profile of their populations.

The size of the population in each county can vary substantially. For example, as per the Central Statistics Office (CSO) 2016 census, the population of county Dublin was 1.3 million, and the population of county Leitrim was 32,000 [60], see figure 2.1 and table 2.1.

Figure 2.1: Counties of the Republic of Ireland



Source: Central Statistics Office. Counties colour coded by population density per km^2.

TABLE 2.1: Population characteristics of counties of the Republic of Ireland

Province/County	2016: Population	2016: Population per km^2	2016: Percentage of population over 65
Ulster (part of):			
Cavan	76,176	39.43	14
Donegal	159,192	32.76	16
Monaghan	61,386	47.42	14
Connacht			
Galway	258,058	41.98	14
Leitrim	32,044	20.17	17
Mayo	130,507	23.37	18
Roscommon	64,544	25.33	17
Sligo	65,535	35.67	16
Munster			
Clare	118,817	34.45	15
Cork	542,868	72.37	14
Kerry	147,707	30.74	17
Limerick	194,899	70.72	14
Tipperary	159,553	37.06	15
Waterford	116,176	62.52	15
Leinster			
Carlow	56,932	63.49	13
Dublin	1,347,359	1455.67	12
Kildare	222,504	131.28	10
Kilkenny	99,232	47.89	14
Laois	84,697	49.25	11
Longford	40,873	37.44	14
Louth	128,884	155.88	12
Meath	195,044	83.24	11

Source: Central Statistics Office

It is difficult to isolate the independent impact of regional characteristics such as rurality, demographics, deprivation and health. Traditionally, there are inherent differences between rural and urban populations. Rural areas tend to have older demographics, potentially greater deprivation due to fewer employment opportunities, and have different environmental factors which impact on the health of the population, e.g. lower levels of air pollution due to less concentrated traffic [65]. Therefore, these characteristics cannot be viewed in isolation and must be considered in combination where possible.

2.3 Regional characteristics: rurality

Whether or not a region, or part of a region, is considered to be rural depends on the context in which it is studied. There are significant differences between what is considered a rural area in larger countries such as Canada and Australia, compared to what is considered a rural area in Ireland [66, 67]. There can also be differences in the characteristics of rural areas within countries. For example, in Ireland, the CSO defines a rural area as one that has a population of less that 1,500 inhabitants per km^2 [68]. Even within this definition, the characteristics of rural areas on the east coast of Ireland can be very different to rural areas in the west coast in terms of terrain, availability of amenities and the quality of transport networks and infrastructure [69].

In Ireland, the average population density in urban areas is 2,008 per km^2, while the average population density in rural areas is 27 per km^2 [70]. The most densely populated areas are primarily found in the Greater Dublin Area, which include Dublin and its main commuter counties of Meath, Kildare and Wicklow [70], see table 2.1. Dublin city and suburbs has a population density of 3,677 persons per km^2 as per the 2016 census.

In the 2016 census, it states that there were 41 settlement areas with a population of 10,000 or more. Of these 41 settlements, 27 were in the eastern province of Leinster, 9 were in the southern province of Munster, 3 in the western province of Connacht and 2 were in the northern province of Ulster (part of) [70].

2.4 Regional characteristics: demographics

Similar to many developed western countries, Ireland has an aging population, with an average age of 37.4 years [60]. As of 2016, the number of males aged 65 and over increased by 22%, and the number of females aged 65 and over increased by 16% since the previous census in 2011 [60]. The average number of children per family (1.38) has remained unchanged since 2011 [60].

The average age of the population living in rural areas was 2.4 years older than those in urban areas, an increase from 1.9 years in 2011 [71]. Table 2.1 outlines the population percentage over 65 in each county. There were also differences in demographics between urban and rural areas within counties. For example, the rural population in South Dublin, while small, was on average 6.5 years older than those living in urban parts of the county. In comparison, in county Monaghan the difference between the ages of the rural and urban populations was the lowest seen regionally, with the rural population on average 0.6 years older than those in urban areas within the county [71].
This difference can be explained in part by the fact that younger, healthy people tend to migrate to urban areas in the pursuit of work, while in rural areas, there tends to be an older population [71, 72].

2.5 Regional characteristics: deprivation

Deprivation at a geographical level has the ability to capture *"an area's potential for health risk from ecologic exposures such as from the concentration of poverty, unemployment, economic disinvestment, and social disorganisation"* [73, p. 42].

Internationally recognised measures of deprivation include the Carstairs Deprivation Index [74] and the Townsend Deprivation Index [75, 76]. In Ireland, there are a number of deprivation measures which are reported by the CSO, or are constructed using data collected by the CSO. These measures include unemployment, the Survey of Income and Living Conditions (SILC), the Pobal Haase Pratschke (HP) Deprivation Index, and the

Small Areas Health Research Unit (SAHRU) Deprivation Index. These measures are described in full in **Chapter 6** and **Appendix A**.

A CSO analysis of the 2016 census found that the overall national unemployment rate fell from 19% in 2011 to 12.9% in 2016 [60]. The most recent national unemployment figures, as of December 2018, state that national unemployment currently measures 5.3% [77].

At a county level, Donegal saw the greatest improvement in unemployment figures, falling from a rate of 26.2% in 2011 to 18% in 2016 [78]. Monaghan also saw a substantial improvement from 20.6% in 2011 to 13% in 2016 [78]. As of 2016, Longford had the highest regional unemployment rate (19.6%), while the South Dublin area of Dún Laoghaire Rathdown had the lowest (7.4%) [78].

There is a potential risk of deprivation being hidden when conducting analysis at a large geographical level and it has been argued that the impact of deprivation is more varied in rural areas compared to urban areas [72, 79]. Urban areas in Ireland were found to have a marginally higher unemployment rate (13.9%) than rural areas (11.2%). This was mainly driven by higher unemployment in small towns (just over the threshold to be considered an urban area with a population of 1,500 - 2,999 per km^2), rather than larger towns or cities [78]. Simultaneously, according to the 2016 Pobal HP Deprivation Index, the most affluent counties in Ireland were Cork, Dublin, Galway, Kildare, Meath and Wicklow, all counties with, or adjacent to, large urban centres [80].

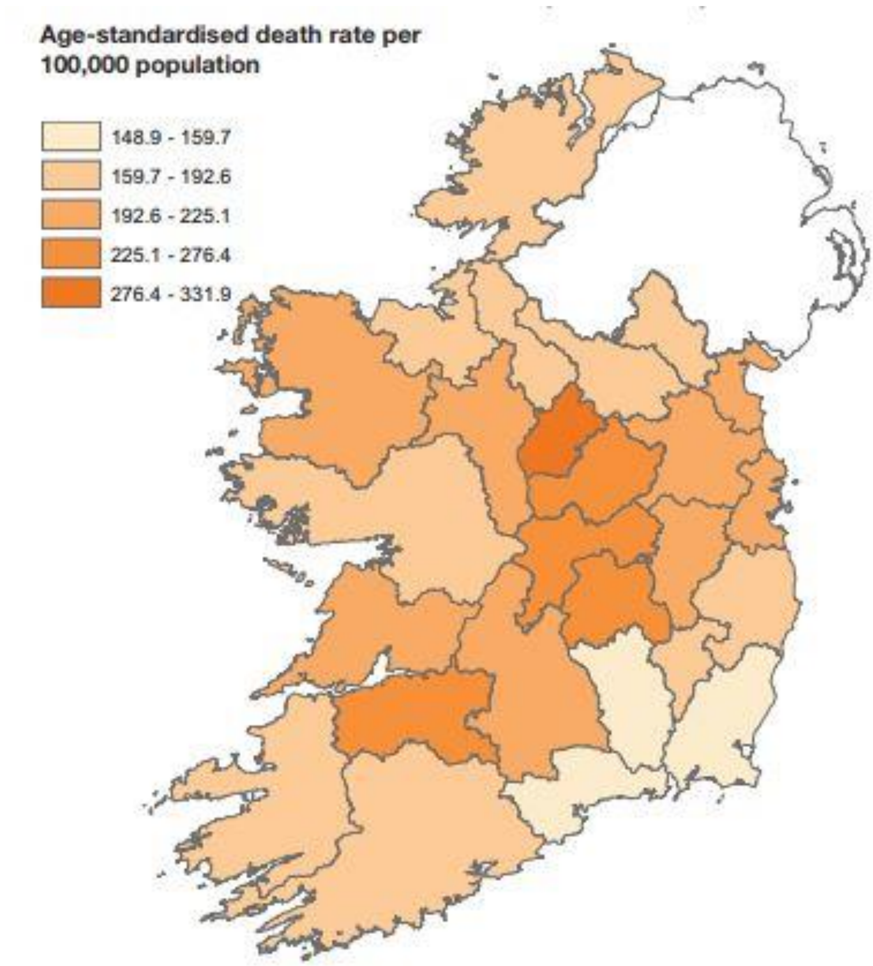
2.6 Regional characteristics: health

In general, studies have found that while living in a rural area may restrict access to, and the provision of health services, this does not always translate into a health disadvantage [81–84]. A 2008 systematic review of studies conducted in a number of countries found that there was no consistent urban-rural differences across specific health conditions [81]. In relation to the incidence of disease and illness, for the majority of conditions the review found that the causes of variation between what is observed in rural areas compared to urban areas are primarily due to occupational hazards and personal behaviour, rather than 'rurality' [81]. The review states that *"when controlling for major risk determinants, rurality per se does not necessarily lead to urban-rural disparities, but may exacerbate the effects of socio-economic disadvantage, ethnicity, poorer service availability, higher levels of personal risk and more hazardous environmental, occupational and transportation conditions"* [81, p. 56]. The review does state that rural populations are more likely to have less healthy behaviours than those in urban areas [81].

Increasingly, it has been found that after adjusting for deprivation, only lower mortality from lung cancer and respiratory disease is seen in rural areas [85, 86]. Mortality from injuries received in accidents, rather than illness, has been found to be higher in rural areas. This is possibly due to either the higher number of farming and road traffic accidents [85, 86] or the increased time to treatment caused by farther distances to hospital care [87]. This pattern is also borne out in Ireland, as mortality from unintentional injury or accident is higher in rural populations compared to those in urban areas [88].

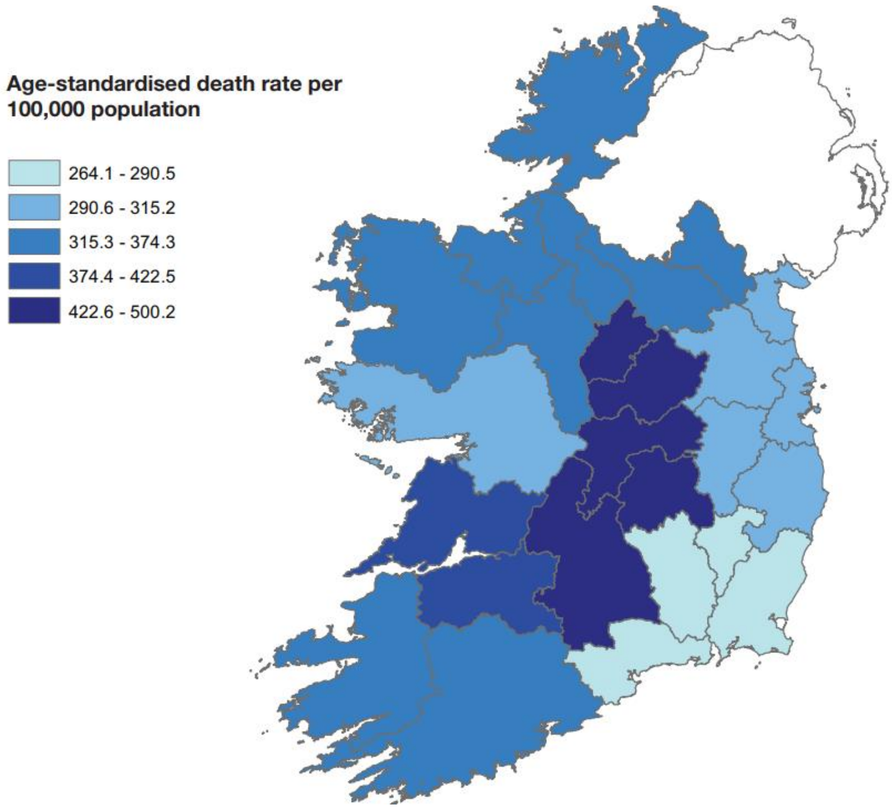
Accurate information on the prevalence of diseases at a regional level in Ireland is scarce. However, as highlighted in **Chapter 1**, respiratory and circulatory disease are the principal causes of mortality in Ireland. As of 2017, the Department of Health found the highest rates of death from respiratory system disease were in Limerick and Longford (figure 2.2), with the highest rates of death from circulatory diseases found in the mid-land counties of Laois, Longford, Offaly, Tipperary and Westmeath, (figure 2.3) [89].

FIGURE 2.2: 5-year age-standardised death rates from respiratory system diseases, Ireland, 2012 to 2016



Source: Public Health Information System (PHIS) - Department of Health [89, p. 24]

FIGURE 2.3: 5-year age-standardised death rates from circulatory disease, Ireland, 2012 to 2016



Source: Public Health Information System (PHIS) - Department of Health [89, p. 24]

2.7 Summary

While rurality, demographics and deprivation may be studied independently in relation to health, there is also an association between each of these which makes it difficult to separate their individual impact. When considering the recommendations for emergency and urgent care reconfiguration in **Chapter 3**, and conducting the analysis in **Chapters 5, 6, 7**, it is important to acknowledge these factors and how they interact. Interventions that are designed to improve health outcomes for either urban or rural areas must take into account not just distance and access to health services, but also the underlying social and economic inequalities, and inequities of resource allocation [81]. If these fundamental issues are not considered in conjunction with the implementation of service and system changes, then it is likely that the desired results will not be achieved.

Chapter 3

Background - health system context

3.1 Introduction

This chapter provides a general overview of the health system in Ireland and specific focus is given to the delivery of emergency and urgent care. A brief description is given of what constitutes an emergency or urgent condition, and the services that can be used in the treatment of these conditions. This chapter outlines how the organisation of these services has changed in Ireland since the mid-2000s, analysing the numerous reports and policy documents published with the aim of regional system reconfiguration. A summary of the subsequently implemented regional changes is also discussed, together with an exploration of the drivers of those changes.

3.2 An overview of the Irish health system

In Ireland, health policy is primarily the remit of the Department of Health. The role of this department is to *"advise on the strategic development of the health and social* *care system, including policy and legislation, and to evaluate performance of the health and social care system"* [90]. This department has previously been amalgamated with the Department of Children (1997-2011) [91, 92]. A separate government agency, the Health Service Executive (HSE), is responsible for the delivery of services. The HSE was established in 2005 to replace the previous regional health boards and is answerable to the Minister for Health [90]. Based on funding allocated by the Department of Health, an annual service plan is agreed for the provision of services [34]. Under the Health Act 2007, the Health and Information Quality Authority (HIQA) was established to drive quality, safety, accountability and to ensure the best use of resources in health and social care services across all providers [90, 93].

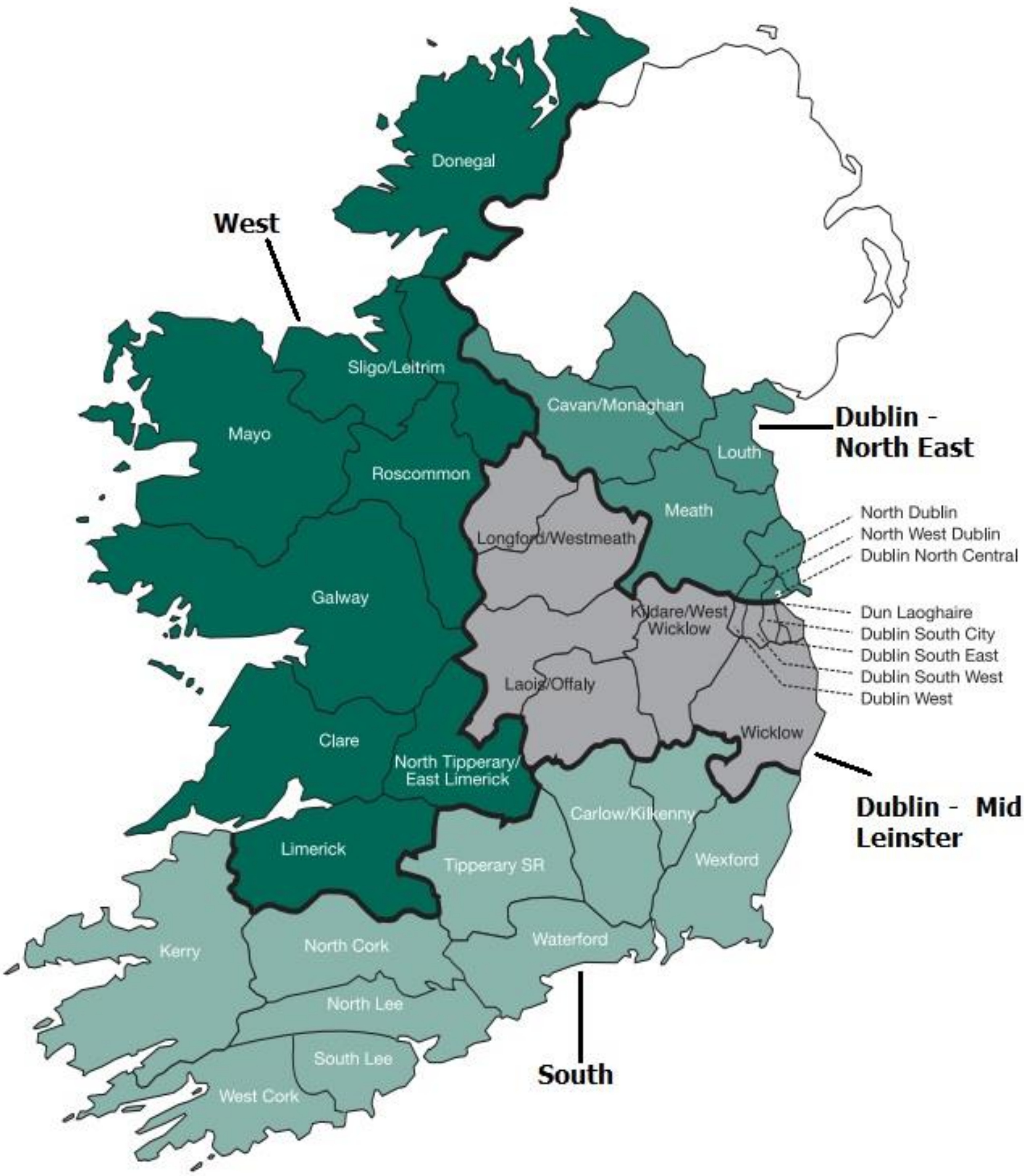
3.2.1 Primary, community and continuing care (PCCC) services

With the introduction of the HSE in 2005, 4 main administrative geographical areas were established, which contained a total of 32 local health offices (LHOs) [94]:

- **HSE West:** Donegal, Sligo/Leitrim, Mayo, Roscommon, Galway, Clare, Limerick, North Tipperary/East Limerick;
- **HSE South:** Kerry, North Cork, North Lee, South Lee, West Cork, Tipeprary SR, Waterford, Carlow/Kilkenny, Wexford;
- **HSE Dublin North East:** Cavan/Monaghan, Louth, Meath, North Dublin, North West Dublin, Dublin North Central;
- **HSE Dublin Mid Leinster:** Longford/Westmeath, Laois/Offaly, Kildare/West Wicklow, Wicklow, Dun Laoghaire, Dublin south City, Dublin South East, Dublin South West, Dublin West,

These regions are outlined in figure 3.1 [94]. Each of these regions represents the organisation of services for approximately one million people [90]. The aim of LHOs was to provide a range of primary, community and continuing care services (PCCC) which had previously been provided by local health boards. These services were delivered through a combination of public, voluntary and private providers [90].

FIGURE 3.1: HSE administrative regions and LHOs



Source: Health Service Executive

As of 2015, the delivery of PCCC services by the HSE and its funded agencies have been provided by community health organisations (CHOs) [95]. These services include primary care, social care, mental health, and health and well being services. The areas designated as CHOs are a combination of the previously established LHOs:

- **Area 1:** Donegal LHO, Sligo/Leitrim/West Cavan LHO and Cavan/Monaghan LHO;
- **Area 2:** Galway, Roscommon and Mayo LHO;
- **Area 3:** Clare LHO, Limerick LHO and North Tipperary/East Limerick LHO;
- **Area 4:** Kerry LHO, North Cork LHO, North Lee LHO, South Lee LHO and West Cork LHO;
- **Area 5:** South Tipperary LHO, Carlow/Kilkenny LHO, Waterford LHO and Wexford LHO;
- **Area 6:** Wicklow LHO, Dun Laoghaire LHO and Dublin South East LHO;
- **Area 7:** Kildare/West Wicklow LHO, Dublin West LHO, Dublin South City LHO and Dublin South West LHO;
- **Area 8:** Laois/Offaly LHO, Longford/Westmeath LHO, Louth LHO and Meath LHO.

The newly designated CHOs can be seen in figure 3.3. The populations catered for by these areas range in size from 360,000 in Area 6, to almost 675,000 in Area 7 [96].

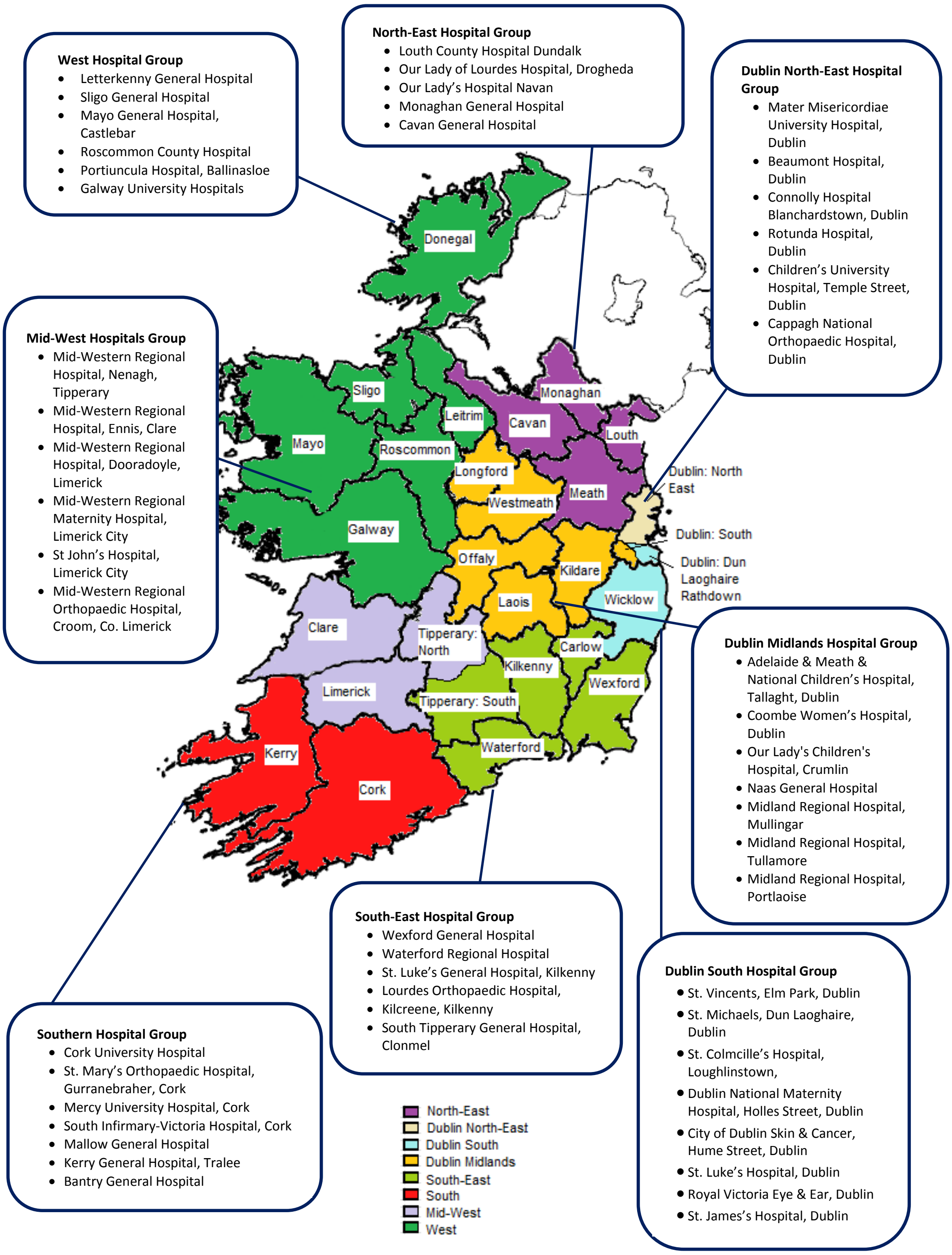
Traditionally in Ireland, general practitioner (GP) services have been described as being *"largely made up of a series of disparate personnel, with individual spheres of activity, relating to separate functional units and employed under a variety of different contracts"*

[97]. GPs are generally self-employed professionals who provide services through individual contracts with LHOs/CHOs and who also administer care directly to private patients. It has been acknowledged that the public-private mix of entitlements can cause problems regarding fairness and equity of access to services [98]. Since the early 2000's the need for primary care to be the focus of the health system, reducing the dependency on hospital services has consistently been reiterated [98, p. 7].

3.2.2 Acute hospital care services

Since the inception of the HSE in 2005, the principal arrangement of acute care has been delivered through established hospital networks [94]. The regions covered by these networks and their corresponding hospitals are outlined in figure 3.2. These hospitals are principally state owned and run. There are exceptions in the capital city, Dublin, where many hospitals are non-statutory and historically have been run by voluntary or charity organisations [90]. The regions identified in figure 3.2 differ from those of both the LHOs and the CHOs, meaning that the regions designated for the delivery of PCCC services differ from the regions in which acute hospital care is delivered.

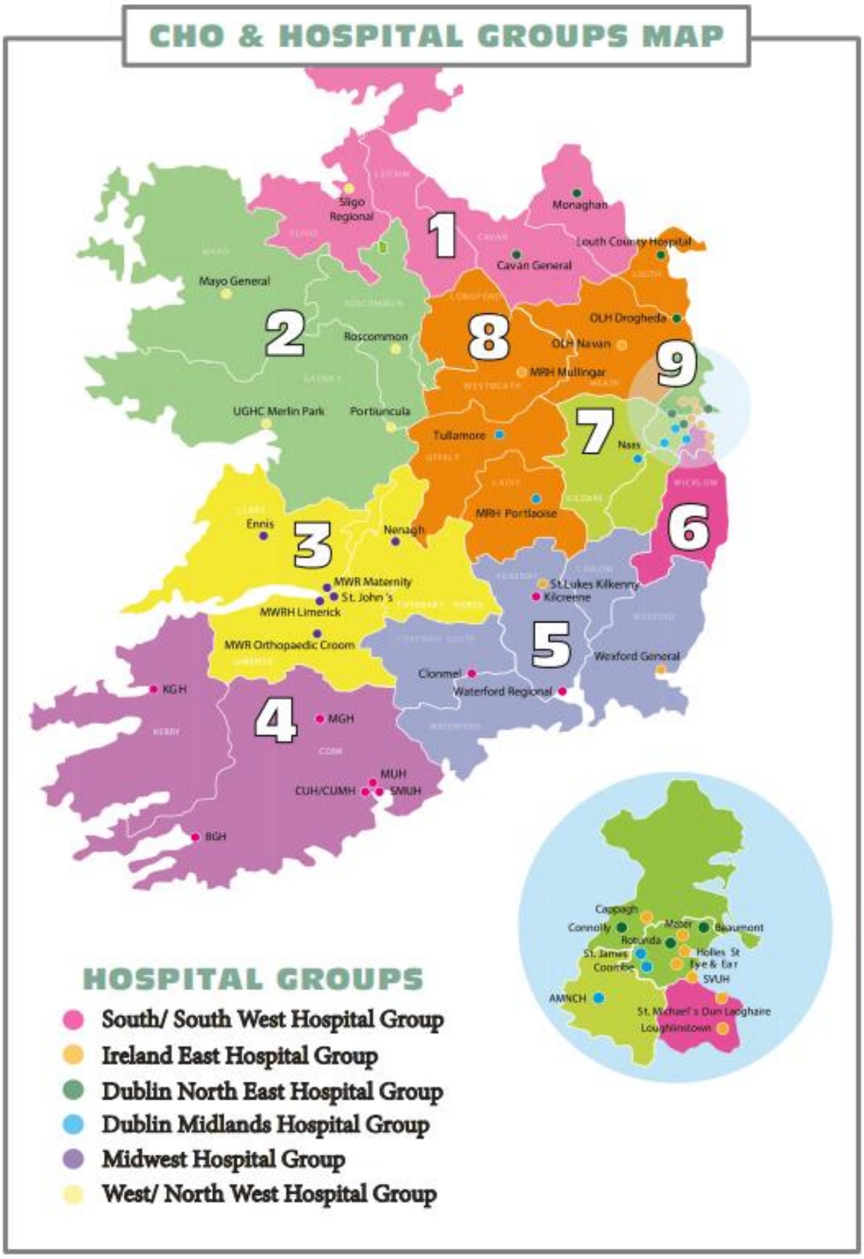
FIGURE 3.2: HSE hospital networks



Source: Health Service Executive

A 2013 report [18] led to the establishment of new hospital groups which resulted in changes to the regional configuration of hospital services. These hospitals services, as situated within their respective CHO areas, are represented in figure 3.3. As can be seen in this figure, the new hospital groups continue to straddle different CHOs.

FIGURE 3.3: HSE hospital groups and CHOs



Source: Health Service Executive

3.2.3 Financing health in Ireland

The Irish health system is financed through a combination of public and private spending, an arrangement that policy makers in Ireland have historically argued *"enhances individual wellbeing and health system performance"* [99, p. 45] providing insurees with greater choice over providers and the timing of care. By promoting cost shifting from the public to the private sector, the additional income streams provided by insurance payments is also seen by policy makers as a way to improve the sustainability of the public health system.

Based on 2015 figures, Ireland spent $5,275.80 per capita on healthcare, the seventh highest in the OECD [100]. Total health service funding has expanded since the austerity budgets that were adopted following the 2008 financial crisis. In the 2010 budget, which was set during the middle of the economic recession in Ireland, the total publicly funded budget available to the HSE was €10,089 million. Of this total, €536 million was budgeted for primary care services including primary care, social inclusion and palliative care. €4,839 million was budgeted for acute hospitals, accounting for close to 50% of all spending [101, p. 4].

In 2017, the total value of the publicly funded budget of the HSE came to €14,556.5 million. There was also a shift in spending priorities, with increased funding for primary care; €1,079.5 million was allocated on primary care, almost double that spent in 2010 [34, p. 95]. €4,600.5 million was ring-fenced for acute hospitals, accounting for roughly a third of all spending. This change of emphasis is indicative of the increased focus of government policy on the importance of the provision of primary services.

Private health insurance

Private health insurance also plays a significant role in the Irish health system; based on CSO population estimates, the percentage of the population with in-patient health insurance plans was 45.3% at the end of March 2018, having peaked at 50.9% in 2008 [102]. As public spending was reduced during the post-2008 recession, the reliance on private spending within the health system increased. Since 2008, the contribution of private sources has grown to 30% of health spending in 2015, up from 21% in 2008 [100].

There have been consistent concerns regarding issues of equity between public and private patients [99]. The main advantages of private health insurance is the provision of a greater choice of providers for policy holders and perhaps, more importantly, an improved timing of care [99]. This has led to what is regarded as a 'two-tier' health system, where treatment is not just received on the basis of need, but on the ability to pay. Providers face incentives to offer preferential treatment and quicker access to private patients in public hospitals, where the majority of private patients are treated. In an attempt to reduce the impact of private health insurance on public hospital waiting times and costs, the cost of treatment for those availing of public healthcare is largely subsidised by the government [99, p. 4]. However, incentivising the demand of insurance holders for private hospital services and increasing the charges for private beds in public hospitals to reflect their full economic cost would help remove further inequities [99, p. 4].

General Medical Services (GMS) scheme and General Practitioner Visit Cards (GPVCs)

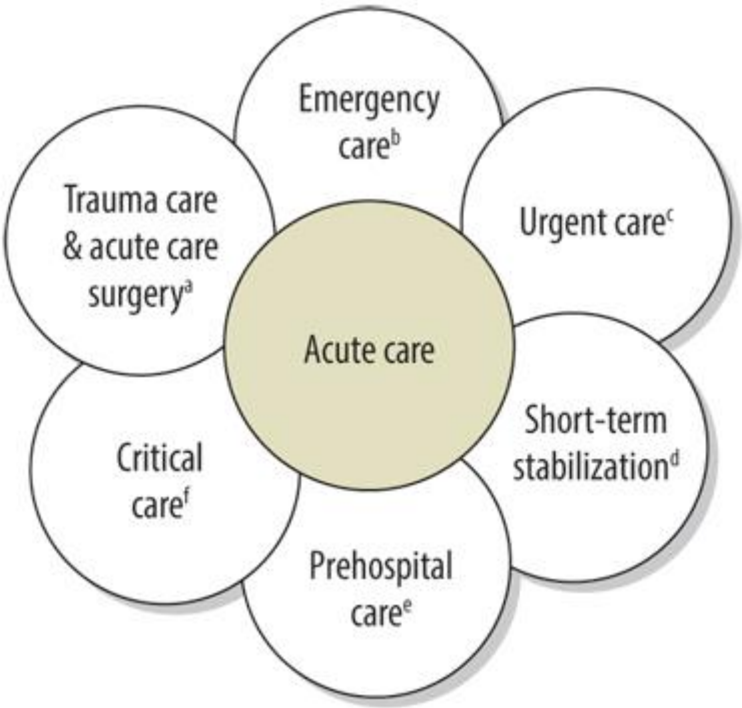
In Ireland a high proportion of the population must pay a fee of between €40 and €60 to visit a GP [103]. This charge can act as a disincentive to those in the population with lower incomes, resulting in a deterioration of the patient's condition which then manifests itself in a necessary hospitalisation. This more complex level of care is more expensive and may increase hospital waiting lists for public patients [100]. There are a number of ways in which the government supports those on lower incomes gain access to necessary health services and medicine. These supports include the General Medical Services (GMS) card, the GP visit card (GPVC), Drug Payment and the Long Term Illness schemes.

Those who fall below a certain income threshold, or for whom there is an undue burden of the cost of an illness, may be eligible for a GMS card. GMS cardholders receive access to the majority of health services free of charge including: GP visits; all in-patient services to public wards in public hospitals and all out-patient services in public hospitals; and the use of EDs, casualty and out-patient services [104, 105]. GPVC holders receive free access to GP services only [106]. As of August 2018, 1,578,155 people were eligible for the GMS card, while 497,359 people were eligible for GPVC cards. The combined population, amounting to a total of over 2 million people, indicate that just under half of the total population of Ireland were eligible for some state subsidised access to health services [107]. As of 2018, the CHO with the highest number of those eligible for the GMS and GPVC was Area 4 (South) and the lowest was Area 6 (Dublin), see figure 3.3 for CHO areas [108].

3.3 What is emergency and urgent care and how is it delivered?

Emergency and urgent care have been defined by the World Health Organisation (WHO) as domains within the wider context of acute care and its delivery [109]. The identified domains of acute care are outlined in figure 3.4 [109].

FIGURE 3.4: Domains of acute care



Source: World Health Organisation

The specific domains can be expanded as follows [109]:

a) **Trauma care and acute care surgery:** Treatment of individuals with acute surgical needs, such as life-threatening injuries, acute appendicitis or strangulated hernias.

b) **Emergency care:** Treatment of individuals with acute life - or limb - threatening medical and potentially surgical needs, such as AMIs or acute cerebrovascular accidents, or evaluation of patients with abdominal pain.

c) **Urgent care:** Ambulatory care in a facility delivering medical care outside a hospital emergency department, usually on an unscheduled, walk-in basis. Examples include evaluation of an injured ankle or fever in a child.

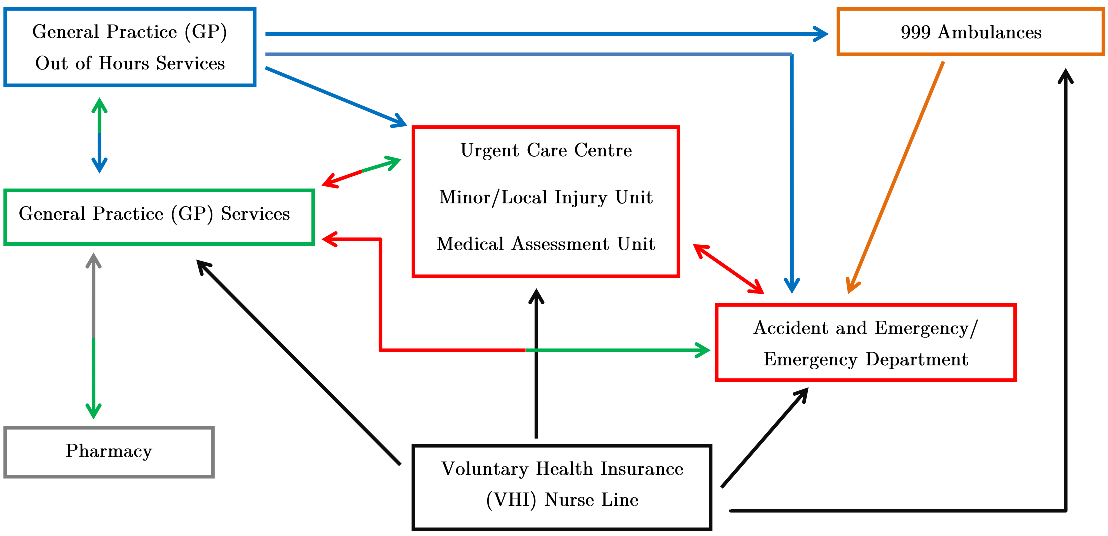
d) **Short-term stabilisation:** Treatment of individuals with acute needs before delivery of definitive treatment. Examples include administering intravenous fluids to a critically injured patient before transfer to an operating room.

e) **Pre-hospital care:** Care provided in the community until the patient arrives at a formal healthcare facility capable of giving definitive care. Examples include delivery of care by ambulance personnel or evaluation of acute health problems by local healthcare providers.

f) **Critical care:** The specialised care of patients whose conditions are life - threatening and who require comprehensive care and constant monitoring, usually in intensive care units. Examples are patients with severe respiratory problems requiring endotracheal intubation and patients with seizures caused by cerebral malaria.

Care for both emergency and urgent conditions is usually delivered at various services within the system depending on need. Figure 3.5, outlines the elements of emergency and urgent care systems in Ireland, indicating the direction in which patients move through the system. In general, the first point of consultation for most patients in need of treatment is primary care, e.g. pharmacy and GP services. Secondary care encompasses health services provided by a specialist, usually in a hospital setting, including acute care. Tertiary care requires more specialised care that is provided by highly trained and specialised healthcare professionals.

FIGURE 3.5: Elements of emergency and urgent care in Ireland



Source: SIREN Work Package 1 [53]

As can be seen in figure 3.5, the delivery of emergency and urgent care can be categorised by the interactions of different components through a network of complicated relationships. The elaborate nature of these interactions has led to the argument that health systems in general can be thought of as complex adaptive systems. A complex adaptive system is *"a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions changes the context for other agents"* [110, p. 625]. Within a complex adaptive system, it is usually the interactions between the individual components, rather than their discrete actions that is of most importance [111, p. 746]. As highlighted in figure 3.5, relationships within emergency and urgent care systems are often non-linear, as is the reality of many complex systems [110]. In general, the boundaries within complex systems are 'fuzzy', i.e. membership can change and individual components can simultaneously be members of several systems [110, p. 625]. For example, a GP provides primary care services and, as stated previously, can be the first point of contact in the case of an emergency incident. The nature of these relationships can complicate problem solving and lead to difficulties or unexpected actions in response to system changes, making the behaviour of any complex system unpredictable.

Similar to the National Health Service (NHS) in the United Kingdom (UK), Ireland's health policy aims to ensure that the connection of emergency and urgent care services work so that the overall system becomes more than the sum of its parts [112]. The over reliance of the population on certain services within the system is of particular concern. Increasingly, across many countries, the pattern of service use has been skewed towards secondary care, with increasing numbers seeking care in EDs, accident and emergency (A&E) departments, and other emergency services [113–115]. The increased pressures on EDs are often cited as being due to an aging population who are experiencing growing complex conditions which often require emergency and urgent care [116, 117]. It is important that those with serious emergency conditions receive treatment in the right facilities with the necessary expertise to increase the chances of survival and improve recovery [112]. Others argue that, in general, EDs and other emergency facilities are being misused and overused by the public [28, 118–120]. If increased activity is due to inappropriate use, there needs to be highly responsive urgent care services outside of a hospital context which can provide viable alternatives to those in need of such services.

In many cases, due to confusion surrounding appropriateness and access to urgent care services, people automatically default to the ED due to the perceived reliability and trustworthiness of the setting [112]. The efficiency and safety in EDs earns significant attention in research and in the media. In the UK, it has been argued that as improvements are made to waiting times and responses in EDs, people perceive the service as the most efficient place to attend, even when it is not appropriate to do so given their symptoms [112]. As a result, there is a risk that only short term improvements are achieved through ED improvements. A study in Ontario, Canada found that most patients (73%) believed that their medical condition was urgent and required attention within 12 hours. However, ED nurses and doctors only corroborated this in two thirds of cases [118]. In the UK, it was found that 40% of patients attending the A&E were subsequently discharged requiring no treatment at all; there were over 1 million avoidable emergency hospital admissions and up to 50 per cent of 999 calls requiring an ambulance to be dispatched could be managed at the scene [112]. In many cases, it may be that patients find it easier to use these services than make an appointment with their GP, particularly out of usual working hours [121]. In Ontario, it was also found that the perception of the urgency of the condition was not necessarily related to the age or presentation time to hospital [118]. However, patients who arrived at weekends were much more likely to perceive their conditions as urgent when compared to those who presented during the week. The authors present the hypothesis that this could be linked to the patient's perception that their own GP is inaccessible at that time [118]. Working towards the establishment of networks which remove traditional boundaries which have existed between hospitals and community based services, supported by better communication and movement of specialist skills, will allow the delivery of patient care in the most appropriate and convenient setting [112, p. 8].

