EVALUATION OF A POPULATION-BASED INTEGRATED CARE MODEL: A CASE STUDY FROM THE LONDON BOROUGH OF HILLINGDON

A thesis submitted for the degree of Doctor of Philosophy

By

Mohammad Hussein Housam Mansour

Department of Health Sciences

Division of Global Public Health

Brunel University

Nov 2023

1 ABSTRACT

Integrated care models (ICMs) are becoming more popular in addressing healthcare concerns because they improve coordination and continuity of care, promote self-management and preventative treatment, and place a premium on personalization of care. These models bring together various healthcare providers to collaborate in a coordinated manner, reducing fragmentation in traditional healthcare delivery models and leading to improved health outcomes and lower healthcare costs. ICMs put the patient at the centre of care, increasing satisfaction and quality of life. Despite earlier research and synthesis attempts to evaluate ICMs, evidence on how successfully the new integrated care models, including those with population-based approaches, may achieve their intended benefits remains limited, especially in contexts like England. This thesis aimed to add to our understanding of the effectiveness and evaluation of ICMs by taking the London borough of Hillingdon, in England, as a case study. The thesis used sophisticated statistical analyses, including interrupted time series, to understand and evaluate effectiveness. The evaluation of the population-based ICM in Hillingdon revealed promising results in terms of reducing non-elective hospital admissions, A&E visits, and hospital stay length. The study also found predictors of Hillingdon hospital activity, such as GP practices, LTCs, and demographics. These predictors can help in stratifying populations based on their risk of requiring hospitalisation, lowering expenses, and putting less strain on health-care systems. The study, however, had limitations, and the findings should be regarded with caution. Further research is required to assess the impact of ICMs on other outcomes, such as condition-related knowledge, and to undertake a process evaluation of the facilitators and barriers to effectiveness and implementation. Despite its limitations, this study is an invaluable resource for health professionals, commissioners, and policymakers in England looking for the most recent evidence synthesis relevant to their context.

2 CONTENTS

3 List of Figures

Appendices Figs:

4 LIST OF TABLES

Appendices Tables:

5 List of Abbreviations:

Integrated Care: IC

Integrated care models: ICMs

World health organisation: WHO

Long-term conditions: LTCs

National Health Service: NHS

Self-management: SM

Case management: CM

Discharge management: DM

Multidisciplinary teams: MDT

Chronic care model: CCM

Complex interventions: CI

General Practitioner: GP

Health Care Professionals: HCPs

Severe acute respiratory syndrome coronavirus two: SARS-CoV-2

Coronavirus inflammatory disease 2019: COVID-19

ITS: Interrupted Time Series

Accident and Emergency: A&E

Non-Elective: NEL

LoS: Length of Stay

The zero-inflated multiple Poisson: ZIMP

Primary Care Network: PCN

Multispecialty Community Providers: MCPs

Primary and Acute Care Systems: PACs

Acute Care Collaborations: ACCs

Clinical Commissioning Groups: CCGs

Hillingdon Health and Care Partners: HCPP

Interrupted Time Series: ITS

National Institute for Health and Care Excellence: NICE

6 ACKNOWLEDGEMENTS

The Almighty God deserves special appreciation and praise for leading me through this journey.

I would like to use this opportunity to convey my heartfelt gratitude to everyone who has helped me along the way with my studies. First and foremost, I would like to express my gratitude to my parents and family for their constant love, encouragement, and support throughout my academic endeavors. I would not have been able to reach this milestone without their help.

I am also grateful to my wonderful fiancée for always being a source of inspiration, motivation, and emotional support. Their unflinching faith in me kept me going when times were rough, and I will be eternally grateful for their presence in my life.

I am very grateful to Mr Ali Bakri for his tremendous financial assistance as well as his crucial emotional guidance and mentorship during my research journey. His constant faith in me and dedication to my development have been critical in assisting me in reaching this milestone.

I would also like to thank my supervisors, Prof Subhash Pokhrel and Prof Nana Anokye, for their insightful input, guidance, and encouragement during my project. Their recommendations and insights were vital in developing research diligence and accomplishing the required outcomes.

Lastly, I want to express my heartfelt gratitude to the panel, particularly my RDA, Dr Terry Dovely, for providing insightful feedback and constructive criticism throughout my research. Their comments have assisted me in improving my work and making it more meaningful.

I want to thank everyone who has contributed to my achievement in any manner, and I look forward to continuing my academic career with the help of such wonderful people.

7 CHAPTER 1: INTRODUCTION

7.1 BACKGROUND

Long-term conditions (LTCs) and multiple long-term conditions (MLTCs) have been fundamental challenges worldwide due to the high disease and disability burden and high cost of healthcare. According to a World Health Organization (WHO) estimate, over 157 million individuals worldwide are severely disabled because of LTCs, such as diabetes, cancer, and heart disease (WHO, 2018, WHO, 2019). These conditions account for a major share of worldwide mortality and morbidity and are expected to become even more frequent in the coming years as the population ages and obesity and sedentary lifestyles rise. Such conditions are thought to account for over 60% of all fatalities globally (WHO, 2019).

In England, the National Health Service (NHS) faces significant challenges in providing healthcare for patients with LTCs. According to a report by the King's Fund, a prominent health policy think tank in the UK, LTCs account for 70% of NHS spending, and the number of people living with multiple long-term conditions is projected to increase by 34% over the next 15 years (The King's Fund, 2018). Patients with LTCs/MLTCs frequently have complicated healthcare needs that necessitate coordination among numerous healthcare providers. Besides, patients with LTCs often experience fragmented care and require access to multiple health and social care settings (Ham, Dixon and Brooke, 2012). Hence, providing such patients with the necessary care is difficult for health providers.

In its five years forward view, the NHS acknowledged the existence of these fundamental challenges in 2014 and presented a justification for the difficulty in addressing them (NHS., 2014). This justification emphasises how patients with LTCs/MLTCs' needs and care change with time. Besides, this five years forward view report also specified the areas where these challenges and pressures lay (NHS., 2014). First, LTCs, rather than diseases with a one-time cure, account for 70% of the healthcare budget. Simultaneously, many (but not all) patients would want to be more educated and active in their treatment, questioning the traditional divide between patients and providers and the opportunities for improved health through increased prevention and assisted self-care. Second, treatments, technology, and how care is delivered have changed and are still evolving. Technological advancements transform the NHS's capacity to anticipate, diagnose, and manage diseases. New therapies will be available soon; more therapies or treatments mean more patient needs.

Along with the challenges highlighted earlier, for example, the increase in the ageing population, these justifications can be proposed as important factors associated with forming arbitrary barriers between hospitals, primary care and social care, and between generalists and specialists within the NHS. These barriers can keep care away from individuals who need it, resulting in care fragmentation, such as delays in receiving care. Furthermore, the lack of coordination and continuity of care between primary and secondary care is an example of such barriers. People with LTCs/MLTCs tend to have frequent hospital admissions and visits to GPs. Yet, there is often a lack of shared information and continuity of care between these different settings, leading to poor health outcomes and wasted resources (Ouwens et al., 2005; Ham, Dixon and Brooke, 2012; Martínez-González et al., 2014; Damery, Flanagan and Combes, 2016; Brunner-La Rocca et al., 2016.

Moreover, there is a lack of emphasis on self-management and preventative care for LTCs (The King's Fund, 2018). While the NHS is geared towards treating acute illnesses, it has not been able to effectively support patients with LTCs in managing their conditions on a daily basis and preventing exacerbations. This and the lack of coordination between different health settings lead to higher utilization of healthcare services and poor health outcomes. For example, over the last 12 years before 2018, the number of emergency admissions in England has increased by 42%, from 4.25 million in 2006/2007 to 6.02 million in 2017/2018 (NHS, 2021). According to the Office for National Statistics, this growth in emergency admissions was higher than the population growth at 9% in the United Kingdom (UK) over the same period (ONS, 2017). Also, a 13% growth in Accident and Emergency (A&E) visits was observed in this period. With this in mind, 29% of those patients were admitted to the hospital from A&E in 2017/2018 compared to 22% in 2006/2007 (NHS, 2021). According to NHS England, emergency admissions and A&E visits continued to rise over 2018/2019 (NHS,2021). In this connection, this, along with all the barriers, challenges, and pressures highlighted earlier, form a primary driver for change in how healthcare should be delivered.

7.1.1 Integrated Care as a new model of healthcare

Integrated care models (ICMs) became the cornerstone of the policy response worldwide and in England (NHS, 2020, Charles, 2021). Several reasons explain why ICMs are gaining popularity as a way to address challenges in healthcare—first, improved coordination and continuity of care. ICMs bring together different healthcare providers, such as primary care physicians, specialists, and community-based services, to work together in a coordinated way to meet the needs of patients with long-term conditions. This is all related to how ICMs are built and the type of interventions they include (See Appendix A for details). This could improve the continuity of care and reduce fragmentation in traditional healthcare delivery models.

Second, better health outcomes. ICMs have been shown to improve health outcomes for patients with long-term conditions by promoting self-management and preventative care (Martínez-González et al., 2014; Baxter et al., 2018). They also could reduce hospital admissions and emergency department visits, reducing healthcare costs (Damery, Flanagan and Combes, 2016).

Finally, personalisation of care. ICMs put the patient at the centre of care, focusing on their needs, preferences, and goals. This leads to improved patient satisfaction and outcomes (Culter, 2018), including quality of life (Flanagan, Damery and Combes, 2017).

7.1.2 Evaluation and Effectiveness of ICMs

Driven by the main aims of ICMs in addressing the challenges highlighted earlier, there have been attempts to evaluate IC pilots suggesting potential effectiveness (Lewis et al., 2010; Goodwin et al., 2013). However, the evidence supporting a fuller understanding of the scale and mechanisms of IC effectiveness is scanty (Wistow et al., 2015) despite the existence of several randomised control trials (RCTs) evaluating the effectiveness of IC interventions (Martínez-González et al., 2014; Baxter et al., 2018). Previous evidence synthesis attempts include systematic reviews and meta-analyses summarising the results of different studies (Ouwens et al., 2005; Martínez-González et al., 2014; Damery, Flanagan and Combes, 2016; Flanagan, Damery and Combes, 2017). Despite this, evidence remains scarce on how effectively the new models of IC interventions can deliver their expected benefits (Brunner-La Rocca et al., 2016). Moreover, it is unclear whether population-based ICMs could be better options than condition-specific interventions and to what extent these models can reduce pressure on health services, including hospital utilization.

In addition to the above, ICMs can be different in delivering their expected benefits when it comes to context. In other words, if evidence of effectiveness is present globally, it cannot be generalisable in other contexts, such as England. Moreover, it is unclear what type/form of integration/model can be effective in the context of the NHS healthcare system. Hence, evaluating and monitoring ICMs is vital in answering those questions. In other words, the systematic evaluation and monitoring process of ICMs is crucial in understanding whether they are delivering their expected benefits and whether those can be generalised in similar contexts.