If appropriate primary and preventative care are not prioritised, and if adequate responses to urgent conditions are not met outside the hospital setting, patients will feel compelled to visit or return to those services that are perceived as being highly responsive. These services may include visiting EDs and contacting ambulances, services that are ultimately intended for the most serious, complex conditions [112]. Therefore, it's important to recognise that the continued focus on ED services will only allow for limited improvements in the system. It is impossible to fully address and measure the success of changes to emergency care without also considering whether the necessary changes are also made to the wider health system. Research and policy must recognise that emergency and urgent care is a system wide concern and must be considered in the wider context of how primary and preventative care is delivered [121].

3.4 Reconfiguration of emergency and urgent cares systems

Health systems face increasing scrutiny over quality of care and patient safety. There is a desire for systems to reduce waste, while also providing reliable care with a high quality of clinical effectiveness [122]. The closure of services and hospitals is often seen as difficult and unpopular, but the belief exists that the resulting reconfiguration of services is better, safer and will ultimately save lives [123].

The literature identifies four main drivers for the reconfiguration of health systems; quality (including safety), access, workforce and cost [4, 124, 125]. The pressures of reconciling these drivers mean there must be trade-offs as priorities compete with each other. This conflict can impact on patient welfare [4, 126, 127]. Therefore, sufficient weight must be given to the consideration of patient safety when system changes are undertaken [126]. Often, stakeholders involved in the reconfiguration of emergency and urgent care systems may interpret the meaning of patient safety differently. For some, safety is maximised by ensuring that the treatment for specific conditions is received in highly specialised centres, with appropriately skilled staff; for others, close access to services and personalised care are seen as the most important aspects [128].

Much of the international evidence, which is seen as justification for system reconfiguration, has focused on the relationship between volume and outcomes. Improvements to outcomes have been seen across a range of procedures and conditions, such as aortic aneurysm and stroke, when conducted in larger units that serve larger populations [129–131]. For issues such as trauma, there is debate regarding the contribution that a higher volume of cases makes to improved outcomes. Some studies have identified linkages between trauma centre volumes and improved outcomes [132], however other studies maintain that how care is organised and delivered plays a more important role [133]. In reality, some high volume centres have poor outcomes and some low volume centres have good outcomes [4].

Changes to services due to reconfiguration has also led to concerns regarding the capacity to safely provide quality services to patients [124]. In the UK, the National Clinical Advisory Team is generally in favour of supporting the centralisation of emergency care, specifically ED services, but have expressed concerns regarding the ability and degree to which community and primary care services in a locality can provide alternatives to reduce emergency care demand [125, p. 36]. It is unclear what proportion of emergency and urgent care patients can be safely seen in community settings and, specifically with regard to emergency conditions, there is little evidence that developing these services will reduce demand for acute services [124].

Evidence suggests that the centralisation of services can result in remaining resources being overwhelmed e.g. beds used to full capacity, patients waiting in crowded EDs or in ambulances to be admitted. Long waits in EDs are associated with high rates of patient mortality and morbidity [134]. The knock on impacts of policy attempts to reduce issues, such as ED waiting times, have caused problems further up stream resulting in increased hospital admissions, a higher burden placed on inpatient clinical staff to meet the targets set and labour-intensive mechanisms required to monitor targets [134].

Workforce related factors are also important to consider with regard to patient safety. It has been argued that workforce drivers are inextricably linked with safety and can be taken as proxy for safety concerns [124]. Analysis of the reconfiguration of the A&E services in the UK has found that, in addition to appropriate diagnostics and critical care, there is good evidence to support consultant-delivered care [125]. Ensuring adequate staffing for smaller hospitals is more challenging and any increased vacancies will lead to a greater workload for trainees and consultants, thereby making these places more unattractive to potential applicants [125]. While, reconfigured services increase access to senior consultant opinion and higher levels of staffing, there is also an increased burden on those services. Additional workloads on remaining acute medicine services, and a more acute case-mix of patient within specific services, can lead to a longer wait time to see a clinician [124, 130]. The impact of this may result in patient care, including safety, being compromised [124, 126, 135, 136].

The implementation of the 2004 European Work Time Directive is argued to have had a significant impact on the reconfiguration of acute services with high emergency workloads. This directive outlines a number of measures to increase worker welfare and safety, including insuring a maximum 48 hour working week for doctors in training [137]. The consolidation of acute services is seen as a vital step towards ensuring a sufficient number of junior doctors to maintain appropriate standards of patient care and also ensuring that there are a sufficient number of patients for satisfactory clinical training [124, 125, 129]. Analysis of Trusts in the UK found that not all services can be safely provided everywhere. Attempting to continue the provision of historic services, while improving patient safety, may result in resources and senior staff being spread too thinly [138]. Therefore, higher levels of senior staffing are needed to promote patient safety. A study by the College of Emergency Medicine [139] in the UK argued that *"every ED should be staffed by at least 10 working-time equivalent consultants to provide a consultant presence in the ED 16 hours per day, 7 days per week"* [125, p. 36]. In the absence of significant reconfiguration, the continuation of prevailing organisational structures may require substantially more consultants than are currently hired.

The centralisation of the services to larger hubs has increased the uncertainty around the future of smaller, rural general hospitals. Rural areas have fewer health services available to them in general, including fewer hospitals and physicians, and are more likely to experience the scale back of services compared to urban centres [65].

Understanding the characteristics of smaller, rural hospital capacity is crucial to determining how to implement and ensure patient safety at the organisational level [140]. It is questioned whether it is possible for rural hospitals to deliver the same quality of care as their urban counterparts. Rural communities have a number of competitive disadvantages with regard to the maintenance of emergency services, including EDs [140]. Rural hospitals tend to be smaller in size, have older facilities, have less opportunity to form important strategic alliances with other hospitals and have staff members that are more likely to be generalists (i.e. primary care physicians and general surgeons) [65, 141–143].

Conflicting views exist in the literature, and between stakeholders, regarding changes to patient 'access' of services. Many of the objections to system reconfiguration are founded on the concept of reduced 'access' particularly for the most vulnerable patients.

It is argued that those suffering from deprivation in rural areas are trapped due to a lack of personal mobility, which means they bear the burden of geographical inaccessibility to health services [79]. As outlined in **Chapter 2**, populations in these areas in Ireland tend to be more elderly, with higher levels of regional deprivation, therefore there are substantial social and quality reasons to provide good access to services in these regions [43]. However, Fulop et al. [4] argue that 'access' is not a straightforward concept and may be defined as the physical distance, time or journey difficulty that must be undertaken by patients to reach services, or it may refer to more bureaucratic procedures which impact the delivery of care within the system [4]. Achieving a reconciliation between these two interpretations of 'access' can be difficult [128].

A much debated subject when considering 'access' in the emergency and urgent care system is the availability of EDs. EDs often serve as the safety net for those patients who lack other options of care [134], therefore, closures or downgradings of these services are usually seen as *"a direct threat"* to the regional population's safety [125, p. 44].

Many conditions that require engagement with the emergency and urgent care system, primarily EDs, are time sensitive. International studies highlight the geographical variation in survival from emergency conditions; there is a greater risk of poorer outcomes due to distance from acute services and the existence of an older more socioeconomically disadvantaged population in rural areas [144–146]. For such conditions the centralisation of services results in trade-offs between an increased clinical risk associated with longer journey times to services on one hand, and improved outcomes from treatment received in larger, specialist regional services on the other [4]. Additional travel time, caused by the removal or reconfiguration of services, may contribute to higher death rates among those who have suffered accidents or acute events in rural communities [65, 147]. A study of hospital closure in the US found that a 1-mile increase in distance to hospital is associated with a 6.5% increase in the number of deaths from AMI, and an 11% to 20% increase in the number of deaths from unintentional external injuries [136, 148]. A UK study found that a 10-km increase in straight-line distance to treatment was associated with a 1% absolute increase in mortality [87]. The impact of this inaccessibility is more apparent in larger countries such as Australia and Canada. For relatively small geographical areas such as the UK, it is less apparent that rural populations are negatively affected by access to services. This suggests that there is some critical distance that exists before an apparent impact is observed between access to health services and health outcomes [81, p. 57]. Therefore, an individual country's needs for their specific rural areas must be taken into consideration when planning the provision of health services, ensuring needs are meet more precisely and in a more effective way [86, 149].

The removal of services may also affect people's willingness to seek timely care if an increased geographical distance needs to be travelled [150–152]. A lack of appropriate services means that an 'unmet need' may exist in these areas. This results in rural populations having less contact with physicians and greater difficulty in accessing care compared to their urban counterparts [65]. The impact of hospital changes have also proven to be under reported as data has consistently focused on hospitalised patients, something that cannot capture the impact of changes to those in the population who never make it to the hospital [147].

In summary, evidence has shown that there are quality and safety gains from service reconfiguration for certain specialist services [124]. Larger centres of care, with more targeted equipment, a greater number of physicians and specialists, and higher rates of interventions performed, are argued to show greater clinical safety and better outcomes than smaller services [4]. A criticism in the literature identifies the tendency to see the centralisation of services as proof itself of quality and safety improvements [125].

However, there is a lack of longitudinal data to track the quality benefits of whole-hospital reconfigurations, including the centralisation of emergency services [124, 125]. Findings from studies in England suggest that smaller hospitals are not inherently less safe or less efficient [124] and for many time sensitive conditions there may be negative consequences associated with travelling further to receive care [87, 136, 148]. However, as previously outlined, there are good arguments for centralising some hospital services or at least providing these services as part of a more integrated network [124].

Since 2006, the health system as a whole in Ireland has undergone extensive changes, including the systems and services that are designed to cater for emergency and urgent care conditions. A number of different policies and reports have been published with the aim of ensuring that patients can access the most appropriate combination of services, whether they live in a rural or urban region. As outlined in **Chapter 1**, the provision of emergency and urgent care services has progressively been centralised to larger, urban based centres with higher staff numbers and a greater volume of cases. The centralising of these services has raised concerns for patient safety and timely treatment, which have not been fully investigated [130].

3.5 Reconfiguration of the Irish emergency and urgent care system

This section discusses the details of the significant reports published since 2006. Many of the recommendations outlined in these reports subsequently informed policy which both directly contributed to the implementation of reconfiguration of the emergency and urgent systems in Ireland, or shaped the context in which reconfiguration occurred.

These reports include national health policy reports, national and regional reconfiguration reports, national clinical programme reports, pre-hospital reports and primary care reports. Table 3.1 outlines the chronological order of the publication of these reports.

TABLE 3.1: Health policy reports

2006	2006: Horwath and Teamwork - An Action Plan for the Health Services in the North East
	December 2006: Health Service Executive Transformation Programme
2008	April 2008: Horwath and Teamwork - An Action Plan for Acute and Community Health Services in the Mid-West
	May 2008: Horwath and Teamwork – A Review of Acute Services and a five year action plan for the South
2009	June 2009: Reconfiguration of Acute Hospital Services, Cork and Kerry – The Reconfiguration Roadmap
	September 2009: Towards Excellence in Critical Care – Review of Adult Critical Care Services in the Republic of Ireland
2010	March 2010: Changing Cardiovascular Health - National Cardiovascular Health Policy 2010-2019
	December 2010: Report of the National Acute Medicine Programme
2011	2011: Chronic Obstructive Pulmonary Disease (COPD) Outreach Programme
2012	January 2012: Heart Failure - Model of Care
	March 2012: Acute Coronary Syndromes Programme - Model of Care
	April 2012: Stroke Clinical Care Programme – Model of Care
	June 2012: Future Health – A Strategic Framework for Reform of the Health Services 2012-2015
	June 2012: The National Emergency Medicine Programme

2013	February 2013: Securing the Future of Smaller Hospitals – A Framework for Development
	March 2013: Healthy Ireland – A Framework for Improved Health and Wellbeing
	June 2013: The Establishment of Hospital Groups as a Transition to Independent Hospital Trusts
	October 2013: Model of Care for Acute Surgery – Clinical Programme in Surgery
2014	April 2014: The Path to Universal Healthcare – White Paper on Universal Health Insurance
2015	May 2015: Activity-Based Funding Programme – Implementation Plan 2015-2017
2016	March 2016: Planning for Health – Trends and Priorities to inform Health Service Planning
	May 2016: National Ambulance Service of Ireland – Emergency Service Baseline and Capacity Review
2017	May 2017: Committee on the Future of Healthcare – Sláintecare Report
	November 2017: A Future Together – Building a Better GP and Primary Care Services
2018	August 2018: Sláintecare Implementation Strategy

Colour legend for reports

	National Health Policy Reports
	National Clinical Programme Reports
	National Reconfiguration Reports
	Regional Reconfiguration Reports
	Pre-Hospital Care Reports
	Primary Care Reports

3.5.1 National health policy reports

Since 2010, a number of national health policy reports were published which describe wider society level health issues which were to be addressed. These reports include:

- *Changing Cardiovascular Health - National Cardiovascular Health Policy 2010-2019*

- *Future Health - A Strategic Framework for Reform of the Health Services 2012-2015*
- *Healthy Ireland - A Framework for Improved Health and Wellbeing*
- *The Path to Universal health - White Paper on Universal Health Insurance*
- *Activity-Based Funding Programme - Implementation Plan 2015-2017*
- *Planning for Health - Trends and Priorities to Inform Health Service Planning*
- *Committee on the Future of Healthcare - Sláintecare Report / Sláintecare Implementation Strategy*

These reports contribute to the context in which more specific service and system changes took place. Across the reports a number of common themes are highlighted, which include Ireland's aging population [153, 154], the increased prevalence of chronic conditions [154, 155], and the historical over-reliance of the Irish health system on hospitals to deliver care [153, 155, 156].

From an emergency and urgent care perspective, the over-reliance on acute hospital-centric services is seen as unsustainable [153], particularly due to the changing demands on the system associated with an older national demographic. Ireland's health system is described as being designed to deal with episodic diseases or accidental injuries [157]. As such, the system is currently unequipped to address the changing landscape of health needs that comes with a growing and aging population [157]. The *'Future Health'* Report [153] stresses the importance of integrated care, defined as that which *"improves the quality and outcome of care for patients and their immediate families and carers by ensuring that needs are measured and understood and that services are well co-ordinated around these assessed needs"* [153, p. 16].

Across the reports, the need to increase the role of primary care in reducing inequalities and inefficiencies is discussed [154, 156–158] and reforms to primary care provision are seen as the foundation to total system change. The *'Future Health'* report envisages the delivery of care through primary care teams, which would refer patients to other services based on their needs. Improved investment and co-ordination of primary care services should lead to a corresponding reduction in the need for more intensive interventions at a later stage in a patient's condition. An emphasis on earlier interventions will therefore decrease the complexity, and potentially the cost, of care that is generally required at a population level [157]. This approach is also supported by the *'Healthy Ireland'* report which outlines the need for increased awareness of individuals to maintain or improve health and ensure the consistent management of chronic and underlying conditions [154]. The combined outcome of these steps would be a possible reduction at a national level in the demand for emergency and urgent services.

The reports highlight the need for a more effective use of resources, stressing the need for improved efficiency and quality, specifically in hospitals. There is a drive towards activity based funding in an effort to provide greater transparency in spending [153, 156] and a call for increased resources for primary care services to cater for a wider range of conditions [153, 155].

A recognition of the need to remove the 'two-tier' system of healthcare provision which remains due to the existence of both public and private patients is at the forefront of national healthcare provision policy. Universal health insurance (UHI), was the first significant policy attempt to address this problem, but it's implementation was found to be too costly [159, 160]. The recent publications of the Sláintecare report [157] and it's implementation strategy [161] in 2017 and 2018 are the most compelling documents which have been published regarding the introduction of universal healthcare which is not defined by the ability to pay for treatment. The report was published as a result of an Oireachtas (parliamentary) committee which had cross-party support [162]. The recommendations of this report outline Ireland's journey to a single-tier, universal health system over the next decade and will shape the provision of all services. The report indicates that health services are being refocused from acute hospital settings to primary and social care in the community. As a result, greater investment is required to increase the recruitment and retention of the necessary professionals in these areas. An increased focus on these services will ultimately reduce pressures within the acute hospital system [157].

3.5.2 National clinical programme reports

Since 2009, a number of clinical programmes have been developed with regard to specific conditions and service areas within the health system. There are currently 33 National Clinical Programmes in operation [163]. Those which specifically incorporate an aspect of the emergency and urgent care system include:

- *Towards Excellence in Critical Care - Review of Adult Critical Care Services in the Republic of Ireland*
- *Report of the National Acute Medicine Programme*
- *Chronic Obstructive Pulmonary Disease Outreach Programme*
- *Acute Coronary Syndromes Programme - Model of Care*
- *Heart Failure - Model of Care*
- *Stroke Clinical Care Programme - Model of Care*
- *The National Emergency Medicine Programme*

- *Model of Care for Acute Surgery - Clinical Programme in Surgery*

These programmes provide a comprehensive outline of the most appropriate pathway of care for any patient who experiences one of the identified conditions.

The *'Review of Critical Care'*, *'National Acute Medicine Programme'*, *'Emergency Medicine Programme'* and the *'Clinical Programme in Surgery'* focus on the more general organisation of the services of care for emergency conditions. Much of the focus of these reports is on the identification of the characteristics required by hospitals to cater for the most serious of emergency conditions [16, 17, 19, 164]. The restructuring of hospital services into appropriate 'levels' or 'models' in line with their capacity, including resources and staff, is outlined. It is believed that the reconfiguration of services to a network approach would lead to patients being treated in the right location at the right time, thereby increasing the probability of the best possible outcomes [17, 19].

In the *'Review of Critical Care'*, three main categories of hospitals are outlined:

1. **'Local' Hospital:** Smaller local hospitals are identified as those that do not have a critical care unit, and provide general ward care. This includes the provision of ambulatory and/or non-acute inpatient services. These hospitals would have a minor/local injury clinic and if necessary, patients would be transferred to the nearest 'spoke' or 'hub' ED department if they experience a deterioration in their condition.

2. **'Spoke' Hospital:** 'Spoke' hospitals are larger than local hospitals and provide a wider range of services. These include a 24/7 ED with acute medical and surgical inpatient services, and a critical care unit. Trauma, with the exception of major organ failure or multiple fractures, would be treated at a 'spoke' hospital. Where

patients require critical care that is long-term and complex, with multiple organ support or sub-specialist care, then they would be transferred to a 'hub' hospital.

3. **'Hub' Hospital:** 'Hub' hospitals are identified as the largest tertiary hospitals and provide 24/7 ED services with a full range of acute medical and surgical inpatient services, including a major trauma centre and a critical care unit. At 'hub' hospitals, patients would receive the most complex levels of care and 'hub' hospitals would receive patients from both 'local' and 'spoke' hospitals depending on the level of care required.

The main recommended model for critical care is a move towards a network approach whereby each of these hospital types work together in a way which ensures the highest quality critical care in a timely manner [19, p. 13]. It would also result in care units having the appropriate throughput of different levels of care to maintain staff competencies [19, p. 20]. The report found that, at the time of publication in 2009, there were 37 hospitals providing critical care, but 10 did not have the throughput of critical care activity to maintain staff skills [19, p. 12]. Nine hospitals were found to provide the vast majority of all critical care with respect to volume and complexity. However, it was found that the capacity in these hospitals was under pressure, making it difficult to meet demands, especially with regards to step-down capacity.

The *'National Acute Medicine Programme'* explains the role of the different grades of medical assessment units within hospitals. The report describes the differences between Medical Assessment Units (MAUs), Acute Medical Assessment Units (AMAUs), and Acute Medical Units (AMUs). Each of these units is attached to a different type of hospital model and is associated with differing levels or degrees of care. This delivery of care is designed to provide *"a clear delineation of hospital services based upon the safe* *provision of patient care within the constraints of available facilities, staff provision, resources and local factors"* [16, p. 8]. These types of hospitals are referred to as Model 1 to Model 4, but very much encompass the same distinctions as outlined by the *'Review of Critical Care.*

- A 'Model 1' hospital is characterised as a community/district hospital, which will cater for patients with rehabilitation, respite and/or non-complex pallative care needs. This hospital will not have an intensive care unit (ICU) or ED. This model does not have direct comparison within the *'Review of Critical Care.*

- A 'Model 2' hospital will provide in-patient and out-patient care for low-risk medical patients. This model of hospital will not have an ICU, so patients are monitored using the early warning score and transferred to a higher model of hospital where required. A MAU is located in 'Model 2' local hospitals and will cater for patients with low risk medical conditions referred by GPs. The services provided at a 'Model 2' hospital correlation with that of a 'local' hospital.

- A 'Model 3' hospital will admit acute medical patients. An AMAU is located in 'Model 3' general hospitals and should also be co-located with an ED. Depending on the location, the AMAU will either operate for 12 or 24 hours. The hospital will also have an ICU. The services in this type of hospital correspond to 'spoke' hospitals.

- A 'Model 4' tertiary hospital would admit acute medical patients. An AMU would be located in the hospital and should be co-located with an ED which operates 24/7. Patients who arrive here would require immediate and early specialist management of their condition. These hospitals correspond to larger 'hub' hospitals.

The introduction of MAU/AMAU/AMUs are based on international recommendations and results in a significant change to how hospital care is delivered to emergency and urgent care patients [16, p.16]. It has been found that such units allow for the efficient streaming of medical patient to the most appropriate location where they can be seen by a senior medical doctor [16, p.10]. This should lead to reduced waiting times and more accurate assessment of whether a patient requires an admission. The main aim of the assessment units is to reduce duplication of clinical assessment and unnecessary diagnostic testing [16].

The *'Clinical Programme in Surgery'* again supports the change to the delivery of hospital care, suggesting that the establishment of new hospital groups would result in improved and better standardised patient care, better resource utilisation and more timely delivery of patient care. The report states that hospitals that receive acute patients need to be organised appropriately into coherent geographical boundaries, under a single governance structure to ensure patients are sent to the correct service. The hospital networks for acute surgery should be defined with regard to:

- Populations within each catchment area;
- Workload and capacity of existing units;
- Specialty and sub-specialty availability;
- Accessibility, transport links and travel times;
- Historical referral patterns based on academic links and previous health board structures where appropriate;
- Potential cross-border services.

Most importantly, the goal is to enable patients to attend the most appropriate service given the nature and complexity of their condition.

Similarly, the *'Emergency Medicine Programme'* programme outlines the importance of appropriate Emergency Care Networks which should include 24/7 EDs, local injury units (LIUs) for patients with non-life-threatening or limb-threatening injuries, and a potential role for Local Emergency Units providing daytime only emergency services on a limited number of sites [17, p. 6].

The collective impact of these reports is the continued emphasis on moving the care of the most serious emergency conditions to the largest hospitals with the highest volume of cases. This approach to the delivery of emergency and urgent care is in line with international trends [165–167].

The individual condition clinical programmes, *'COPD Outreach Programme'*, *'Acute Coronary Syndromes Programme'*, *'Heart Failure'*, *'Stroke Clinical Care'*, focus specifically on the process and outcomes associated with their respective conditions [168–171]. Across these programmes, the aim is to improve the quality and standardisation of care, increase access to the most appropriate best practice care, and ultimately reduce the cost associated with these episodes of care.

As cardiovascular disease is the largest contributor to emergency deaths in Ireland [172, 173], it is unsurprising that there is a significant emphasis on these conditions within the clinical programmes. The programmes seek to incorporate the most up-to-date international best practice, most apparent with regard to the treatment of stroke [171, 174]. The *'Stroke Clinical Care Programme'* highlights the importance of thrombolysis therapy. The report confirms that, at the time of publication, only 8-15% of confirmed ischaemic stroke patients were eligible for such treatment under the prevailing administration guidelines [171, p. 7].

The combination of the recommendations from these reports provided a significant foundation for the changes seen in the delivery of emergency and urgent care in the past decade.

3.5.3 National reconfiguration reports

Nationally, a number of important reconfiguration reports were published from 2006 onwards.

- *Health Service Executive Transformation Programme*
- *Securing the Future of Smaller Hospitals - A Framework for Development*
- *The Establishment of Hospital Groups as a Transition to Independent Hospital Trusts*

The first of these reports, the *'Transformation Programme'* [15] was produced in 2006 after consultation with HSE staff across hospitals and LHOs and among a range of different clinicians including doctors, nurses and therapists. The aim of the report was to provide information to HSE staff with regard to changes that would be undertaken within the health system over the coming years. The changes outlined would be expanded further in following health policy reports and clinical programmes, as outlined in section 3.5.1 and section 3.5.2. Integrated services, emphasis on the prevention and management of chronic illness and the introduction of standards based performance measures were included in the service transformation programme priorities. The programme also calls for the reconfiguration of PCCC services, together with hospital services to deliver optimal and effective results. These priorities would be supported by other subsequent policies and programmes at a national health policy (section 3.5.1), clinical programmes level (section 3.5.2), primary care level (section 3.5.6) and in the other national reconfiguration reports *'Future of Smaller Hospitals'* and *'Establishment of Hospital Groups'*. The *'Transformation Programme'* also recognised the need for changes to governance structures, including stakeholder and relationship management, as well as a shared services strategy and implementation.

The remaining national reconfiguration reports focus specifically on changes to the organisation of hospital care.

The *'Future of Smaller Hospitals'* report was published in February 2013 [8], and describes the changing role of small hospitals within the context of the acute hospital system. The report stresses that the aim is not that smaller hospitals would provide fewer services, but that they would provide more of the 'right' services which are appropriate to the setting, thereby maximising the benefit to patients [8, p. 1]. The report emphasises the importance of an integrated care approach to the success of these system changes. It also confirms the governments continued commitment to UHI to eliminate the current two-tier service [8, p. 1].

Smaller hospitals are characterised as 'Model 2' hospitals, as previously outlined in section 3.5.2. These hospitals provide the majority of hospital services including extended day surgery, selected acute medicine, local injuries, diagnostic services, specialist rehabilitation medicine and palliative care [8, p. 8]. This report highlights nine such hospitals in the following health regions in Ireland:

- **Dublin North East:** Our Lady's Hospital Navan, Louth County Hospital, Dundalk.

- **Dublin Mid Leinster:** St Columcille's Loughlinstown.
- **South:** Mallow, Bantry.
- **West:** Ennis, Nenagh, St John's Limerick, Roscommon County Hospital.

The majority of these ED services in these hospitals have been, or would be, reconfigured to Urgent Care Centres (UCC) which are comprised of MAUs and LIUs.

Conditions assessed by MAUs include chest pain (including suspected heart attack), suspected stroke, respiratory conditions, fever, seizures, headaches, and suspected illnesses such as pneumonia or chest infections. In general, attendance at an MAU is referred by a GP [175, 176], but self-referral is also possible in some MAUs [176].

Conditions assessed by the LIUs include suspected broken bones, sprains, minor facial injuries, scalds and burns, and minor head injuries. Again, general attendance is by GP referral [176, 177], but many LIUs also accomodate self-referral [176].

Appropriate use of these services should result in lower demands on other emergency services which may have limited capacity. Patients within these units would be assessed and tracked using the national early warning score which prompts an acute medicine response and transfer to a higher level 'Model 3' or 'Model 4' hospital where appropriate. In line with these changes, the continued development of smaller hospitals is concerned with increased safety, quality, access, and increased links with primary care.

The *'Establishment of Hospital Groups'* report was published in the same year as the *'Future of Smaller Hospitals'* report. At the time of its publication, the government was working towards the goal of a single-tier health system which would be supported by UHI, see section 3.5.1. Under this system, the aim was to ultimately have the provision of hospital services similar to the NHS in the UK, where hospital care would be provided by independent, not-for profit trusts and private hospitals, with hospitals paid according to the care they deliver.

The objective of the *'Establishment of Hospital Groups'* report was to move towards a system of independent hospital trusts. The aim of the new groups is to ensure the optimum configuration of hospital services to deliver *"high quality, safe patient care in a cost effective manner"* [18, p. 31]. The established hospital groups would each have their own governance and management structure and would allow for appropriate integration and flow of patients across an episode of care. Each group would also be partnered with a primary academic partner which would promote a *"culture of learning and openness to change"* [18, p. 8]. Similar to previous reports, the continued integration between primary and hospital care is stressed as a vital aspect to the establishment of the hospital groups.

The new outlined groups broke some of the traditional relationships between hospitals and regions as established by the HSE hospital groups, outlined earlier in figure 3.2. It was recommended that the previous eight region hospital groups system be changed to a six group option, the largest change occurring due to the amalgamation of the South and South-East region, thereby cutting the historical ties between the South-East (University Hospital, Waterford) and Dublin (teaching links with the Royal College of Surgeons, Dublin).

3.5.4 Regional reconfiguration reports

Four regional reconfiguration reports were published between 2006 and 2010. These were:

- *Horwath and Teamwork, Improving Safety and Achieving Better Standards - An Action Plan for Health Services in the North-East*
- *Horwath and Teamwork, A Review of Acute Hospital Services in HSE Mid-West - An Action Plan for Acute and Community Health Services*
- *Horwath and Teamwork, Securing Clinically Safe and Sustainable Acute Hospital Services - A review of acute services in HSE South and a five year action plan for Cork and Kerry*
- *Reconfiguration of Acute Hospital Services, Cork and Kerry - A Roadmap to Develop an Integrated University Hospital Network (The Reconfiguration Roadmap)*

Three regional reconfiguration reports for the the North-East, Mid-West and South were published by Horwath Consulting Ireland and Teamwork Management Services between 2006 and 2008.

These reports outline recommendations for changes to specific services, specifically hospital services. In the North-East and the South, the reports found that due to small populations, the quality of care delivered posed increased risks to patients. It argued that the small volume of emergency patients typically seen in these facilities could result in consultants de-skilling due to lack of exposure to certain conditions in large numbers [178, p. 3] [179, p. 22]. These findings, and the theme of low volume leading to de-skilling of staff, would also appear in subsequent national reconfiguration reports, see section 3.5.3.

In the Mid-West, the report states that too many people were admitted unnecessarily to hospital, with a wide variation in non-elective hospitalisation rates by county [180, p. 3]. The report also found that once admitted, the length of stay for patients in hospital was too long. It is estimated that, if set to the same benchmark as national and international comparisons, in-patient bed use in the Mid-West could be reduced by 32% [180, p. 3].

The common recommendation across all three reports is a centralisation of emergency care to the larger regional hospitals with smaller hospitals becoming 'local centres of excellence'. The benefits of these reconfiguration measures would include safe and sustainable local and regional services [179, p. 6] in which more care would be received locally, with increased ease of access and care tailored to the needs of patients, rather than the needs of the services. However, the authors of the reports acknowledge that the implementation of these recommendations would require *"frontline health professionals being prepared to challenge the status quo ... to work on the imperative to improve patient safety not withstanding any local agendas not in tune with this"* [178, p. 8].

Following the publication of the Horwath and Teamwork report on the reconfiguration of health services in the South in 2008, another report, the *'Reconfiguration of Acute Hospital Services, Cork and Kerry - A Roadmap to Develop an Integrated University Hospital Network (The Reconfiguration Roadmap)'*, was published for this region. It was compiled by a number of health service managers and professionals working in Cork and Kerry. The report was published in 2010 [181] following consultation with the staff of the HSE South, the major hospitals in Cork, as well as GPs, political representatives and patient advocates. The report states that over 40 working groups, which represented every healthcare specialty delivered in the region, were consulted as to how health could best be delivered to regional patients [181]. The report supports many of the findings concluded by the Horwath and Teamwork report, and indicates that through these changes, the organisation of services would be placed in the right hospital or healthcare facility, with a greater integration of acute and community services. The authors believe that due to real engagement with a range of stakeholders, including service users, staff and the general public, and the fact that hospitals in the region would be working together *"sharing a common vision"* there would be a greater chance of successful outcomes from the process of reconfiguration in this region [181, 182].

3.5.5 Pre-hospital care reports

The National Ambulance Service (NAS) report was published in 2016.

- *National Ambulance Services of Ireland - Emergency Service Baseline and Capacity Review*

This review [183] was commissioned by the HSE to understand the underlying capacity within the ambulance service to meet the required standard of response performance across Ireland. The study was conducted by a UK based consultancy agency, Lightfoot Solutions UK Limited. In presenting its findings, the report highlights some key distinctions between the NAS and the English ambulance service [183, p. 9]:

1. The NAS serves a greater rural population; 40% of incidents in Ireland are in a rural location compared to 12% in a typical English service;
2. The NAS only has 40% of the number of ambulance calls per head of population experienced in England. It is suggested that this may be because access to GPs in Ireland is easier than in the UK, particularly out of hours.

High rurality and low levels of calls per capita results in a higher cost per incident in Ireland when compared to England. The combination of these characteristics lead to the ultimate conclusion that the NAS *"cannot possibly achieve the HIQA prescribed target of 80% in 8 minutes"* for Echo and Delta (life-threatening and potentially life threatening) calls in Ireland [183, p. 8]. The analysis found that if fully resourced and operating to international good practice standards across all operational processes, then at best, the service could only achieve 60.6% in 8 minutes [183, p. 8].

Some of the main wider system recommendations provided by the report include [183, p. 14-16]:

- A review of the target times set by HIQA, given an inability to currently meet them.
- An investigation into why the number of emergency calls per population are so low in Ireland compared to England. It is suggested that this would allow future patterns of growth in Ireland to be better understood and accommodated.
- NAS should develop a suite of appropriate clinical outcome and patient experience measures.
- It is also recommended that NAS should work with the wider health system. The report acknowledges the general policy the NAS has with regard to conveying all patients to EDs; in England alternative care pathways allow ambulance services to treat up to 50% of patients by means other than transportation to the ED. The report recommends the NAS review its policy of taking all patients to EDs and should consider developing a "See and Treat" approach. By increasing the linkages that the NAS has with other care providers including out of hours GP co-ops, social services and community pharmacists, there would be an increased development of integrated programmes and the provision of alternative care pathways.

3.5.6 Primary care reports

The following report on primary care services was published in 2017:

- *A Future Together - Building a Better GP and Primary Care Service*

'A Future Together' report [184] outlines the government policy commitment to introducing universal healthcare, making GP care free at the point of access. The main goal is to move the emphasis from acute care towards *"preventative, planned and well coordinated care, health surveillance and disease prevention"* [184, p. 7], similar to the previously outlined policies in section 3.5.1. It acknowledges that the population is living to an older age. This will lead to more people with chronic illnesses and increased expectations among patients for more extensive healthcare. There are also advances in technology, and effective interventions can often prolong the quality of life. Many of these interventions are expensive, and governments continue to look for more cost effective ways of delivering healthcare, usually by facilitating the treatment of patients in their home or community [184, p. 9].

The following conclusions are made by the report [184, p. 71-73]:

1. **Funding and staffing:** Additional costs will be incurred in order for general practice and primary care to develop, specifically due to the need to up-skill staff and services. The report finds that the reliance on direct fees in Irish general practice is at odds with healthcare funding internationally and that the more complicated the reimbursement system the higher the costs.

2. **Diagnostics-radiology:** The lack of diagnostics such as x-rays, ultrasound and magnetic resonance imaging in a primary care setting is seen as frustrating to GPs as it prevents them from fully managing their patient within their practice.

3. **Data usage and IT:** It is agreed that general practice is a rich source of data that is poorly utilised. It is suggested that a data management unit should be established with a representative number of practices resourced to supply anonymised data.

4. **Current contract and workforce:** The report states that the current GP contract with the state has become inflexible and a source of frustration for GPs and management. The report envisages a system of GP led primary care which would require increased co-ordination between individual GPs. It acknowledges that while the number of GPs per capita is important, access to diagnostics, ancillary staff, good IT and governance are of equal importance.

5. **Long term illness:** Evidence points to continuity of care as an important factor in reducing hospital admissions. The potential involvement of pharmacists in the management of chronic illness would require significant co-operation between representative bodies, GPs and pharmacists.

6. **Patient and key informant feedback:** The report states that satisfaction with GPs in Ireland is high and that fundamental to this satisfaction is continuity of personal care. Other important factors include ease of access, quality of communication and the quality of practice nurses.

7. **GPs in training feedback:** GPs who are currently training wish to work as part of a team with other professionals for patient care. Ultimately, it is found that the current system is not professionally satisfying for them and this may lead many to consider returning to the hospital sector or leaving the system.

The implementation of the Sláintecare recommendations [157] will result in increased demands on the primary care sector. The report finishes by stating that the next phase of developing primary care is *"for the professional leadership in the primary care disciplines to come together with the HSE to develop a plan for the future"* [184, p. 74].

3.6 Summary

While the previously outlined reports range in focus from national health policy, to national clinical programmes and national and regional reconfiguration reports, there are a number of common themes and aims across the publications.

There is an acknowledgement that due to Ireland's small regional populations, the historical organisation of acute services is less than optimally positioned to maintain staff skills and resources to ensure the best possible outcomes for emergency and urgent care patients [8, 16–18, 164]. The need to attune service capacity to the volume of cases and the need to maximise the efficiency and outcomes of all hospitals, most specifically smaller hospitals is repeatedly stressed [8, 16–19, 164, 178–180].

The reconfiguration reports (section 3.5.3 and section 3.5.4), national clinical programmes (section 3.5.2), pre-hospital care (section 3.5.5) and primary care reports (section 3.5.6) outline in more detail how the systems and services, and in some cases condition specific services [171], should be tailored to help meet the aims of national health policy. However, it can be seen from table 3.1, as provided earlier, that many of the regional reconfiguration reports were published prior to the national policy and reconfiguration documents. This indicates a local to national approach, i.e. initial investigations of potential regional changes were followed by wider national policy changes. It is not apparent whether this 'bottom-up' approach is of greater benefit than nationally outlined policy funnelling down to a regional level, or whether it indicates a potentially fragmented approach to larger scale national policy formation. It is possible that there was a time overlap between the development and publication of these reports. Regardless, the number and scope of the reports published in a relatively short period of time indicates a decade of great change and upheaval within the health system.

Table 3.2 outlines a summary of where many of the recommendations from these reports were implemented at a regional level [54].

This table is taken from a qualitative study among stakeholders conducted by the SIREN project [54].

The table indicates that the most significant reconfiguration of emergency and urgent care systems took place in the South and Mid-West, two regions containing some of the most rural and deprived counties in Ireland, see table 2.1 and section 2.5. While Dublin, and the surrounding regions, have seen relatively little reconfiguration measures.

Table 3.2: Regional characteristics and summary of reconfiguration undertaken in the Republic of Ireland

Significant Reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
South (Cork and Kerry)	Population: 663,176 Area (km^2): 12,161	**Regional Reconfiguration** • Region-specific reconfiguration plan largely implemented, beginning 2012-2013. • Region-wide clinical governance structures established. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • Acute stroke, coronary and major trauma care provided at hub in Cork [Cork University Hospital] with support of ambulance protocols and outlying centres [Kerry: University Hospital Kerry; Cork: Bantry General Hospital]. • Two EDs reconfigured to LIUs [Cork: Mallow General Hospital (2013) and Bantry General Hospital (2013)]. • One ED closed [Cork: South Infirmary Hospital (2012)].
Mid-West (Limerick, Clare and Tipperary North)	Population: 378,210 Area (km^2): 8,252	**Regional Reconfiguration** • Region-specific reconfiguration plan largely implemented, 2009 – 2013. • Ambulance bypass protocols and region-wide clinical directorates established. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • All emergency care centralised to one hospital [Limerick: University Hospital Limerick] • Two EDs reconfigured to LIUs [Clare: Ennis Hospital (2009); Tipperary North: Nenagh Hospital (2009)]
Some Reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
West (Galway, Roscommon, Mayo, Leitrim, Sligo, Donegal)	Population: 702,966 Area (km^2): 22,649	**Regional Reconfiguration** • Clinical directorates established across the region. • Several out of hours GP co-operatives. **Emergency Department Services Reconfiguration** • Single hub for acute coronary and major trauma care [Galway: University Hospital Galway] with major trauma support services provided at other centres [Mayo: Mayo University Hospital; Donegal: Letterkenny University Hospital; Sligo: Sligo University Hospital]. Acute stroke care at all centres, excluding Roscommon General Hospital. • One ED reconfigured to LIU [Roscommon: Roscommon General Hospital (2011)]. • No ED in Leitrim.
North East (Cavan, Meath, Louth and Monaghan)	Population: 440,211 Area (km^2): 6,395	**Regional Reconfiguration** • Region-specific reconfiguration plan partly implemented from 2006 – 2010. • Limited regional clinical governance. • Roll-out of GP out of hours care. **Emergency Department Services Reconfiguration** • Some centralisation of trauma, acute stroke and coronary care [Cavan: Cavan General Hospital; Louth: Our Lady of Lourdes Drogheda] with rehab

		support in other hospitals. • Dublin North [Mater Hospital] is the percutaneous coronary intervention (PCI) centre with supporting ambulance protocols. • Two EDs reconfigured to LIUs [Louth: Louth County Hospital (2010); Monaghan: Monaghan General Hospital (2009)].
South East (Carlow, Kilkenny, Wexford, Waterford and Tipperary South)	Population: 497,305 Area (km^2): 9,451	**Regional Reconfiguration** • Informal clinical network with shared regional rota for emergency medicine consultants. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • Designated hub for major trauma, and acute coronary care [Waterford: Waterford Regional Hospital – PCI centre supported out of hours by Cork] with ambulance bypass protocols. • Acute stroke care available at all 4 hospitals. • No ED in Carlow.
Dublin South (Dublin South City, Dun Laoghaire Rathdown, Wicklow)	Population: 563,560 Area (km^2): 2,168	**Regional Reconfiguration** • Multiple out of hours GP co-operatives. **Emergency Department Services Reconfiguration** • Centralisation of acute stroke, coronary and trauma care to two hospitals (both in Dublin South City) but limited differentiation and integration between both. • One ED reconfigured to LIU [Dun Laoghaire Rathdown: St Columcille's Hospital (2013)]. • One ED with reduced hours [Dun Laoghaire Rathdown: St Michaels (2003)]. • No ED in Wicklow.
Little reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
Dublin North East (Fingal, Dublin North City)	Population: 578,317 Area (km^2): 532	**Regional Reconfiguration** • No major changes. • Out of hours GP co-operative established. **Emergency Department Services Reconfiguration** • Three large EDs with limited governance integration and differentiation of services. PCI Centre established [Dublin North: Mater Hospital].
Dublin Midlands (Dublin South, Longford, Westmeath, Laois, Offaly, Kildare)	Population: 761,324 Area (km^2): 8,442	**Regional Reconfiguration** • Limited integration of clinical governance. • Several out of hours GP co-operatives operating. **Emergency Department Services Reconfiguration** • Centralisation of acute stroke [Kildare: Naas General Hospital; Westmeath: Midlands Regional Hospital Mullingar, and Dublin South: Tallaght Hospital) coronary care [Dublin South: Tallaght Hospital] and trauma [Offaly: Midland Regional Hospital Tullamore; Dublin South: Tallaght Hospital) at several hospitals, supported by ambulance bypass protocols. • No ED in Longford.