7.1.3 The Hillingdon Case

Hillingdon, like many other localities in England and London, presents substantial issues in providing healthcare to its residents. To establish a stronger link between integrated care and Hillingdon, it is necessary to explain how the Hillingdon healthcare landscape influences the development and implementation of the Integrated Care Model (ICM).

Hillingdon's particular healthcare situation informs the demand for innovative healthcare solutions considerably. Hillingdon has a rapidly ageing population, with 13.3% of its citizens over 65 years old, according to the most recent data from the Office for National Statistics (ONS) in England. This cohort is expected to grow by 19% by 2024, adding to the difficulty of managing long-term health concerns (ONS, 2020).

Furthermore, Hillingdon has a greater prevalence of several Long-Term Conditions (LTCs) than the rest of London. For example, the prevalence of hypertension and diabetes in Hillingdon, in 2018 remained much higher, with rates of 12.52% and 7.43%, respectively, which were approximately 2.50% and 1% higher than the London average (BPTRS, 2019). A substantial proportion of Hillingdon's population, over 34,000 people (15%), are affected by life-limiting or chronic illnesses, and nevertheless, a mere 6417 people account for 50% of all emergency hospital admissions (HCPP, 2018).

Additionally, discussions with Hillingdon Health and Care Partners (HCPP) stakeholders found that at least 21% of these admissions may have been avoided with better ambulatory care management. According to this data, the rate of unplanned hospital admissions for adults with chronic ambulatory care-sensitive conditions in Hillingdon exceeds the national average and is 46% higher than in the best-performing Clinical Commission Groups (CCGs) in the country. These people also had a higher rate of A&E visits (Blunt, 2014) and longer hospital stays (Baek et al., 2018).

Given the healthcare challenges faced by Hillingdon, the former Hillingdon CCG, now part of the North West London (NWL) CCG, in collaboration with Hillingdon Health and Care Partners (HCCP), introduced a tailored Integrated Care Model (ICM). This initiative was driven by the pressing need to reduce hospital activity, mitigate care fragmentation, and ultimately enhance patient satisfaction overtime.

The Extended Kaiser Pyramid, a population-based Integrated Care strategy, serves as the model's foundation. The Extended Kaiser Pyramid takes into account Hillingdon's special healthcare demands, notably individuals with multiple Long-Term and Complex Conditions (MLTCs). Appendix A has a complete description of the specifics of this novel method, including numerous interventions and strategies.

In essence, the Hillingdon ICM seeks to address the specific healthcare challenges posed by the demographic and healthcare characteristics of Hillingdon, aiming to improve the overall health and well-being of its residents while optimizing healthcare resource utilization. Furthermore, the model recognizes the importance of addressing MLTCs and provides a framework for delivering more efficient and patient-centered care to this vulnerable population. This is related to the fact that ICMs in line with the "The Extended Kaiser Pyramid" approach has been thoughtfully designed to accommodate the intricacies of populations' healthcare landscape by including key components highlighted earlier in paragraph 7.1.1. Those include improved coordination and continuity of care, better health outcomes, and personalization. Now the questions remain on how these concepts interact to address challenges in caring for populations with MLTCs which will be discussed in detail in chapter 2.

7.2 Aims and Objectives of the Thesis

Case studies are an excellent way to bridge knowledge gaps in public health intervention evaluations because they allow for an in-depth examination of the implementation and impact of a given intervention in a real-world situation (Merriam, 1998). This can provide valuable insights into the factors contributing to an intervention's success or failure and the problems and hurdles that must be overcome to attain desired results. Case studies can also highlight the unique environment (e.g., social) in which an intervention is conducted/implemented, which can aid in creating and implementing similar interventions in other settings. Despite its advantages and aiding in assessing interventions in different contexts, case studies and their focus on a single example (Hillingdon) can make it difficult to generalise the findings to other contexts or populations (Merriam, 1998). Moreover, the case study approach may limit the broader knowledge of the intervention's success by focusing primarily on a single aspect, such as the outcomes for a particular population (Merriam, 1998). As a result, interpreting their findings should be regarded cautiously, especially in generalisability.

In line with the challenges that the NHS is facing in caring for patients with one or more LTCs, and the importance of evaluating ICMs, this thesis aims to provide an initial impact evaluation for the commissioners and policymakers to study the effect of population-based ICMs and understand if they can achieve their initial goals.

7.2.1 Objectives

- Deliver a clear and comprehensive overview of available evidence from the global context on the effectiveness of different IC interventions
- Assess the effectiveness of the Hillingdon ICM in reducing non-elective Admissions, Length of stay (LoS) at the hospital, and accident and emergency (A&E) visits.
- Evaluate the potential impact of COVID-19 lockdown on hospital activity and, if any, validate previous effectiveness evaluations.
- Identify potential predictors of hospital activity in Hillingdon to validate:
    a. Potential confounding factors that were taken into consideration in previous evaluations.
    b. Aid in future evaluations and implementation of ICMs/interventions in Hillingdon and design of risk stratification tools.
- To discuss the implications for other ICMs of the findings on Hillingdon ICM.