This study [54] found that among stakeholders there were four perceived main drivers of the reconfiguration of emergency and urgent care systems: efficiency, patient safety, access, and arguments related to community values and local politics. Three of these drivers, efficiency, patient safety and access, correspond to themes that emerged from the previously outlined reports within this chapter. However, results from this study raise doubts regarding the merit of arguments supporting these drivers, specifically with regard to where reconfiguration has been implemented. Droog et al. argue that if efficiency was the main concern, then a greater focus on Dublin could have potentially yielded better results due to the large duplication of services within that county [54, p. 374]. With regards to patient safety, there has been too little study of the trade-off between the volume-outcome relationship and increased travel time to larger hospitals. For certain time-sensitive conditions, e.g. stroke, cardiac arrest, it is possible that increased distance to 'hub' hospitals could lead to worse outcomes [54, p. 375]. The limitations of 'access' as a legitimate driver of reconfiguration is also questioned. The over reliance on Dublin providing the majority of acute care for surrounding counties has restricted acute services provision within those counties, limiting service availability for those regional populations [54, p. 375].

The need to consider the impact of policy changes in 'patient-centred system-wide' terms in increasingly recognised. As complex adaptive systems, emergency and urgent care systems are sensitive to their context and initial condition, therefore the same policy objectives may lead to multiple, but equally agreeable, outcomes [185, p. 207]. Many claims have been made within the reports outlined in this chapter regarding the benefits to be gained from the regional reconfiguration of emergency and urgent care systems, and challenges to the implementation of change have also been highlighted. Therefore, this thesis aims to determine whether the benefits of improved access, process and outcomes have been achieved at a county level as a result of regional reconfiguration. Where relevant, and when data permits, quantitative performance indicators will also refer to the HSE Hospital Networks [94] which were the principal arrangement of regional hospital systems at the time of initial reconfiguration measures. These regions, and their corresponding hospitals, were outlined earlier in figure 3.2.

Chapter 4

Methods

4.1 Framework of analysis

4.1.1 Introduction

To understand whether or not adequate improvements have been seen within a health system, its performance must be measured and monitored over time. Performance can be assessed by considering the interactions between measurable performance indicators and a framework of analysis in which those indicators can be appraised. A framework of analysis outlines the domains (areas) under which indicators can be grouped and interpreted in a meaningful way. Certain objectives should be outlined and concrete conclusions drawn as to whether or not those objectives have been achieved.

This chapter will briefly outline a number of conceptual frameworks that have been adopted by health systems in different countries. A conceptual framework is defined as *"a group of concepts that are broadly defined and systematically organised to provide a focus, a rationale, and a tool for the integration and interpretation of information"* [186]. Also included is an outline of some of the common performance indicators included in each framework. The framework and performance indicators selected as the basis of the analysis conducted within this thesis will then be reviewed.

4.1.2 The role of frameworks of analysis and performance indicators

As stated by Wolfson, *"data and facts are not like pebbles on a beach, waiting to be picked up and collected. They can only be perceived and measured through an underlying theoretical and conceptual framework, which defines relevant facts, and distinguishes them from background noise"* [187, p. 309].

An appropriately chosen framework of analysis should enhance the understanding of the measures and data that are being gathered and allow an interpretation of how the health system itself is performing.

The measurement of health system quality is usually undertaken by assessing relevant key performance indicators (KPIs). Indicators are summary statistics that can be used to convey information in lieu of something that cannot be measured directly. KPIs are important tools which are used to measure health system related trends [188].

It is important to recognise the difference between a measure of quality and an indicator of quality [189]. Measuring the exact quality of care received may not be possible, but certain processes (adherence to best practice guidelines) or outcomes (case fatality from certain conditions) are frequently used as proxy measures for quality [190, 191]. Indicators are frequently used for accountability as part of the evaluation and quality improvement of a health system [191]. Many KPIs are currently used at both a hospital and health system level in different countries [188, 192, 193]. The appropriate use of indicators is seen as an integral part of planning and designing health services [194].

They are often used to compare specific outcomes to a certain expected standard, or to allow comparability between different organisations or services [192]. It is also argued that KPIs can be used from the perspective of population analysis [194].

An argument frequently made against the significance of performance indicators is that their use results in the oversimplification of complex issues [191]. Therefore, the decision regarding the most appropriate indicators to adopt requires thoughtful consideration. Understanding the limitations of the methods used in the construction of performance indicators is also crucial [191]. For example, in many cases, rather than collecting new data, extensive use is made of data that already exists resulting in a trade-off between *"scientific objectivity and feasibility"* in order to conform with existing databases [188, p. 392]. Therefore, indicators should only be seen as one useful source of data and should not be used to the detriment of other data [190].

4.1.3 Framework domains

Previous studies [188, 193] have investigated the domains of performance that are measured across multiple health system frameworks in the United Kingdom [195–197], Australia [198], the United States [199], Canada [200–202], the Netherlands [203] and Scotland [204]. A number of international organisation frameworks were also considered, specifically those created by the WHO [188, 205, 206] and the OECD [172, 188, 193].

Common domains were found across these frameworks, specifying the areas that performance indicators should be suitable to monitor and measure. Table 4.1 contains a summary of these domains as identified by Braithwaite et al. [193, p. 5]. This table has been adapted in this thesis to incorporate the current domains included in the Irish

National Health Quality Reporting System [47–50], and the domains within the WHO Framework for Health System Performance Assessment [206].

TABLE 4.1: Domains of health system performance frameworks

	Australia - PAF	Australia - ROGS	England - High Quality Care For All	England - NHS Outcomes Framework	Canada - Canadian Health Indicator Framework	The Netherlands - dimensions of healthcare performance	The Netherlands - healthcare needs	Scotland - Quality Measurement Framework	United States - Agency for Healthcare Research and Quality	United States - Commonwealth Fund	Ireland - The National Healthcare Quality Report	OECD	WHO - Health System Performance Assessment	Total
Effectiveness	X	X	X	X	X	X			X		X	X		9
Access	X	X			X	X		X		X		X	X	8
Safety	X		X	X	X	X			X		X	X		8
Outcomes of care/ health improvement				3 domains relate to outcomes			4 domains relate to outcomes	X		X	X		X	6
Efficient	X	X			X			X				X		5
Responsiveness	X					X					X	X	X	5
Quality	X	X				X		X						4
Appropriateness	X	X			X			X						4
Patient-centred/experience			X	X					X			X		4
Cost						X				X		X		3
Equity	X	X										X		3
Competence/capability	X				X									2
Continuity	X				X									2
Timely									X					1
Acceptability					X									1
Sustainability	X													1
Avoidable hospital use										X				1

Source: Braithwaith et al. [193, p. 5]

As can be seen from Table 4.1, the most commonly included domains across each framework are effectiveness, access, safety, outcomes of care/health improvement, efficiency and responsiveness. The concept of 'effectiveness', refers to the degree to which objectives of a programme, care, service, or system are achieved [207], and is found to be the most frequently occurring term in these frameworks. 'Effectiveness' is generally operationalised by incorporating other domains such as appropriateness, timeliness, fair access, safety, continuity, availability and quality of care [188, p. 380, 388]. Most of the KPIs constructed to capture 'effectiveness' refer to process and/or outcomes measures. The emphasis is on desired outcomes and the processes that achieve them.

There is also a continued emphasis on hospital based indicators when assessing health system performances. In a 2017 study of performance frameworks in multiple countries, Braithwaite et al. [193] found the majority of indicators, 231, were measures at a hospital level, with only 37 at a population level, see table 4.2.

TABLE 4.2: Number of international indicators by domain and community, hospital and population

Domain	**Community**	**Hospital**	**Population**	**Total**
Access	41	45	0	86
Patient experience	25	21	1	47
Safety and quality	146	145	2	293
Efficiency	2	11	0	13
Population health outcomes	5	9	34	48
Total	**219**	**231**	**37**	**487**

Source: Braithwaith et al. [193, p. 7]

Some of the indicators that are included under these domains, across the frameworks include:

- age-standardised rate of deaths due to hypertensive disease for persons aged 50–64 years;
- avoidable hospitalisations by selected conditions;
- percentage flu vaccination among people aged 65 years and over;
- percentage of patients aged 65 years and over discharged home within 28 days following hospital treatment for fractured hip;
- primary care management (emergency admission rates for acute conditions);
- mental health in primary care (age-standardised prescribing rates of benzodiazepines);
- prescribing rates of antibacterial drugs;
- prescribing rates of ulcer healing drugs, and organ donor rates;
- wmergency admission rate for asthma and diabetes per 100,000 population (age and sex standardised).

The frameworks outlined in these studies have a primary emphasis on process and outcome [188, 193]. However, within Donabedian's 1966 paper titled *"Evaluating the Quality of Medical Care"* [208], the three key aspects of performance measurement are identified as structure, process and outcome. Braithwaite et al. outline in the discussion of their study that *"a conceptual framework encompassing multiple domains and with balanced representation across structure, process and outcome indicators is considered to be a key element of health reform over time"* [193, p. 8] [209]. Donabedian concluded that structure measures have an effect on process measures, which in turn affect outcome measures [210].

The health system performance frameworks above relate to health systems as a whole and do not refer solely to the emergency and urgent care system. Commonality can be seen across many of the frameworks. Improvement to health and outcomes are a priority across each of the frameworks, as is appropriateness of care and efficiency. Given data restrictions and limitations of the studies included in this thesis, the ability to adhere to an overly complex framework is not possible. This work considers that domains across the majority of the frameworks could be simplified and combined into a composition similar to the Donabedian quality framework. Therefore, this thesis proposes that the Donabedian model is the most appropriate to evaluate regional emergency and urgent care system performance and supports the aims and objectives of this study.

Selected performance indicators for chosen performance framework

Consistently across the reports outlined in **Chapter 3** the importance of conducting performance measurement is stressed [15, p. 14] [19, p. 172] [174, p. 140]. Those reports that include a breakdown of performance indicators are primarily the national clinical programmes, including, *'COPD Outreach Programme'* [168, p. 44-45] and *'Heart Failure Model of Care'* [170, p. 44]. With regards to those policies which address the delivery of emergency and urgent care, both the *'The National Acute Medicine Programme'* [16, p. 98-99] and *'The National Emergency Medicine Programme'* [17, p. 377-378] highlight areas in which indicators will be needed to measure performance, with details provided on access and structural indicators. These indicators include ambulance patient handover times, arrival to clinician time with a standard 95% of all patients to wait less than 6 hours [17], as well as the number of assessment beds and proportion of medical consultant positions who have a 50% or more commitment to acute medicine [16]. However, the national reconfiguration reports [8, 18] do not include any detail or guidance on indicators which should be considered to measure regional changes. However, the *'Hospital Groups'* report does state that *"all hospital groups should provide an assurance framework which would include key performance indicators for high-quality, safe patient care and patient perception"* [18, p. 62].

As part of the SIREN study, a systematic review of KPIs and a delphi exercise conducted among experts in emergency and urgent care in Ireland was undertaken in 2014 [55]. The systematic review yielded 42 unique indicators for consideration. A ranking exercise during the delphi exercise resulted in 17 indicators with a median score greater than 7, identifying these as potentially good indicators to assess the performance of an emergency and urgent care system. The results included 12 process indicators and 5 outcome indicators, e.g. case fatality rates from emergency conditions, hospital emergency admission rates for urgent conditions that could be managed outside of the hospital, a number of indicators regarding the timeliness of treatment and adherence to good practice guidelines [55, p. 5-6].

Panel members were specifically requested not to consider the feasibility of collecting data to calculate the indicators, in essence creating a list of KPIs that would be possible in an ideal measurement and monitoring setting. As stated by the authors, *"this may mean that the chosen performance indicators are not immediately measurable; however, we are hopeful that progress in data collection may allow these performance indicators to be measured in the future"* [55, p. 6].

As outlined in **Chapter 1**, the aim of this research is to understand the impact of the reconfiguration of emergency and urgent care systems at a population level. On considering the indicators selected by the expert panel from the delphi exercise, many were not viable for this study due to a lack of relevant data collection. The absence of data generally related to process indicators, such as adherence to evidence-based good practice guidelines and time to treatment at various stages within an episode of care. Consequently, the ability to construct certain performance indicators was limited by the availability and access to the necessary data.

Therefore, for this study, using the Donabedian framework to assess system performance, and taking into consideration the results of the delphi where practical, the following indicators were selected to assess the impact of reconfiguration on regional emergency and urgent care systems.

Domain: Structure

Assessing structure involves considering the setting in which care itself takes place. This may include administration and other elements directly related to the supports required for the direct provision of care. It is assumed that when supported by the appropriate structure, good medical care is more likely to follow [208].

Indicator: Emergency department trolley numbers

Overcrowding in EDs is considered to be a major barrier to the delivery of timely emergency care [192, 211–213]. ED overcrowding reflects a mismatch of demand and supply within the health system [192]. To understand the reasons for this mismatch, it is important to examine the context of the entire system and measure system capacity [192]. In emergency and urgent care, shortcomings in the structural resources available within the system can manifest through increased ED trolley numbers. Therefore, under the domain of structure, this work will investigate the impact of reconfiguration of ED services on ED trolleys. The availability of in-patient beds, and changes to emergency admissions will help to inform the increased pressures captured by this indicator.

Domain: Process

Indicators used under the domain of process measure the process of care, rather than the outcome. Using process indicators may appear to be less stable and not as clear-cut as those which report outcomes [208], however these indicators are used to capture appropriateness and completeness of care. Process indicators are often constructed from management data such as waiting lists, ambulance times, etc. [189] used to support performance management.

Indicator: 'Potentially avoidable' emergency admission rates

One of the many goals of the reconfiguration of emergency and urgent care services is to ensure that there is appropriate care in the appropriate setting. It has been highlighted that emergency admissions for chronic ambulatory care sensitive conditions are indicative of poor condition management and poor co-ordination between different elements of the health care system, specifically the provision of primary care [214]. Within this thesis, the rate of 'potentially avoidable' emergency admissions in Irish regions will be analysed to identify the drivers of these admissions.

Domain: Outcome

The measurement of outcomes remains the predominant means of assessing the effectiveness and quality health system performance [208].

There are many advantages associated with using outcomes as a measure of healthcare quality. Outcomes tend to be concrete and are therefore considered a more precise measurement than other alternative measures [208]. Examples of outcomes frequently measured include mortality, morbidity and physiological parameters [215]. However, often these measures are used as the sole means of measuring performance of a system.

One of the limitations of focusing entirely on outcomes is that, in many cases, an extended period of time may be required for the full impact of system changes on outcomes to be apparent [208]. There may be problems with comparability over time [208]. The use of outcomes in isolation do not give a complete insight into what has led directly to the results seen [189, 208]. For instance, outcomes for elderly patients might be as a result of unmeasured confounders, such as severe co-morbid conditions that increase the risk of death [216].

Indicator: Case fatality ratios

A frequently used outcome indicator is in-hospital mortality rate. The validity of this indicator for assessing outcomes in emergency care has been criticised due to the nature of the acute medical setting [189]. They are frequently used in the construction of hospital league tables [217–219] and can be used to either unfairly reward or punish hospitals [189]. It has been found that the in-hospitality rate is heavily influenced by the case-mix received by the hospital, particularly the percentage of cases that are emergency admissions [220]. As many emergency networks and systems are now generally co-ordinated to ensure that the most serious conditions are treated in the same hospitals within a region, it would appear that these hospitals have a disadvantage due to the nature of the cases they receive. The probability of a positive outcome for these events is lower than for other less serious conditions. Therefore, to assess outcomes from a population level, this study will focus on case fatality ratios (CFRs) for emergency conditions, combining deaths both in and out of hospital. Results will also be reported from the place of residence of the person who suffered the event or death, thereby eliminating the emphasis on outcomes based on hospital attended.

4.2 Data Sources

The analysis undertaken for each study in this thesis, to be outlined in section 4.3, is conducted using secondary, administrative data. There is a significant amount of anonymised and publicly available data in the Irish health system. However, much of this data is not centrally stored and is dispersed across multiple providers. This thesis allows the investigation of how available data can be compiled to achieve the overall aim of understanding the impact of reconfiguration on the performance of regional emergency and urgent care systems.

The primary sources of data incorporated in this statistical analysis were:

- The Central Statistics Office (CSO) census demographic data, by county;
- Hospital In-patient Enquiry (HIPE) annual hospital discharge data, by hospital and county of residence;
- The CSO annual mortality data, by county of residence;
- The Irish Nurses and Midwives Organisation (INMO) ED trolley data, by hospital;
- Primary Care Reimbursement Scheme, General Medical Services eligibility by LHO;
- Pobal Haase Pratschke (HP) Deprivation Index, by enumerative districts;

- Small Area Health Research Unit (SAHRU) Deprivation Index, by small area;
- CSO Survey of Income and Living Conditions (SILC);
- CSO Unemployment, by county;
- Health Service Executive (HSE) Performance Assurance Reports which report emergency department attendances and emergency presentations, by hospital.

This data is outlined in greater detail in **Appendix A**, where information is provided regarding the collation, format and dissemination of this data. As previously discussed in section 2.2, secondary data has been collected for previous specific purposes. Therefore, the use of such data may require compromises with regard to the scope of the analysis that can be conducted. The ability to capture all aspects of the indicators selected by the SIREN delphi group was restricted for several measures due to limited data availability. The limitations of this data is outlined in greater detail within each study presented.

4.3 Statistical analysis

4.3.1 Introduction

This section provides a detailed overview of the statistical methods used within the three studies of this thesis.

Chapter 5, titled *"A study of the impact of emergency department reconfiguration on regional emergency department trolley numbers in Ireland from 2005-2015"*, is a study of changes to the number of ED trolleys observed in regional hospitals over time. This study uses time-series analysis to investigate the underlying pattern of ED trolley numbers and determine the impact of ED reconfiguration on the ED trolley numbers in remaining regional hospitals.

Chapter 6, titled *"Drivers of 'potentially avoidable' emergency admissions in Ireland: an ecological analysis"*, is a study of the regional variation in 'potentially avoidable' emergency admissions and an investigation of the main drivers in this variation. This study uses direct standardisation and negative binomial regression as its main statistical methods to identify the drivers of these admissions.

Finally, **Chapter 7**, which refers to the paper titled *'Case-fatality ratios for serious emergency conditions in the Republic of Ireland: a longitudinal investigation of trends over the period 2002-2014 using joinpoint analysis"* is a study of fatality ratios for serious emergency conditions, investigating changes over time and between regions. This study uses direct standardisation, negative binomial regression, joinpoint analysis and funnel plots to investigate the regional trends in CFRs.

This analysis was conducted using Stata (Version 13 and Version 15).

4.3.2 Standardisation

Standardisation is used when comparing the relative health of populations at a given time or examining change in events (mortality or morbidity) over time while also adjusting for changes in the age distribution [221]. This thesis is particularly interested in age-standardisation which enables the comparison of outcomes in different populations, while allowing for differences in the age distribution.

There are two approaches for standardisation, direct and indirect methods. Both methods will be described here and the differences between them will be highlighted.

Direct standardisation

Direct standardisation is used in the construction of standardised emergency admission rates in **Chapter 6** and to construct CFRs in **Chapter 7**.

To calculate the directly standardised event rate, the age-specific event rate for each age interval is multiplied by a standard population and then summed. The total is then divided by the total standard population to gain the directly standardised rate. This rate is then interpreted as the hypothetical event rate that would occur if the observed age-specific rates were present in a population whose age distribution is that of a standard population [221, 222].

The directly standardised rate, S_R, is defined by

$$S_R = \frac{\sum_{i=1}^{k} N_i r_i}{\sum_{i=1}^{k} N_i} \tag{4.1}$$

where r_i is the rate in stratum i of the population of interest and N_i is the number in the i^{th} stratum in the standard population [223].

A standard population is either internal or external to the population of interest. Internal standards are created from the data to be used in the analysis, e.g. the average age distribution of all populations to be compared. External standards are standard populations drawn from sources outside of the analysis, e.g. the European standard population, etc. If an internal standard population is adopted then results cannot be compared directly to other studies which have used a different standard population.

Indirect standardisation

For indirect standardisation, the expected number of cases (deaths), E, in each population is obtained by applying the standard population stratum-specific rates, $R_1..., R_i$, to the number in each of the study populations stratum, n_i:

$$E = \sum_{i=1}^{k} n_i R_i \tag{4.2}$$

The indirectly adjusted rate is then:

$$R_{indirect} = C \times \frac{O}{E} \tag{4.3}$$

where O is the observed deaths in the sub-population, E is the expected deaths in the sub-population and C is the crude rate in the standard population.

A commonly used indirect standardisation index is the ratio of the observed to expected number of events. This ratio is called the standardised mortality ratio (SMR) when deaths are the events of interest. The SMR is the ratio of the observed number of deaths in the local population, divided by the number of deaths if the national rates applied locally. In the above equation, O/E is the study population's SMR if death is the event of interest or the standardised incidence ratio for studies of disease (or other) incidence.

Comparing direct and indirect standardisation

Direct standardisation aims to standardise the studied population, whereas indirect standardisation aims to standardise the studied incidence rates. As a result indirect standardardisation should not be used when comparing sub-populations or regions. Indirect standardisation is frequently used in the construction of hospital SMRs, which contribute to hospital league tables. The process of indirect standardisation is used to allow for hospital case-mix. However, when an interaction between hospital and case-mix is present and case-mix differs between hospitals, indirectly standardised hospital SMRs are found to vary between hospitals which provide the same quality of care [224, p. 3]. Even when the age-specific rates in two populations are equal, their indirectly standardised rates may differ. Therefore, direct standardisation is theoretically preferable over indirect standardisation as it is not affected by the presence of interaction between hospital and case-mix [224].

A limitation of direct standardisation is that if the number of events is small then calculated rates can exhibit a large degree of random variation. It is suggested that in such a situation, where the number of events is small, then data should be aggregated over a number of years, or several small geographical areas could be combined into larger areas [222]. In general at least 25 total events are required for direct standardisation to be appropriate [222]. Alternatively, indirect standardisation is preferable when there are small numbers in particular age groups. Indirect adjustments rates can also be selected from a large standard population, thereby minimising the effects of sampling error.

4.3.3 Poisson regression

The count data that formed the basis of analysis in **Chapters 5, 6** and **7** was initially assumed to have a Poisson distribution. The Poisson distribution can be seen as an extension of the binomial distribution in which the number of 'trials' (n) becomes infinite and the expected number of events, $n \times p$ where p is the probability of an event, remains finite. It is assumed that events are independent and that the event rate does not vary between people or over time. The Poisson distribution is completely defined by the mean number of events, λ. If the Poisson distribution holds then the mean and variance will be equal. If the value of the variance exceeds that of the mean there is over-dispersion [225].

Poisson regression models the mean number of events as a function of covariates. Specifically,

$$E[y_i|X_i] = \lambda_i = exp(x_i^{'}\beta) = exp(\beta_0 + \beta_1 x_{1i} + ...\beta_k x_{ki}) \tag{4.4}$$

or

$$lnE[y_i|X_i] = ln\lambda_i = x_i^{'}\beta = \beta_0 + \beta_1 x_{1i} + ...\beta_k x_{ki} \tag{4.5}$$

The basic assumptions of the Poisson model are:

- There is a quantity called the incidence rate which reflects the rate at which events occur. For example, 20 stroke deaths per 100 person-years.
- The incidence rate can be multiplied by an exposure to obtain the expected number of observed events. For example, a rate of 20 stroke deaths per 100 person-years multiplied by 200 person-years means that 40 stroke deaths are expected.
- Over very small exposures ϵ, the probability of finding more than one event is small compared with ϵ.
- Non overlapping exposures are mutually independent.

Maximum likelihood estimation is used to estimate parameter (β) values. Poisson regression is a particular case of a general linear model in which a function of the mean is modelled as a linear sum of covariates. Generalised linear model specifically uses an iterative re-weighted least squares algorithm for estimation, which is a simplification of the full maximum likelihood method [225, p. 13]. Weights are introduced in order to take the dependence between the mean and variance into account, allowing a larger spread between observed and fitted value from the regression if the observed value is large [226].

Interpretation

Poisson regression models the log of the expected count; therefore the β coefficients describe a change in the log of the expected count. It is common to express effects associated with each variable as an incident rate ratio (IRR). For every one unit increase in the predictor, the predicted count changes by:

$$(IRR - 1) \times 100\% \tag{4.6}$$

Consequently, an IRR of 1.10 would mean that a one unit change in the explanatory variable would be associated with a 10% increase in the expected count; likewise, an IRR of 0.90 one unit change would be associated with a 10% decrease in the expected count.

Goodness of fit and over-dispersion

As previously mentioned, a Poisson model assumes that the variance (V) is equal to the mean (μ). Over-dispersion occurs when the response variance is greater than the mean. It can be caused by positive correlation between responses or by an excess variation between response probabilities or counts. It may also arise when there are violations in the distributional assumptions of the data [225]. Over-dispersion may cause a variable to appear to be a significant predictor when it is in fact not significant. The presence of over-dispersion indicates that there is extra-Poisson variance and that a different model, such as negative binomial regression, is more appropriate. Both the Pearson and deviance statistics are commonly used measures to test the goodness of fit of a Poisson model.

The Pearson chi-square statistic (χ^2) is a weighted sum of the squared residuals and can be compared to the number of observations (n) minus the number of parameters (k) [225].

$$Pearson\ \chi^2 \ = \sum_{i=1}^{n} \frac{(y_i - \mu_i)^2}{\mu_i} \tag{4.7}$$

The deviance statistic compares two different models, a null model and a full model. The null model is a model that has only one parameter $\mu_i = \mu$ to represent the expected value of all outcomes, whereas the saturated (full) model represents the observed values perfectly, $y = \hat{\mu}$. The deviance is assessing the fit of a model by comparing it to the full model [225].

The deviance, D, is expressed as:

$$D = 2(l(y, \phi; y) - l(\hat{\mu}, \phi; y)) \tag{4.8}$$

where the full model is $l(y, \phi; y)$ and the the current model is represented by $l(\hat{\mu}, \phi; y)$, where ϕ is a scaling parameter. Essentially, the deviance measures twice the difference between the log-likelihood achievable and the log-likelihood of the fitted model.

Comparing models

The preferred model is that which has the lowest deviance, or highest log-likelihood, as well as the lowest Aikake Information Criterion (AIC) or Bayesian Information Criterion (BIC). The AIC is based on the log-likelihood function, while the BIC was originally based on the deviance but is now usually formulated in terms of the log-likelihood [225, p. 27]. Generally models with the smaller value for either AIC or BIC are considered to represent a better fit [225].

4.3.4 Negative binomial regression

To account for extra-Poisson variation, various extensions of the Poisson model write the variance as a function of the mean [225].

$$\begin{aligned}
&Poisson : Var = \mu \\
&\textit{Quasi-Likelihood Poisson} : Var = \mu(\phi) \\
&Geometric : Var = \mu(1+\mu) \\
&NB\text{-}1 : Var = \mu(1+\alpha) \\
&NB\text{-}2 : Var = \mu(1+\alpha\mu)
\end{aligned} \tag{4.9}$$

Negative binomial model NB-1 is the constant-dispersion model, while NB-2 is the mean-dispersion Negative binomial model [227]. Each of these can be compared to a Poisson model using a likelihood ratio test. The fit of NB-1 and NB-2 can compared using AIC or BIC.

NB-2 is the most commonly used method of accounting for extra-Poisson variance [225] and is the model used for the studies within this thesis. As indicated above:

$$Var = \mu(1 + \alpha\mu) \tag{4.10}$$

Note that:

$$Var[\frac{O}{E}] = \frac{Var[O]}{\mu^2} = \frac{\mu(1 + \alpha\mu)}{\mu^2} = \frac{1}{\mu} + \alpha \tag{4.11}$$

This means that α can be interpreted as the extra-Poisson variation in the ratio of observed to expected events. If $\alpha = 0$, then this reduces the NB-2 model to a Poisson model. This result is used in **Chapter 6** when describing the impact of allowing for differences in population and health system factors when examining variation in 'potentially avoidable' emergency admissions.

Similar diagnostics as those previously outlined for Poisson models are suitable for NB-2 models [225].

4.3.5 Spearman rank correlation

Spearman's correlation coefficient is a statistical measure of the strength of a monotonic relationship between paired data. This coefficient is used to calculate the changes in rank of county CFRs over time in **Chapter 7**.

Spearman's rank correlation is a direct non-parametric counterpart of Pearson's correlation coefficient [228].

Values near 1 indicate a strong positive association. Values near - 1 indicate a strong negative association. Values around 0 indicate a weak association.

4.3.6 Variance inflation factor

Collinearity occurs when explanatory variables are included in a statistical model which are correlated with other explanatory variables. When fitting multiple regression models collinearity can lead to major increases in the variance of the estimated coefficients. Variance inflation factors (VIF) are often used to quantify collinearity [229]. In **Chapter 6**, VIF is used to investigate the collinearity between variables. The VIF for each explanatory variable is defined as:

$$VIF = \frac{1}{1 - r_j^2} \tag{4.12}$$

where, r_j^2 is the coefficient of determination of x_i on the other covariates (a regression that does not involve the response variable y). In general, VIF values of less than 10 are not regarded as significant.

4.3.7 Joinpoint modelling

Joinpoint regression is an extension of traditional piecewise linear regression. The association is continuous and piecewise linear where the slope changes at specific joinpoints [230]. This method was used to assess the longitudinal change in trend in CFRs in **Chapter 7**. Joinpoint regression analysis was conducted using a programme developed by the United States National Cancer Institute for the analysis of data from the Surveillance Epidemiology and End Results Program.

The number of appropriate joinpoints are determined by assessing the model with the minimum number of joinpoints (i.e. zero joinpoints, thereby setting a straight line) and then testing whether more joinpoints, up to a maximum of four, leads to a significant improvement in model fit [231]. This allows testing of whether or not an apparent change in trend is statistically significant.

Within the program, tests of significance are conducted using a Monte Carlo permutation method. An annual percentage change (APC) for each line segment, together with the corresponding 95% confidence interval is estimated. The null hypothesis of no change, i.e. an APC of 0%, is tested against the estimated APC to determine if a significant difference exists. Each joinpoint included in the final model represents a statistically significant change in the trend (p-$value < 0.05$), as represented by an APC and can represent either an increase or decrease in the trend [231, 232].

4.3.8 Funnel plots

Funnel plots graph an observed performance indicator against a measure of its precision, while control limits form a 'funnel' around the value. The funnel is constructed using upper and lower control limits, such as 95% limits (± 2 standard deviations), as an alert limit which identify any areas that differ significantly from the specified target result [233]. Standardised longitudinal trends in **Chapter 7** were estimated at region and county level using an inverse standard error weighted generalised linear model with a log link, informed by the identified joinpoint in national trends. The inverse standard error allowed for precision in comparing areas with differing case populations [234]. Any region or county whose rate of change in CFR was outside the funnel control limits was identified as being significantly different from the national rate of change in CFRs.

4.3.9 Lowess smoothing

Lowess refers to locally weighted regression scatter plot smoothing [235]. It is an analysis technique for producing a 'smooth' set of values from a time-series which has been contaminated with noise, or from a scatter plot with a 'noisy' relationship between the two variables. The technique is considered an improvement over least squares smoothing when the data is not equally spaced (as least squares smoothing assumes) [236]. In **Chapter 6** lowess smoothing was used when graphing the absolute difference between observed and expected admissions for each model.

4.3.10 Moving average

An initial exploration of the ED trolley data and emergency admissions in **Chapter 5** utilised a simple moving average. As weekly data was available for both ED trolleys and total emergency admissions, the moving average was constructed using a 50-week window, beginning with the final 24 weeks of 2005 and the first 25 weeks of 2006, moving a week at a time, ending before the final 25 weeks of 2015. This 50-week window allowed an examination of the underlying trend having removed seasonality.

4.3.11 Decomposition of longitudinal time-series model

Chapter 5 models the mean trolley numbers over 11 years using a negative binomial model, accounting for the complex nature of data used in the analysis by replacing the traditionally used linear trend with a spline term. The model was also adjusted for seasonality by including cosinor terms. Due to concerns regarding the completeness of data collection over the last week of December and first week of January, these weeks have been omitted in the construction of the time series model. Therefore, the model considers

50 weeks to represent a full year. To determine the suitability of the model to be adopted, several possible iterations were assessed. This required investigating the appropriateness of including multiple cosinor terms, determining the degree of autocorrelation within each model and considering the ability to adopt the model over multiple regions. As the finalised model was required to assess the trend and seasonality across four regions, it was essential that the model wasn't over-fitted, which would have resulted in poor generalisability.

The following model was ultimately adopted:

$$log(\mu) = f(t) + \beta_1 Sin(\frac{2\pi t}{50}) + \beta_2 Cos(\frac{2\pi t}{50}) + \beta_3 Sin(\frac{2\pi t}{25}) + \beta_4 Cos(\frac{2\pi t}{25}) \tag{4.13}$$

- $f(t)$ is a restricted cubic spline function of time, allowing for the non-linearity of the data. The spline function is cubic between specified time points (knots) and continuous, with continuous first and second derivatives, at the knots. The knots were placed at every 100 weeks. This results in a smooth and flexible model that can react to local changes.
- Cos, Sin allow for seasonality with periods of 6-months and 12-months (25 and 50 weeks),

This model was then subsequently decomposed into its three relevant components: the underlying trend, seasonality and noise. The relationship between the trend and the seasonality in the model was assumed to be multiplicative. The noise was identified as the difference between the observed and expected counts.

The model also allowed for serial autocorrelation based on a visual inspection of the autocorrelation (ACF) and partial autocorrelation (PACF) graphs [237]. The ACF plot displays the coefficient of correlation between a time-series and lags of itself and identifies the moving average component of the model. The PACF plot shows the partial correlation coefficients between the time-series and lags of itself and identifies the autoregressive components of the model [237]. The model includes a heteroskedastic error and autocorrelation consistent estimators lag of three, as determined by the observed pattern in the ACF and PACF graphs [225].

4.3.12 Interrupted piecewise linear time-series

Interrupted piecewise linear time-series analysis is a method of estimating changes in levels and trends in an outcome associated with an intervention [237].

In **Chapter 5**, having assessed the underlying trend of the full model outline above, an interrupted time-series was then applied to a shorter time period, i.e. 12-months prior to the first intervention (ED reconfiguration) and 12-months following the final intervention. When plotted, the shorter time period was found to be compatible with a linear model. Seasonality was included as before, but the cubic spline term was replaced by a piecewise linear function with a break-point at the time of each ED reconfiguration.

Three important assumptions exist [238]:

- The trends observed prior to the intervention in question are assumed to be linear.
- The model estimates have not been controlled for covariates. It is assumed that the characteristics of the population remains unchanged throughout the study period. Therefore, any changes to the population that might explain changes in the outcome are not accounted for.

- The final the model is unable to isolate changes that occur due to the intervention itself and those that cannot be attributed to the intervention.

Within this model there are three time based covariates. The regression coefficients associated with these covariates estimates the pre-intevention slope, the change in the level at the intervention point and the change in the slope from pre-intervention to post-intervention [238].

The time-series regression equation for this model followed this general format [239]:

$$\hat{Y}_t = \beta_0 + \beta_1 t_1 + \beta_2 I + \beta_3 t_2 + e_t \tag{4.14}$$

where $\hat{Y}_t$ is the outcome; t_1 indicates the number of consecutive weeks over the full range of the data; I is a dummy variable taking the values of 0 in the pre-intervention segment and 1 in the post-intervention segment; t_2 is 0 in the pre-intervention segment and counts the consecutive weeks in the post-intervention segment of time; the coefficient β_0 is the base level of the outcome at the beginning of the series; β_1 is the base trend, i.e. the change in outcome per week in the pre-intervention segment; β_2 is the change in level of the outcome in the post-intervention segment; β_3 is the change in trend at the time of intervention; and e_t is the error. When the underlying trend is not linear the earlier model 4.13 can be extended to include a sudden change in level and trend at intervention.

Where more than one intervention takes place, a backwards hierarchical stepwise approach was taken to determine which level and trend change were significant and would stay in the full model. A significance level of *p-value* < 0.05 was set, with the model accounting for the impact of the reconfiguration of the first ED, and then the second.

This was done by first considering a model that included a level and trend change at both intervention times. We then decided whether to keep or remove the trend or level changes at the first intervention time. Finally, we decided whether to include trend or level changes at the second intervention.

The final model for each region, with the significant components and deseasonalised counts, was then graphed against a counter-factual model in which the intervention had not occurred and therefore the change in trend and level was set to zero. A key assumption is that the pre-intervention slope would have continued unchanged for the full time period if the specified intervention had not been introduced, and that there were *"no external factors systematically affecting the trends"* [238].

Chapter 5

A study of the impact of emergency department reconfiguration on regional emergency department trolley numbers in Ireland from 2005-2015

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Keywords: Health services research, reconfiguration, emergency department trolleys

Background

During the mid-2000s in Ireland, a number of EDs were closed or reconfigured into smaller UCCs or LIUs. These changes were implemented with the aim of improving efficiency and safety. Over the same period a steady increase in the number of patients on ED trolleys waiting for admission to a hospital bed was observed. The aim of this paper is to understand the impact of ED reconfiguration on the number of patients waiting for hospital beds in four geographical regions in Ireland.

Methods

The moving average of both ED trolleys and emergency admissions was assessed. Changes in trolley number distribution between hospitals was also charted. Negative binomial regression analysis was used to model regional trolley numbers from 2005-2015. The model was adjusted for seasonality and allowed for a non-linear underlying trend. This model was subsequently decomposed into its three relevant components: the underlying trend, seasonality and noise. An interrupted piecewise linear time-series was applied to the 12-months prior to reconfiguration and 12-months after reconfiguration of each ED within the region. In regions where two ED closures took place, a backwards hierarchical step-wise approach was taken to determine whether the impact of each ED closure was significant at a regional level.

Results

All four regional ED trolley patterns reflect a non-linear underlying trend. Lowest average trolley numbers were observed in 2007, while peaks in the trend were observed in 2011/2012. Three of the four regions experienced a significant change in ED trolley numbers in the 12-months post ED reconfiguration. Two of these regions, the South and the Mid-West, displayed a convergence between the observed and expected trolley numbers. The North-East shows a much steeper increase, one that extends beyond the 12-months post ED reconfiguration.

Conclusion

Findings suggest that the impacts of ED reconfiguration on regional level ED trolley trends are either non-significant or cause a short term shock which converges on the pre-reconfiguration trend over the following 12-months. However, the North-East is identified as an exception due to increased pressures in one regional hospital, which causes a change in trend beyond the 12-months post-reconfiguration.

5.1 Background

Over the past decade Ireland's emergency care services have come under increasing pressure. Since the mid 2000's both national ED attendances [240] and emergency admissions have increased [241], while both staff [242] and acute bed numbers [243] were reduced due to the financial recession of 2008 [32].

Regional system reconfiguration, has also seen changes to the availability and location of ED services in Ireland. Much of this reconfiguration was proposed due to concerns regarding the quality and safety of the delivery of care in smaller EDs [8]. There have also been continued difficulties in staffing smaller EDs, and debates regarding the inefficiencies associated with having small EDs in close proximity to each other [8, 244]. The reduction of these services, combined with increased activity in the form of emergency attendances and emergency admissions has been proposed as the cause of increased overcrowding in remaining acute hospitals with EDs [242, 245, 246].

A visible and measurable manifestation of this overcrowding is the presence of patients on trolleys in EDs. Patients on ED trolleys have been admitted to the hospital, but are waiting for an appropriate in-patient hospital bed to become available [247, 248]. This restricted flow of patients through the hospital system occurs when the need for specific services exceeds what can be provided in a particular location at a particular time [249]. Consequently, a high number of ED trolleys is considered to be indicative of poor availability, management or use of hospital resources, particularly beds. This issue has been at the forefront of discourse within the Irish health system for many years and is considered to be one of the most persistent failings of the hospital system in Ireland [250]. It is also an issue that draws particular media attention [245, 246]. As of 2018, trolley numbers are seen to be consistently high year round, particularly at the major regional hospitals [251].

Internationally, overcrowding in EDs has led to different policy approaches in an attempt to reduce growing pressures on the services. These measures include limits to length of stay, access to 24/7 GPs, increasing the number of private sector hospitals and implementing tele-medicine phone services [252]. The inability to transfer emergency patients from the ED to in-patient beds is considered to be the single most important contributor to trolley numbers [253, 254]. One study found that with a 10% absolute increase in bed occupancy, patients wait on average 5% longer to be admitted to a hospital bed [255]. More specifically, the waiting times in EDs increased when hospital occupancy exceeded 90% [255]. Consistent reports have found that an acute bed occupancy of 90% or greater will result in periodic bed crises [256]. An OECD study of Ireland's health system has found that Ireland has one of the highest rates of acute bed occupancy, measured at 93.8% in 2015 [257].

The impact of ED overcrowding can have knock-on impacts on other areas and large numbers of patients on trolleys should not be viewed in isolation. It has been highlighted that the pressure of caring for ED patients requiring assessment and admission has resulted in non-urgent elective surgery appointments being cancelled to accommodate the need for additional beds for emergency cases [258, 259]. This has contributed in part to increasing numbers of patients on waiting lists for scheduled surgery [258]. The end result of this action is that delayed surgery contributes to a higher probability that these patients then require care as an emergency case [258].

The rate of ED trolley use also varies between hospitals. This can be due to individual hospital features such as bed capacity, but may also be driven by regional factors such as increases in local population need and the closure of nearby ED services [211]. It can be hypothesised that when ED services are halted or reduced in one location, nearby hospitals will see increased patient flows. These increased numbers will impact the movement from the ED to in-patient beds unless capacity is increased in the new destination hospital. In Ireland, there is evidence to suggest that the reconfiguration of hospital services has impacted on patterns of patient flow specifically for those presenting with self-harm in the Mid-West [260]. It is likely that similar patterns are evident across other conditions and regions. EDs that are geographically further from the closed ED would also be expected to be less impacted by an increase in the number of attendances from that hospital [211]. To date these hypotheses have not been tested using trolley numbers as a signal of overcrowding. To reduce the potential for adverse effects caused by the restructuring of services, it is vital to understand where patient volume and possibly overcrowding will increase as a consequence [211].