7.3 Thesis Outline

This thesis aims to give an initial impact evaluation for commissioners and policymakers to analyze the effect of population-based ICMs and determine whether they can meet their initial goals. Fig 1 shows an outline for the research presented in the thesis, which comprises the primary research questions each study is based on. This project was a novel attempt to evaluate a new model of care introduced in the last five years in England and, more recently, in Hillingdon. Evaluating ICMs in England has faced several challenges, especially from the commissioner's perspective (Kumpunen et al., 2019). It was argued that more realistic timeframes and an openness to diverse methods and approaches, including more formative evaluation, are required (Kumpunen et al., 2019).

Regarding population-based ICMs, it is widely known that rapid evaluations are frequently required to discover "quick successes" and accelerate learning within health and social care systems (McCarthy et al., 2019). The NHS's evaluation strategy for the new models of care, including the most recent vanguard program (Morciano et al., 2020), included rapid evaluations. Accordingly, when we speak about a formative evaluation, there should be an estimation of outcomes in the short and long term. That being said, the first method that comes to mind that could capture those changes in outcomes is interrupted time series (ITS) rather than experimental studies, which are not feasible in the context of such approaches. ITS is the most robust quasi-experimental approach for evaluating the longitudinal effects of interventions (Wagner et al., 2002).

Given the highlighted points, this study adopts an ITS design to evaluate the impact of the Hillingdon ICM. A second objective within the study in relation to the first aim is to evaluate the model in the short term and give indications on its long-term effects to try to overcome the limitation highlighted by McCarthy et al. Two datasets with different data points were acquired. The limitations can be applied to the first dataset and the initial analysis; however, the second dataset included more data points and a control group. This is thought to give a more accurate estimation in the long term and confirm the possibility of short-term effects if similar estimations were obtained.

Nevertheless, regardless of the highlighted limitations, the segmented ITS still has a predictive power to estimate long-term effects. Consequently, this study could provide a systematic method to study the effect of population-based ICMs and understand if they achieved their initial goals. Furthermore, the study could serve as an initial impact evaluation model to capture the short-term and intermediate outcomes and better indicate such models' long-term effects. Such indications could be achieved by comparing those models to other contexts.

The emergence of the COVID-19 pandemic and the implementation of the lockdown could have changed hospital activity in Hillingdon regardless of any effects of any intervention. That being said, in addition to the stage two analysis, the last objective concerning the first aim of this study was to assess the impact of COVID-19 lockdown on the intervention impact. In other words, this analysis tried to validate the analysis highlighted earlier.

The last objective of this thesis was to provide the commissioners and policymakers with a predication analysis that can aid in developing a simple risk segmentation criterion for the Hillingdon CCG commissioners. In line with what was highlighted above, this analysis was conducted to add how population-based models could be more effective in achieving better outcomes. Nevertheless, designing a risk segmentation criterion could specify the populations with higher risks of need to be targeted with specific interventions as a part of a whole model. This analysis can open a door for future evaluations of such models with the possibility of conducting cluster analysis. Such cluster analysis can identify what part of the models target what populations.

Consequently, this might aid in further developing and enhancing population-based ICMs. Furthermore, this analysis can show the extent to which time-varying confounders on any analysis that aims to capture an evaluation of an ICM. This can also validate the effect of such factors that were considered in the first analysis. Those can include sociodemographic factors such as gender.

Currently, the QAdmission tool is being used in Hillingdon (Hippisley-Cox and Coupland, 2013). The tool uses an algorithm to predict hospital emergency admissions via a Cox regression analysis. The variables used for prediction include demographics (age, gender, postcode, ethnicity) and information on lifestyle (e.g., smoking status), medical conditions (e.g., Asthma), blood tests (e.g., Hemoglobin), Drugs (e.g., anticoagulants), and BMI. The model calculates the risk of admission as a score that could be converted into a percentage. However, the tool only predicts unplanned hospital admissions risk; thus, the tool might miss some critical groups in population-based models. This is related to the fact that admissions alone could only identify specific risk groups in terms of admissions related to the tool's predictors. Nevertheless, predicting the risk of A&E visits besides LoS at the hospital and non- elective hospital admissions might provide a more straightforward and more effective risk stratification in a general population. This is related to the fact that individuals who visit the A&E could be assigned to different risk groups, including those with the lowest needs.

Moreover, it is still likely for this tool to over -or- underestimate risk stratification concerning care needs as it uses hospital admissions as the only outcome. Although population-based ICMs focus on groups with the highest needs, the model also targets the entire population and aims to reduce outcomes other than non-elective hospital admissions. Second, in the final risk score, precise information on the characteristics of high-risk individuals, such as age, morbidities, and ethnic background, may be lost. All patients in the top stratum have high-risk scores. However, the factors contributing to this high score can vary greatly. These should be considered while implementing and designing interventions to determine which patients are most likely to respond. Accordingly, the study used available data on demographics and LTCs to predict the risk of three hospital activity outcomes, including NEL admission, A&E visits, and LoS at the hospital. With this in mind, once predictors are identified, a simple criterion can be developed, and this could serve as a platform for future population-based integrated care model expansions and developments, including the ones implemented in the context of England.

Fig 1: Thesis Outline

Chapter 1: Introduction

- Why LTCs and MLTCs have been significant challenges, globally and in England?
- Why has the NHS been unable to address these challenges?
- Integrated Care (IC) as a new model of healthcare?
- Introducing the Hillingdon Case

Aims and Objectives of the Thesis

Thesis Outline

Chapter 2: Reviewing Evidence

Research Questions

- Is IC effective in improving patient care and reducing hospital activity?
- Does combining multiple ICC interventions produce better outcomes?
- What outcomes can be used to predict effectiveness?

Knowledge Gap

Chapter 4: Effects of the Hillingdon ICM on Hospital Activity

Research Questions

- Is the Hillingdon ICM effective in reducing hospital admissions, LoS at the hospital, and A&E visits in the short term?
- Can the Hillingdon ICM, as a multi-component, be more effective than controls (Model with fewer components)?
- Can the Hillingdon ICM produce effects in the long term?

Chapter 5: Evaluating the Impact of COVID-19 lockdown on Hospital Activity

Research Questions

- Did the emergence of COVID-19 pandemic have an impact on the preceding analyses' findings?

Chapter 6: Predictors of Hospital Activity in Hillingdon

Research Questions

- What are the demographic and condition-specific predictors of hospital activity in Hillingdon?

Chapter 7: Discussions and Conclusions

- What are the implications of the findings in this thesis (Hillingdon ICM evaluation) on other contexts and ICMs?
- What does this thesis add?
- What are the limitations of this thesis?

7.3.1 Summary

While chapter 1 highlighted the rationale behind conducting this research besides its aims and objectives, chapter 2 presents a systematic review of published reviews and meta-analyses to comprehensively examine the outcomes and effectiveness of four primary IC interventions: Case management (CM), Multidisciplinary teams (MDT), Self-management (SM), Discharge management (DM), or any construct combining any of these interventions (Complex interventions or CI). On the other hand, chapter 3 highlights the thesis outline.

Chapter 4 presented the impact evaluation of the Hillingdon ICM in two stages. While stage 1 presented the short-term evaluation, stage 2 introduced a secondary analysis with more data points and included a control group. Advanced statistical analyses were carried out using a quasi-experimental design (ITS). Advanced segmented ITS regression models were used to check for trends before and after implementing the Hillingdon ICM. Chapter 5 considered some limitations in the initial analysis and increased the accuracy and power of the study by comparing the Hillingdon ICM to the partly implemented ICM in Ealing. In chapter 5, the impact of COVID-19 lockdown measures on hospital activity in both treatment and control groups were evaluated to validate the findings of chapter 4.

In chapter 6, advanced regression modelling was carried out to predict the risk of three outcomes related to hospital activity: non-elective hospital admissions, LoS at the hospital, and A&E visits. Demographics, LTC, and GP practice predicted the risk.

Finally, chapter 7 summarises the thesis, examines its limitations and methodological and conceptual contributions, and highlights topics for further research and policy implications before the conclusion.

8 CHAPTER 2: SYSTEMATIC REVIEW OF REVIEWS TO ASSESS THE EFFECTIVENESS OF IC INTERVENTIONS TARGETING PATIENTS WITH LTCS

8.1 INTRODUCTION

Achieving a fuller understanding of the effectiveness of ICMs is crucial before implementing and evaluating such models in different contexts. Moreover, it is essential to understand what type of interventions shape the design of ICMs. In population-based healthcare systems, multiple interventions might need to be involved. However, it is not clear weather combining different interventions can deliver benefits on the population level, especially with the existence of some evidence suggesting that the combination of multiple ICIs, including SM, MDT, DM, and CM, could produce better results (Damery, Flanagan and Combes, 2016). For instance, when SM was incorporated into MDT care or individualised patient education was included in discharge planning, it showed the most promise.

Considering the enrichment of the literature with studies assessing the effectiveness of different ICMs, a review of reviews might capture a broader understanding. Accordingly, a review of reviews was chosen to achieve the first objective of this thesis.

Patients with LTC were chosen as the population of interest, considering their higher experience of care fragmentations. Such populations could be the most to be benefiting from ICMs. If the IC interventions provided beneficial outcomes to such populations, it is likely for other populations to have similar outcomes. However, in this case, we will be talking about population-based interventions and not diseases specific. Accordingly, the review also captured the IC interventions' diversity and target populations. Besides, understanding and locating different outcomes that can be used in future evaluations of IC is crucial especially in line with another objective and expected benefits of this review highlighted below.

In addition to its benefits in this thesis, the review is also expected to provide evidence for decision-makers who need a synthesis of the most current and reliable data relevant to their context (Pieper et al., 2014). In the case of this study, the review could support the commissioners and policymakers to have relevant data on the possible effects of ICMs. Note that a summary of this analysis was published in the British medical journal under the integrated healthcare journal (Mansour, Pokhrel, and Anokye, 2022).

8.2 METHODS

I did an umbrella review to synthesise findings from studies examining the effectiveness of several integrated care approaches (see below). Umbrella reviews provide an efficient method of evidence synthesis with various advantages. They provide a comprehensive overview of a topic, assess evidence quality, identify consistency and contradictions, provide cumulative evidence, demonstrate time, and resource efficiency, provide transparency and repeatability, and aid in policy and clinical decision-making. This methodology effectively synthesises existing evidence and informs key research, healthcare, and policy decisions (Belbasis, Bellou, & Ioannidis, 2022). What distinguishes this review from others like it (Damery, Flanagan, and Combes, 2016) is the emphasis on examining the effectiveness of ICMs a. at the population level, b. the effectiveness of IC interventions not only standing alone but in combination, and c. synthesizing the most recent evidence.