The aim of this paper is to assess the impact of ED reconfiguration on regional levels of trolley use in proximal EDs. The findings will then be considered in line with information available on changes in need/demand and bed capacity.

5.2 Methods

5.2.1 Study population

Within Ireland, there are eight hospital regions, four of which have seen signficant changes to their ED services [94]. Table 5.1 outlines the changes in these regions. ED services at some smaller hospitals were re-designated to UCCs which consist of both LIUs and MAUs, or re-designated to LIUs only. These services do not provide 24/7 emergency care and cater only for low acuity conditions. In the West, one ED was reconfigured to a UCC in 2011. In the Mid-West, two EDs were reconfigured to UCCs from 2012 to 2013, while in the North-East two EDs were reconfigured to LIUs during the period 2009-2010.

The South experienced changes to three EDs: two rural EDs in county Cork were re-designated to UCCs, and one urban ED was permanently closed. These changes occurred over the period 2012-2013.

Table 5.1: Reconfiguration of regional ED services

Region	Characteristics	Summary of Regional Change
West (Galway, Roscommon, Mayo, Leitrim, Sligo, Donegal)	2016 population: 702,966 Area (km^2): 22,649	• One ED closed and reconfigured [Roscommon: Roscommon General Hospital (July, 2011)]. • Reconfigured to UCC: • LIU, 8am-8pm, 7 days a week; • MAU, 9am-5pm, 5 days a week.
North East (Cavan, Meath, Louth and Monaghan)	2016 population: 440,211 Area (km^2): 6,395	• Two EDs closed and reconfigured [Monaghan: Monaghan General Hospital (July, 2009); Louth: Louth County Hospital (June, 2010)]. • Both reconfigured to LIUs: • Monaghan General Hospital LIU, 9am-5pm, 5 days a week; • Louth County Hospital LIU, 9am to 8pm, 7 days a week.
South (Cork and Kerry)	2016 population: 663,176 Area (km^2): 12,161	• One ED permanently closed [Cork: South Infirmary Hospital (July, 2012)]. • Two EDs closed and reconfigured [Cork: Mallow General Hospital (March, 2013) and Bantry General Hospital (July, 2013)]. • Both reconfigured to UCCs: • Mallow General Hospital LIU & MAU, 8am-8pm, 7 days a week; • Bantry General Hospital, LIU 8am-8pm, 7 days a week; MAU 9-4.30pm, 5 days a week.
Mid-West (Limerick, Clare and Tipperary North)	2016 population: 378,210 Area (km^2): 8,252	• Two EDs closed and reconfigured [Tipperary North: Nenagh Hospital (September, 2012); Clare: Mid-Western Regional Hospital Ennis (July, 2013)]. • Both reconfigured to UCCs: • LIUs, 8am-8pm, 7 days a week; • MAUs, 8am-6pm, 5 days a week.

5.2.2 Data sources

Trolley data for each region and hospital was provided by the Irish Nursing and Midwives Organisation (INMO) weekly trolley data spreadsheets from 2005-2015 as reported by the Department of Health [247, 248]. The data refers to the number of patients on trolleys in EDs awaiting admission to an in-patient hospital bed, as counted at 8am by the INMO [248, 261]. The weekly counts refer to the number of patients on trolleys from Monday to Friday only, excluding bank holidays [247, 248]. This data is collected by contacting bed managers in each hospital, who provide the requested information. Data is then centrally located by the INMO and cross-checked daily against a HSE database, TrolleyGAR [261]. Week 1, 52 and 53 of the data provided straddles the Christmas season and the INMO have directly advised that the accuracy and completeness of data collection over this period is reduced. Therefore, these weeks have not been included in the final analysis.

Information regarding emergency admissions to public acute hospitals from 2005 to 2015 was available via the Hospital In-Patient Enquiry (HIPE) system [241]. The average number of annual in-patient beds [243] and the number of monthly ED attendances at each hospital [262] from 2006 to 2015 were provided directly by the Acute Business Intelligence Unit in the HSE.

5.2.3 Statistical analysis

5.2.3.1 Moving average

An initial analysis of the moving average of ED trolleys and total emergency admissions within the hospitals with full EDs in each region was conducted to assess the general underlying trend in both. Weekly data was available for both ED trolleys and total emergency admissions. The moving average was constructed using a 50-week window, beginning with the final 24 weeks of 2005 and the first 25 weeks of 2006, moving a week at a time, and ending before the final 25 weeks of 2015. This 50-week window allowed an examination of the underlying trend having removed seasonality. The average number of annual in-patient beds in hospitals with full EDs was also considered over the same time period. Data for those hospitals that saw removal of full ED services are included in the regional averages up to and including the year of their closure.

5.2.3.2 Distribution of ED trolleys among regional hospitals

In order to understand how individual hospital trolley numbers, contribute to the regional total over time, the annual average of the weekly trolley numbers in each hospital were combined and graphed. This visualisation allows a greater understanding of how the distribution of trolley share by hospital varies before and after ED closure/reconfiguration, thereby identifying those hospitals most impacted by the changes in ED services.

5.2.3.3 Decomposition of observed trolley numbers

The full time-series for the ED trolley numbers in each region were modelled using a negative binomial regression analysis of the full data from 2005 to 2015. The model was adjusted for seasonality and allowed for a non-linear underlying trend. The following model was used:

$$log(\mu) = f(t) + \beta_1 Sin(\frac{2\pi t}{50}) + \beta_2 Cos(\frac{2\pi t}{50}) + \beta_3 Sin(\frac{2\pi t}{25}) + \beta_4 Cos(\frac{2\pi t}{25}) \tag{5.1}$$

Where $f(t)$ is a restricted cubic spline function of time. The spline function is cubic between specified time points (knots) and continuous, with continuous first and second derivatives, at the knots. The knots were placed at every 100 weeks. This results are a smooth and flexible model that can react to local changes. The Cos and Sin terms allow for seasonality with periods of 12-months and 6-months (25 and 50 weeks).

This model was then subsequently decomposed into its three relevant components: the underlying trend, seasonality and noise. The relationship between the trend and the seasonality in the model was assumed to be multiplicative. The noise was identified as the difference between the observed and expected counts. The model also allowed for serial autocorrelation based on a visual inspection of the ACF and PACF graphs. A function was included to allow the standard errors to have a heteroskedastic error and autocorrelation consistent lag of three, as determined by the observed pattern [225].

5.2.3.4 Interrupted piecewise linear time-series

Having assessed the underlying trend, an interrupted time-series was then applied to a shorter time period. In the West region, where there was a single ED closure, we considered the time period 12-months prior to the ED reconfiguration and the 12-months post-reconfiguration. For regions where there were two ED reconfiguration, the period from 12-months prior to the first ED reconfiguration to the 12-months after the second ED reconfiguration were considered.

When plotted, the shorter time period was found to be compatible with a linear model. Seasonality was included as before, but the cubic spline term was replaced by a piecewise linear function with a break-point at the time of ED reconfiguration. A dummy variable and an interaction term were considered for each of the ED reconfiguration to allow for both a jump and slope change in the trend.

In regions where two ED reconfigurations took place, a backwards hierarchical stepwise approach was taken to determine which impact for each ED closure was significant at a regional level. A significance level of $p\text{-}value < 0.05$ was set, with the model accounting for the impact of the reconfiguration of the first ED, and then the second. For one region, the South, there are three total ED reconfigurations. The final two reconfigurations happened in very close succession, with only roughly a five month period between them. The closeness of these reconfigurations made it difficult to distinguish the impact each. As the final closure (Bantry) was a smaller ED, with a small number of emergency admissions, it was excluded in order to simplify the final analysis.

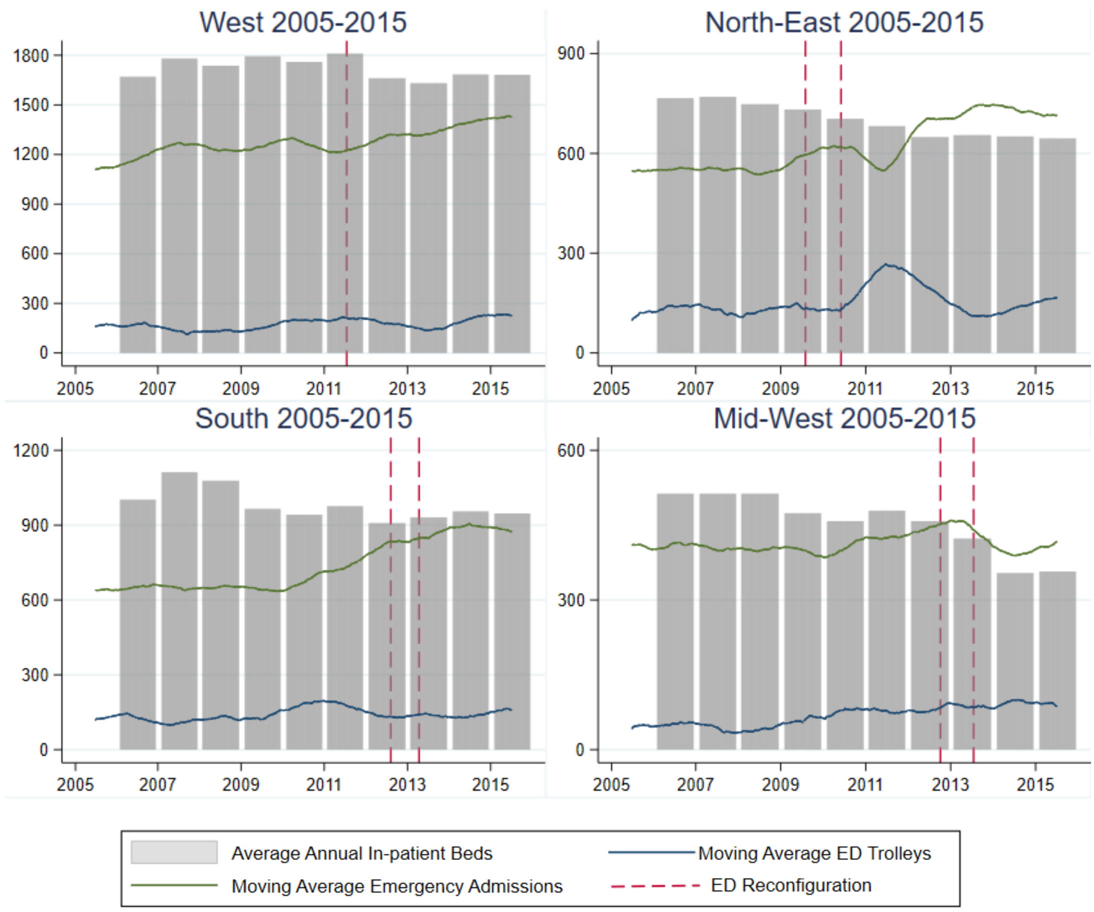
The final model for each region, with the significant components and deseasonalised trolley counts, was then graphed against a counterfactual model which set the ED reconfiguration and its potential change in trend and level to zero.

5.3 Results

5.3.1 Moving average

The moving average plots removed seasonality and revealed varying non-linear trends in both ED trolley use and emergency admissions over the period 2005-2015. These can be observed in figure 5.1 and in further detail in **Appendix B.1**, with annual average figures outlined in tables 5.2, 5.3, and 5.4. The number of average annual in-patient beds for the hospitals with full EDs are represented by the grey bar chart component and the reconfiguration of each ED is represented by the dashed red line. The weekly moving average number of emergency admissions is represented by the green line and the weekly moving average number of trolleys is represented by the blue line. **Appendix B.1** also includes details of regional annual average ED attendances, comprising of both new and repeat attendances.

FIGURE 5.1: Regional ED trolleys, emergency admissions and in-patient beds, 2005/2006 - 2015



5.3.2 In-patient beds

The annual average number of in-patient beds available in the regional hospitals were analysed, including the hospitals that underwent reconfiguration to their ED services up to and including the year of the reconfiguration. Figure 5.1, shows the maximum level of in-patient beds were observed in 2007 (North-East 770, Mid-West 513, South 1,112), see table 5.2. All of these regions saw decreases in in-patient bed numbers available between 2005 and 2015 (North-East decrease of 16%, Mid-West decrease of 30%, South decrease 5%). The exception is the West, which saw an increase to the average number of in-patient beds of 0.7% from 2005 to 2015. For both the Mid-West and the North-East, since 2013 and 2012 respectively, the average number of emergency admissions per week exceeds the number of in-patient beds available.

TABLE 5.2: Annual average in-patient beds, 2006-2015

	West	**North -East**	**South**	**Mid-West**
2005	N/A	N/A	N/A	N/A
2006	1,670	766	1,002	513
2007	1,780	770	1,112	513
2008	1,737	748	1,078	513
2009	1,794	732	965	474
2010	1,760	704	942	458
2011	1,810	682	976	479
2012	1,661	649	908	458
2013	1,631	655	931	423
2014	1,684	651	955	354
2015	1,682	645	947	357
TOTAL	**1,721**	**700**	**982**	**454**

5.3.3 Emergency admissions

In the West there was a steady increase in emergency admissions in the relevant hospitals over the period 2005-2015, increasing from a weekly average per year of 1,109 emergency admissions in 2005 to 1,428 in 2015, representing a 29% increase, see table 5.3.

The pattern in the three other regions was more erratic. In the North-East the number of emergency admissions was relatively constant up to 2009 (approximately 550 per week on average each year), after which there was a period of increase until midway through 2010. A subsequent fall and sharp increase between 2011 and 2012 was observed (an increase from an average of 554 per week in 2011 to 706 per week in 2012). This increase was maintained thereafter resulting in a 31% increase over the full study period.

In the South and Mid-West regions, the average number of emergency admissions per week was relatively consistent between 2005 and 2010; approximately 650 per week in the South and 400 per week in the Mid-West. Emergency admissions in the South started to rise after 2010 (728 per week in 2011) and levelled off after 2014 (874 per week in 2015). In the Mid-West, emergency admissions rose after 2010, peaking at an average of 446 per week in 2012, although there was a substantial fall in emergency admissions in 2014 to an average of 389 per week. Over the full study period the South saw a 27% rise in emergency admissions compared to only 2% in the Mid-West.

Table 5.3: Annual weekly average emergency admissions, 2005-2015

	West	**North East**	**South**	**Mid-West**
2005	1,109	547	638	410
2006	1,171	551	651	415
2007	1,271	556	649	399
2008	1,224	538	654	399
2009	1,245	593	639	400
2010	1,269	615	670	403
2011	1,222	554	728	424
2012	1,317	706	831	446
2013	1,323	737	846	443
2014	1,395	735	906	389
2015	1,428	715	874	417
TOTAL	**1,270**	**622**	**735**	**413**

5.3.4 Trolley numbers

The trend in trolley numbers varied among regions. Trolley numbers in the West fluctuated over the 10-year period between a minimum average of 132 trolleys per week in 2007 and a maximum of 226 per week in 2015, see table 5.4.

In the North-East, there was a steady pattern until 2010, with numbers almost doubling over the next 12-months (increasing from an average of 141 per week in 2010 to 264 per week in 2011). After this point, levels dropped back to a similar pattern to that observed prior to 2011. By 2015, the average trolley number had increased to 166 per week, compared to 99 per week in 2005.

In the South, trolley numbers peaked in 2010 with an average of 186 trolleys per week compared to a minimum of 106 per week in 2007. The Mid-West saw the average number of trolleys more than double from 42 per week in 2005 to 87 in 2015, peaking in 2014 at 99 per week.

Table 5.4: Annual weekly average ED trolley numbers, 2005-2015

	West	**North-East**	**South**	**Mid-West**
2005	160	99	119	42
2006	173	138	127	52
2007	132	132	106	45
2008	133	125	134	40
2009	150	134	121	56
2010	197	141	186	81
2011	212	264	179	77
2012	181	196	132	76
2013	135	111	141	86
2014	207	135	134	99
2015	226	166	158	87
TOTAL	**173**	**149**	**140**	**67**

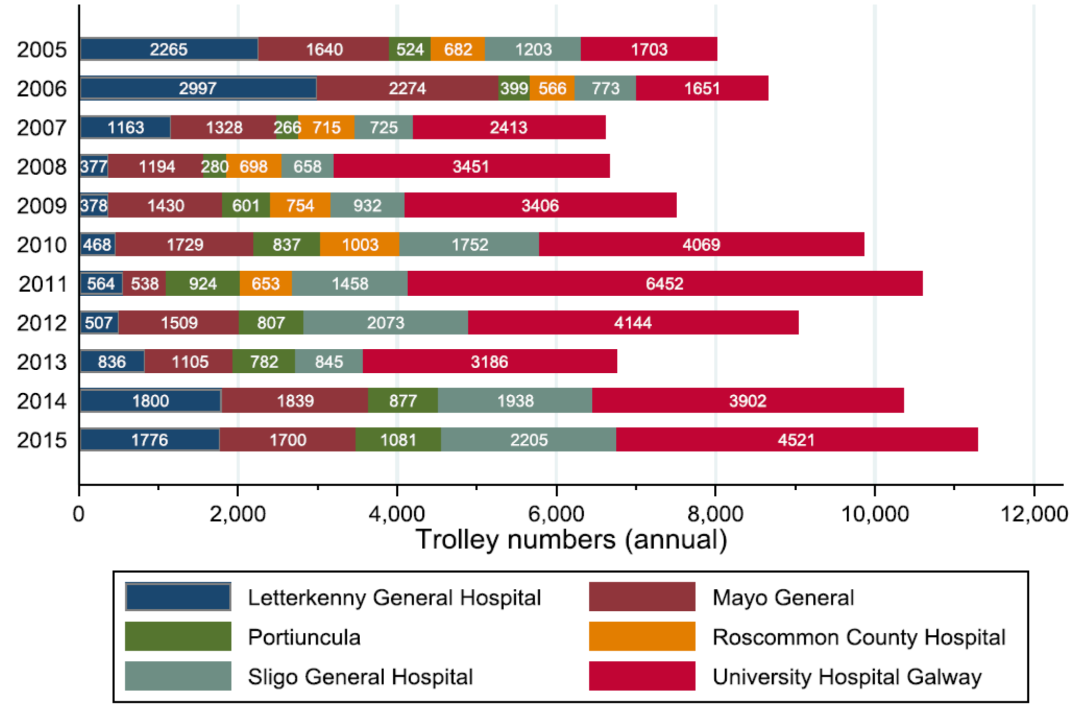
5.3.5 Distribution of ED trolleys among regional hospitals

Regional trolley numbers are the sum of trolley numbers across the hospitals within a region. We examined how, when a particular ED is closed or reconfigured it impacts on the emergency admissions to the remaining regional hospitals with full ED services. The full results are presented in table 5.5, describing the changes in emergency admissions in the years before and after ED reconfiguration.

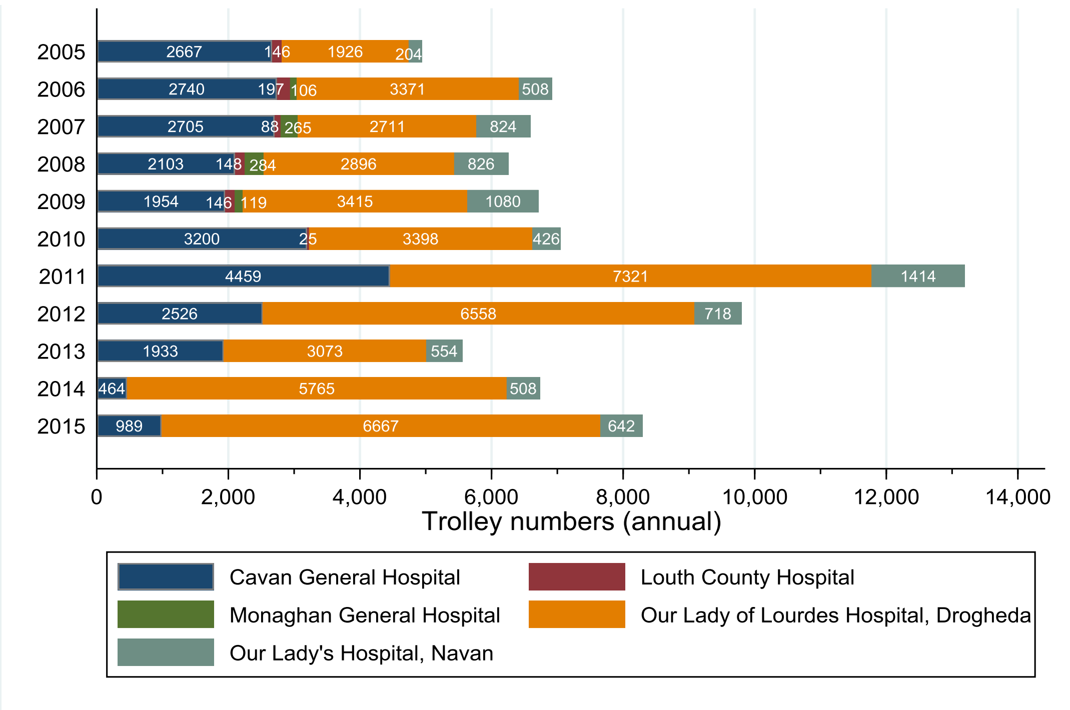
Figure 5.2 illustrates the variation in distribution across hospitals in each region of the weekly average trolley numbers over time. The regional totals are broken down by hospital to identify those EDs which contribute the most to the total regional trolley numbers. The starkest change can be observed in the North-East. As seen in figure 5.2, following the closure of Louth County Hospital in 2010, the average number of patients on trolleys each week in the neighbouring hospital in Drogheda, Our Lady of Lourdes Hospital, increased from 3,398 total in 2010 (an average of 68 per week) to 7,321 in total in 2011 (an average of 146 per week).

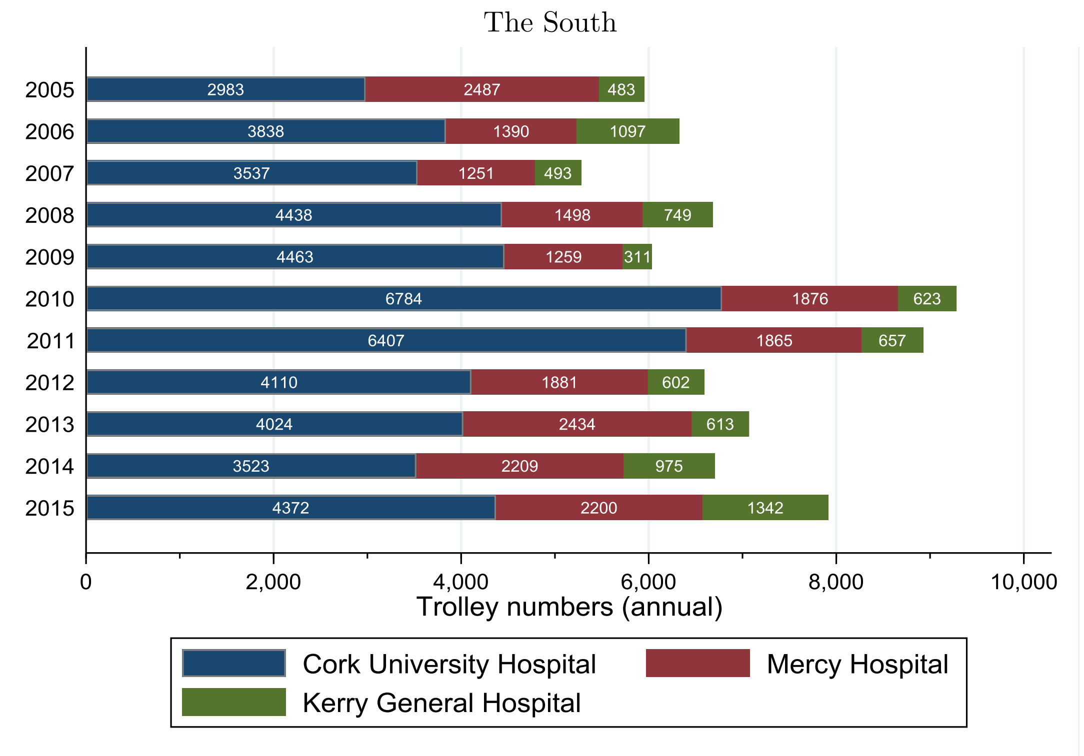
FIGURE 5.2: Regional distribution of ED trolleys among hospitals, 2005-2015

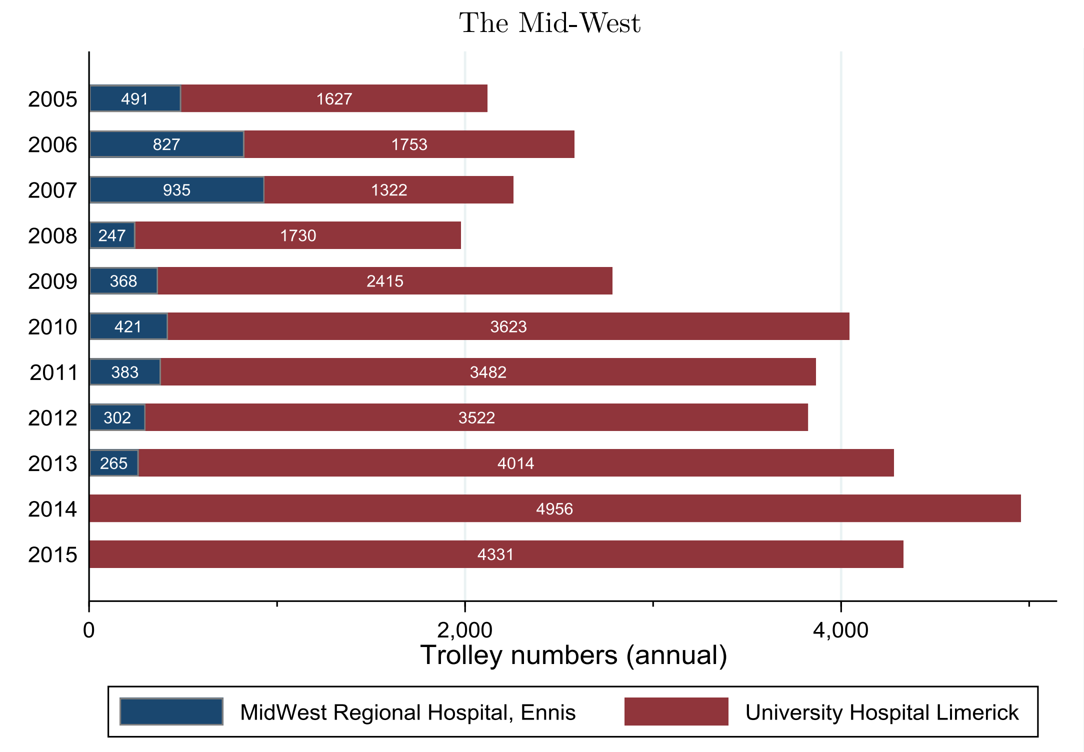
The West



The North-East







In 2009, the year prior to ED reconfiguration, 4,891 emergency admissions (representing 51% of those from Louth) were to Our Lady of Lourdes Hospital, Drogheda, and 3,229 (34% of all emergency admissions from Louth) were to Louth County Hospital. In 2011, following the Louth County Hospital ED reconfiguration, an additional 2,000 patients from Louth were admitted on an emergency basis at Our Lady of Lourdes, Drogheda, indicating that 85% of all emergency admissions of patients from Louth were received at that hospital. In 2012, the number of emergency admission patients from Louth admitted to Our Lady of Lourdes had increased to over 10,000. Table 5.5 provides a full break-down of the distribution of emergency admissions.

TABLE 5.5: Distribution of patients from the county of ED reconfiguration to remaining regional hospitals with full ED services

The West

Patients from Roscommon	**2010** **(n=5,315)**	**2011** **(n=3,777)**	**2012** **(n=5,044)**
Letterkenny General Hospital (%)	2 (<1%)	1 (<1%)	3 (<1%)
Mayo General Hospital (%)	239 (5%)	311 (8%)	575 (11%)
Portiuncula Hospital (%)	884 (16%)	1,137 (30%)	1,586 (31%)
Roscommon County Hospital (%) *ED reconfiguration July 2011*	2,185 (41%)	78 (2%)	513 (10%)
Sligo Regional Hospital (%)	753 (14%)	846 (23%)	1,042 (21%)
University Hospital Galway (%)	889 (17%)	954 (25%)	864 (18%)
Hospitals outside the West (%)	363 (7%)	450 (12%)	461 (9%)

The North-East

Patients from Monaghan	**2008 (n= 5,574)**	**2009 (n= 5,493)**	**2010 (n= 5,429)**	**2011 (n=5,054)**
Cavan General Hospital (%)	1,497 (27%)	2,390 (44%)	3,455 (64%)	3,281 (65%)
Louth County Hospital (%) *ED reconfigured June 2010*	538 (10%)	502 (9%)	311 (6%)	0 (<1%)
Monaghan General Hospital (%) *ED reconfigured July 2009*	2,180 (39%)	1,257 (23%)	0 (<1%)	0 (<1%)
Our Lady's of Lourdes, Drogheda(%)	862 (15%)	772 (14%)	1,097 (20%)	1,157 (23%)
Our Lady's, Navan (%)	15 (<1%)	36 (<1%)	48 (<1%)	40 (<1%)
Hospitals outside the North-East (%)	482 (9%)	536 (10%)	518 (10%)	576 (11%)
Patients from Louth	**2008 (n=9,862)**	**2009 (n=9,524)**	**2010 (n=9,555)**	**2011 (n=8,144)**
Cavan General Hospital (%)	14 (<1%)	18 (<1%)	11 (<1%)	19 (<1%)
Louth County Hospital (%) *ED reconfigured June 2010*	3,447 (35%)	3,229 (34%)	1,343 (14%)	1 (<1%)
Monaghan General Hospital (%) *ED reconfigured July 2009*	10 (<1%)	4 (0%)	0 (<1%)	0 (<1%)
Our Lady of Lourdes, Drogheda (%)	5,304 (54%)	4,891 (51%)	6,840 (72%)	6,885 (85%)
Our Lady's, Navan (%)	26 (<1%)	104 (1%)	133 (1%)	51 (<1%)
Hospitals outside the North-East (%)	1,061 (11%)	1,278 (13%)	1,228 (13%)	1,188 (15%)

The South

Patients from Cork	**2011** (n = 32,827)	**2012** (n= 38,295)	**2013** (n=36,610)	**2014** (n=41,944)
Bantry (%) *ED reconfigured July 2013*	42 (<1%)	2,975 (8%)	685 (2%)	3,662 (9%)
Cork University Hospital (%)	20,346 (62%)	24,013 (63%)	22,778 (62%)	24,802 (59%)
Mallow General Hospital (%) *ED reconfigured March 2013*	2,678 (8%)	2,827 (7%)	3,175 (9%)	3,634 (9%)
Mercy University Hospital (%)	5,553 (17%)	6,339 (17%)	8,374 (23%)	8,316 (20%)
South Infirmary Cork (%) *ED closed July 2012*	3,332 (10%)	1,305 (3%)	676 (2%)	642 (1%)
Tralee General Hospital (%)	92 (<1%)	91 (<1%)	102 (<1%)	94 (<1%)
Hospitals outside the South (%)	781 (2%)	745 (2%)	820 (2%)	794 (2%)

The Mid-West

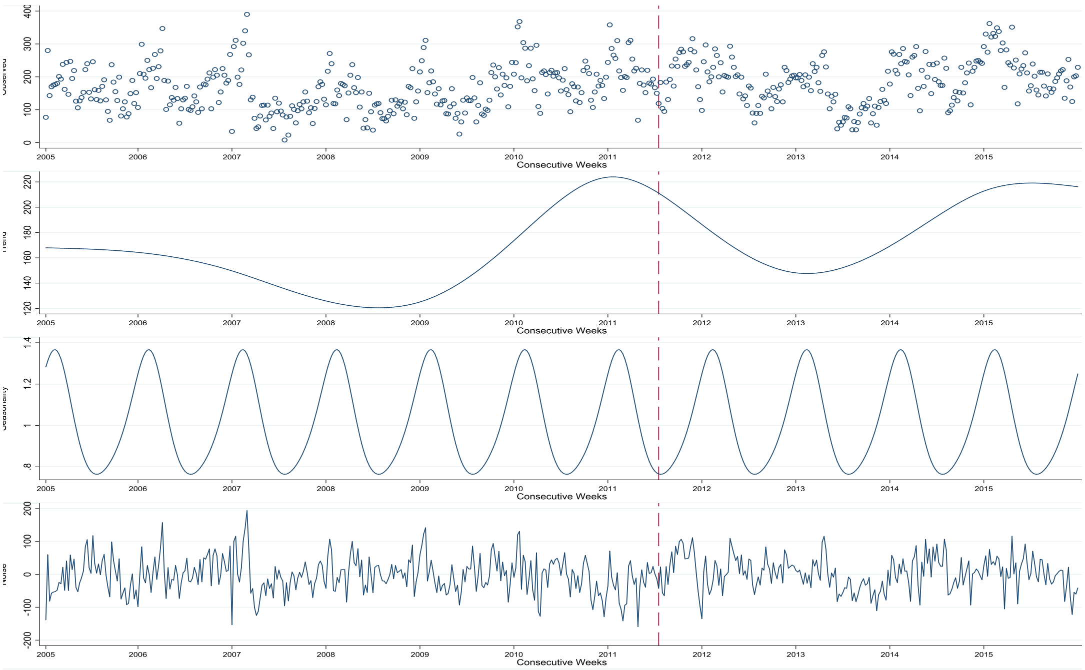
Patients from Clare	**2011** **(n=8,985)**	**2012** **(n=9,224)**	**2013** **(n=8,956)**	**2014** **(n=9,436)**
Ennis Regional (%) *ED reconfigured July 2013*	2,894 (32%)	2,763 (30%)	2,027 (23%)	2,867 (30%)
University Hospital Limerick (%)	4,905 (55%)	5,144 (56%)	5,687 (64%)	5,344 (57%)
Nenagh Hospital (%) *ED reconfigured September 2012*	73 (<1%)	85 (<1%)	66 (<1%)	46 (<1%)
Hospitals outside the Mid-West (%)	1,113 (12%)	1,232 (13%)	1,176 (13%)	1,179 (12%)
Patients from Tipperary **(County Tipperary split between South-East and Mid-West)**	**2011 (%)** **(n=14,378)**	**2012** **(n=15,488)**	**2013 (%)** **(n=16,301)**	**2014** **(n=16,039)**
Ennis Regional (%) *ED reconfigured July 2013*	9 (<1%)	9 (<1%)	6 (<1%)	21 (<1%)
University Hospital Limerick (%)	1,930 (13%)	2,215 (14%)	2,559 (16%)	2,408 (15%)
Nenagh Hospital (%) *ED reconfigured September 2012*	2,241 (16%)	1,692 (11%)	1,191 (7%)	1,329 (8%)
Hospitals outside the Mid-West (%)	14,378 (71%)	11,572 (75%)	12,545 (77%)	12,281 (77%)

5.3.6 Decomposition of observed trolley numbers

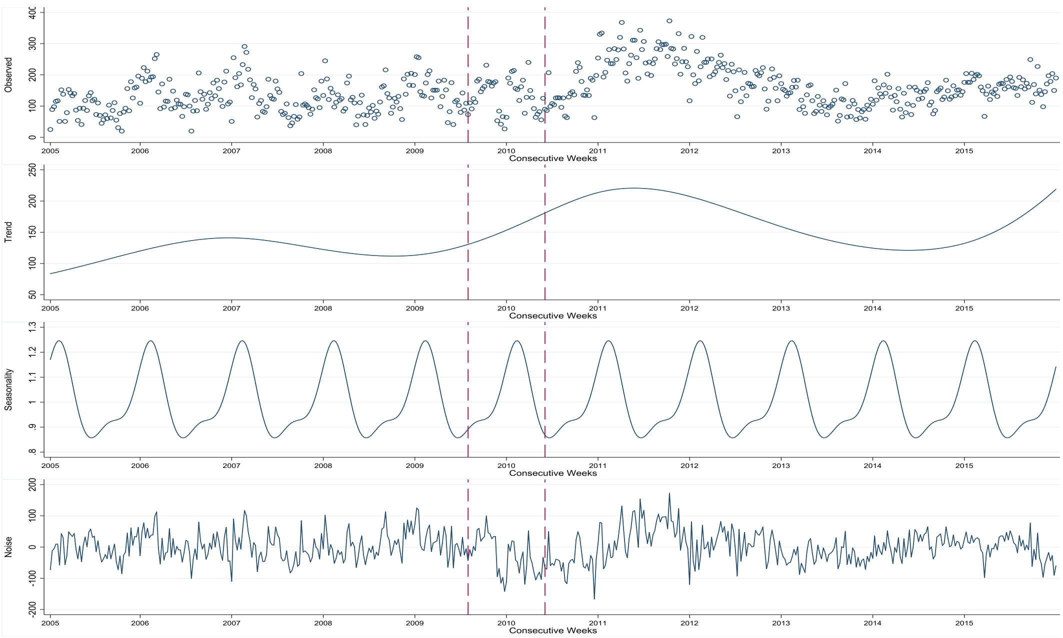
The decomposition of each region's observed ED trolley numbers from 2005 to 2015 can be seen in figure 5.3. The observed trolley numbers are seen in the first part of the graph, followed by the underlying trend, the observed seasonal component and finally the remaining, unexplained noise. The included red dash lines signify the reconfiguration of an ED.

FIGURE 5.3: Regional decomposition of ED trolleys; observed, trend, seasonality and noise, 2005-2015

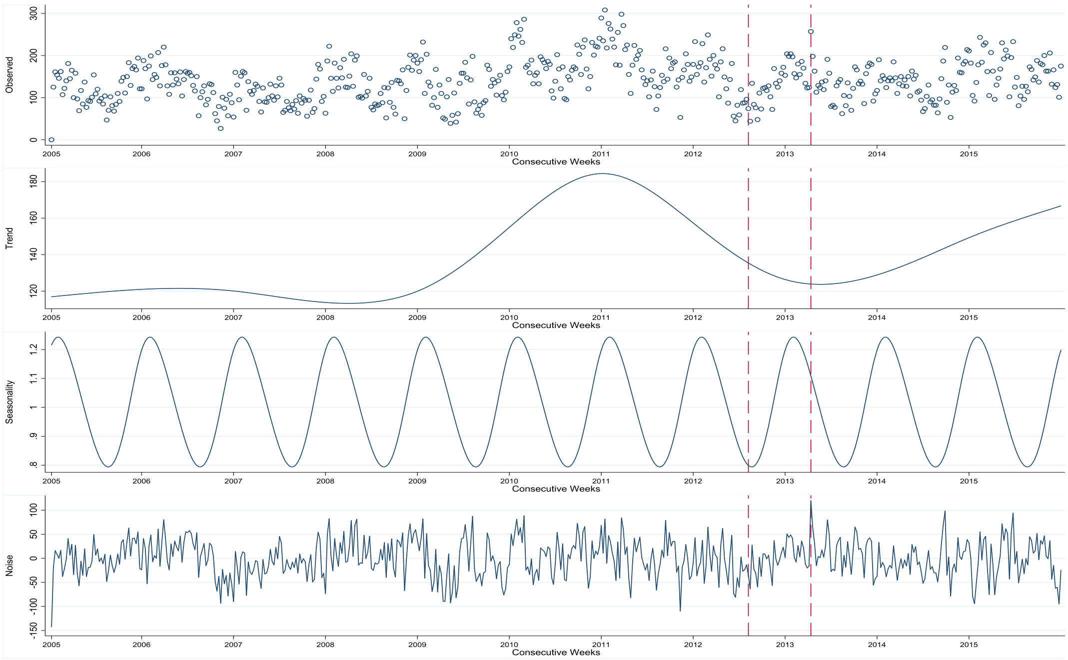
The West



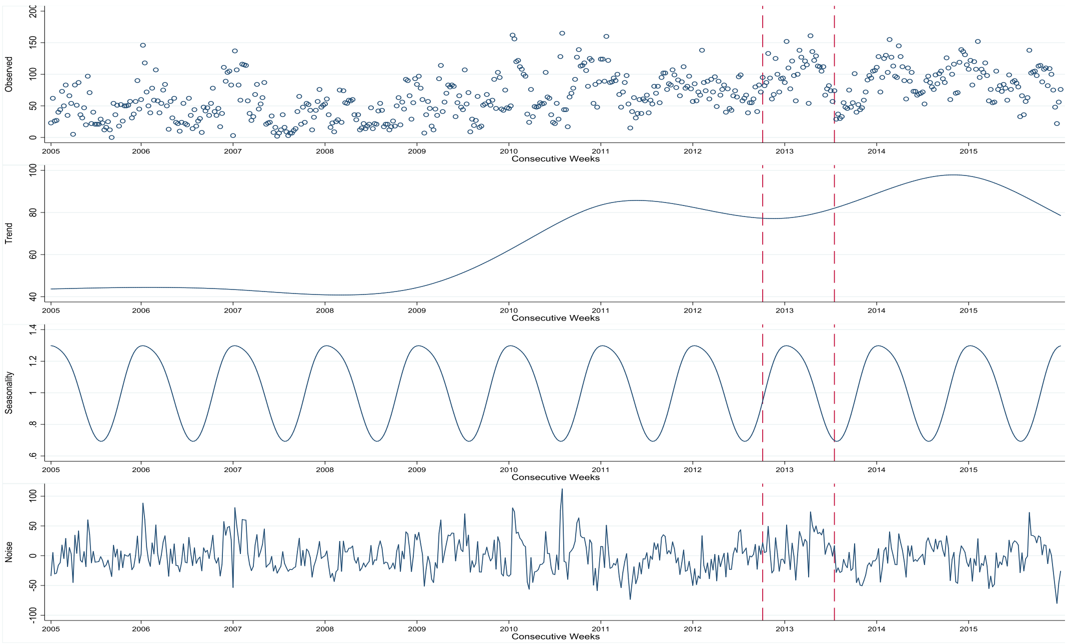
The North-East



The South



The Mid-West



The second component of each graph, identifying the trend, shows that the most substantial changes in the underlying pattern are witnessed in each region from 2009 onwards. Similar to the moving averages outlined in figure 5.1, peaks are seen in the observed trend around 2011/2012, with the exception of the Mid-West, which sees a peak in 2015. It's important to note the difference in scales across all four regional plots, with the lowest numbers seen in total in the Mid-West, which also has the smallest population.

5.3.7 Interrupted piecewise linear time-series

The results of regional interrupted time-series analysis of trolley numbers are outlined in figure 5.4 and in table 5.6.

FIGURE 5.4: Regional piecewise linear analysis of ED reconfiguration

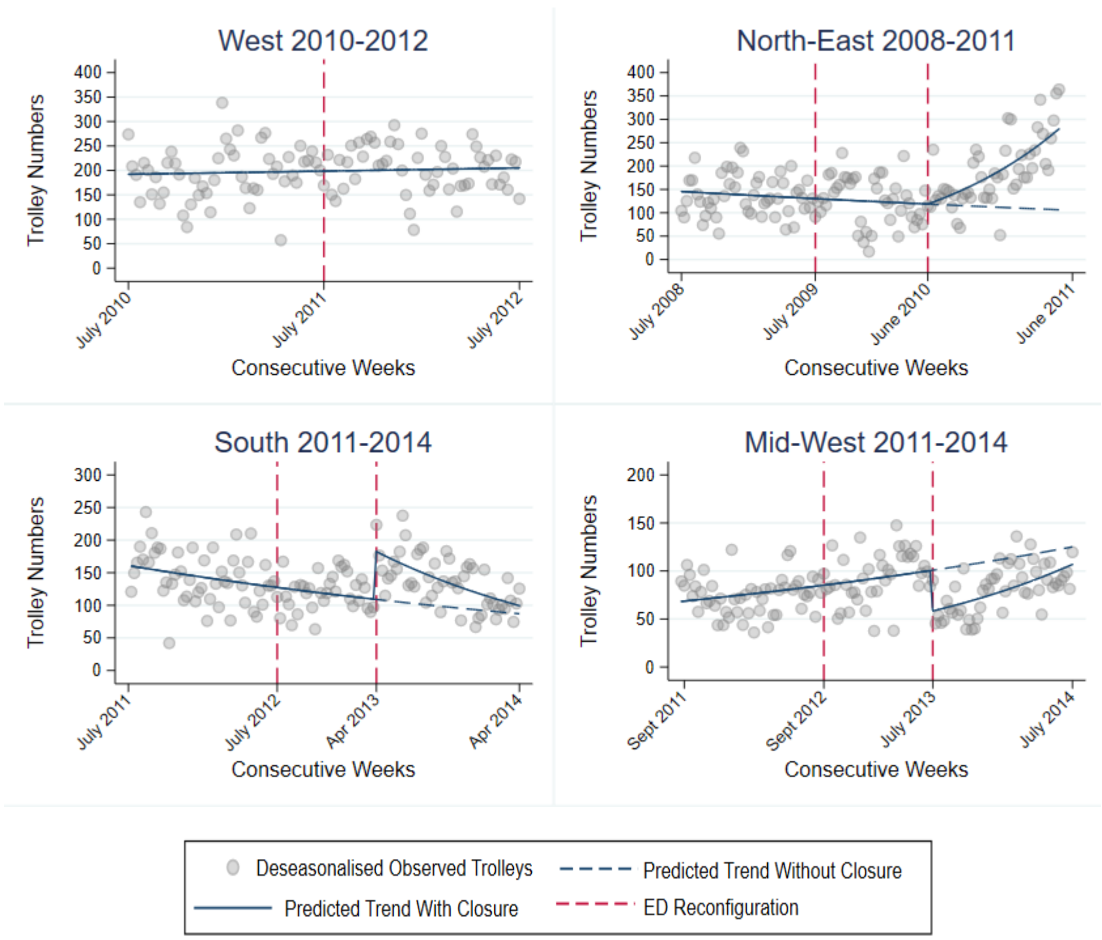


Table 5.6: Regional piecewise linear analysis of ED reconfiguration - results

Region (Hospital ED)	**IRR (95% confidence interval)**	***P*-value[1]**
West (Roscommon General Hospital)		
Trend before and after ED reconfiguration	1.03 (0.92, 1.16)	0.55
North-East (Louth County Hospital)		
Trend before ED reconfiguration	0.88 (0.77, 1.02)	0.095
Trend after ED reconfiguration[2]	2.53 (2.03, 3.15)	< 0.001
Trend ratio	2.85 (2.04, 3.99)	<0.001
South (Mallow General Hospital)		
Trend before ED reconfiguration	0.80 (0.70, 0.90)	< 0.001
Trend after ED reconfiguration[2]	0.54 (0.415, 0.69)	< 0.001
Trend ratio	0.68 (0.51, 0.89)	0.006
Level change[3]	1.68 (1.36, 2.09)	< 0.001
Mid-West (Mid-West Regional Hospital, Ennis)		
Trend before ED reconfiguration	1.25 (1.09, 1.43)	< 0.001
Trend after ED reconfiguration[2]	1.81 (1.30, 2.51)	< 0.001
Trend ratio	1.44 (1.03, 2.03)	0.03
Level change[3]	0.58 (0.45, 0.73)	< 0.001

1: p-value for change in annual slope or level after ED closure
2: IRR for slope change refers to slope for 12-months post-reconfiguration
3: IRR for level change refers to after vs before ED closure

In the West, the reconfiguration of Roscommon ED to a UCC was not found to have a statistically significant impact on either the level or slope of the observed deseasonalised trolley numbers. The deseasonalised observed trolley numbers did not have a significant trend in the 12-months prior to, or post, ED reconfiguration (annual IRR 1.03; 95% CI 0.920, 1.16).

In the remaining three regions, where there were two ED reconfigurations/closures, the impact of the second ED reconfiguration was found to have a significant impact on the observed trolley numbers, but not necessarily in the expected direction, and without a long-term continuation of the immediate change in trend.

In the North-East, there was a significant increase in the upward trend in trolley numbers in the 12-months following the reconfiguration of Louth County Hospital ED to a LIU, (pre-reconfiguration of Louth ED annual IRR 0.88; 95% CI 0.77, 1.02: post-reconfiguration of Louth ED annual IRR 2.53; 95% CI 2.03, 3.15). However, there was no significant change in level or trend following the first ED closure (Monaghan - level change $p\text{-}value = 0.44$, trend change $p\text{-}value = 0.21$).

In the South, no significant change in the level or trend of the trolley numbers was observed following the closure of the first ED (South Infirmary - level change $p\text{-}value = 0.17$, trend change $p\text{-}value = 0.10$). However, there was a significant immediate increase of 68% to the level of observed trolleys following the reconfiguration of Mallow ED to a UCC (IRR 1.68; 95% CI 1.36, 2.09). There was a subsequent significant downward trend (annual IRR 0.54; 95% CI 0.415, 0.69) in the 12-months post closure which causes the trend to converge with the predicted pattern if no reconfiguration had occurred (pre-reconfiguration IRR 0.795; 95% CI 0.701, 0.90).

Finally, in the Mid-West there was no significant change in level or trend associated with the first ED reconfiguration (Nenagh - level change *p-value* = 0.64, trend change *p-value* = 0.16), but there was a significant immediate fall of 42% in trolley numbers at the time of the reconfiguration of Ennis ED to a UCC (IRR 0.58; 95% CI 0.45, 0.733). There was also a significant increase in the observed slope for the 12-months post-reconfiguration (annual IRR 1.81; 95% CI 1.30, 2.51) which ultimately results in a convergence with the predicted pattern if no reconfiguration had taken place (pre-reconfiguration IRR 1.25; 95% CI 1.09, 1.43).

5.4 Discussion

5.4.1 Summary of findings

The total regional emergency admissions to acute hospitals with full ED services have increased in Ireland since 2005. At the same time, the total number of in-patient beds available at these hospitals have not returned to their pre-recession levels.

Our analysis of the distribution of trolley numbers over time has highlighted increased short-term pressures on surrounding hospitals following the reconfiguration of ED services. This pattern is most specifically observed in the North-East region which saw a substantial increase in its observed trolley numbers following the closure of Louth County hospital.

All four regional ED trolley patterns reflect a non-linear underlying trend. In general, the findings show that the regionally observed ED trolleys follow a similar pattern; the lowest levels are seen around 2007, while peaks in the trend are observed in 2011/2012, with the exception of the Mid-West.

Analysis found that for three of the four regions (the South, the Mid-West and the North-East) the re-designation of the second regional ED had a significant immediate impact on ED trolley numbers at a regional level. The projected results showed that both the South and the Mid-West displayed a convergence within the 12-months post-reconfiguration between the observed trolley numbers and the expected trolley numbers if the ED reconfiguration had not taken place. However, the North-East shows a much steeper increase over time that does not display a short-term convergence with the expected trend if the ED reconfiguration had not taken place.

5.4.2 Interpretation

In three regions the immediate impact of ED reconfigurations is either non-significant or associated with a short term shock to observed ED trolley numbers followed by convergence with the pre-reconfiguration trend over the following 12-months.

Only the North-East was subject to a longer term shock after reconfiguration. The full long term trend in the North-East, as seen in figure 5.3, shows that the number of trolleys continues to increase up to mid-2011, marginally beyond the 12-months post ED reconfiguration. It is only from mid-2011 onwards that a gradual improvement is seen.

The anomalous results in the North-East cannot be explained by unique background conditions. Bed capacity in the North-East fell by 7% over the reconfiguration period (2009-11), but larger decreases were seen in the West (9% from 2011-12) and the Mid-West (29% from 2012-14) with only the South region experiencing a rise in bed capacity during reconfiguration. Emergency admissions fell by 7% in the North-East over the reconfiguration period compared to rises in the West (8%) and South (9%) and a fall of 13% in the Mid-West. This may indicate that other determinants which we have not measured, such as efficiency of bed management within hospitals, may be better predictors of overcrowding.

It is also important to note that EDs in the North-East were reconfigured to LIUs only, with no MAU provided within the hospitals to replace the ED services. In all other regions, EDs were reconfigured to UCCs incorporating both LIU and MAU facilities.

5.4.3 Strengths and limitations

A strength of this study is the wealth of data used in the analysis conducted; 11 years of weekly trolley data and emergency admissions, and 10 years of monthly emergency attendance data. The granularity of this data allows for an analysis of seasonality which is an important consideration when studying the immediate impact of reconfiguration on ED overcrowding.

The models adopted to perform this analysis allow for a more complex, non-linear underlying pattern within the data. The methods presented here illustrate how the patterns in trolley data can be decomposed, allowing the identification of underlying trends. Since 2005, the INMO have collected information on trolley numbers in hospital wards and these are reported regularly in the media. Although the trolley data is freely available it is largely under-utilised. This is, to our knowledge, the first study to use this data together with a more sophisticated time-series model to study the long-term trends in trolley numbers.

The inclusion of emergency admissions data at a population level has allowed us to capture whether emergency admissions to hospitals outside of the regions studied have changed as a result of ED reconfiguration, as outlined in table 5.5. The trends point to a generally consistent pattern in the numbers and proportions of emergency admissions to hospitals outside the region over time. Therefore, the risk that our study interpretations do not account for changes in inter-regional patient movements is minimal.

The limitations of this study include difficulty in separating and interpreting the impact of individual service changes when two ED reconfigurations occurred within the space of 12-months.

It is also possible that the trolley data is biased in some way as it is not officially validated using an external source. However, it is collected using systematic methods across all hospitals and these methods have not changed over the study period. Therefore, the greatest risk is likely to be consistent over or under-estimation at a national level rather than in comparisons across hospitals or time [44, 263].

It is important to also acknowledge that conditions outside the hospital setting have an impact on the observed trend. For example, at the beginning of 2011, EDs across the country saw an increase in activity due to increased numbers of patients presenting with flu, flu like symptoms and swine flu [264]. This also resulted in a sudden increase in the numbers on ED trolleys due to overcrowding. Such an incident highlights the difficulty of modelling complex temporal patterns that combine non-linear and seasonal pattern and are sensitive to the effects of national and local conditions.

5.4.4 Policy implications

ED reconfiguration is likely to continue, therefore, where possible, research should try to determine which service restriction is most likely to impact ED overcrowding at other locations [256]. Increasing hospital bed access and the use of other hospital services such as acute medical units have been seen as possible ways to offset the impact of ED closures [249]. Our findings suggest that other factors, such as the efficiency of local bed management, may also be important determinants. It is possible that trolley numbers may increase when there is below maximum hospital occupancy. This may occur if patients need care in specialised units, such as oncology wards. These may be fully occupied even when there is still capacity in the hospital as a whole [255]. Admissions are usually done on a specialty basis and it is the availability of beds in speciality areas that may ultimately have an impact, rather than the total number of beds. There are also issues regarding the closure of beds due to infection and the increased need for specialised isolation facilities [265]. Therefore, bed management forms an important component of the wider efficient use of hospital resources, a concern encapsulated by operational capacity planning and control [266–268]. In general, operational capacity management is considered to be poorly developed in most acute hospitals [266, p. 155]. The operations functions of a hospital addresses activities such as scheduling and work flow to ensure the demands placed on resources are met in a way which maximises their efficiency [266]. In reality, bed management is often reduced to finding beds in times of high demand, effectively *'firefighting once a crisis is occurring'* [266, p. 149], rather than contributing to crisis avoidance [266, 269]. It is recommended that better capacity management can increase 'slack' in system through lower bed occupancy, and operational research and planning can aid the anticipation of day to day needs [266, p. 152]. A combined approach of both demand and supply management is needed. From a demand management perspective, promoting the appropriate use of beds, reducing delayed discharges, gate-keeping GP urgent referrals, influencing the volume, timing and placement of elective services to match bed capacity is required. At the same time, supply management measures can establish and maintain a discharge focus [266, p. 155].

The pace at which changes are implemented should also be carefully considered, particularly if resource reductions are to occur at the same time. Ensuring the efficiency and capacity of remaining resources is maximised is vital to minimise the impact of closures [256]. Certain patient management strategies have been highlighted as ways in which crowding may be reduced. Identifying non-urgent referrals, implementing ambulance diversion, and destination control have been studied as means to achieve improvements [249].

The full impact of system level factors, such as service closures, on ED trolley numbers has been largely under-investigated [256]. A study of service reduction in the US found that only 80% of the predicted ED volume from hospital closures was seen in nearby EDs [211]. Many patients, who may have attended an ED previously due to proximity, may now decide that they do not need to access emergency care, potentially due to the increased distance [44, 211]. These patients might now attend an urgent care centre or seek other alternatives to emergency care [211].

Strategies that simply transfer the problem of trolleys from the ED to the ward should be avoided, as this does not present a solution [254]. Since 2014, the INMO have collected information on trolley numbers in hospital wards, this seeks to prevent the movement of patients simply from one area of the hospital to another in an attempt to improve certain measures.

A growing contributor to the overcrowding in the ED is the large numbers of older patients awaiting discharge to a chronic care facility [270]. These demographics will differ across hospitals, therefore a one size fits all approach to reducing trolley numbers should not be adopted.

Finally, it can be assumed that distributing a set number of patients on trolleys across multiple EDs is less likely to result in unpleasant conditions than having the same number concentrated in one ED. Although unmeasured in this study, it is reasonable to suggest that the quality of patient care, stress on staff and overall time spent waiting on a trolley are worse when a high number of trolley patients are cared for in a single facility. This implies that harm may be caused by ED reconfiguration even if trolley numbers do not increase.

5.5 Conclusion

Our main findings suggest that the impact of ED reconfigurations at a regional level are either non-significant or cause a short term shock to observed ED trolley numbers which will converge on the pre-reconfiguration trend over the following 12-months. The North-East has been identified as an exception; this region experienced a longer term impact on regional trolleys, specifically caused by increased pressures on one regional hospital.

Chapter 6

Drivers of potentially avoidable emergency admissions in the Ireland: an ecological analysis

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Keywords: Health services research, ambulatory care, emergency department

Background

Many emergency admissions are deemed to be 'potentially avoidable' in a well performing health system. The aim of this paper is to measure the impact of population and health system factors on county level variation in 'potentially avoidable' emergency admissions over the period 2014 -2016.

Methods

Admissions data were used to calculate 2014-2016 age-adjusted emergency admission rates for selected conditions by county of residence. Negative binomial regression was used to identify which *a priori* factors were significantly associated with emergency admissions for these conditions and whether these factors were also associated with total/other emergency admissions. Directly standardised IRRs associated with a one standard deviation change in risk factors were reported.

Results

Nationally, 'potentially avoidable' emergency admissions for the period 2014-2016 (266,395) accounted for 22% of all emergency admissions.

Of the population factors, a one standard deviation change in the county level unemployment rate was associated with a 24% higher rate of 'potentially avoidable' emergency admissions (IRR 1.24; 95% CI 1.04, 1.41). Significant health system factors included emergency admissions with length of stay equal to 1 day (IRR 1.20; 95% CI 1.11, 1.30), and private health insurance coverage (IRR 0.92; 95% CI 0.89, 0.96). The full model accounted for 50% of unexplained variation in 'potentially avoidable' emergency admissions in each county. Similar results were found across total/other emergency admissions.

Conclusion

Results suggest 'potentially avoidable' emergency admissions and total/other emergency admissions are primarily driven by socioeconomic conditions, hospital admission policy and private health insurance coverage. The distinction between 'potentially avoidable' and all other emergency admissions may not be as useful as previously believed when attempting to identify the causes of regional variation in emergency admission rates.

6.1 Background

Since the early 2000's, countries such as England, Wales and Northern Ireland have experienced increases in emergency admissions to acute hospitals [113, 114]. Over the past 10 years in Ireland, emergency admissions have increased by almost 1,000 per annum from 32,000 in 2005 to 41,500 in 2016 [241]. As of 2016, emergency admissions accounted for approximately one in four of all hospital admissions [241].

'Potentially avoidable' emergency admissions have been deemed indicative of health system performance [20, 62, 271]. These admissions may occur due to an exacerbation from an underlying condition, in which case the admission may have been preventable if the appropriate management of the condition was observed. For example, it has been proposed that the risk of emergency admission due to an exacerbation of asthma may be reduced if the condition is monitored by specialist nurses within the primary care system [62]. An emergency admission may also be considered 'potentially avoidable' if the patient could have been treated more appropriately elsewhere, such as in the patient's home or in a community setting [62, 271]. The designation 'potentially avoidable' refers to a subset of total emergency admissions, and focuses on conditions which are assumed to be sensitive to the quality of primary care management and the availability of alternatives to hospitalisations [62].

To understand the drivers of 'potentially avoidable' emergency admissions, it is important to distinguish between population and health system factors.

At a population level, older demographics [21, 112, 272], socioeconomic deprivation [149, 272, 273] and rurality [79, 273, 274] are major sources of geographical variation in emergency admissions.

At a health system level, continuity of primary care and barriers to accessing primary care [21, 272] including the number of available GPs, have been identified as reasons for regional disparities of emergency admissions within a country [275]. Certain hospital level factors such as the availability of acute beds [276] and ED admission procedures [120] have also been shown to drive geographical variation in 'potentially avoidable' emergency admissions.

EDs practices play an increasing role in admissions for almost all conditions [120]. In Ireland, attendance at an ED can occur as a result of a patient's self-referral, or due to the referral of a GP. In addition to need, the use of such services may be motivated by whether the patient or GP believes viable alternative services exist [277]. Since 2010, a number of EDs have been reconfigured to urgent care centres, which include MAUs and LIUs. There are now 10 such centres in Ireland [278]. These centres provide an alternative to traditional acute services which are required for serious emergency conditions. In 2016, there were 83,354 attendances at LIUs, representing 6% of all emergency presentations [278]. However, this leaves a large majority of emergency presentations still occurring at EDs.

The OECD found that in 2015 Ireland had a high occupancy rate of acute beds; 93.8% in Ireland, compared to an OECD average rate of 84.3% [257]. It argued that this was due to an excess of people seeking care and being treated at a secondary care level [257]. It strongly recommended a focus on reducing avoidable emergency admissions for those cases that could be treated in a primary care setting [257]. Improving primary care services to prevent and manage disease is a key aim of recent government policies and a focus of recent reports [154, 157, 279].

Service use in Ireland, regardless of condition, may also be driven by eligibility for medical card schemes [271]. For example, the GMS card allows the use of the majority of health services free of charge including doctor visits, all in-patient services to public wards in public hospitals and all out-patient services in public hospitals, as well as use of EDs, casualty and out-patient services [104, 105]. Eligibility for this card is based on income thresholds and consideration of an undue burden of the cost of an illness. In 2016, 68% [60, 280] of those over 65 years of age were eligible for this scheme [281]. The Irish Longitudinal Study on Ageing (TILDA) found that among older adults in poor health, those with a medical card were more likely to have a hospital admission, have a GP visit, and an ED attendance than those not covered by the GMS or those with medical insurance [282].

A factor that has not been fully considered in the Irish context is the role of private health insurance. Ireland's public hospital system is financed through a mix of both public and private spending, with roughly 46% of the population in possession of private health insurance [283]. Older adults with private health insurance are more likely to have an overnight stay in a public hospital than those without insurance [284], possibly because it is financially beneficial for public hospitals to keep such patients within the health system for longer. It is suggested that this may also reflect a general lower threshold for a hospital admission for patients with private health insurance [284].

Given the multitude of factors identified by the literature as potentially influencing the level of emergency admissions, this paper aims to explore the population and health system factors that contribute to the county variation in 'potentially avoidable' emergency admission within Ireland. We also investigate whether the drivers of these emergency admissions differ from those that impact total/other emergency admissions.

6.2 Methods

6.2.1 Study area and context

Ireland is a country of 70.2 thousand km^2 on the west of Europe with a population of 4.8 million as of 2016 [60]. The smallest geographical area level at which emergency admissions, population drivers of admission, and health system factors can be studied is county. There are 26 counties, the populations of which range from 1.3 million in Dublin to 32,000 in Leitrim [60].

6.2.2 Admissions data sources

Fourteen conditions derived from consensus work carried out in the UK [52] were included in the definition of 'potentially avoidable' emergency admissions. These conditions include non-specific chest pain, chronic obstructive pulmonary disease (COPD), urinary tract infection, non-specific abdominal pain and falls for those over 74 years of age, see table 6.1 for full list of conditions. A group of 48 clinicians, researchers and health commissioners identified these conditions as being rich in 'potentially avoidable' emergency admissions and such admissions could be reduced by a well performing health system [52, 285]. Similar consultation work was undertaken by a study in Ireland [286] to ensure that these conditions were applicable to the Irish context. Many of these conditions have also been assessed across a number of international studies of ED attendance and hospital admissions [287–289].

Table 6.1: Number of admissions for 14 conditions rich in avoidable admissions, 2014-2016

Conditions	ICD-10	Numbers (%)
Non-specific chest pain	R072-R074	55,333 (21)
Chronic Obstructive Pulmonary Disease (COPD)	J40-J44	41,544 (15)
Urinary tract infection	N390	33,454 (13)
Non-specific abdominal pain	R10	31,974 (12)
Falls over 74 years	W0-W1	27,749 (10)
Cellulitis	L03	17,722 (7)
Acute mental health crisis	F	15,940 (6)
Hypoglycaemia	E10- E15; E161; E162	13,393 (5)
Angina	I20	10,022 (4)
Epileptic fit	G40-G41	9,907 (4)
Deep vein thrombosis	I80-I82	5,649 (2)
Blocked tubes, catheters and feeding tubes	T830	329 (<1)
Minor head injuries	S00	2,410 (<1)
Pyrexial child under 6 years	R50	969 (<1)
Total		**266,395 (100)**

The incidence of emergency admissions for the selected conditions is available from the HIPE admissions system [241]. The county population required to determine admission rates was made available from the CSO 2016 census [60].

6.2.3 A priori factors and data sources

Two principal studies were identified as the most appropriate for considering drivers of 'potentially avoidable' emergency admissions in Ireland, one based in Ireland [271] and one in the UK [62]. *A priori* factors were chosen from these studies and other literature, and adapted for the Irish context, see table 6.2 and **Appendix C** for factor construction.

Population factors relating to age, deprivation and rurality were included. Deprivation at a geographical level may be defined as *"an area's potential for health risk from ecological concentration of poverty, unemployment, economic disinvestment, and social disorganisation"* [73]. For this study, four measures of deprivation were considered: a measure of unemployment [290]; the SILC measure of deprivation [291]; the Pobal HP Deprivation Index [292]; and, the SAHRU Deprivation Index [293]. These are outlined in further detail in **Appendix C**, table C.1.

Also considered were health system factors that related to hospital activity/turnover (the rate of short term lengths of stay for emergency admissions, and conversion rates of emergency presentations to emergency admissions) and a proxy measure for the availability of primary care (the number of GPs per 100,000). The proportion of admissions with a length of stay (LOS) of one day and conversion rates were not included in the same model given the possible tautological association between the two factors.

Two factors related to health care funding were considered, eligibility for the GMS scheme and the percentage of the population with private health insurance in each county, by age group. Both of these factors have been shown to be important drivers of service use in Ireland [284].

Table 6.2: A priori factors considered for inclusion in analysis

Population factors:	
Age	
Age stratification	Six age groups (0-19, 20-44, 45-54, 55-64, 65-74 and 75+). Age stratification was constrained by the age specific level of the other independent factors included.
Deprivation	
Unemployment	2016: Percentage of population unemployed
SILC Deprivation	2014, 2015, 2016: Percentage of population deprived. Based on the Survey of Income and Living Conditions (SILC) deprivation scale regarding ability to buy certain goods and services.
HP Deprivation	2016: Percentage of population with greater than average levels of deprivation. Based on the Pobal HP (HP) deprivation index.
SAHRU Deprivation	2011: Percentage of population living in electoral districts in the lowest quintile of deprivation. Based on the Small Area Research Health Unit (SAHRU) deprivation index.
Geography	
Rurality	2016: Percentage of the population living in rural areas. Areas with a population below 1,500 inhabitants per km^2 are classified as belonging to the Aggregate Rural Area.
Health system factors:	
Hospital	
Conversion rate	2014, 2015, 2016: Conversion rate of all emergency presentations to emergency admissions by hospital, weighted by the probability of a person from each county being admitted to that hospital.
LOS of one day	2014, 2015, 2016: Percentage of all emergency admissions with a length of stay of one day, by county of residence.
Primary Care	
GPs	2011: Number of general practitioners (GPs) per 100,000 population.
Funding of health care	
GMS	2014, 2015, 2016: Percentage of the population eligible for the general medical services (GMS) card.
Private health insurance	2015: Percentage of the population with private health insurance.

6.2.4 Level of data availability

The explanatory factors used in this analysis were available from administrative sources and the majority of the data was available at a county level. SILC deprivation [294] was only available at a larger geographical regional level. The larger regional rates were attributed to each of the counties nested within the areas.

HP Deprivation Index [292], SAHRU Deprivation Index [293], and GMS eligibility [295] were available at a sub-county level. These factors were weighted by their respective smaller area population and summed to construct the factor at a county level.

Each of the following factors: unemployment [290]; LOS of one day [241]; GMS [295]; and private health insurance [283, 296], was available at an age-specific county level.

All hospital admissions and hospital based factors were reported by the county of residence of the patient. The details of patient's length of stay following admission were available by county of residence from HIPE [241]. However, the conversion rate of all emergency presentations to emergency admissions at a county level was constructed by weighting the ratio of emergency admissions to emergency presentations for each hospital by the probability of a patient from each county being admitted to that hospital.

6.2.5 Statistical analysis

6.2.5.1 Avoidable admission rates

The age-specific admissions for a three-year period 2014-2016 were calculated for the 26 counties, using six age groups (0-19, 20-44, 45-54, 55-64, 65-74, 75+). Age stratification was constrained by the age-specific level of the other independent factors included. The rates were directly standardised to the national population's age distribution in 2016.

6.2.5.2 Model selection - negative binomial regression

Initial goodness-of-fit tests indicated significant extra-Poisson variation or over dispersion. Therefore, mean adjusted negative binomial regression models, in which over dispersion is modelled as the impact of unmeasured confounders, were fitted. The yearly, age-specific admissions by county for the 14 selected conditions was set as the dependent variable. Analysis was clustered by county to allow for intra-group correlation.

Three multivariable models were run: an age-adjusted model (M1); a model with all population level factors (M2); and finally, a full model that included included age, population level and health system factors (M3). The Pearson chi-square (χ^2) measure of model fit was assessed, with χ^2 values close to 1 deemed to be the better fit. The results from each negative binomial model, M1, M2 and M3, were used to predict the number of 'potentially avoidable' emergency admissions in each county. The observed number of admissions were compared to that expected based on each model. The degree of over-dispersion remaining after each model was also measured by calculating the absolute difference between observed and expected admissions for each model and graphed using lowess smoothing.

Additional analysis considered other emergency admissions, defined as total emergency admissions minus the selected 14 conditions, and total emergency admissions. To assess the sensitivity of the results, the analysis was repeated with each of the top five 'potentially avoidable' emergency admission conditions alternatively excluded. Finally, to identify factors associated with the ratio of 'potentially avoidable' to total emergency admissions, a negative binomial model with 'potentially avoidable' emergency admissions as the outcome and total emergency admissions equal to the population was fitted.

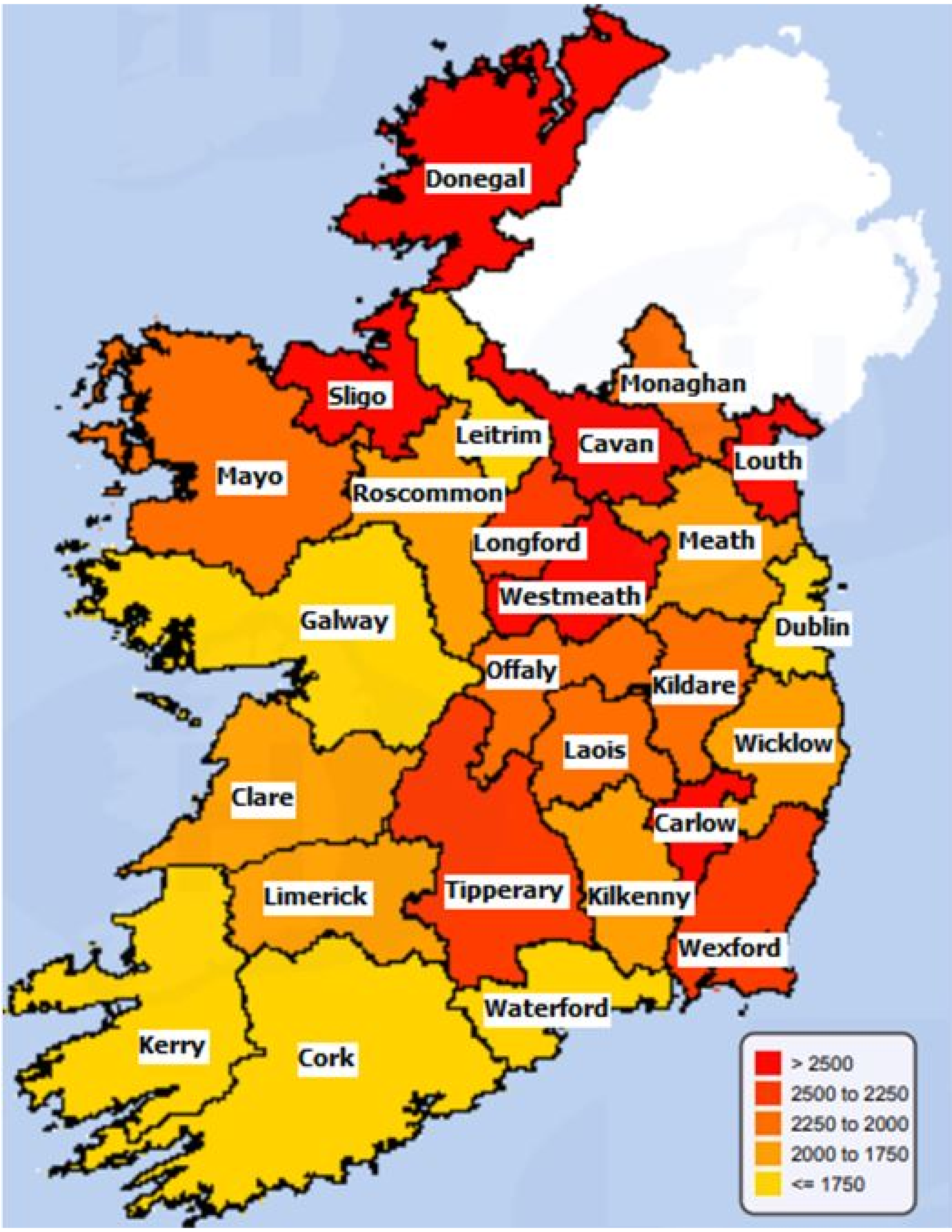
Results were presented as the IRR and 95% confidence intervals. The quoted IRR represents the incidence rate ratio associated with a one standard deviation change in the risk factor. This allows for different units across the independent factors, making the IRRs comparable. Statistical significance was defined as $p < 0.05$.

6.3 Results

6.3.1 Avoidable admissions rates

There were 266,395 emergency admissions for the selected 14 conditions in 2014-2016 [241]. They accounted for 22% of total emergency admissions over the 3 year period [241]. The age-adjusted admission rates for the combined 14 conditions were found to vary across counties over the period of 2014-2016. Six of the 26 counties had age-adjusted rates greater than 2,500 per 100,000 population. Six had age-adjusted rates below 1,750 per 100,000 population, including counties with the largest urban centres, Dublin, Cork and Galway, see figure 6.1.

FIGURE 6.1: Age-adjusted 'potentially avoidable' emergency admission rates per 100,000, 2014-2016



6.3.2 Analysis and selection of factors for inclusion in the model

The age-adjusted analyses of individual factors revealed each of the following to be significant: each measure of deprivation, LOS of one day, GMS and private health insurance coverage, see table 6.3 and table 6.4 for results. Due to the previously outlined concerns regarding the conversion rate and LOS of one day, and based on the univariate analysis, conversion rate was not included in the full model. Of the four measures of deprivation, unemployment and HP Deprivation Index were found to have the lowest, and very similar, AIC values (11.29 and 11.27). Unemployment was included as it most closely matched that of the UK study [62]. Tests indicated low levels of multicollinearity (VIF = 3.71 for GMS, VIF = 3.09 for LOS and VIF=1.66 for unemployment).

Table 6.3: Standardised age-adjusted negative binomial univariate analysis – significant factors

Factor name	Factor	IRR (95% CI)	*P*
Unemployment	Percentage of population unemployed	1.50 (1.26-1.78)	<0.001
SILC Deprivation	Percentage of population deprived regarding ability to buy goods and services	1.05 (1.01-1.10)	0.02
HP Deprivation	Percentage of population with greater than average levels of deprivation	1.13 (1.08-1.18)	<0.001
SAHRU Deprivation	Percentage of population living in electoral districts in the lowest quintile of deprivation	0.91 (0.86-0.97)	0.002
LOS of one day	Percentage of emergency admissions with length of stay equal to one	1.19 (1.08, 1.30)	<0.001
GMS	Percentage of the population eligible for the GMS card	1.40 (1.13, 1.74)	0.002
Private Health Insurance	Percentage of population with private health insurance	0.902 (0.87, 0.93)	<0.001

6.3.3 'Potentially avoidable' emergency admissions

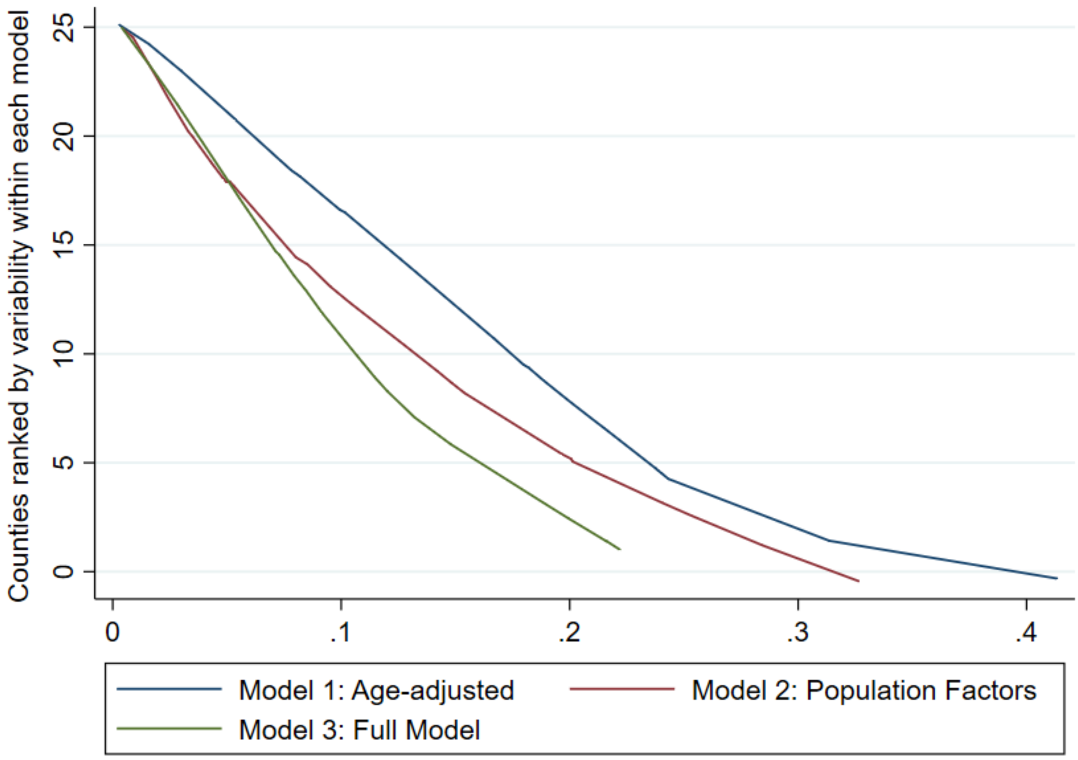
The results for each of the three models (M1, M2, M3) are given in table 6.4. The full model (M3) found unemployment, LOS of one day and private health insurance were significant. Higher levels of unemployment were associated with a greater level of 'potentially avoidable' emergency admissions (IRR 1.24; 95% CI 1.04, 1.41). Those counties whose patients had a high percentage of short stays following an emergency admission were also more likely to see higher 'potentially avoidable' emergency admissions (IRR 1.20; 95% CI 1.11, 1.30). Higher levels of private insurance, were associated with lower rates of 'potentially avoidable' emergency admissions (IRR 0.92; 95% CI 0.89, 0.96).

TABLE 6.4: Negative binomial regression results for models 1-3, (n=468, 26 counties, 6 age groups, 3 years)

Factor (standardised)	Model 1 (M1)/univariate: Pearson χ^2 = 1.039 α= 0.05		Model 2 (M2): Pearson χ^2 = 1.005 α = 0.04		Model 3 (M3): Pearson χ^2 = 1.029 α = 0.027	
	IRR (95% CI)	*P*	IRR (95% CI)	*P*	IRR (95% CI)	*P*
Age 1 (0-19)	1.00	<0.001	<0.001	<0.001	<0.001	<0.001
Age 2 (20-44)	1.35 (1.23, 1.48)		0.52 (0.31, 0.89)		0.86 (0.54, 1.37)	
Age 3 (45-54)	2.10 (1.89, 2.33)		1.11 (0.77, 1.62)		1.79 (1.31, 2.45)	
Age 4 (55-64)	3.03 (2.78, 3.30)		1.33 (0.83, 2.14)		2.63 (1.78, 3.87)	
Age 5 (65-74)	5.22 (4.79, 5.69)		3.98 (3.27, 4.84)		5.26 (4.07, 6.79)	
Age 6 (75+)	15.21 (13.94, 16.59)		15.22 (13.95, 16.59)		14.79 (7.94, 27.54)	
Percentage of population unemployed	1.50 (1.26, 1.78)	<0.001	1.47 (1.20, 1.81)	0.003	1.24 (1.04, 1.41)	0.018
Percentage of the population living in rural areas	1.04 (0.96, 1.12)	0.348	1.02 (0.95, 1.09)	0.597	0.97 (0.91, 1.03)	0.295
Conversion rate of emergency department presentations to admissions	0.98 (0.93, 1.04)	0.471				
Percentage of emergency admissions with length of stay equal to one	1.19 (1.08, 1.30)	<0.001			1.20 (1.11, 1.30)	<0.001
Number of GPs per 100,000	0.97 (0.91, 1.04)	0.430			1.01 (0.96, 1.05)	0.801
Percentage of the population eligible for the GMS card	1.40 (1.13, 1.74)	0.002			1.24 (0.98, 1.57)	0.07
Percentage of population with private health insurance	0.902 (0.87, 0.93)	<0.001			0.92 (0.89, 0.96)	<0.001

The degree of over-dispersion fell from $\alpha = 0.05$ following age-adjustment to $\alpha = 0.04$ after adjusting for the population level factors of unemployment and rurality. This represents a decrease of 20%. This fell by a further 30%, to $\alpha = 0.027$, having allowed for health system factors, see table 6.4. The inclusion of all factors, population level and health system level reduced the absolute difference between the observed and expected admissions by approximately 50%, see figure 6.2.

FIGURE 6.2: Absolute differences between observed and expected 'potentially avoidable' admissions across all three models



The proportional difference between the observed and expected admissions are given in figure 6.2. This figure is a cumulative distribution function graph which ranks counties within each model, M1 to M3, by degree of variability after the inclusion of factors. The county with the greatest degree of variability within each model is represented by 0 on the y-axis, while county 25 represents the county with the lowest variability in each model. The figure indicates that M3, the full model, results in the lowest degree of variability when compared to the other two models.

For model M1, the values range from 40% above for Carlow and 30% below for Kerry, with 10 of the 26 counties within 10% of a difference. The number of counties within 10% increases to 62% (16 of the 26 counties) based on model M3. The range also decreases to 20% below for Kerry and 20% above for Sligo, see 6.3. An analysis of total emergency admissions and other emergency admissions, defined as total emergency admissions minus the selected 14 conditions, revealed that for most factors the effect size was similar whether looking at ‘potentially avoidable’, total, or other emergency admissions, see table 6.5. The results for the selected 14 conditions combined were not sensitive to the exclusion of individual conditions, see table 6.6.