8.2.1 Population

The focus was on male and female patients aged 18 years or over with one or more LTC under management. I selected the most common diseases included in multimorbidity indices (Diederichs, Berger & Bartels, 2011). LTCs included: heart conditions (e.g., stroke), diabetes (Type 1 and 2), renal diseases (e.g., Chronic Kidney Disease (CKD)), respiratory conditions (e.g., asthma and Chronic Obstructive Pulmonary Disease (COPD), and cancer.

8.2.2 Intervention

The following Interventions (For comprehensive descriptions, see Appendix A) assessed by the included reviews or meta-analyses were examined:

•**Case management (CM)**

Providing care through a collaborative process between one or more care coordinators or case managers and the patient

•**Discharge management (DM)**

Mainly facilitates effective transitions from hospital care to other settings.

•**Multidisciplinary teams (MDT)**

Teams composed of multiple health and/or social care professionals working together to provide care.

•**Self-management (SM)**

Designed to provide patient support, typically via tailored education.

•**Other complex or broad interventions**

Interventions with multiple components, any combination of the above).

8.2.3 Comparator and Outcomes

There was no restriction on the control groups included in the reviews. The reviews included different types of comparators, including usual care. As one of my objectives was to identify and describe the outcome measures relevant to IC interventions, there was no restriction on the type of outcomes assessed.

8.2.4 Inclusion and Exclusion criteria

To be included in this study, a review needed to be published in the English language and meet the following requirement: (a) a systematic review that examined the effectiveness of four IC interventions focusing on patients with one or more LTC in the last ten years; or (b) a meta-analysis combining effect sizes from various studies quantitatively. The following criteria was used to identify a systematic review (SR): (i) included a clearly established set of objectives for the investigations with pre-defined eligibility criteria; (ii) included a clear description of methods with a systematic search through different databases; (iii) included a review of findings with an assessment of the validity of the included studies, and (iv) included a systematic presentation, and synthesis, of the characteristics and findings of the included studies.

A systematic review or meta-analysis that did not meet the PICO was excluded. Reviews that included populations such as adolescence or children, or populations with conditions other than the conditions of interests (e.g., mental health) were excluded. Reviews that focused on interventions other than those of interest were also excluded (e.g., chronic and collaborative care models). Only interventions that showed potential when combined, such as MDT, SM, and DM were included. (Thielke, Vannoy & Unützer, 2007)

To be considered as crossing between settings, the intervention needed to be delivered simultaneously by medical personals or caregivers within a community (e.g., social care settings), acute (e.g., GP surgery), and or secondary care settings (e.g., hospital). Hence, studies that included interventions that did not cross the boundary between at least two health and/or social care settings were excluded. Finally, I excluded studies for other reasons, such as accessibility or year of publication (Fig 2).

8.2.5 Search Strategy

A search strategy involving a combination of key words, informed by PICO and scoping review, was used (See Appendix B). This strategy was deliberately broad to cover the breadth of the literature. Three electronic databases (MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews) were searched for systematic reviews and meta-analyses between 2009 and 2019. The search was conducted from August to September 2019.

A pilot review (See appendices) informed the design of the search strategy. Expected key terminologies were initially used to extract the reviews in the pilot study. Following the inclusion of these reviews those were used to select a wide range of terminologies related to IC. Those were divided based on their relation to the PICO compartments. For example, integrat* OR multidisciplinary OR management OR discharge were assigned to the intervention and/or comparator group, while chronic/long term were assigned to the population. This approach was adopted to make the search strategy as wide as possible in line with the main objective of the review of reviews to conduct a general and wide evidence synthesis.

8.2.6 Eligibility Assessment, Data Extraction, and Data Analysis

Search results were collected into a single reference manager software (Refworks). Titles and abstracts were screened for inclusion. In case of doubt regarding the study's inclusion, the full text was screened for eligibility.

Due to the vast number of reviews retrieved and, by extension, the high number of outcomes and heterogeneity, the evidence synthesis was limited to a narrative review of interventions and outcomes. For the same reason, I summarized the effects of outcomes by intervention using the criteria presented in table 1, which consists of two main categories, including positive and uncertain/mixed effects. The evaluation was fully outcome-based.

Table 1: Criteria adopted to report effect by outcome.

↓ ↑ + + **(Positive effect)**	• Statistically significant positive effect in the outcome measure (Meta-analysis) • At least half of the studies included in a review reported a positive increase or decrease in the outcome measure (Narrative)
↔ **(Uncertain/Mixed effect)**	• Statistically insignificant positive/negative increase/decrease in the outcome measure (Meta-analysis) • Low-quality evidence due to issues with bias, follow-up, and heterogeneity • At least half of the studies included in a review reported negative or no effect (Narrative)