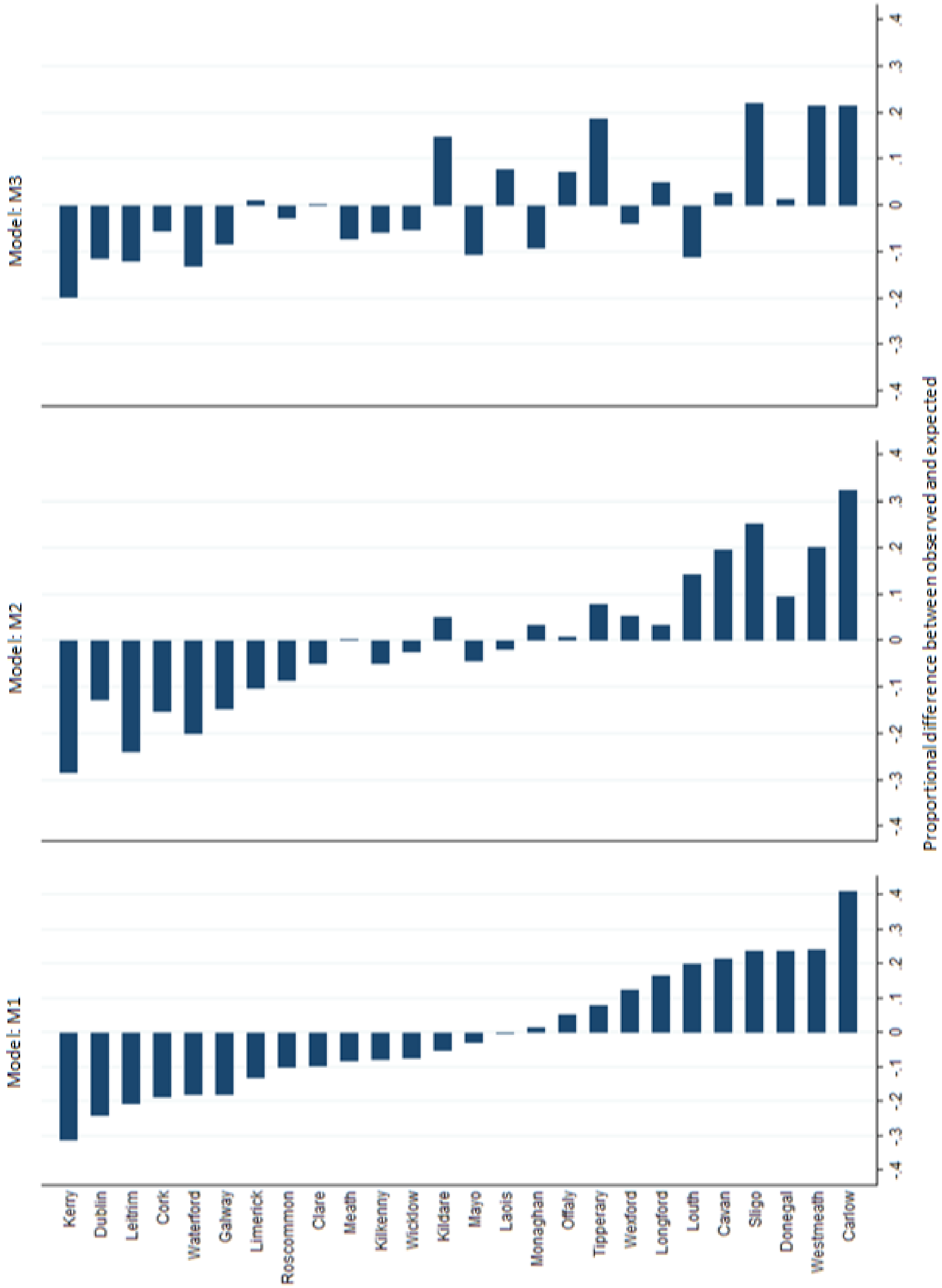


Figure 6.3: Proportional difference between observed and expected ‘potentially avoidable’ emergency admissions

TABLE 6.5: Negative binomial regression results for other emergency admissions and total emergency admissions, (n=468, 26 counties, 6 age groups, 3 years)

Factor (standardised)	Other Emergency Admissions: Univariate results Pearson χ^2 = 1.04 α=0.04		Other Emergency Admissions: Model 3 (M3) Pearson χ^2 = 1.05 α = 0.02		Total Emergency Admissions: Univariate results Pearson χ^2 = 1.04 α=0.04		Total Emergency Admissions: Model 3 (M3) Pearson χ^2 = 1.04 α = 0.02	
	IRR (95% CI)	*P*	IRR (95% CI)	*P*	IRR (95% CI)	*P*	IRR (95% CI)	*P*
Age 1 (0-19)	1.00	<0.001	1.00	<0.001	1.00	<0.001	1.00	<0.001
Age 2 (20-44)	0.78 (0.72, 0.85)		0.66 (0.49, 0.90)		0.86 (0.79, 0.93)		0.68 (0.50, 0.93)	
Age 3 (45-54)	1.01 (0.93, 1.10)		1.05 (0.84, 1.31)		1.15 (1.05, 1.26)		1.15 (0.92, 1.44)	
Age 4 (55-64)	1.52 (1.39, 1.65)		1.71 (1.27, 2.28)		1.71 (1.57, 1.86)		1.83 (1.37, 2.46)	
Age 5 (65-74)	2.67 (2.45, 2.90)		3.13 (2.61, 3.76)		2.99 (2.76, 3.25)		3.42 (2.81, 4.16)	
Age 6 (75+)	5.46 (5.00, 5.95)		6.19 (4.36, 8.80)		6.70 (6.16, 7.30)		7.37 (4.92, 11.09)	
Percentage of population unemployed	1.33 (1.16, 1.53)	<0.001	1.12 (0.98, 1.27)	0.093	1.37 (1.19, 1.57)	<0.001	1.14 (0.99, 1.31)	0.052
Percentage of the population living in rural areas	1.06 (0.99, 1.13)	0.088	1.00 (0.96, 1.04)	0.856	1.05 (0.98, 1.13)	0.139	1.00 (0.95, 1.04)	0.824
Percentage of emergency admissions with length of stay equal to one	1.19 (1.10, 1.28)	<0.001	1.19 (1.14, 1.26)	<0.001	1.19 (1.10, 1.28)	<0.001	1.20 (1.13, 1.26)	<0.001
Number of GPs per 100,000	0.98 (0.93, 1.04)	0.578	1.02 (0.98, 1.06)	0.358	0.98 (0.93, 1.04)	0.534	1.02 (0.98, 1.06)	0.435
Percentage of the population eligible for the GMS card	1.33 (1.09, 1.61)	0.004	1.17 (1.01, 1.34)	0.035	1.34 (1.10, 1.63)	0.003	1.18 (1.00, 1.38)	0.042
Percentage of population with private health insurance	0.912 (0.88, 0.94)	<0.001	0.93 (0.89, 0.97)	<0.001	0.91 (0.88, 0.94)	<0.001	0.93 (0.89, 0.96)	<0.001

TABLE 6.6: Sensitivity analysis of negative binomial regression results full model by individual condition (share greater than 10%) (n=468, 26 counties, 6 age groups, 3 years)

Factor (standardised)	Outcome: Admissions minus Non Specific Chest Pain (21%) Exposure: Population		Outcome: Admissions minus COPD (15%) Exposure: Population		Outcome: Admissions minus UTI (13%) Exposure: Population	
	IRR (95% CI)	*P*	IRR (95% CI)	*P*	IRR (95% CI)	*P*
Age 1 (0-19)	1.00	<0.001	1.00	<0.001	1.00	<0.001
Age 2 (20-44)	0.62 (0.42, 0.91)		0.84 (0.53, 1.34)		1.03 (0.64, 1.66)	
Age 3 (45-54)	1.08 (0.82, 1.42)		1.67 (1.22, 2.27)		2.15 (1.55, 3.00)	
Age 4 (55-64)	1.77 (1.25, 2.50)		2.17 (1.47, 3.19)		3.09 (2.05, 4.65)	
Age 5 (65-74)	3.96 (3.02, 5.20)		3.72 (2.90, 4.76)		5.58 (4.29, 7.27)	
Age 6 (75+)	12.30 (6.83, 22.14)		12.59 (6.98, 22.71)		13.63 (7.20, 25.82)	
Percentage of population unemployed	1.24 (1.08, 1.43)	0.003	1.24 (1.04, 1.48)	0.019	1.22 (1.02, 1.47)	0.029
Percentage of the population living in rural areas	0.99 (0.94, 1.04)	0.579	0.97 (0.91, 1.02)	0.317	0.96 (0.90, 1.03)	0.236
Percentage of emergency admissions with length of stay equal to one	1.15 (1.08, 1.23)	<0.001	1.21 (1.13, 1.31)	<0.001	1.21 (1.11, 1.31)	<0.001
Number of GPs per 100,000	1.02 (0.97, 1.08)	0.406	1.01 (0.96, 1.05)	0.779	1.01 (0.96, 1.05)	0.763
Percentage of the population eligible for the GMS card	1.25 (1.00, 1.55)	0.049	1.22 (0.98, 1.52)	0.052	1.29 (1.01, 1.66)	0.04
Percentage of population with private health insurance	0.91 (0.87, 0.95)	<0.001	0.92 (0.88, 0.96)	<0.001	0.93 (0.89, 0.97)	<0.001

Factor (standardised)	**Outcome: Admissions minus Non Specific Abdominal Pain (12%) Exposure: Population**		**Outcome: Admissions minus Falls over 74 Exposure: Population**	
	IRR (95% CI)	***P***	**IRR (95% CI)**	***P***
Age 1 (0-19)	1.00	<0.001	1.00	<0.001
Age 2 (20-44)	0.93 (0.60, 1.46)		0.87 (0.54, 1.40)	
Age 3 (45-54)	2.41 (1.80, 3.25)		1.80 (1.30, 2.48)	
Age 4 (55-64)	3.81 (2.64, 5.50)		2.64 (1.78, 3.93)	
Age 5 (65-74)	9.01 (7.29, 11.13)		5.26 (3.98, 6.95)	
Age 6 (75+)	30.75 (17.73, 53.34)		10.21 (5.10, 20.43)	
Percentage of population unemployed	1.26 (1.05, 1.50)	0.012	1.23 (1.03, 1.47)	0.023
Percentage of the population living in rural areas	0.96 (0.91, 1.02)	0.154	0.97 (0.92, 1.03]	0.384
Percentage of emergency admissions with length of stay equal to one	1.24 (1.15, 1.34)	<0.001	1.20 (1.11, 1.29)	<0.001
Number of GPs per 100,000	0.99 (0.95, 1.03)	0.545	1.00 (0.96, 1.05)	0.979
Percentage of the population eligible for the GMS card	1.14 (0.93, 1.40)	0.219	1.24 (0.96, 1.61)	0.098
Percentage of population with private health insurance	0.93 (0.89, 0.96)	<0.001	0.92 (0.88, 0.96)	<0.001

For both total and other emergency admissions, 25% of the over-dispersion was explained by population factors. An $\alpha = 0.04$ following age-adjustment fell to $\alpha = 0.03$ after adjusting for the population level factors of unemployment and rurality. The inclusion of both population and health system factors reduced the unexplained variation by a total of 50%, $\alpha = 0.02$, see table 6.5. This reduction was similar to that found by the models run for 'potentially avoidable' emergency admissions, see table 6.4.

Analysis of the ratio of 'potentially avoidable' emergency admissions to total emergency admissions identified age, unemployment and rurality as significant factors, see table 6.7. As expected the ratio of 'potentially avoidable' emergency admissions to total emergency admissions increased with age. Although rurality was not associated with either 'potentially avoidable' or other emergency admissions, it was associated with the proportion of 'potentially avoidable' emergency admissions among total emergency admissions.

TABLE 6.7: Negative binomial regression results with total emergency admissions as exposure (n=468, 26 counties, 6 age-groups, 3 years)

Factor (standardised)	**Outcome: Potentially avoidable emergency admissions** **Exposure: Total emergency admissions**	
	IRR (95% CI)	***P***
Age 1 (0-19)	1.00	<0.001
Age 2 (20-44)	1.34 (1.14, 1.57)	
Age 3 (45-54)	1.64 (1.46, 1.85)	
Age 4 (55-64)	1.55 (1.32, 1.81)	
Age 5 (65-74)	1.58 (1.39, 1.80)	
Age 6 (75+)	2.01 (1.56, 2.60)	
Percentage of population unemployed	1.08 (1.01, 1.15)	0.027
Percentage of the population living in rural areas	0.97 (0.95, 0.99)	0.006
Percentage of emergency admissions with length of stay equal to one	1.00 (0.97, 1.04)	0.990
Number of GPs per 100,000	0.99 (0.96, 1.16)	0.276
Percentage of the population eligible for the GMS card	1.05 (0.96, 1.16)	0.282
Percentage of population with private health insurance	0.99 (0.98, 1.01)	0.359

6.4 Discussion

6.4.1 Summary of findings

This study found that variation exists in 'potentially avoidable' emergency admission rates between counties in Ireland. The model, which included population and health system factors, identified unemployment, a hospital LOS of one day and the rate of private health insurance as being significantly associated with 'potentially avoidable' emergency admissions. The full model accounted for almost 50% of the degree of unexplained variation in emergency admissions in each county. The results also suggest that the identified associations apply equally to 'potentially avoidable' and total/other emergency admissions.

6.4.2 Interpretation

6.4.2.1 Deprivation

Deprivation has previously been identified as a significant contributing factor to variation in standardised illness ratios [79] and hospital admission rates [62, 271, 297]. In the UK study, employment deprivation was found to account for 72% of the variation in 'potentially avoidable' emergency admissions [62].

Attendance at EDs is also higher among deprived populations [298]. Higher levels of unemployment can be associated with higher rates of ill health [299]. Therefore, it is more likely that those counties with high unemployment will experience high emergency admissions for the 14 selected conditions [300]. As it currently stands, those who are unemployed and with low incomes may be supported in accessing health services through the GMS card scheme, thereby reducing the negative impact of deprivation [271]. However, other aspects of health may suffer such as quality of diet, levels of physical activity, etc. [301]. The result of these changes may have long-term consequences on health, particularly with regard to chronic conditions [302], and health service use [62].

Addressing health inequalities, and reducing the impact of the inverse care law [303], i.e. the tendency for medical care to be available to those in the population that need it the least, has been a significant theme of recent government policy documents [154, 157, 279]. These policy documents acknowledge the need to tackle the broader determinants of health, including increased education, which may help to increase job opportunities in deprived areas, and promote the early identification of disease and secondary prevention of complications.

Our findings underline the importance of risk adjustment for differences in deprivation levels when comparing health system performances at a geographical level. Ireland, in common with many countries covered by the OECD, uses region-level hospitalisation rates for a select group of chronic conditions (asthma, diabetes, COPD and heart failure) to detect variation in the quality of primary care [47–50]. These comparisons are age-sex standardised but do not adjust for county level variation in deprivation. Our findings suggest that these un-adjusted comparisons may reveal little about primary care performance, particularly for conditions such as COPD where most hospitalisations occur on an emergency basis [304].

6.4.2.2 Short term length of hospital stay

Short stay emergency admissions were associated with a higher rate of emergency admissions for both 'potentially avoidable' and total/other emergency admissions, which may point to limited capacity to cater for longer lengths of stay [276], resulting in a revolving door readmission pattern [305]. It may also reflect the hospital policy or the availability of more senior emergency doctors or consultants [306]. For example, smaller hospitals tend to have more junior staff and a culture of admitting patients overnight for observation may exist [286, 307]. It could also be argued that short LOS may be a consequence, rather than a cause, of a high volume of 'potentially avoidable' emergency admissions, perhaps driven by the need to meet certain waiting time targets for emergency presentations [308].

The availability of clear frameworks and local protocols for the management of patients with the selected 14 conditions could help to reduce the impact of this factor. Ideally, each ED should have frameworks/ protocols based on national guidelines and staff should be familiar with these documents and how to implement them. Further analysis of this finding is required to understand whether a consistent inference can be applied. Therefore, this result should be interpreted with caution.

6.4.2.3 Private health insurance

This study's analysis shows private health insurance is associated with lower 'potentially avoidable' emergency admissions and total/other emergency admissions to public hospitals. This may reflect the engagement with other services such as outpatient services, GP visits or admissions to private hospitals or better access to care. The Irish Longitudinal Study on Ageing (TILDA) reports that there is *"suggestive evidence that insured people are likely to use slightly more outpatient services"* [284]. In addition, the study found that those with private health insurance are more likely to have a GP visit and to have an overnight stay in hospital. It is suggested that this may reflect lower thresholds for hospital admissions for patients using private services [284]. While a longer length of stay once admitted may be more likely for private patients, it has been found that there is equity of access among public and private patients with regard to emergency services [99]. A study of the characteristics of ED admissions at four Irish hospitals found that *"privately insured patients and individuals with no additional cover are significantly less likely to be admitted relative to medical card holders"* [309]. This report also found that unemployed individuals and GMS medical card holders were both more likely to be admitted and that this may be in line with assumptions of higher deprivation and poorer health among this group [309].

6.4.3 Strengths and limitations

A strength of this study is the investigation of both population and health system factors as drivers of 'potentially avoidable' emergency admissions, extending the traditional methods used by previous studies [62, 271]. In addition to a previous Irish study, which focused on primary care resources and deprivation [271], this study widens the number of potential drivers to include hospital factors and the role of private health insurance. Although 'potentially avoidable' emergency admissions were the initial focus of this study, the associations with total emergency admissions were also examined. This allowed the identification of factors associated with total emergency admissions, while also highlighting those factors that have a differential effect on 'potentially avoidable' and other emergency admissions. The robustness of results to the inclusion of particular conditions in the definition of 'potentially avoidable' emergency admissions was also considered.

There are a number of limitations to this study. Firstly, this study is an ecological study and therefore may be subject to ecological fallacy, i.e. the assumption that county level associations apply at an individual level.

Data was collected from administrative sources. As the majority of this data was only available at a county level, the ability to capture all existing variability within a large geographical level is limited. It is possible that small area associations between variables such as primary care resources and emergency admissions may not be detected when data is aggregated to county level. For example, the study results suggest that higher rates of unemployment at a county level are associated with higher 'potentially avoidable' emergency admissions. Although smaller area deprivation details are available, the study was limited by the fact that there are only 26 counties and data on many of the predictor variables, such as primary care resources, is unavailable at a smaller level than county, or at an age-specific level.

A further limitation of the study is our inability to directly measure quality of care factors at primary and secondary level, factors that might be expected to drive emergency admission rates. This information is not available at present in Ireland and we have had to rely on proxy variables instead.

Emergency admissions to private hospitals were not included in this analysis as private hospitals are not required to submit data to HIPE. Therefore, results for counties with a high level of private hospital usage may be higher than reported here.

The prevalence rates of each individual of the 14 conditions are also not available at a county level. This data would further the understanding of causal mechanisms in the pattern of emergency admissions.

The ability to assess appropriateness of service use based on final diagnosis also has its limitations. The diagnosis of patients may lead to the conclusion that the hospital was an inappropriate setting to receive care. However, that determination may only be possible in hindsight; investigations and tests may have been necessary to exclude a more serious diagnosis [310].

6.4.4 Policy implications

Previous research in Ireland has highlighted deprivation and primary care provision (GP supply and general medical services coverage) as important factors in partially explaining the variation of emergency admissions [271, 297]. In Ireland [157, 279] and elsewhere [311], GPs and primary care are increasingly expected to relieve hospitals of patient care [312]. As more pressures are placed on GPs, the risk of growing inequality of access is also a concern, particularly among more vulnerable and disadvantaged patients [312]. The level of resources available to primary care has a significant role in ensuring quality where such services are most needed [313, 314]. Therefore, as Ireland continues to move towards providing care at the safest, lowest level of complexity, a consistent and agreed upon measure of monitoring quality in primary care is necessary [157]. An information system for primary care services in Ireland, similar to the hospital system of HIPE [241], may help support this monitoring. Our findings suggest that unless this data is available, it will not be possible to determine how large a role primary care quality has in light of our findings regarding the impact of deprivation and hospital policy.

Continued investment in the management of chronic conditions should also be considered. There is also a good evidence base on management approaches that minimise the risk of admission for specific conditions. A recent Cochrane review found that self-management interventions for COPD that include an exacerbation plan are associated with a lower probability of a respiratory-related hospital admission [315]. Of the 'potentially avoidable' conditions included in this study, COPD had the second highest share of emergency admissions at 15%. However, if other services in the wider care system were available such as a 'hospital at home' [316] or 'care outreach' model [168] which can respond to the patients need, it may be possible to avoid such admissions [62, 317].

At a county level, our findings show that the emergency admissions we designated as 'potentially avoidable' seem to be driven by the same factors as total emergency admissions, and are influenced strongly by regional deprivation and hospital level policies. This implies that the main drivers of regional variation in emergency admission rates may not be at the primary care level, although this finding is tentative as we have not directly measured primary care quality and have used resource levels as a proxy. These findings have two important policy implications. First, the 'potentially avoidable' designation may not be as useful as previously believed when attempting to identify the causes of regional variation in emergency admission rates. Secondly, 'potentially avoidable' emergency admission rates may not be a useful quality indicator for regional (e.g. county level) primary care systems [308].

This study has also revealed the need to consider the role that hospital factors have to play in the patterns of total emergency admissions, specifically the role of short term lengths of stay. Continued monitoring of hospitals which experience a high number of short term lengths of stay should be studied closer to determine the causes for these patterns. As previously suggested, the availability of clear frameworks and local protocols for the management of patients with the selected 14 conditions could help to reduce the impact of this factor.

6.4.5 Conclusion

'Potentially avoidable' emergency admission rates have been proposed as a method to detect variation in the performance of regional health systems, particularly the primary care services that manage conditions where the risk of exacerbation related hospital admission is high [318].

However, this study shows that at a regional level much of the variability in emergency admission rates can be explained by socioeconomic deprivation, hospital policies and private insurance coverage. While deprivation may be associated with lower resources for primary care (a manifestation of the inverse care law), it is likely that much of the variation in county level 'potentially avoidable' emergency admissions does not relate to the quality of primary care. At present, the relevant data does not exist to categorically confirm the role that the quality of primary care plays in reducing 'potentially avoidable' emergency admissions. This study does show that reductions across all emergency admissions, including 'potentially avoidable' emergency admissions, may be achieved by targeting deprived regional populations, the drivers of short term lengths of stay and the way in which patients with private health insurance are managed.

Chapter 7

Case-fatality ratios for serious emergency conditions in Ireland: a longitudinal investigation of trends over the period 2002-2014 using joinpoint analysis

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Keywords: Reconfiguration, emergency care, health systems, regional variations

Background

In the past decade, the Republic of Ireland has undertaken significant reconfiguration programmes to improve emergency services. During this time the public health system experienced a large real decrease in resources. This study assesses national and regional population outcomes over the period 2002-2014, and whether changes coincide with system reconfiguration and the financial restrictions imposed by the 2008 recession.

Methods

CFRs were constructed for emergency conditions for 2002-2014. Total emergency conditions and individual condition trends were analysed nationally using joinpoint analysis. National results informed the investigation of trends at a regional and county level using an inverse standard error weighted generalised linear model with a log link to construct funnel plots. County-level CFRs were compared for the first and last three years of the period to further investigate the changes to county results over the 13 year period, specifically in comparison to the national level CFR.

Results

Nationally, there was an annual fall in CFRs (2.1%). The decline was faster from 2002-2007 (annual percentage change = -3.4; 95% CI -4.4, -2.4), compared to 2007-2014 (annual percentage change = -1.2; 95% CI -1.9, -0.5). The South-East had a lower rate of decrease and the West had a higher rate. Cross sectional analysis of two periods (2002-2004 and 2012-2014) showed high consistency in the counties performance relative to the national CFR in both periods.

Conclusion

Change in the national trend coincided with the onset of economic stress on the public health system. Attributing the decline in CFR improvement to economic factors is weakened by the uneven nature of the trend change. No distinct pattern of change was identified among regions which underwent substantial reconfiguration of emergency services.

7.1 Background

Conditions requiring emergency medical treatment are significant contributors to global mortality. Ischaemic heart disease, including myocardial infarction, accounted for almost 16% of total deaths in 2015 (8.9 million deaths) [1]. Ischaemic and haemorrhagic stroke were the second largest cause of total deaths at 11.3% (6.3 million deaths) [1]. A further 8.5% of total deaths (4.7 million deaths) were due to external injuries [1].

Outcomes from serious emergency conditions in Ireland are broadly similar to other OECD countries. Analysis of hospital mortality in Ireland found significant reductions in deaths from AMI, heart failure and ischaemic stroke between 2005 and 2015 [319]. The most recent 2011 analysis by the OECD found in-hospital mortality for ischaemic stroke in Ireland (9.9 deaths per 100 admissions) was higher than the OECD average of 8.5, but was lower than the OECD average (7.9) for myocardial infarction (at 6.8 deaths per 100 admissions) [172]. In Ireland, no previous research of total case fatality for serious emergency conditions has included patients who die outside of hospital. Also, no research has been performed on outcomes for residents of different geographical regions; the focus continues to be on hospital level outcomes [47–49].

Similar to other countries, emergency care services have been centralised to varying degrees across Ireland in the last decade [8, 16–18]. Common features include reducing access to EDs in smaller hospitals, centralising specialist emergency care at a 'hub' hospital, and integrating ambulance and general practice referral protocols for given conditions. These changes coincided with the establishment of many similar international best practice recommendations, clinical programmes and guidelines for the treatment of emergency conditions including stroke, AMI and trauma [132, 320–322].

Centralising emergency care services has proven controversial. While patients are theoretically transported directly to services appropriate to the severity of their condition, longer journey times exacerbate underlying risks associated with rural areas [87]. International studies highlight the geographical variation in survival from emergency conditions; there is a greater risk of poorer outcomes due to distance from acute services and the existence of an older more socioeconomically disadvantaged population in rural areas [144–146]. The interactions between rurality and deprivation contribute to the complexity of understanding any variation in total mortality [85]. However, the majority of studies consistently emphasis the impact of hospital closures on in-hospital mortality. The continued focus on this outcome may conceal potential increases to out-of-hospital deaths caused by increased travel times.

In Ireland, the changes to services brought about by reconfiguration have not happened in isolation. From 2008, the country experienced an economic recession which resulted in substantial decreases in funding and staff across the public health service. It is estimated that public funding for healthcare was reduced by 22% over the period 2009-2013 and staffing of public services fell by 10% from a peak level in 2007 [32].

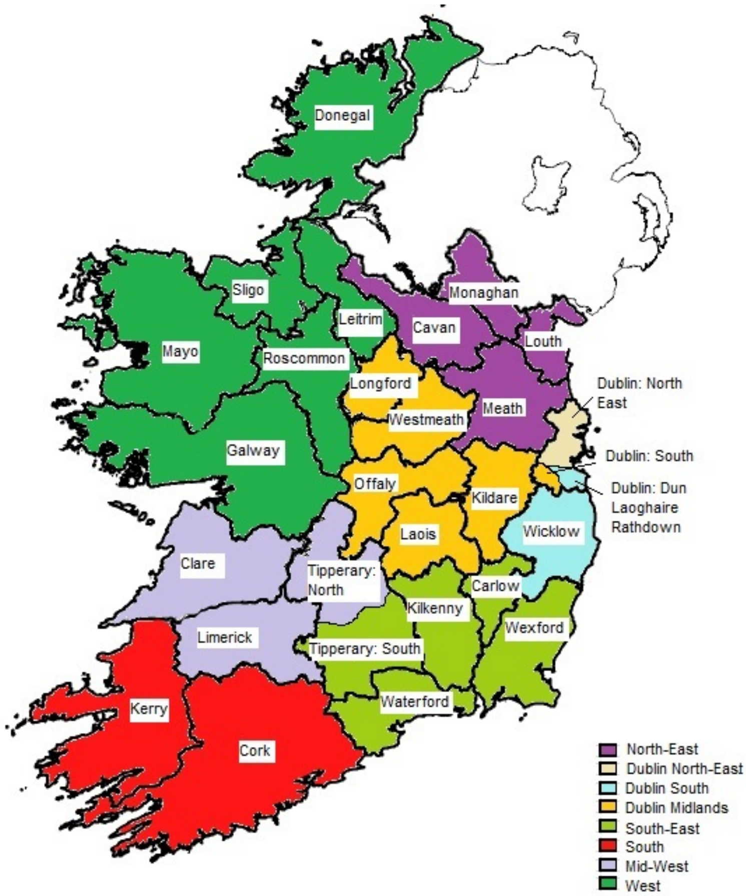
Within this paper, case fatality for a number of serious emergency conditions in Ireland over the period 2002-2014 is investigated at a national, regional and county level. The aim is to describe trends in case fatality and establish if, and how, any changes coincide with reconfiguration events and the timing of the economic recession.

7.2 Methods

7.2.1 Study area and context

The Republic of Ireland is a country of 70.2 thousand km^2 on the west of Europe with a population of 4.5 million [323]. It is divided into 26 counties, which for the analysis of emergency care reconfiguration may be grouped into eight regions based on hospital networks identified by the organisation that delivers public health services in Ireland, see figure 7.1 [94].

FIGURE 7.1: Ireland: Regions and counties



Regional characteristics and reconfiguration of services are presented in table 7.1, as previously outlined in **Chapter 3**. Two regions (South and Mid-West) have implemented significant reconfiguration of urgent and emergency care over the period 2012 to 2014. Four regions (West, North-East, South-East and Dublin-South) have introduced some reconfiguration measures since 2006, but these do not cover all services. The two remaining regions (Dublin Midlands and Dublin North-East) have undertaken no major changes since 2006. EDs were eliminated in four largely rural counties: Clare (2009), Tipperary North (2009), Roscommon (2011) and Monaghan (2009). Four other rural counties did not have an ED throughout the study period: Leitrim, Wicklow, Carlow and Longford.

TABLE 7.1: Regional characteristics and summary of reconfiguration undertaken in the Republic of Ireland

Significant Reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
South (Cork and Kerry)	Population: 663,176 Area (km^2): 12,161	**Regional Reconfiguration** • Region-specific reconfiguration plan largely implemented, beginning 2012-2013. • Region-wide clinical governance structures established. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • Acute stroke, coronary and major trauma care provided at hub in Cork [Cork University Hospital] with support of ambulance protocols and outlying centres [Kerry: University Hospital Kerry; Cork: Bantry General Hospital]. • Two EDs reconfigured to LIUs [Cork: Mallow General Hospital (2013) and Bantry General Hospital (2013)]. • One ED closed [Cork: South Infirmary Hospital (2012)].
Mid-West (Limerick, Clare and Tipperary North)	Population: 378,210 Area (km^2): 8,252	**Regional Reconfiguration** • Region-specific reconfiguration plan largely implemented, 2009 – 2013. • Ambulance bypass protocols and region-wide clinical directorates established. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • All emergency care centralised to one hospital [Limerick: University Hospital Limerick] • Two EDs reconfigured to LIUs [Clare: Ennis Hospital (2009); Tipperary North: Nenagh Hospital (2009)]
Some Reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
West (Galway, Roscommon, Mayo, Leitrim, Sligo, Donegal)	Population: 702,966 Area (km^2): 22,649	**Regional Reconfiguration** • Clinical directorates established across the region. • Several out of hours GP co-operatives. **Emergency Department Services Reconfiguration** • Single hub for acute coronary and major trauma care [Galway: University Hospital Galway] with major trauma support services provided at other centres [Mayo: Mayo University Hospital; Donegal: Letterkenny University Hospital; Sligo: Sligo University Hospital]. Acute stroke care at all centres, excluding Roscommon General Hospital. • One ED reconfigured to LIU [Roscommon: Roscommon General Hospital (2011)]. • No ED in Leitrim.
North East (Cavan, Meath, Louth and Monaghan)	Population: 440,211 Area (km^2): 6,395	**Regional Reconfiguration** • Region-specific reconfiguration plan partly implemented from 2006 – 2010. • Limited regional clinical governance. • Roll-out of GP out of hours care. **Emergency Department Services Reconfiguration** • Some centralisation of trauma, acute stroke and coronary care [Cavan: Cavan General Hospital; Louth: Our Lady of Lourdes Drogheda] with rehab

		support in other hospitals. • Dublin North [Mater Hospital] is the percutaneous coronary intervention (PCI) centre with supporting ambulance protocols. • Two EDs reconfigured to LIUs [Louth: Louth County Hospital (2010); Monaghan: Monaghan General Hospital (2009)].
South East (Carlow, Kilkenny, Wexford, Waterford and Tipperary South)	Population: 497,305 Area (km^2): 9,451	**Regional Reconfiguration** • Informal clinical network with shared regional rota for emergency medicine consultants. • Single GP out of hours co-operative. **Emergency Department Services Reconfiguration** • Designated hub for major trauma, and acute coronary care [Waterford: Waterford Regional Hospital – PCI centre supported out of hours by Cork] with ambulance bypass protocols. • Acute stroke care available at all 4 hospitals. • No ED in Carlow.
Dublin South (Dublin South City, Dun Laoghaire Rathdown, Wicklow)	Population: 563,560 Area (km^2): 2,168	**Regional Reconfiguration** • Multiple out of hours GP co-operatives. **Emergency Department Services Reconfiguration** • Centralisation of acute stroke, coronary and trauma care to two hospitals (both in Dublin South City) but limited differentiation and integration between both. • One ED reconfigured to LIU [Dun Laoghaire Rathdown: St Columcille's Hospital (2013)]. • One ED with reduced hours [Dun Laoghaire Rathdown: St Michaels (2003)]. • No ED in Wicklow.
Little reconfiguration		
Region	**Characteristics**	**Summary of Regional Change**
Dublin North East (Fingal, Dublin North City)	Population: 578,317 Area (km^2): 532	**Regional Reconfiguration** • No major changes. • Out of hours GP co-operative established. **Emergency Department Services Reconfiguration** • Three large EDs with limited governance integration and differentiation of services. PCI Centre established [Dublin North: Mater Hospital].
Dublin Midlands (Dublin South, Longford, Westmeath, Laois, Offaly, Kildare)	Population: 761,324 Area (km^2): 8,442	**Regional Reconfiguration** • Limited integration of clinical governance. • Several out of hours GP co-operatives operating. **Emergency Department Services Reconfiguration** • Centralisation of acute stroke [Kildare: Naas General Hospital; Westmeath: Midlands Regional Hospital Mullingar, and Dublin South: Tallaght Hospital) coronary care [Dublin South: Tallaght Hospital] and trauma [Offaly: Midland Regional Hospital Tullamore; Dublin South: Tallaght Hospital) at several hospitals, supported by ambulance bypass protocols. • No ED in Longford.

7.2.2 Data sources

We considered 16 serious emergency conditions, derived from consensus work carried out in the UK, for which the risk of death could be reduced by a well performing emergency care system [52]. The conditions were grouped into three categories; stroke, acute myocardial infarction/cardiac arrest, and 'other', see table 7.2.

The incidences of deaths from the selected emergency conditions are available from the CSO (table 7.3). The incidence of hospital admissions for these conditions is available from the HIPE admissions system.

The regions and constituent counties analysed are outlined in figure 7.1. Due to concerns regarding the completeness of HIPE data for Roscommon over the period 2011-12, this county has been omitted from all analyses for these years.

Historically, Dublin County has been divided into three sections with respect to emergency care delivery, Dublin North-East, Dublin-South and Dublin Midlands. However, mortality and admissions data is not available at a sub-county level. Therefore, CFRs for Dublin were analysed as a whole and reported independently. As a consequence we only present data for the Midlands part of the Dublin-Midlands region (i.e. counties Kildare, Laois, Offaly, Westmeath and Longford) and for the Wicklow part of the Dublin-South region. Results produced at a county level also allow for comparisons with routinely collected measures from other administrative data sources.

Table 7.2: Basket of Emergency Conditions by ICD-9 and ICD-10

Emergency Conditions		
	ICD-9 **HIPE (2002-2004)/ CSO (2002-2006)**	**ICD-10** **HIPE (2005-2012)/ CSO (2007-2012)**
STROKE		
a. Stroke	432.9; 431; 433; 434; 436	I61; I63; I64; I62.9
AMI and CA		
a. Acute Myocardial Infarction	410	I21; I22; I23
b. Cardiac Arrest	427.5	I46; I46.9
OTHER		
a. Acute Heart Failure	428	I50
b. Anaphylaxis	995.0; 995.6	T78·0; T78.2; T80.5;T88.6
c. Asphyxiation	799.0; 994.7	R09.0; T71
d. Asthma	493.0; 493.1; 493.8; 493.9	J45; J46
e. Falls under 75	E880−E888	W00−W19
f. Fractured Neck of Femur	820; 821	S72
g. Meningitis	320−322; 036; 027	G00−G03; A32; A39
h. Pregnancy	630−679	O00−O99
i. Road Traffic Accident	E800−E807; E810−E829	V0−V7; V80.2−V80·5; V82.1; V83.0−V83.3; V84.0−V84.3; V85.0−V85.3; V86.0−V86.3; V87.0–V87.8; V89.2
j. Ruptured Aortic Aneurysm	441.0; 441.1; 441.3; 441.5; 441.6	I71.0; I71.1; I71.3; I71.5; I71.8
k. Self-Harm	E950−E959	X6−X84
l. Septic Shock	38	A40; A41
m. Serious Head Injury	800-804; 830; 850−854; 870−874; 900; 925; 940−941; 950−951	S02−S09

TABLE 7.3: Deaths for emergency conditions used in the indicator analysis by year

Condition	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011[a]	2012[b]	2013	2014	Total (Col%)
Stroke														
Stroke	1,967	1,808	1,625	1,535	1,449	1,528	1,500	1,480	1,599	1,491	1,478	1,534	1,489	**20,483 25.28%**
AMI and CA														
Acute Myocardial Infarction and Cardiac Arrest	3,686	3,242	3,195	2,938	2,976	2,762	2,660	2,458	2,369	2,086	2,234	2,122	1,867	**34,595 42.70%**
Other														
Acute Heart Failure	698	660	606	536	556	511	496	438	558	484	491	555	495	**7,084 8.74%**
Anaphylaxis	-	-	1	-	-	2	-	1	1	-	-	1	-	**6 0.01%**
Asphyxiation	253	281	305	325	334	315	365	405	386	426	423	373	379	**4,570 5.64%**
Asthma	70	64	76	62	52	61	52	53	44	53	39	48	40	**714 0.88%**
Falls <75	30	29	29	37	37	34	26	31	33	36	27	18	25	**392 0.48%**
Fractured Neck of Femur	167	172	139	154	134	111	104	87	87	107	96	90	129	**1,577 1.95%**
Meningitis	23	26	13	22	13	18	20	12	12	8	12	9	7	**195 0.24%**
Pregnancy and Birth Related	5	-	1	1	1	2	3	3	1	2	2	3	1	**25 0.03%**
Road Traffic Accident NECs	249	214	211	214	214	181	139	114	103	95	88	85	93	**2,000 2.47%**
Ruptured Aortic Aneurysm	235	243	200	224	243	254	228	215	225	221	221	238	187	**2,934 3.62%**
Self-Harm	214	205	174	174	130	156	144	158	127	137	124	128	125	**1,996 2.46%**
Septic Shock	57	40	38	50	44	85	67	78	100	98	81	91	141	**970 1.20%**
Serious Head Injury	324	288	287	322	271	269	269	255	247	255	227	233	227	**3,474 4.29%**
Other:Subtotal	**2,325**	**2,222**	**2,080**	**2,121**	**2,029**	**1,999**	**1,913**	**1,850**	**1,924**	**1,922**	**1,831**	**1,872**	**1,849**	**25,937 32.02%**
Total	**7,978 9.85%**	**7,272 8.98%**	**6,900 8.52%**	**6,594 8.14%**	**6,454 7.97%**	**6,289 7.76%**	**6,073 7.50%**	**5,788 7.14%**	**5,892 7.27%**	**5,499 6.79%**	**5,543 6.84%**	**5,528 6.82%**	**5,205 6.42%**	**81,015 100%**

[a] Roscommon excluded
[b] Roscommon excluded

TABLE 7.4: Events (deaths + emergency admissions discharged alive after a minimum 2 day length of stay) for emergency conditions used in the indicator analysis by year

Condition	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011[a]	2012[b]	2013	2014	Total (Col%)
Stroke														
Stroke	5,861	5,768	5,595	5,281	5,342	5,405	5,465	5,648	5,786	5,526	5,535	5,612	5,727	**72,551 14.74%**
AMI and CA														
Acute Myocardial Infarction and Cardiac Arrest	7,738	7,177	7,297	7,194	7,295	7,130	6,950	6,690	6,494	6,234	6,391	6,319	6,081	**88,990 18.08%**
Other														
Acute Heart Failure	5,028	4,695	4,546	4,381	4,401	4,366	4,211	4,274	4,327	3,955	4,116	4,294	4,253	**56,847 11.55%**
Anaphylaxis	48	36	30	41	32	25	34	30	34	21	36	32	35	**434 0.09%**
Asphyxiation	271	300	313	357	360	335	390	442	422	461	457	404	418	**4,930 14.74%**
Asthma	2,580	2,771	2,570	2,512	2,425	2,104	2,086	1,834	1,775	1,632	1,861	1,597	1,789	**27,536 5.60%**
Falls <75	6,266	6,186	6,187	5,858	6,282	6,552	6,318	6,168	6,779	5,403	5,292	5,340	5,352	**77,983 15.85%**
Fractured Neck of Femur	3,674	3,796	3,742	3,702	3,827	3,694	3,837	3,781	3,895	3,630	3,554	3,750	3,940	**48,795 9.91%**
Meningitis	350	365	322	314	344	294	283	287	225	215	191	233	196	**3619 0.74%**
Pregnancy and Birth Related	54	57	29	54	82	52	75	73	60	37	11	4	3	**591 0.12%**
Road Traffic Accident NECs	2,993	2,676	2,673	2,269	2,235	2226	2,029	1,779	1,573	1,378	1,317	1,295	1,392	**25,835 5.25%**
Ruptured Aortic Aneurysm	283	318	270	294	311	327	299	294	316	286	308	338	286	**3,930 0.80%**
Self-Harm	1,906	1,845	1,654	1,632	1630	1,703	1,706	1,556	1,551	1,421	1,466	1,382	1,393	**20,845 4.24%**
Septic Shock	753	751	787	816	869	972	1,036	1,108	1,207	1,163	1,449	1,598	1,956	**14,465 2.94%**
Serious Head Injury	3,840	3,701	3,818	3,878	3,646	3,778	3,472	3,609	3,350	3,106	2,874	2,814	2,915	**44,801 9.10%**
Other: Subtotal	**28046**	**27470**	**26,941**	**26,108**	**26,444**	**26,428**	**25,776**	**25,235**	**25,514**	**22,708**	**22,932**	**23,081**	**23,928**	**330,611 67.18%**
Total	**41,645 8.46%**	**40,415 8.21%**	**39,833 8.09%**	**38,583 7.84%**	**39,081 7.94%**	**38,963 7.92%**	**38,191 7.76%**	**37,573 7.63%**	**37,794 7.68%**	**34,468 7.00%**	**34,858 7.08%**	**35,012 7.11%**	**35,736 7.26%**	**492,152 100%**

[a] Roscommon excluded

[b] Roscommon excluded

TABLE 7.5: Number (%) of deaths and survivors by emergency conditions, 2002-2014

Condition		**Status**		**Total**
		Alive	**Dead**	
Stroke				
Stroke	Count	52,068	20,483	72,551
	% within condition	71.77%	28.23%	100.00%
AMI and CA				
Acute Myocardial Infarction and Cardiac Arrest	Count	54,395	34,595	88,990
	% within condition	61.12%	38.88%	100.00%
Other				
Acute Heart Failure	Count	49,763	7,084	5,6847
	% within condition	87.54%	12.46%	100.00%
Anaphylaxis	Count	428	6	434
	% within condition	98.62%	1.38%	100.00%
Asphyxiation	Count	360	4,570	4,930
	% within condition	7.30%	92.70%	100.00%
Asthma	Count	26,822	714	27,536
	% within condition	97.41%	2.59%	100.00%
Falls <75	Count	77,591	392	77,983
	% within condition	99.50%	0.50%	100.00%
Fractured Neck of Femur	Count	47,218	1,577	48,795
	% within condition	96.77%	3.23%	100.00%
Meningitis	Count	3,424	195	3,619
	% within condition	94.61%	5.39%	100.00%
Pregnancy and Birth Related	Count	566	25	591
	% within condition	95.77%	4.23%	100.00%
Road Traffic Accident	Count	23,835	2,000	25,835
	% within condition	92.26%	7.74%	100.00%
Ruptured Aortic Aneurysm	Count	996	2,934	3,930
	% within condition	25.34%	74.66%	100.00%
Self-Harm	Count	18,849	1,996	20,845
	% within condition	90.42%	9.58%	100.00%
Septic Shock	Count	13,495	970	14,465
	% within condition	93.29%	6.71%	100.00%
Serious Head Injury	Count	41,327	3,474	44,801
	% within condition	92.25%	7.75%	100.00%
Total	**Count**	**411,137**	**81,015**	**492,152**
	% within condition	**83.54%**	**16.46%**	**100.00%**

7.2.3 Statistical analysis

7.2.3.1 National CFRs

The primary outcome of interest is case fatality. Annual CFRs from 2002 to 2014 inclusive were calculated. 2002 was chosen as the initial year of analysis as it is the first year that HIPE allows restriction by admission type, i.e. emergency admission.