8.2.7 Quality Assessment

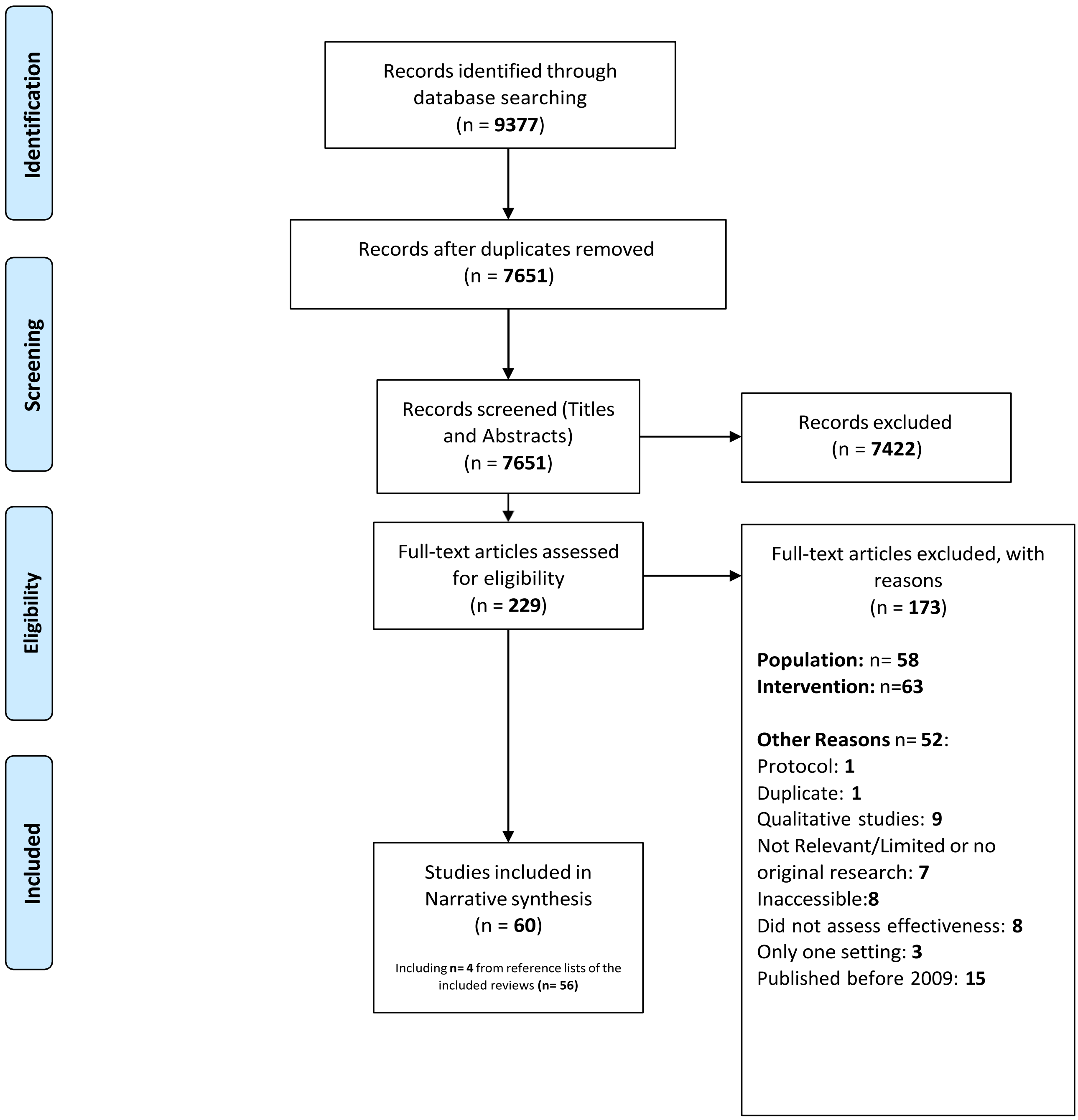
The quality of studies was appraised using the Centre for Evidence-Based Medicine (CEBM) tool for critical appraisal of systematic reviews. Generally, the tool is composed of 5 questions: (i) clarity of the research question(s), (ii) clarity and appropriateness of search methods and the likelihood of missing some studies, (iii) clarity and appropriateness of the inclusion criteria; (iv) discussion of heterogeneity and its reasons; and (v) issues related to quality assessment including the use of the appropriate quality assessment tool (see Appendix B). The tool gives a score of one on each question and scores each review overall from 0 to 5, where 5 is the highest score which implies the highest quality.

While I applied the checklist to all included reviews, Nana independently applied the same tool on 10% (n=6/60) of the included studies. The studies chosen for Nana to review included a wide breadth of my scores for representativeness reasons (3, 3.5 (two studies), 4, 4.5, and 5). Nana and I agreed on the scores given to this sample of included studies.

8.3 RESULTS

A total of 9,377 potentially eligible reviews were identified (Fig 2). Two hundred thirty-three articles were eligible for the full-text assessment following titles and abstracts screening. Following a full-text assessment, 173 articles were excluded for not aligning with the PICO and other reasons (Fig1). The final number of studies which met the inclusion criteria and were included in my review was 60.

Fig 2: PRISMA diagram of search results



8.3.1 Characteristics of the Included Studies

Among the included studies, around half were published between 2017 and 2019 (n=32), while other studies ranged between 2009 and 2016.

Forty-nine reviews specified patient numbers (Total 1,057,251; median 5,735; range 835-277,100), but across the 11 that did not, two studies only specified the range or the median (Table 2). Seven reviews did not specify follow-up duration for their included studies, but across the 53 that did, follow-ups ranged from 2 days to 15.9 years, with most lasting up to 6 or 12 months. Besides, 41 reviews included meta-analysis, and 19 were narrative syntheses. Among the 41 reviews which included meta-analysis, 3 were reviews of reviews, while four studies among the narrative reviews were reviews of reviews.

Patients with LTCs, multimorbidity, or complex needs were the most commonly studied (n= 29), followed by patients with COPD (n= 12), Diabetic patients (n= 8), patients with heart conditions including stroke, heart failure, and myocardial infarction (n= 6). Patients with chronic kidney disease (CKD) (n= 3), cancer (n= 1), and asthma (n= 1) were the least commonly studied. In most reviews (n= 44), usual care was the comparator. Other reviews included the absence of an intervention, other interventions, or attention controls as comparators. Five reviews did not specify their comparator (Table 2: Reviews: 12,27,47,48, and 49).