CFRs were calculated by dividing deaths due to the relevant conditions by an estimate of the case incidence. Case incidence was constructed by adding the number of patients who were admitted to a public hospital with one of the emergency conditions and discharged alive after at least a two day length of stay, to the number of deaths from that condition, see table 7.4 [52].

CFRs have been found to be dependent on condition and age, but not sex [52]. Therefore, all CFRs were directly standardised using estimates of the national population's age and case-mix composition in 2014. With 16 conditions and 18 age groups, the age and condition specific CFRs in some regions were small and often zero, see table 7.3 and 7.4 [52]. Therefore, conditions were grouped, and ages reduced to those under 65 and then 5 year age groups to 85+ to allow for meaningful direct standardisation. To adjust for case-mix, the national case incidence rate for each of the condition categories, by age group, were generated and these weights were multiplied by each region and county's case fatality rate.

7.2.3.2 Joinpoint analysis of national trends

Joinpoint analysis was conducted on the annual adjusted national CFR observations from 2002 to 2014. This identifies possible change-points where a significant change in the linear trend in national case fatality on a log scale is detected over the study period [230]. The analysis was conducted using the software developed by the Surveillance Research Program Version 4.2.0.1 of USA National Cancer Institute.

Models with a single joinpoint were considered and the optimal piecewise linear model was compared to one with no joinpoints i.e. a straight line. To describe linear trends by period, the estimated annual percent change (APC) is computed for each trend by fitting a regression line to the natural logarithm of the rates using the calendar year as a regressor variable [230]. A negative APC signifies an annual decrease in case fatality, while a positive result denotes an increase. National results were deemed to have a statistically significant change in trend if the results from the estimated regression coefficients for the difference in the slopes had a *p-value* < 0.05.

7.2.3.3 Generalised linear model and funnel plot of regional and county CFR trends

Longitudinal trends in directly standardised CFRs were estimated at region and county level using an inverse standard error weighted generalised linear model with a log link, informed by the identified joinpoint in national trends. The inverse standard error allows for precision in comparing areas with differing case populations [234]. Models included the age and case-mix adjusted rate as the dependent variable, with area and an interaction between year and area as independent variables. Trends were compared to the national annual trend using a funnel plot with 95% limits ($\pm$ 2 standard deviations) to identify any areas that differed significantly from the national result.

7.2.3.4 Cross sectional analysis of county CFRs in two time periods

A cross sectional analysis was used to compare county CFRs in two different three year time periods, 2002-2004, and 2012-2014. The focus on county CFRs allows specific examination of areas that had ED closures. Results were compared to the national CFR to establish if a county was above or below the national result in both periods, and a Spearman rank correlation of results was calculated to describe the consistency in county performance over the two periods. The coefficient of variation was calculated to determine if the variance between county results had increased or decreased between the two periods.

7.3 Results

7.3.1 National CFRs

Case fatality ratios were constructed for each year from 2002 to 2014 inclusive. For 2002-2004 the national annual CFR was 187 per 1,000, falling to 151 per 1,000 over the period 2012-2014. The national annual percentage change in national total CFRs over the period 2002-2014 was a decrease of 2.12%.

Between 2002 and 2014 the national total deaths from the selected conditions fell from 7,978 to 5,205, decreasing across all groups, see table 7.3. Total cases also decreased from 41,645 to 35,736, again decreasing in each group, see table 7.4.

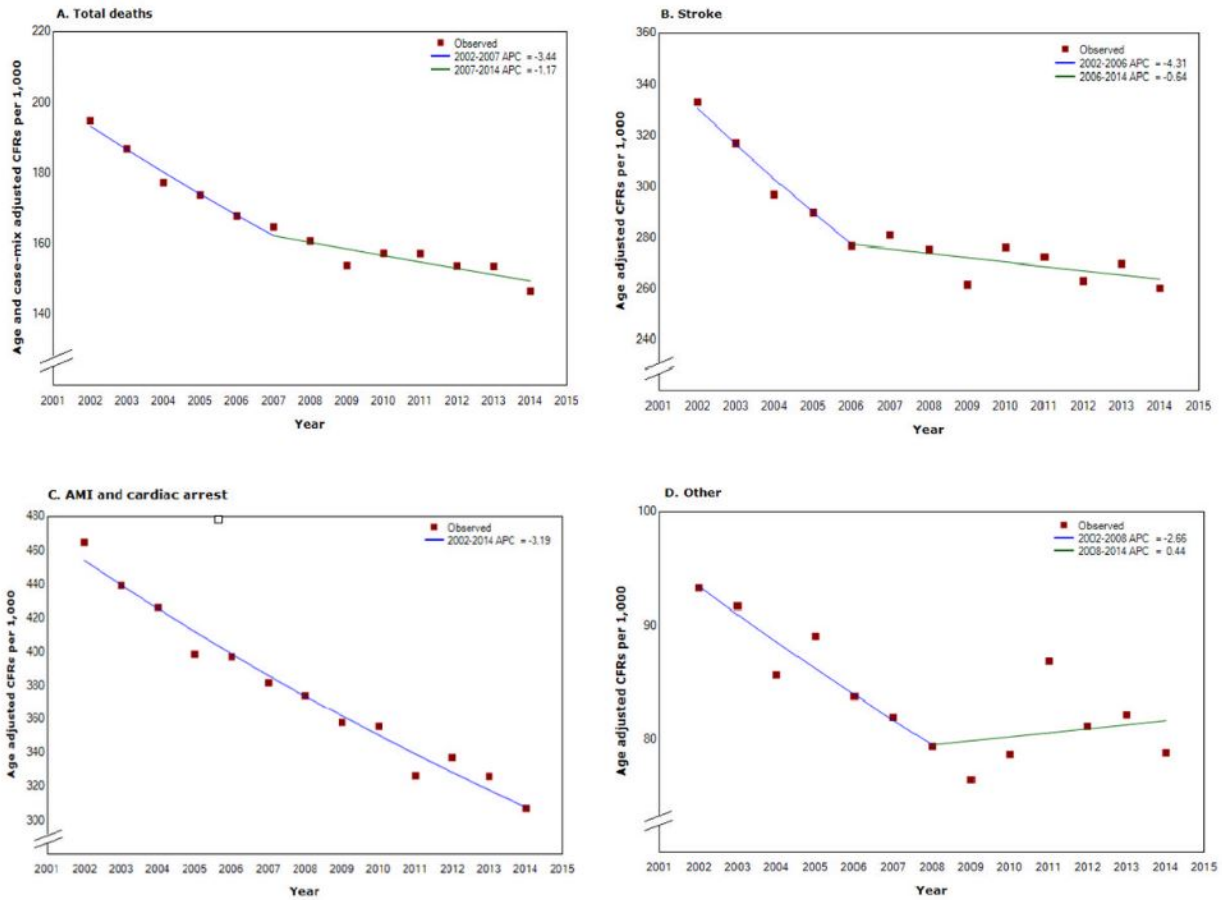
7.3.2 Joinpoint analysis of national trends

Joinpoint analysis found a statistically significant change in the CFR trend for total conditions in 2007, see figure 7.2. The APC for the period 2002 to 2007 was -3.4 (95% CI -4.4, -2.4), with the APC decreasing to -1.2 (95% CI -1.9, -0.5) from 2007 to 2014.

Analysis of the individual condition groups showed a significant change in trend for stroke; from 2002 to 2006 an APC of -4.3 (95% CI -6.2, -2.4) was observed, which decreased to -0.6 (95% CI -1.4, 0.1) from 2006 to 2014. A significant change was also seen for the 'other' group; from 2002 to 2008 an APC of -2.7 (95% CI -4.6, -0.7) was observed, reducing to 0.4 (95% CI -1.7, 2.6) from 2008 to 2014.

The AMI and cardiac arrest group showed a consistent downward APC of -3.2 over the full period (95% CI -3.5, - 2.9), see figure 7.2.

FIGURE 7.2: Joinpoint analyses of adjusted CFRs



(A) Age and case-mix adjusted total CFRs: 2002-2007 APC= -3.4 (-4.4,-2.4), 2007-2014 APC= -1.2 (-1.9,-0.5)
(B) Age adjusted stroke CFRs: 2002-2006 APC= -4.3 (-6.2, -2.4), 2006-2014 APC= -0.6 (-1.4, 0.1)
(C) Age adjusted AMI and cardiac arrest CFRs: 2002-2014 APC= -3.2 (-3.5, -2.9)
(D) Age adjusted "other" CFRs: 2002-2008 APC= -2.7 (-4.6, -0.7), 2008-2014 APC= 0.4 (-1.7, 2.6)

7.3.3 Generalised linear model and funnel plot of regional and county CFR trends

Having identified 2007 as the relevant joinpoint in the national trend, analysis of the regional total CFR trend revealed a statistically significant downward trend from 2007 in three regions; Mid-West, West, Dublin, see table 7.6.

When compared to the national annual decrease (-1.2%) for this period, two regions were found to have a statistically significant difference; the South-East had a lower rate of decrease, and the West had a higher rate of decrease, see figure 7.3.

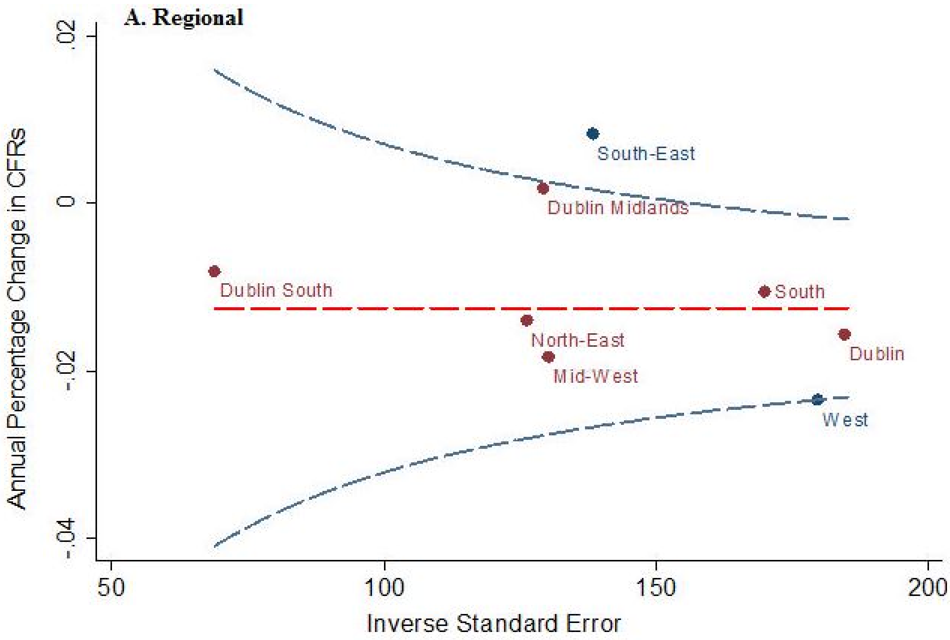
The county results identified six counties with significant decreases in their CFR trends (Donegal, Dublin, Kerry, Louth, Mayo, and Sligo) from 2007 to 2014, see table 7.6. Carlow and Mayo were found to be outside of the 95% limit when compared to the national trend, see figure 7.3 and 7.4.

TABLE 7.6: Regional and County APC (2007-2014) and CFRs (2002-2004 and 2012-2014)

	APC: 2007-2014 (95% CI)	***P*** $\|z\|$	**CFR per 1,000 2002-2004 (95% CI)**	**CFR per 1,000 2012-2014 (95% CI)**
Rep. of Ireland	**-1.25 (-1.80, -0.70)**	**0**	**187 (184 , 189)**	**151 (149 , 153)**
Region				
Dublin	-1.56 (-2.62 , -0.5)	0.004	180 (175 , 184)	138 (134 , 142)
Dublin Midlands	0.17 (-1.34 , 1.69)	0.823	192 (185 , 198)	156 (150 , 162)
Dublin South	-0.82 (-3.66 , 2.02)	0.573	192 (179 , 204)	154 (142 , 166)
Mid-West	-1.83 (-3.34 , -0.33)	0.017	204 (197 , 211)	168 (161 , 174)
North-East	-1.4 (-2.95 , 0·15)	0.077	166 (160 , 172)	141 (135 , 147)
South	-1.05 (-2.21 , 0.1)	0.073	197 (191 , 202)	170 (165 , 175)
South-East	0.83 (-0.58 , 2.25)	0.249	175 (170 , 181)	153 (147 , 158)
West	-2.35 (-3.44 , -1.26)	<0.001	195 (190 , 200)	150 (145 , 155)
County				
Carlow	3.18 (-0.27 , 6.63)	0.071	187 (169 , 205)	165 (148 , 182)
Cavan	-1.91 (-4.59 , 0.78)	0.164	169 (157 , 182)	148 (134 , 162)
Clare	-2.07 (-4.32 , 0.19)	0.073	204 (191 , 218)	163 (151 , 176)
Cork	-0.58 (-1.66 , 0.5)	0.293	197 (190 , 203)	164 (158 , 170)
Donegal	-2.14 (-3.95 , -0.33)	0·021	186 (176 , 195)	140 (131 , 149)
Dublin	-1.56 (-2.39 , -0.73)	<0.001	180 (175 , 184)	138 (134 , 142)
Galway	-1.51 (-3.14 , 0.12)	0·070	189 (181 , 198)	149 (140 , 157)
Kerry	-2.04 (-3.69 , -0.39)	0.015	198 (188 , 208)	189 (178 , 201)
Kildare	0.29 (-1.79 , 2.37)	0.785	188 (176 , 200)	152 (141 , 163)
Kilkenny	-0.3 (-3.01 , 2.41)	0.83	166 (153 , 179)	145 (132 , 159)
Laois	-0.05 (-3.07 , 2.97)	0.973	183 (165 , 201)	146 (131 , 161)
Leitrim	0.98 (-2.77 , 4.72)	0.609	208 (185 , 230)	171 (149 , 193)
Limerick	-0.39 (-2.04 , 1.26)	0.644	202 (191 , 212)	179 (170 , 189)
Longford	-0.06 (-3.59 , 3.48)	0.975	201 (181 , 221)	168 (148 , 187)
Louth	-2.48 (-4.69 , -0.28)	0.027	173 (162 , 184)	136 (125 , 148)
Mayo	-4.6 (-6.31 , -2.88)	<0.001	261 (249 , 273)	155 (145 , 165)
Meath	-1.38 (-3.65 , 0.88)	0.23	154 (143 , 164)	131 (121 , 141)
Monaghan	1.47 (-1.45 , 4.4)	0.324	173 (159 , 187)	164 (147 , 180)
Offaly	-1.56 (-4.36 , 1.24)	0.274	200 (184 , 216)	161 (145 , 176)
Roscommon[a]	-0.38 (-2.99 , 2.23)	0.773	147 (134 , 159)	186 (165 , 207)
Sligo	-3.31 (-6.12 , -0.5)	0.021	203 (187 , 218)	136 (122 , 150)
Tipperary	-1.12 (-2.98 , 0.74)	0.237	201 (191 , 210)	154 (144 , 164)
Waterford	0.16 (-2.17 , 2.5)	0.892	169 (158 , 181)	137 (126 , 149)
Westmeath	1.2 (-1.32 , 3.72)	0.352	192 (177 , 206)	163 (149 , 176)
Wexford	-0.36 (-2.31 , 1.59)	0.715	170 (159 , 180)	159 (148 , 169)
Wicklow	-0.82 (-3.04 , 1.41)	0.472	192 (179 , 204)	154 (142 , 166)

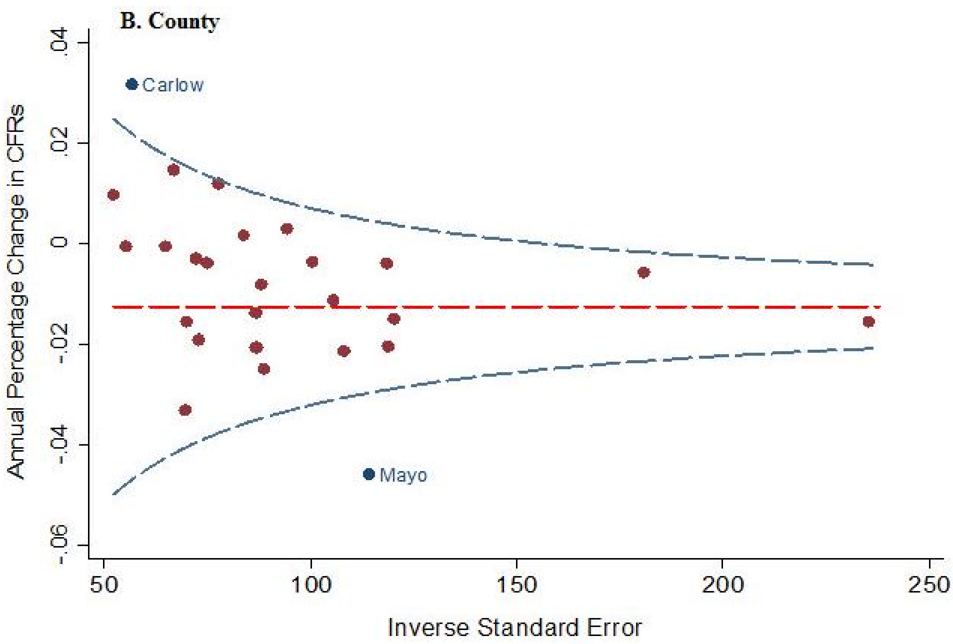
[a]Roscommon result does not include 2011/2012

FIGURE 7.3: Regional: APC in age and case-mix adjusted CFRs with a 95% control limit



(A) Regional: The target is the national APC of -1.2%, represented in the graph as 0.012.

FIGURE 7.4: County: APC in age and case-mix adjusted CFRs with a 95% control limit

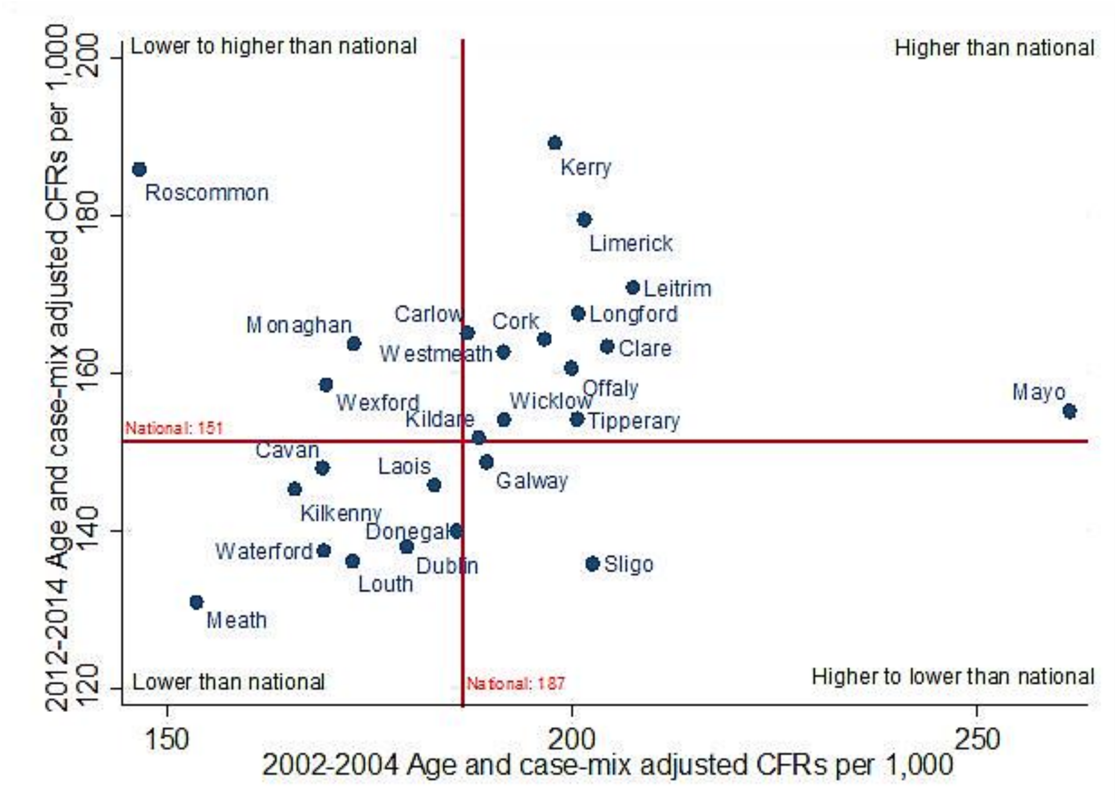


(B) County: The target is the national APC of -1.2%, represented in the graph as 0.012.

7.3.4 Cross sectional analysis of county CFRs in two time periods

A comparison of county total CFR results in 2002-2004 and 2012-2014 to the respective national CFRs can be seen in figure 7.5, represented by the horizontal and vertical red lines, and table 7.6.

FIGURE 7.5: Comparison of CFRs for 2 time periods; 2002-2004 and 2012-2014



The Spearman rank correlation of the CFRs found a statistically significant relationship between county results over the 2 periods ($\rho = 0.40$, $p = 0.04$). Three counties (Monaghan, Roscommon and Wexford) had a decline in their position with regards to the national result between periods, and two counties (Galway and Sligo) improved, see figure 7.4. The two counties identified as significantly different from the national trend, Carlow and Mayo, were above the national result in both periods.

The coefficient of variation found that variability between county CFRs decreased in the two periods; 11.45 for 2002-2004 and 9.72 for 2012-2014.

7.4 Discussion

7.4.1 Summary of findings

There was a large decline nationally in case fatality from serious emergency conditions over the period 2002-2014. The continued decrease in case fatality, albeit at a slower rate from 2007, is a positive outcome at a national level. Pronounced changes for stroke and the 'other' group were seen, while the rate of decline for AMI and cardiac arrest did not slow. The number of events for acute myocardial infarction has consistently decreased during the period of study, see table 7.4. This is despite changes in how the condition is defined, and continued improvements in its detection [324, 325].

Variability in outcomes persists at a regional level. Two of the eight regions showed a significant difference in total condition fatality when compared to the 2007-2014 national rate; the South-East improving slower, while the West improved faster. Variation at county level also demonstrates that within region results are not homogenous.

Cross-sectional analysis revealed many counties in the South-East, North-East and Dublin performed consistently better than the national CFR. These regions underwent limited attempts at reconfiguration. The South, Mid-West and Midlands regions were consistently worse than the national average CFR over the study period. Of these, the South and Mid-West regions underwent significant reconfiguration.

There is little evidence that identified changes in CFRs at a regional or county level were associated with the reconfiguration of services, such as the removal of EDs. For example, counties such as Monaghan and Roscommon, which experienced the closure of EDs, saw a decrease in their position relative to the national CFR over the two time periods (2002-2004 and 2012-2014) studied. However, the rate of CFR decrease in these counties was not statistically different from the national rate between 2007 and 2014, as per the constructed funnel plots.

7.4.2 Interpretation

The findings from this research reveal a complex picture. Undoubtedly outcomes have improved over the period in question; however the national rate of improvement slowed in the most recent years. An argument can be made that mortality may be the last thing affected by system change. Clinical professionalism may limit any potentially negative consequences of such changes. Aspects of quality, safety and morbidity, including a delay in care and unrelieved pain, may be more likely to experience adverse effects.

The concentration of emergency care to specialist centres is intended to improve outcomes [132, 320, 321, 324]. In the UK, for example, the reconfiguration of trauma care services led to a 60% improvement in the odds of surviving a major trauma over the period 2008 to 2014 [326]. The findings presented in this paper suggest that reconfiguration in Ireland, mainly implemented after 2006, has not resulted in improved outcomes, and has not altered long-term geographical differences between regions and counties. This may be due to poor resourcing and implementation of reconfiguration plans. It may also be due to long-term structural differences between geographical areas in social determinants of health such as rurality and deprivation. Any detailed cross sectional analysis of variations between counties would need to account for these characteristics. A study of mortality in England and Wales found that deprivation accounted for the majority of differences seen between urban and rural areas, with the exception of lung cancer, respiratory disease and accidents [85].

The period of study also saw improved clinical guidelines and documents of best practice, the establishment of offices of clinical audit, as well as the introduction of clinical care programmes for conditions such as stroke and AMI.

The National Stroke Programme launched in 2010 is considered to have substantially changed the level of specialised stroke care received by patients [327]. A 2015 national audit of stroke highlighted in-hospital improvements for stroke mortality, decreasing from 19% to 14% since 2008 [51]. One of the principal aims of this programme was the development of stroke units in all hospitals which accept stroke patients [327]. However, issues exist regarding the full implementation and staffing of these units. According to the audit, only 29% of patients were admitted directly to a stroke unit and almost 50% did not receive treatment in a unit during their stay in hospital [51]. Also, nearly a quarter of the hospitals providing acute stroke care did not meet the minimum standards of a stroke unit [51]. The goal of full national 24/7 thrombolysis has still not been achieved. It is currently supported through bypass protocols to larger tertiary hospitals when required, and the development of the Telemedicine Rapid Access for Stroke and Neurological Assessment. This assessment allows doctors to provide consultations via video and supervise thrombolysis where necessary. Where implemented, the rate of thrombolysed patients is 1 in every 3.5 patients, compared to 1 in 5 elsewhere [327]. However, delays have been experienced in the full roll out of this programme [327].

In terms of cardiac care, the Acute Coronary Syndromes Programme was launched in

2012 [169]. This programme has supported the adoption of five 24/7 primary percutaneous coronary intervention (PCI) centres and one 9-5 Monday to Friday centre nationally [163]. Improvements have also been made to pre-hospital services for patients as a result of changes to pre-hospital emergency care council and ambulance protocols. It has subsequently been reported that the number of reperfused ST-Elevation Myocardial Infarction patients that receive PCI increased from 55% in 2011 to 94% in 2015 [163].

The impact of these condition specific service changes and other clinical programmes, together with higher level system changes, can be seen in the results of our analysis. The slowing of improvement, particularly for stroke, may now be a result of gains being harder to achieve as programmes start to focus on more complex changes. At a regional level, initial emergency care system resources and quality of care were not uniform and the implementation of reconfiguration differed widely across regions. Changes took place in the context of an initial period of national investment and growth, followed by an economic recession. Budgetary cuts were a contributing factor to the structural changes which resulted in the closure of emergency services. Restrictions on staff recruitment across EDs and ambulance services continue to be experienced to date. For instance, a review of the Irish ambulance service, the NAS, in 2015 found that almost 300 additional staff would be required to cover best achievable performance [328], while the 2016 National Service Plan highlighted the continued gap between pre and post-recession employment in the acute hospital sector [329].

7.4.3 Context of the literature

The restructuring of emergency services has been previously studied internationally, particularly with regard to the closure of rural EDs. Conflicting results have been found. Some studies [87, 330] have found a risk of higher mortality when distance to treatment is increased. In the UK, a study found that a 10-km increase in straight-line distance to treatment was associated with a 1% absolute increase in mortality [87]. Conversely, a study in the United States concluded that higher in-hospital mortality did not necessarily occur after the closure of a local ED [148]. It argued that where other appropriate services exist, the closure or reduction of certain services will not have a negative impact on in-hospital mortality outcomes [148]. However, remaining facilities must be adequately resourced and staffed to meet new demands [331].

7.4.4 Strengths and limitations

A strength of this study is the shift from in-hospital mortality as the main measure of outcome. Using hospital mortality rates to predict the quality of hospital care can result in good or average hospitals being penalised [332]. Its continued use in outcome reporting [47–49] over-emphasises the concerns of providers, rather than the needs of the population. Case fatality constructed by area of residence allows analysis of outcomes for those who need to engage with the system, rather than focusing on outcomes from a specific service [52].

This study is subject to a number of limitations. Emergency admissions to private hospitals were not included in this analysis; private hospitals are not required to submit data to HIPE. Consequentially, CFR results reported may represent a maximum level; results for counties with a high level of private hospital usage may be lower than stated here. However, we estimate the impact of private hospital admission on our results is low due to a number of factors. First, there were only five small private EDs open in Ireland over the study period and many of those were not open for the full study period. Second, these hospitals generally worked on a 8am-5pm schedule, Monday to Friday [333, 334] and during our study period would not have operated a weekend service.

Third, private EDs generally did not accept the most serious emergency conditions, such as major trauma and acute stroke, over the study period [333–335]. Fourth, serious emergency cases requiring ambulances were not taken to private EDs over the study period [333, 334].

Our analyses rely on the accuracy of the HIPE system for recording emergency admissions. A study by the Department of Health in 2013 has confirmed the robustness of the data available from HIPE, specifically as a tool for the development of indicators of quality of care in hospitals [336]. As a result, this data has formed the basis of the National Healthcare Quality Reporting System (NHQRS) annual reports [47–49] and such use is in line with the analysis produced within this study. However, within our analysis particular caution should be used when interpreting results for County Roscommon. Due to the absence of a HIPE coder for a period spanning part of 2011-2012 in Roscommon County Hospital, the accuracy of coding is limited for much of the county's patient population.

The primary aim of this study is the evaluation of major system change. Reconfiguration of such a scale is likely to lead to improved results for certain conditions, but the deterioration of results for others. Therefore, to assess the overall impact on the system, the focus is necessarily on aggregated higher level data. The analysis of patients, or each condition, at an individual level is of limited benefit. Cautions should be taken when using county level data in understanding change in complex, multi-factor situations. However, it is important to note that any lower level analysis is restricted in Ireland due to lack of access to more detailed data. Access to admissions data through the hospital admissions system is limited to county level. Similarly, personal individual level mortality data is unavailable from the CSO due to concerns of identifiability.

Ireland also differs from many other European countries in that it does not have a unique patient identifier. This restricts the ability to link individuals to admissions and subsequent death for a specific condition. Therefore, analysis was limited to the ratio of deaths to cases in a year, as opposed to the rate of deaths per cases. There are measures underway as of 2014 to introduce a National Register of Individual Health Identifiers [337].

7.4.5 Policy implications

There is currently no independent routine health planning on behalf of populations in Ireland. The majority of planning is done by, or on the behalf of, the provider, the HSE. Such planning is primarily based on once off national reports, as previously outlined [8, 16–18], which focus on the performance of the provider. This study provides a counterpoint to such reports, and aims to refocus attention to how well populations are served.

Our findings show that changes to the national CFR trend coincided with a period of recession in Ireland. With additional budget allocations as of 2015, [329] further monitoring will determine if there are future improvements to CFRs. Additionally, policies of reconfiguration do not appear to have significantly influenced CFRs. Continued observation will determine if on-going implementation of these policies also result in greater improvements. It may also be argued that much of the variance in case-fatality can be explained by non-health system factors such as deprivation and rurality [85, 149, 338], which have not been included in our model and merit further investigation.

7.5 Conclusion

National outcomes for serious emergency conditions have improved over the period 2002-2014 in Ireland. However, a slowing of the rate of improvement since 2007 coincided with a period of economic contraction. Changes to fatality trends varied by condition; therefore, results cannot be solely attributed to recessionary factors. The impact of individual clinical programmes, and subsequent system changes to services such as stroke units and PCI centres, must also be considered. Persistent geographical variation in case fatality remains despite attempts to reconfigure regional services. A distinct pattern cannot be identified between regions and counties that undertook substantial reconfiguration of emergency services and those that did not. Further research on the role of rurality and deprivation in driving outcome and process variation, the role of regional variation in resources, and the extent to which reconfiguration plans were fully implemented, is planned by the SIREN research collaboration.

Chapter 8

Discussion and conclusion

8.1 Introduction

This thesis adds to the evidence regarding the impact of the reconfiguration of emergency and urgent care systems in Ireland on regional populations. This chapter outlines the main findings of the thesis. The main strengths and limitations of this work are highlighted, and areas for consideration by health service planners and policymakers are outlined. Potential areas for future research are proposed and a conclusion to the overall work presented in this thesis is provided.

8.2 Main findings

The overall aim of this thesis was to investigate the impact of emergency and urgent care system reconfiguration at a regional population level from 2006 onwards. This aim was to be achieved by addressing three objectives:

1. To investigate the impact of changes to ED services in smaller hospitals on the remaining EDs within regional emergency and urgent care systems;

2. To investigate the regional variation in 'potentially avoidable' emergency admissions and identify the drivers of those admissions within regional emergency and urgent care systems;

3. To determine if the CFRs for emergency conditions have improved in line with reconfiguration carried out at a regional level.

To do this, a number of quantitative indicators which have traditionally been used to assess health system performance were constructed and considered within the context of the Donabedian framework as described in **Chapter 4**. The adoption of this framework allowed for a broad analysis of the changes to the emergency and urgent care system by incorporating different aspects of the system under the domains of structure, process and outcome.

Domain: Structure

The first objective of this thesis was to investigate the impact of changes to ED services on the remaining EDs within regional emergency and urgent care systems.

This objective was addressed in **Chapter 5**. This study included a time-series analysis which focused on the changing trends in regional ED trolley numbers, and specifically assessed the impact of ED reconfiguration on remaining regional ED services. In three regions the immediate impact of ED reconfigurations is either non-significant or associated with a short-term shock to observed ED trolley numbers, followed by convergence with the pre-reconfiguration trend over the following 12-months. Only one region, the North-East, saw a longer term change in trend post-reconfiguration following the changes to the second ED in the region.

The characteristics that contributed to the trend seen in the North-East post-reconfigur -ation were not consistent across the other regions studied. For example, bed capacity in the North-East fell over the reconfiguration period, but larger decreases were seen in the West and Mid-West. Emergency admissions fell in the North-East over the reconfiguration period compared to rises in the West and South, and a fall in the Mid-West. The inconsistency in these findings across the four regions may indicate that other determinants not measured in this study are better predictors of the drivers which cause increased pressures on ED trolley numbers. These characteristics may include other processes, such as the degree of efficiency of bed management within hospitals.

Domain: Process

The second objective of this thesis was to investigate the regional variation in 'potentially avoidable' emergency admissions and identify the drivers of those admissions within regional emergency and urgent care systems.

In **Chapter 5**, the longitudinal aspect of all emergency admissions was considered. An analysis of the long-term moving average of emergency admissions revealed increases over time in four of the regions that experienced changes to their ED services.

In **Chapter 6**, analysis was conducted on the emergency admissions for a select group of conditions. Using negative binomial regression analysis, a cross sectional study of the factors identified possible drivers of these admissions, having considered both population level and health system factors.

This study found that differences existed across counties in the age-adjusted rates of emergency admissions for the considered conditions. Higher rates of emergency admissions were not consistent across those regions that had undergone significant emergency and urgent care reconfiguration.

The main findings of the study suggest that the primary contributor to the variation seen in results across counties was the level of deprivation, as measured by unemployment. Other factors which were found to have an impact were the level of short-term lengths of stay in hospital and the rate of private health insurance. The results also suggest that the identified associations apply equally to 'potentially avoidable' and total/other emergency admissions.

Historically, high levels of 'potentially avoidable' emergency admissions have been used as an indicator of poor system performance, specifically the performance of primary care. The findings of this study underline the importance of risk adjustment for differences in deprivation levels when comparing health system performances at a geographical level.

Domain: Outcome

The third and final objective was to consider outcomes, specifically whether CFRs for emergency conditions have improved in line with reconfiguration carried out at a regional level.

In **Chapter 7**, the outcome of CFRs for a selection of emergency conditions was analysed at a county and regional level. This study showed that there were significant improvements for the main emergency conditions of stroke and AMI at a national level, with the rate of improvement slowing from 2007 for stroke. However, the study was unable to attribute improvements seen at a regional level to the degree of reconfiguration undertaken. There was no consistent pattern in findings between or across regions which were deemed to have undergone significant reconfiguration and those which hadn't.

Summary and interpretation

As outlined in section 3.4 the literature which addresses system reconfiguration of services is complex and conflicting. Many of the justifications for emergency and urgent care system reconfiguration in Ireland have centered around claims that changes to services within the system would result in improved safety, efficiency and outcomes for patients [8, 153, 156]. The findings of this thesis highlight that there is no consistent pattern across regions to indicate that improvements to outcomes, or improvements based on increased efficiency in processes or better co-ordination of structural resources can be attributed to reconfiguration of emergency and urgent care systems. This is despite numerous proposed changes across regional services and systems, see section 3.5.

The absence of significant findings regarding the population effects of system reconfiguration may be due to a number of factors. While the publication of a report or policy, as outlined in **Chapter 3**, might be considered a general indicator of when reconfiguration comes into effect, in many cases it is possible that these changes were in motion before national or regional policy was officially announced. It is possible that many of the changes were informally in place before the time-line identified by the reconfiguration reports. For example, many of the most serious emergency conditions may have already bypassed smaller hospitals in favour of larger urban hospitals even before such a policy was formally put in place. It is also possible that in reality full implementation of certain recommendations was never completed. Therefore, time-lines cannot be absolute for many of the changes. The analysis included in this thesis has aimed to be as specific as possible, but in reality a margin of error may exist.

The scale and scope of reconfiguration also varied depending on the starting point of each regional system. Context plays a vital role in how complex adaptive systems respond to interventions [339]. For some, more rural regions with few hospitals, such as the South and Mid-West, changes to small hospitals dramatically changed the landscape of the system of care, see table 7.1. For other more complex and larger networks with multiple large hospitals, specifically Dublin, large scale changes are required before 'reconfiguration' can make an impact. The reality of what constitutes system reconfiguration is therefore different in each region with many changes introduced at different rates and to differing degrees across the systems [54]. Therefore, a more individualist approach may be needed, looking at each region in isolation and considering the context in which reconfiguration took place in much greater detail, in order to truly determine the degree to which changes were observed.

As identified in **Chapter 3**, it is important to recognise that other measures outside of what would be considered 'reconfiguration' were also introduced at the same time as changes to the emergency and urgent care system were taking place. For example, the implementation of condition specific clinical programmmes occurred at the same time as many reconfiguration measures were introduced. Many of these programmes have contributed significantly to improved processes and outcomes. The degree to which changes to the treatment of individual conditions co-exist with broader system level changes means isolating the impact of health system reconfiguration has proven to be difficult. As a result, the ability to attribute either improvements or dis-improvements solely to reconfiguration measures is implausible.

The three studies within this thesis challenge many of the commonly proposed policy solutions offered to improve the delivery of emergency and urgent care, highlighting a lack of evidence to support them.

Our findings from **Chapter 5** suggest that some hospitals are more vulnerable to ED trolley problems than others, even when the capacity and need issues of the hospital are no worse than average. Therefore, a policy of increasing the number of in-patient hospital beds in isolation without improving the efficiency of bed management is unlikely to yield the desired impact [340, p. 303]. A recent report looked at delayed discharges and associated bed blockage in Irish hospitals [341]. The authors concluded that the number of delayed discharges were underestimated and that there was an imbalance between discharge requirements and community capacity. For example the report highlighted the fact that 33% of patients going to nursing homes could be delayed discharges. Those 65 years old and older account for almost 90% of delayed discharges [341]. In the most recent 2018 HSE health service capacity review, it is stated that a net requirement of 2,590 acute hospital beds would be needed in the public system by 2031 [40, p. 4]. Encouragingly, the report acknowledges that adding acute beds is only part of the solution. As hospitals in Ireland have almost 100% bed occupancy rate, introducing additional beds may be counter-productive; rather than reducing occupancy rates, these beds would likely be filled by unmet demand immediately and they would not contribute to improving bed efficiency. The review highlights the need for *"efforts to strategically plan and deliver services at a national and hospital group level"* [40, p. 5]. This operational focus and system level approach is supported by the findings from **Chapter 5**. The implementation of frameworks which address operational modelling of hospital resources, promoting a thorough understanding of the system together with detailed information for decision-making would help to support this approach [342].

The findings presented in **Chapter 6** highlight that expanding primary care capacity may not reduce the rate of 'potentially avoidable' emergency admissions if the socio-economic context in which care is provided is not also considered [343]. Furthermore, the continued emphasis on 'potentially avoidable' emergency admissions may not be as useful an indicator, particularly regarding the quality of primary care, as previously believed. As the prevalence of multi-morbidity, and specifically 'complex' multi-morbidity (3 or more chronic conditions) increases in both younger and older populations, there is increased healthcare utilisation including emergency admissions [344]. There is also recognition of socio-economic, cultural and environmental characteristics that play a role in what are termed 'complex chronic patients' [345]. Such patients, their behaviour and their experiences with health services, are evidence of social inequalities in health [345, p. 1-2]. The characteristics that these patients display, including high incidences of mental health illness, socio-economic challenges and individual behaviours or traits, add to the complexity of caring for chronic conditions and will continue to do so going forward [346]. There is a strong likelihood that such patients will continue to require a high level of hospital services, even with improved primary care services.

Finally, the reconfiguration of emergency services, specifically the closure of smaller EDs and increased focus on larger 'hub' EDs, was done in part to improve population outcomes. However, the findings of the study described in **Chapter 7** suggest that such improvements have not happened across all regions that have undergone significant reconfiguration. There are several reasons that can be put forward for this. It may be that the most serious conditions were already bypassing the smaller EDs in favour of 'hub' EDs, even before reconfiguration. As a result, the pattern in CFRs has continued as it would have without reconfiguration. Another possible reason is that extra travel time to definitive care has offset the benefits associated with better quality of care received at 'hub' hospitals [330, 347]. For some patients, the additional travel distance to a 'hub' ED may have dissuaded them from using the service, even in the event of a potentially serious condition [150, 151]. It is also possible that claims regarding the superiority of care provided in 'hub' EDs is exaggerated. For example, the NHQRS reports published by the HSE consistently show little variation in age-sex standardised in-hospital SMRs for conditions such as AMI and stroke [50, p. 97 & 103].

As previously discussed in **Chapter 3**, the complex adaptive nature of health systems, and the often unpredictable interactions between components, means that there are no universal solutions to the challenges faced within the system. Evidence with regard to system performance cannot be mapped perfectly in every context. A planned intervention (reconfiguration) and the circumstances in which it is introduced (the regional characteristics) are intertwined and 'reciprocally interact' [339, p. 2]. To fully research this area, evidence which encompasses the whole population who use emergency and urgent care services, taking socio-demographics and geography into consideration, while also accounting for all the different service types nested within each region is required. The studies included in this thesis attempt to incorporate as many of these aspects as possible, however, the difficulty of isolating the 'signal' of policy change within all of the influences of variation remains.

8.3 Strengths and limitations

Strengths

The aim of the study was to focus on the impact of the reconfiguration to regional emergency and urgent care systems at a population level and the analysis within this thesis is the first, to the best of our knowledge, to do so. Previous analysis [47–51] has concentrated on specific conditions or services, whereas this study has widened the focus to consider how the populations within a health system interact with, and are affected by, changes in the delivery of health services. This higher level system approach to emergency and urgent care reconfiguration highlights the importance of the circumstances, or context, in which action is taken in order to understand its implementation and possible impact [348]. This thesis encourages a 'systems thinking' approach to reconfiguration, adopting a *"broad, holistic, long-term perspective on the world and examines the linkages and interactions among its elements"* [348, p. 221]. By doing so, research and policy makers are in a better position to ask the "right questions" [348, p.84]. The completion of the studies in this thesis provides a substantial foundation on which to take this approach.

This thesis applied complex statistical modelling throughout. The INMO ED trolley dataset is one of the most frequently discussed measures of resource performance within the health system, as outlined in **Chapter 5**. However, the capability of this data to inform system performance has not been fully realised. In **Chapter 4** and **Chapter 5** we developed new methodologies for the analysis of complex longitudinal trolley number profiles that, to the best of our knowledge, have not appeared elsewhere. Traditionally, piecewise linear models are used to model longitudinal variation. The analysis within **Chapter 5** has made major advances by extending these models to allows for complex non-linear trends using cubic spline modelling. These were further extended to allow for the seasonal effects using a double cosinor model and incorporated into negative binomial models that allow for the presence of extra-Poisson and autoregressive correlations. These structures were deconstructed in underlying trend, seasonality and noise so at better identify changes in underlying trend. Although the extended time series model was not required for our analysis of changing trends in trolley numbers, because the piecewise linear model was adequate over a sort time-period, these models could be used to model more complex longitudinal patterns and represent a major contribution to the statistical methodology for the analysis of interrupted time series.

Given the limited resources available to the health system, specifically with regard to the collection and dissemination of data, it is imperative that every resource is used to it's maximum capability. The introduction of the EU General Data Protection Regulation in the last 12-months has added to restrictions on what data can be collected. Therefore, it is important, where possible, for researchers and policy makers to use existing data in a way that maximises it's benefit to the wider public before additional data collection costs are incurred. This thesis has used existing data from multiple administrative sources within each study. The use of this existing data provides a multi-faceted profile of the health data landscape in Ireland. The analysis and methods of across all studies within this thesis provide a template for what is possible with publicly available secondary data.

Chapter 6 also extended traditional methods used in previous studies which investigated 'potentially avoidable' emergency admissions. This was accomplished by investigating the population factors and widening health system factors to include hospital factors and the prevalence of private health insurance. Such considerations are increasingly important to the implementation of Sláintecare, which aims to remove the two-tier system that currently exists between public and private patients, and promote the delivery of care in primary care settings. Therefore, possible supplier-induced demand, i.e. additional demand for services due to actions by suppliers of those services, must be considered when attempting to reduce, or promote, the use of certain services [349]. The findings of **Chapter 6** provide important insight into those health system supply factors that are inextricably linked with specific service use of interest.

Chapter 7 also expanded the use of SMRs by constructing CFRs by area of residence. This allowed outcomes to be assessed outside of a hospital setting and includes all those who experienced an emergency condition, rather than focusing on outcomes from a specific service. As previously outlined in section 3.4, the full impact of system reconfiguration is rarely fully realised due to the under-reporting of outcomes across the whole population. The continued dependency on hospital based measures to determine the changes in system performance fails to capture the impacts on those patients who do not, due to multiple possible reasons, engage with the health system. To omit these patients in the consideration of health system performance measurement is a fundamental flaw which can lead to poor decision making. The analysis provided in **Chapter 7** emphatically promotes the possibility of adapting existing methods of analysis to rectify this omission going forward.

Limitations

Due to the complex nature of health system analysis, this thesis is subject to limitations.

Isolating the exact measures of reconfiguration across all aspects of the regional emergency and urgent care systems in Ireland proved to be difficult. Some changes are easily observed, such as when EDs are closed or reconfigured, whereas changes to governance structures are much more difficult to measure or isolate to a specific time point.

The timing of much of the change within the emergency and urgent care system also coincided with the 2008 financial recession. The need to restrict budgetary spending across all departments and areas of government was used as a catalyst to curtail increased spending within the health service [350]. It is difficult, therefore, to untangle what aspects of system change were introduced as cost-saving measures and which were introduced to improve delivery of care. As outlined by the study of drivers and barriers of reconfiguration in Ireland [54], people's beliefs of what motivated changes to their regional systems differed, with both costs and safety identified by different stakeholders as important drivers. While the end result might ultimately be the same, the motivation behind implemented changes makes it more difficult to determine whether those changes have been successful. For example, if the motivation was to reduce costs, this would require a different perspective on what is considered a successful outcome compared to a change that was motivated by improving safety.

Analysis within this thesis has also been conducted at a regional level. This study's main focus was on county of residence, followed by a definition of regions which centred on the 2005 HSE definition of a hospital region. This was decided due to the fact that the majority of emergency and urgent care is delivered in a hospital setting, and the 2005 HSE hospital regions represented the configuration of hospitals at the beginning of the period of study. By primarily using these regions, there is an assumption that all aspects of an intervention for an emergency and urgent care episode will exist within that region. This may not be the reality in all cases.

As outlined by **Chapter 3**, the delivery of primary and community services, as well as the network of hospitals have changed during the period of study. This, in and of itself, is an outcome of reconfiguration [18, 95]. However, by the very nature of this change, there was a lack of consistency in the boundaries of data collected. This has made interrogation of administrative data more difficult. For example, in **Chapter 6**, the ability to track the impact of different factors on 'potentially avoidable' emergency admissions over time was limited by the lack of existing administrative data to support an analysis of the time trends and changes to administrative data boundaries over time. There are issues regarding the usefulness of routinely collected quantitative data and as previously outlined in **Chapter 2** compromises must be made with regard to what can be achieved when relying on data that has primarily been collected for other purposes.

Wolpert and Rutter state in their 2017 study that administrative data-sets contain 'Flawed, Uncertain, Proximate and Sparse' data, the use of which can fall between two extremes - over-interpretation or complete dismissal [351]. They argue that such data should be embraced for its potential to highlight areas worth interrogating, while also recognising that it cannot completely capture the complexity of the system it aims to represent [339, 351].

8.4 Health services research and policy implications

Despite the strengths of the individual studies, we recommend some caution should be adopted in drawing policy implications from the findings. This is due to the fact that the studies are single observational studies of association rather than causality. With this understanding, some recommendations are included in this section based on the three studies as one combined body of research.

From a practical and immediate health services research and policy perspective, the launch of the most recent national health policy report, Sláintecare, makes reference to the need for *"investment in measurement and evaluation of outcomes and impact"* [161, p. 62]. However, there are are no details regarding the measures or indicators the policy intends to adopt. A clear and informed break-down of those indicators which will be measured should be highlighted as soon as possible to ensure changes to the system can be monitored. The Department of Health continues to report indicator measures in the annual *'National Healthcare Quality Reporting System'* reports [47–50]. As highlighted in this thesis, there are limitations associated with these reports, specifically the need to include aspects outside both health services and the health system such as deprivation and geographical context.

From a broader policy perspective, as discussed multiple times within this thesis, health systems are typically large and complex with many interacting components [352]. In many cases, they are too complex to model deterministically due to their unpredictability. In a recent paper published by Greenhalgh et al. the nature of complex adaptive systems is re-iterated, underlying the belief that *"there are no universal solutions to the challenges of complex health systems, nor is there a set of universal methods that will bring us closer to the truth"* [339, p. 2]. Therefore, more research that attempts to account for complexity is required, removing a narrow focus on adherence to strict implementation and considering instead the local context in which change is being introduced. This would require working closely with local stakeholders and recognising the long-term process of implementation, one that is incremental and iterative [353, 354]. There is danger in only listening to what are perceived to be the most powerful inside voices, specifically with regard to how they contribute to constructing a narrative around health system policy. Possible information processing biases can exist, including the tendency to overvalue one piece of information when making a decision ('anchoring') and the tendency to overvalue the opinion of a perceived authority or one's own judgment (authority bias) [355, p. 3].

Given the existence of imperfect evidence, any one stakeholder perspective will be 'framed' by their own goals and aims. 'Framing' results in the interpretation of situations using a narrow lens [355]. To avoid this, multiple perspectives or 'frames' are required in the discussion about configuration of time sensitive care, including those of public representatives, academics, journalists and service providers. The discourse between stakeholders must include consistent criticality, honesty about personal biases and a willingness to engage fully with the evidence, even if it does not correspond with the ‘frame’ with which the stakeholder has approached the conversation. Without considering these approaches to health system reconfiguration, policy solutions may not work, or will result in poor outcomes due to the discordance between the evidence and the reality of the context.

8.5 Future research recommendations

This thesis has approached emergency and urgent care system reconfiguration from a population perspective and has applied a uniform understanding of what reconfiguration represents across these regions. However, future research could isolate individual regions and counties and take into account the specific contextual factors which shaped the implementation of reconfiguration in that region in more detail. Such research could also identify the organisational factors beyond reconfiguration which impacted the implementation of system changes and which may also contribute to outcomes in patient care. This could include a review of the organisational culture, leadership and decision making processes within each region, the HSE and the Department of Health.

It is possible that the full impacts of reconfiguration have still not been identified or measured, therefore continued monitoring of the indicators outlined in this study should be considered.

As the Irish government has now committed to the full implementation of Sláintecare [157], continued monitoring and measurement of changes to the emergency and urgent care system is required to determine how changes from this policy impact on the structures, process and outcomes for emergency and urgent care.

Chapter 6 has identified some of the key drivers of 'potentially avoidable' emergency admissions, which included deprivation, short-term lengths of stay and private health insurance. There is potential for future studies to investigate these findings at a smaller area level, in specific hospitals or over time.

The study outlined in **Chapter 7**, reveals significant improvement in serious emergency conditions. Further research should be conducted to reveal if improvements have continued beyond the end point of that study, 2014.

8.6 Conclusion

Since 2006, the HSE has undertaken varying degrees of changes to regional emergency and urgent care systems, including the reconfiguration of acute hospital services, revisions to underlying governance structures and alterations to GP services, including out of hours services. The extent of these changes has varied across regions. Numerous other policies, clinical programmes, financial restrictions, changes to staff resources and hospital beds have also occurred simultaneously. Some improvements have been seen in outcomes (CFRs) at a national level. However, increases in emergency admissions, emergency attendances and ED trolley numbers, nationally and regionally, indicate that there have not been improvements across all performance indicators. There is also no consistent pattern in the constructed performance indicators across regions which underwent significant system reconfiguration. Therefore, it is not possible to attribute indicator results definitively to reconfiguration measures. As changes to the emergency and urgent care system continue into the future, appropriate population level performance measurement should be implemented and evaluation from a complexity perspective should be adopted.

Appendix A

Appendix: Data sources

The analysis in this thesis was conducted using secondary administrative data. This appendix will outline the data used, and how this data was collected by the relevant organisations.

A.1 Demographics

Ireland's population has been getting progressively older since the 1980's. The most recent census in 2016 found that 37.2% of the population were aged 45 and over, compared with 34.4% in 2011 and 27.6% in 1986. Almost a third of the population, 33.2%, was less than 25 years old, while 29.5% were in the 25-44 age group [356].

In 2016 the national average age was 37.4 years. The average age for rural populations was 2.4 years older than the urban population, an increase of 0.5 years on the 2011 census. Females were on average 1.3 years older than their male counterparts [356].

Population results from census 2016 are available online through the Central Statistics Office (CSO) online database, Statbank Ireland, as part of the 'Summary Results: Part 1'. Data used in the analysis contained in this thesis is available from table *'EY004:*

Population and Actual and Percentage Change 2006 to 2016 by Sex, County and City, CensusYear and Statistic' [357].

A.2 Deprivation

There are many different measures of deprivation in Ireland which could be considered for inclusion in this study's analysis. The construction of these deprivation measures vary in focus, area level and the detail of information.

A.2.1 Central Statistics Office (CSO) unemployment

The CSO national census is conducted every 5 years. Within the census there are questions regarding population characteristics, including socio-economic factors such as unemployment.

The 2016 national survey was conducted in April 2016. A person was considered unemployed if that they were without work for the week before the survey, were available for work within the next two weeks and had been actively looking for work in the preceding four weeks [358]. Once results were compiled, they were subsequently made available online through the CSO online database, Statbank Ireland, as part of the 'Summary Results: Part 2'.

The details of unemployment that have been used within this study are available from table *'EZ005: Rates for Labour Force Participation and Unemployment 2011 to 2016 by Sex, Age Group, County and City, Detailed Marital Status, Census Year and Statistic'* [290]. The available age groups are 15 - 24 years, 25 - 34 years, 35 - 44 years, 45 - 54 years, 55 - 64 years, 65+.

A.2.2 Survey of Income and Living Conditions (SILC)

The Survey of Income and Living Conditions (SILC) is an annual survey that collects information on the income and living conditions of different types of households in Ireland. From this data, indicators on poverty, deprivation and social exclusion are constructed. The survey size is 5,452 households (incorporating 13,793 individuals) [291]. Within the survey, respondents answer a number of questions regarding their ability to buy certain goods and services. The goods of interest include a wide spectrum of items ranging from possession of consumer durables, quality of housing and neighbourhood environment to health status. A score of 2 or more on certain questions considers the respondent to be deprived [359]. Results are then available through the CSO online database, Statbank Ireland, 'Survey of Income and Living Conditions'.

The most recent SILC data included in this study is available from the table *'SIA20: Income and Poverty Rates by Region, statistical indicator and Year'* [294].

A.2.3 Pobal Haase Pratschke (HP) Deprivation Index

The Pobal HP Deprivation Index is constructed from three different dimensions of affluence/disadvantage: demographic profile, social class composition and labour market situation [360].

The constructed 'Demographic Profile' is measured by six indicators:

- the percentage change in population over the previous five years (positive association);
- the percentage of population aged under 15 or over 64 years of age (negative association);

- the percentage of population with a primary school education only (negative association);
- the percentage of population with a third level education (positive association);
- the percentage of households with children aged under 15 years and headed by a single parent (positive association);
- the mean number of persons per room (positive association).

'Social Class Composition' includes five indicators:

- the percentage of population with a primary school education only (negative association);
- the percentage of population with a third level education (positive association);
- the percentage of households headed by professionals or managerial and technical employees, including farmers with 100 acres or more (positive association);
- the percentage of households headed by semi-skilled or unskilled manual workers, including farmers with less than 30 acres (negative association);
- the percentage of households with children aged under 15 years and headed by a single parent (positive association);
- the mean number of persons per room (negative association).

Finally, the 'Labour Market Situation' is measured by three indicators:

- the percentage of households with children aged under 15 years and headed by a single parent (negative association);
- the male unemployment rate (negative association);
- the female unemployment rate (negative association).

Each of the three dimensions is calculated in the same way for each census and then combined to form an Absolute Index Score and Relative Index Score.

The Absolute Index Scores have a mean of zero and a standard deviation of ten in 2006, with varying means and standard deviations in 2011 and 2016 that reflect the underlying trends.

The Relative Index Score is specific to a given census wave, and does not capture trends over time. By removing the national trend from the index scores, this index highlights differences in their relative values. The standard deviation is set to ten for each census, so that the Relative Index Scores provide a standardised measurement of relative affluence and deprivation within each year of interest [360].

A district is considered very affluent with a relative index score of greater than 20, affluent (10 to 19), marginally above average (1 to 9), average (0), marginally below average (-1 to -9), disadvantaged (-10 to -19) and very disadvantaged (greater than -20).

Data included in this study is available online from *'The 2016 Pobal HP Deprivation Index for Small Areas: Dataset for Enumerative Districts/EDs (NUTS5) (Excel)'* [292]

A.2.4 Small Area Health Research Unit (SAHRU) Deprivation Index

A total of five census based indicators, widely believed to represent or be a determinant of material disadvantage, were considered for possible inclusion in the SAHRU Deprivation Index, 2011.

- **Unemployment:** proportion of the economically active population (15-64 year olds) unemployed or seeking a 1st time job;
- **Low social class:** proportion of the population (social classes 1 to 6 only) in social class 5 or 6;

- **No car:** proportion of permanent private households with no car;
- **Rented accommodation:** proportion of permanent private households rented privately or from a local authority, or in the process of being acquired from a local authority;
- **Overcrowding:** the average number of persons per room in permanent private housing units.

Principal components analysis is then adopted to generate a self weighting index with weights derived directly from the data.

The principal components analysis attributed the following weights to each of the five census based indicators, with original indicators standardised: PC1 = 0.50 (Unemployment) + 0.45 (Low social class) + 0.44 (Rented accommodation) + 0.46 (No car) + 0.34 (Overcrowding).

The principal components analysis generates a continuous variable (the deprivation score) which is then standardised (mean 0, standard deviation 1). Finally, for mapping purposes, this score is converted to an ordinal scale or deprivation level of 1 (least deprived) to 5 (most deprived) [293, 361].

A.3 Rurality

Each 5-year national census collects details of the population who live in rural and urban areas. As of 2011, in line with United Nations (UN) criteria, a census town was defined as having a minimum of 50 occupied dwellings, with a maximum distance between any dwelling and building closest to it of 100 metres, and where there was evidence of an urban centre (shop, school, etc.).

An 'aggregated town area' or 'urban area' refers to settlements with a total population of 1,500 or more. Any settlements with a population below this is considered to be an 'aggregated rural area' [358].

Results are then available through the CSO online database, Statbank Ireland, 'Profile 2 - Population Distribution and Movements'.

The data used in this analysis is available online from table *'E2008: Population Percentage in the Aggregate Town Areas and Aggregate Rural Areas 2011 to 2016 by Sex, County and City, Census Year and Statistic'* [362].

A.4 Central statistics office (CSO) mortality

Deaths in Ireland are reported by the CSO. They are compiled from administrative data supplied by the General Registers Office, Gardaí and coroner reports. Access to condition, age and gender specific mortality data is granted once the researcher has applied and been confirmed as an officer of statistics, on approval from the General Registers Office.

The following details, as outlined by the *'Standard Report on Methods and Quality (v1) for Death Registration'* [173] highlight how this data is collected.

A.4.1 Data collection

All deaths occurring in Ireland are legally obliged to be registered, (there are approximately 28,000 deaths annually). Non-registration is rare as a death certificate is required for many legal purposes. However, delays in registration may occur when the cause of death requires an inquest. Currently, only deaths registered in the calendar year they occur, or registered in the next calendar year, are included in the official annual statistics. Each death is geographically coded and given a socio-economic group and social class code. Deaths are classified by the residence of the deceased. The classification is at the level of counties, cities and certain towns [173].

The medical certificate is of the cause of death completed by the attending physician on paper. This information, together with demographic information provided by the next of kin or other qualified informant, is entered electronically at registry offices and forwarded to the General Registers Office. Weekly encrypted excel files are sent from the General Registers Office to the CSO. For unexpected deaths or deaths due to external causes, the cause of death is determined by the coroner, following a post mortem and possibly an inquest. For some deaths, the CSO will send a query letter to the attending doctor, seeking details that will improve the quality of the code. Deaths involving an inquest are all coded manually. The form 104 received from Gardaí concerning a death will help determine the correct code [173].

A.4.2 Cause of death coding

Deaths from 1979 to 2006 were coded according to The World Health Organisation's (WHO) International Classification of Diseases, Version 9 (ICD-9). All deaths registered on or after 1, January 2007 are classified according to ICD-10. ICD-10 codes are continuously being updated to include revisions by the WHO. As cause of death coding strictly follows WHO guidelines, statistics are internationally comparable. These guidelines also ensure comparability over time [173].

'An Underlying Cause of Death Code' is the main form of coding and is determined from the four lines on the medical certificate of the cause of death and through use of the ICD-10 guidelines. For deaths not involving an inquest, the Medical Mortality Data System software package provided by the US National Centre for Health Statistics is used. The Medical Mortality Data System package codes the underlying cause of death in about three-quarters of deaths not involving an inquest, while the remaining one-quarter more complicated cases are coded manually [173].

For some deaths a supplementary cause of death code is given in addition to the underlying cause of death. The most usual use of this is where the underlying cause of death is external (i.e. due to an accident, homicide or suicide), and the supplementary code describes the nature of the injuries sustained by the deceased [173].

A.5 Hospital In-Patient Enquiry (HIPE)

The Hospital In-Patient Enquiry (HIPE) scheme is the principal health information system designed to collect national clinical and administrative data on discharges from, and deaths in, acute hospitals in Ireland. The Healthcare Pricing Office oversees the administration and management of this scheme. This includes the development and support of the data collection and reporting software, training of coders and data quality audit, reporting, and responding to requests for data [363].

A.5.1 Data entry to HIPE

A discharge summary is completed by a physician and the chart is compiled. The administrative data is downloaded from the hospitals patient administration system. Charts are reviewed by HIPE coders and the relevant clinical data is extracted. This data is then entered into the HIPE system. Data is exported monthly to the Health Pricing Office where a national file is created. Central data quality activities are conducted.

Entries to the HIPE system are subject to data checks, audits and coders undergo relevant training to ensure accuracy of their coding. Data is disseminated to the Health Service Executive (HSE) and the Department of Health (DOH) [363].

A.5.2 Condition coding

From January 1, 1990 the clinical modification version of the ninth revision of the International Classification of Diseases, known as ICD-9, was in use in Ireland for coding both diagnoses and procedures within HIPE. Use of this code was maintained until year end 2004. All HIPE discharges from 1st January 2005 to present were coded using ICD-10 [363].

A.5.3 Data available from HIPE

HIPE collects information on in-patient and day patient activity from participating hospitals. A HIPE discharge record is created when a patient is discharged from (or dies in) hospital. This record contains administrative, demographic and clinical information for a discrete episode of care. An episode of care begins at admission to hospital, as a day or inpatient, and ends at discharge from (or death in) that hospital [363].

The data used within this analysis was made available through the Health Atlas Ireland online portal [241]. Access to this was granted after applying to the Health Intelligence Unit of the HSE.

A.6 Private health insurance

A.6.1 Health Insurance Authority

The Health Insurance Authority is an independent statutory regulator of the private health insurance market. The Authority was established in 2001 under the Health Insurance Act.

It's principal functions include:

- monitoring the health insurance market and to advise the Minister for Health (either at his or her request or on its own initiative) on matters relating to health insurance;
- taking action it considers appropriate to increase the awareness of members of the public of their rights as consumers of health insurance and of health insurance services available to them [364].

The Health Insurance Authority also collects market statistics regarding the number of people in Ireland that have private health insurance and the market share of each insurance company, across each of the age categories. Data included in this analysis is available from their website under *'Market Statistics'* [365].

A.6.2 Laya health insurance

Laya health insurance is the second largest provider of private health insurance in Ireland and has over half a million members [366].

Laya have provided a break down of their coverage of different age groups in each county in Ireland directly to this research. From this and the Health Insurance Authority market share statistics it is possible to estimate the total numbers in each county and each age group with private health insurance.

A.7 Institute of Public Health

The Institute of Public Health collects data regarding obesity, chronic conditions, health inequalities and community profiles. It's aim is to promote cooperation for public health between Northern Ireland and the Republic of Ireland and bring about sustained improvements in health and reducing health inequalities. It's main objectives are:

- strengthening public health intelligence;
- building public health capacity;
- policy and programme development and evaluation [367].

Included in this analysis is data regarding the number of general practitioners (GP) per 100,000 people. This measure is constructed from the Primary Care Reimbursement Service (PCRS) GP data in 2011, and based on the population in the census in 2011. The number of GPs relates to those participating in the General Medical Services (GMS) scheme. Also included in the data is 481 GPs not contracted to the GMS scheme who are registered to provide services under the Primary Childhood Immunisation Scheme, the Health (Amendment) 1996 Act, Heartwatch, Methadone Treatment Scheme and the National Cancer Screening Service. The original data is available at Local Health Office (LHO) Area level. This has been converted to administrative county area [368].

A.8 Irish Nurses and Midwives Organisation (INMO)

The Irish Nurses and Midwives Organisation (INMO) collect daily data regarding the number of patients on trolleys in emergency departments and wards in public hospitals in the Republic of Ireland. Trolley Watch, which commenced in late 2004, relates to trolleys in emergency departments. Ward Watch, launched in April 2013, is a count of the number of additional patients on beds, trolleys or chairs, on inpatient wards/units above the stated complement of that ward/unit and provides a picture of whole hospital overcrowding [247]. The number of patients is counted at 8am, Monday-Friday, excluding bank holidays [248].

Included in the analysis of this paper is the weekly count of patient's on trolleys in emergency departments, as measured by the INMO and provided to the Department of Health [248].

A.9 Health Service Executive (HSE)

The HSE's Performance Assurance Reports provide an overall analysis of key performance data from areas such as acute, mental health, social care, primary care, health and wellbeing as well as finance and HR.

These reports are part of the performance assurance process overseen by the National Planning Oversight Group, led by the Deputy Director General on behalf of the Director General. The activity data reported is based on performance activities and Key Performance Indicators (KPIs) outlined in the current National Service Plan. The report is collated by the Planning and Business Information Unit [369].

Data included in this analysis is available from the monthly management data reports which contain service use information including emergency department attendances and emergency presentations per hospital [369]. The Business Information Unit also directly provided details regarding number of annual in-patient beds.

A.10 Primary Care Reimbursement Scheme (PCRS)

The Primary Care Reimbursement Service (PCRS) is part of the HSE, and is responsible for making payments to healthcare professionals including doctors, dentists and pharmacists for providing free or reduced cost services to the public [370].

In addition to this role, the PCRS compiles statistics and trend analyses which are provided to other areas within the HSE, the government, customers, stakeholders and to members of the public [370].

Much of this data is available from the *'PCRS Annual Reports: Statistical Analysis of Claims and Payments'*. These annual reports contain information on the drug payments and statistical data by community healthcare organisation (CHO) area (2015-2016) or local health office (LHO) area (2011-2014) and HSE region (2005-2010).

Data from the PCRS included in this analysis relates to the general medical services (GMS) card eligibility for each of the regional populations. This data is available for each year within the relevant annual reports [295].

Appendix B

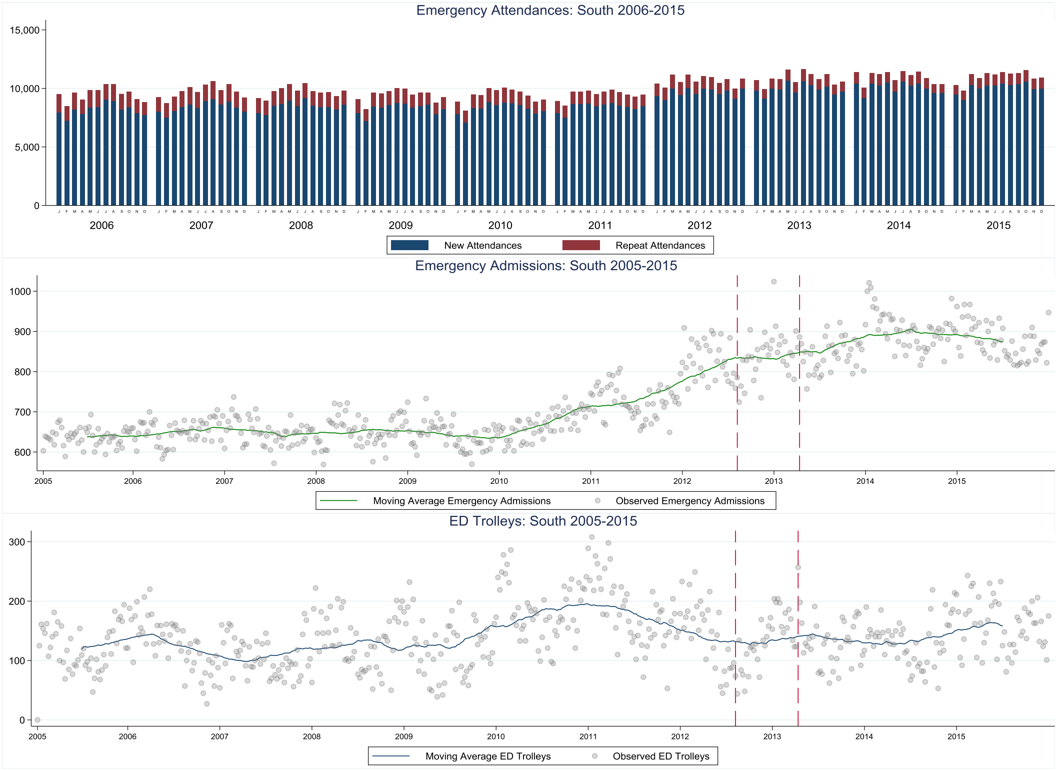
Appendix: Chapter 5 supplementary material

FIGURE B.1: Emergency attendances, emergency admissions and emergency department trolleys 2005/2006 - 2015

The West

The North-East

The South



The Mid-West

Appendix C

Appendix: Chapter 6 supplementary material

Table C.1: Construction of a priori factors

Block 1: Population factors			
Deprivation			
Years	**Factor Name**	**Geographical level**	**Source**
2016	Unemployment	County	Central Statistics Office
Percentage of population unemployed • **Indicator numerator:** Table EZ005: Rates for Labour Force Participation and Unemployment 2011 to 2016 by Sex, Age Group, County and City, Detailed Marital Status, Census Year and Statistic. • **Indicator denominator:** County population based on CSO 2011 and 2016 census population. • Unemployment rate by age group 15 - 24 years, 25 - 34 years, 35 - 44 years, 45 - 54 years, 55 - 64 years, 65+. Average unemployment calculated for 20-44. Assumed that 0-19 close to or equal to 0. Assumed that 65+ related to those aged between 65 and 74, and that 75+ equalled 0. 2016 figures were applied across all 3 years, 2014, 2015 and 2016.			
Years	**Factor Name**	**Geographical level**	**Source**
2014, 2015, 2016	SILC Deprivation	Area: NUTS 2 region	Central Statistics Office
The Survey of Income and Living Conditions • **Indicator numerator:** SIA20: Income and Poverty Rates by NUTS2 Region, statistical indicator and Year. • **Indicator denominator:** County population based on CSO 2011 and 2016 census population. • Deprivation rate is based on the SILC (Survey of Income and Living Conditions) which asks a certain number of questions regarding ability to buy goods and services. The set of deprivation questions posed covered a wide spectrum of items ranging from possession of consumer durables, quality of housing and neighbourhood environment to health status. A score of 2 or more on certain questions considers the respondent to be deprived. Rates were applied to counties nested in the NUTS 2 region.			
Years	**Factor Name**	**Geographical level**	**Source**
2016	HP Deprivation	Electoral Districts	Trutz Haase/ Pobal
The Pobal HP Deprivation Index • The Pobal HP deprivation rate is based Demographic Profile (including percentage with third level education, population under 15 and over 64 etc.), Social Class Composition (including percentage of households headed by professional, managerial, semi-skilled workers) and Labour Market Situation (including unemployment rate).			

• A district is considered very affluent with an index score of greater than 20, affluent (10 to 19), marginally above average (1 to 9), average (0), marginally below average (-1 to -9), disadvantaged (-10 to -19) and very disadvantaged (greater than -20). • The percent of the population who lived in below average electoral districts within each county was included in the model. Results were available for 2016 only; therefore the same value was entered into the model for each year.			
Years	**Factor Name**	**Geographical level**	**Source**
2011	SAHRU Deprivation	Electoral Districts	SAHRU Trinity College Dublin
The Small Areas Health Research Unit Deprivation Index • Principal components analysis generates a self- weighting index with weights derived directly from the data and the 1st PC constitutes the index: • The 1st Principal Component (PC) was computed as follows (with original indicators standardised): • PC1 = 0.50 (Unemployment) + 0.45 (Low social class) + 0.44 (Rented accommodation) + 0.46 (No car) + 0.34 (Overcrowding) • The index allowed the population to be grouped into quintiles of population. • The percentage of the county population living in electoral districts in the bottom lowest quintile was included in the model. Results were available for 2011 only; therefore the same value was entered into the model for each year.			
Geography			
Years	**Factor Name**	**Geographical level**	**Source**
2016	Rurality	County	Central Statistics Office
Percentage of the population living in rural areas • **Indicator numerator:** Total number in county living in a rural area. • **Indicator denominator:** County population based on CSO 2016 census population.			

<table>
<tr><td colspan="4">Block 2: Health system factors</td></tr>
<tr><td colspan="4">Hospital</td></tr>
<tr><td>Years</td><td>Factor Name</td><td>Geographical level</td><td>Source</td></tr>
<tr><td>2014, 2015, 2016</td><td>Conversion rate</td><td>County</td><td>Hospital In-Patient Enquiry (HIPE) &
Health Service Executive (HSE)</td></tr>
<tr><td colspan="4">Conversion rate of emergency presentations to admissions at hospital, weighted by the probability of a person from each county being admitted to that hospital.
• Indicator numerator: All emergency presentations for each year 2014, 2015 and 2016, by each hospital.
• Indicator denominator: All emergency admissions for each year 2014, 2015 and 2016, by each hospital.
• Constructed the ratio of emergency admissions to emergency presentations for each hospital.
• Construction of probability weighting:
• All emergency admissions data to each hospital, by county of residence, is taken from HIPE for each year. This allows the calculation of the probability of a patient from each county being admitted to that hospital i.e. what percentage of all emergency admissions from Kerry are at Cork University Hospital. This probability is then multiplied by the constructed conversion ratio for each hospital to get a weighted probability of people being admitted to hospital based on their county of residence.</td></tr>
<tr><td>Years</td><td>Factor Name</td><td>Geographical level</td><td>Source</td></tr>
<tr><td>2014, 2015, 2016</td><td>LOS of one day</td><td>County</td><td>Hospital In-Patient Enquiry (HIPE)</td></tr>
<tr><td colspan="4">Percentage of emergency admissions with a length of stay of one day, by county of residence
• Indicator numerator: All emergency admissions with a length of stay of 1 day only for each year 2014, 2015 and 2016, by county of residence were downloaded from HIPE.
• Indicator denominator: All emergency admissions for each year 2014, 2015 and 2016, by county of residence from HIPE.
• Constructed rate of admissions with a length of stay of 1 day from all emergency admissions for all counties.</td></tr>
</table>

<table>
<tr><td colspan="4">Primary Care</td></tr>
<tr><td>Years</td><td>Factor Name</td><td>Geographical level</td><td>Source</td></tr>
<tr><td>2011</td><td>GPs</td><td>County</td><td>IPH</td></tr>
<tr><td colspan="4">Number of general practitioners (GPs) per 100,000.
• Indicator numerator: Number of general practitioners participating in the General Medical Services scheme
• Indicator denominator: Census 2011 population as per the CSO.
• The original data is available at Local Health Office (LHO) Area level. This has been converted to administrative county area.</td></tr>
<tr><td colspan="4">Funding of health care</td></tr>
<tr><td>Years</td><td>Factor Name</td><td>Geographical level</td><td>Source</td></tr>
<tr><td>2014, 2015, 2016</td><td>GMS</td><td>County</td><td>Primary Care Reimbursement Scheme (PCRS)</td></tr>
<tr><td colspan="4">Percentage of the population eligible for the general medical services (GMS) card.
• Indicator numerator: The Primary Care Reimbursement Scheme (PCRS) reports the number of people eligible for a general medical services (GMS) card by Local Health Office (LHO) in 2014 and by Community Health Office (CHO) in 2015/2016.
• There is some overlap of counties within LHOs and CHOS e.g. Kildare/Wicklow. Where areas overlap, counties are grouped and the percentage eligibility is taken to be consistent across those counties.
• Indicator denominator: County population based on CSO 2011 and 2016 census population.</td></tr>
<tr><td>Years</td><td>Factor Name</td><td>Geographical level</td><td>Source</td></tr>
<tr><td>2015</td><td>Private health insurance</td><td>County</td><td>Laya Health Insurance & Health Insurance Authority (HIA)</td></tr>
<tr><td colspan="4">Percentage of the population with private health insurance
• Indicator numerator: The market distribution by age groups 0-49, 50-59, 60-69, 70-79, 80+ for each county were provided by Laya for 2015.
• The total number of people insured nationally was available from the Health Insurance Authority (HIA) for 2015.</td></tr>
</table>

- Applied the 25.6% coverage that Laya has at a national level to give a total insured number of 509,919 (1.9million X 25.6%) in 2015 for Laya. Setting this as 100% of the Laya's market share and using the county distribution provided by Laya, the total numbers by each county were estimated for Laya.
- Then using the percentage market share that Laya has in each age group as per HIA, assuming it is consistent across all counties, estimated the total coverage rates, regardless of insurance company in each county and age bracket.
- The age groups were then redistributed to match the existing study groups, 0-19, 20-44, 45-54, 55-64, 65-74, 75+.
- **Indicator denominator**: County population estimate in 2015, based on CSO 2011 and 2016 census population.

Appendix D

Appendix: List of papers and research dissemination

PEER RELATED PUBLICATIONS

- Lynch, B., Fitzgerald, A. P., Corcoran, P., Healy, O., Buckley, C., Foley, C., Browne, J. (2018). 'Case fatality ratios for serious emergency conditions in the Republic of Ireland: a longitudinal investigation of trends over the period 2002–2014 using joinpoint analysis.' *BMC Health Services Research*, 18(1), 474.
- Lynch, B., Fitzgerald, A. P., Corcoran, P., Buckley, C., Healy, O., Browne, J. (2018). 'Drivers of potentially avoidable emergency admissions in Ireland: an ecological analysis.' *BMJ Quality and Safety*, bmjqs-2018.

OTHER PEER PUBLICATIONS

- Griffin, E., Murphy, C., Perry, I. J., Lynch, B., Arensman, E., Corcoran, P. (2018). 'Acute hospital reconfiguration and self-harm presentations: a before-and-after study.' *Irish Journal of Medical Science* (1971-), 1-4.

POSTER PRESENTATIONS

- *2015 - Society of Social Medicine Conference, Dublin, September 2015:* Regional variation in in-hospital fatality from emergency conditions 2007-2012 in Ireland
- *2015 - Irish Association of Emergency Medicine Conference, Cork, October 2016:* Regional variation in in-hospital fatality from emergency conditions in Ireland, 2007-2012
- *2016 - SPHeRE Conference, Dublin, January 2016:* Case fatality ratios for emergency conditions: regional variation in Ireland, 2002-2012
- *2016 - Society of Social Medicine Conference, York, September 2016:* Population mortality rates, case fatality ratios and the reconfiguration of services: regional and longitudinal variation in Ireland, 2002-2012
- *2017 - Society of Social Medicine Conference, Manchester, September 2017:* Avoidable emergency admissions in the Republic of Ireland: analysis of regional determinants, 2014-2016
- *2018 - SPHeRE Conference, Dublin, February 2018:* Avoidable emergency admissions for ambulatory care sensitive conditions in the Republic of Ireland: analysis of regional determinants, 2014-2016

ORAL PRESENTATIONS

- *2016 - National Health Services Research Institute Conference, Cork, November 2016:* Diminishing improvements in outcome indicators for emergency conditions in national and regional systems of care

- *2017 - SPHeRE Conference, Dublin, January 2017:* Diminishing improvements in outcome indicators for emergency conditions in national and regional systems of care
- *2018 - International Conference of Integrated Care, Utrecht, May 2018:* Avoidable emergency admissions in for ambulatory care sensitive conditions in the Republic of Ireland: analysis of regional determinants

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