All reviews presented an outcome-based evaluation of the effectiveness of IC interventions. As a result, the reviews mainly included studies with a similar evaluation method, particularly adopting an experimental design (mainly RCTs). This characteristic was shared across the reviews with complex IC interventions consisting of multiple models (Table 2: studies in bold, n=12). However, none of these reviews examined the combination of the four IC interventions combined and assessed their effectiveness on general populations with LTCs in all settings simultaneously.

8.3.2 Quality of the Included Reviews

Most of the included reviews scored 4/5 (n= 18), followed by 4.5/5 (n= 15), and 3.5/5 (n= 9). Thirteen reviews had a full score, while only five studies scored 3/5. The overall quality of studies was high, with a mean quality assessment score (QA) of 4.2/5. The mean QA score across the intervention categories ranged from 4.2 (SM) to 3.75 (CM), 4.25 (DM), 3.5 (MDTs), and 4.46 (C).

Overall, studies lost points on the likelihood of missing relevant studies as they either restricted their search to a few databases or their search did not include a search of reference lists from relevant studies. In addition, heterogeneity and its possible reasons were not explored in some of these studies.

8.3.3 Characteristics of the Intervention Models

Twenty-eight studies focused on SM interventions, while four were purely CM, ten focused on DM, five focused on MDTs, and thirteen were labelled as complex (Table 2). Among the thirteen reviews labelled as complex, six included studies that assessed the effectiveness of different interventions separately, including SM, CM, DM, and MDTs. On the other hand, seven reviews among the thirteen labelled as complex assessed the effectiveness of a combination of different IC interventions (Table 2: Reviews: 50,52, 54, 55,56, 57, 59).

Thirty-eight studies assessed interventions which crossed the boundary between three settings, including primary, secondary, and community. On the other hand, thirteen reviews assessed interventions which crossed the boundary between primary and community settings, while the rest were between secondary and community or primary and secondary.

Interventions assessed by reviews were heterogeneous. The heterogeneity was confined to three main dimensions: components, mode of delivery, and personnel delivering or facilitating the support. However, interventions across each category shared common characteristics. For instance, across the twenty-eight studies which assessed the effectiveness of SM interventions, most interventions included one or more of the following components related to disease management: action plans, goal setting, decision-making, self-monitoring, self-efficacy, and problem-solving. Also, the educational components of the interventions varied with the target population. However, the educational programs included two or more of the following components: general disease education, medication (e.g. inhaler usage techniques, insulin injection), and lifestyle (e.g. exercise, smoking cessation). The mode of delivery of interventions included individual or group-based delivered face-to-face or/and via telephone with follow-up. On the other hand, personnel mainly were health care professionals (HCPs), including pharmacists, nurses, and physicians. Pharmacists and nurses worked as multidisciplinary team members or in pure pharmacist or nurse-led interventions.

Interventions assessed by the four reviews in the CM category were characterised by including case managers responsible for delivering and coordinating services following care plans. Two reviews included studies with interventions that included SM components such as education, and DM components, such as transitional care services (Joo and Liu, 2017; Joo et al., 2019). In addition, all four reviews included CM interventions delivered by nurses, social workers, nurse practitioners, pharmacists, and general practitioners (GP) who were either a member of an MDT or acted independently. Home visits and telephone follow-ups were standard service delivery components in the four reviews.

Among the ten reviews that assessed the effectiveness of DM interventions, five included studies with post-discharge interventions (Echevarria et al., 2016; Shepperd et al., 2016; Langhorne and Baylan, 2017; Gonçalves-Bradley et al., 2017; Yang et al., 2017). Those interventions consisted mainly of 'hospital at home' support, including plans to manage patients' conditions following discharge from the hospital. The plans primarily consisted of the following components: home visiting, symptom management, and rehabilitation services delivered by HCPs who were either members of an MDT or acted independently. Four reviews included different transitional care interventions, which consisted of pre and post-discharge support with discharge planning, pre-discharge patient-centred instructions and post-discharge care with different forms of contact, including in patient's home or clinic visits and telephone (Prvu et al. 2012; Allen et al., 2014; Braet, Weltens and Sermeus, 2016; Roper et al., 2017). Among these five reviews, three included interventions with additional SM components, including education and patient empowerment (Prvu et al., 2012; Allen et al., 2014; Braet, Weltens and Sermeus, 2016). Moreover, one review included interventions consisting of both SM and CM components and DM as a primary intervention (Leppin et al., 2014).

Among the five reviews which assessed the effectiveness of MDTs interventions, one review included MDT interventions with additional DM components, including discharge planning (Hickman et al., 2015). Moreover, the interventions in this review included hospital initiated tailored exercise program followed by home visits and telephone follow-ups. Besides, one review included MDTs intervention which consisted primarily of medication review and optimisation in addition to educational counselling (Siaw et al., 2019). One review included interventions to provide formalised links between primary and specialist care with education, medication review, and SM components, including physical activity, lifestyle counselling, and self-care (Health Quality Ontario, 2012). Finally, the same author conducted a review which included MDTs interventions focusing on information management and relational continuity (Health Quality Ontario, 2013).

Four reviews across the 13 reviews labelled as complex included interventions with multiple sub-interventions (Mitchell et al., 2015, Valentijn et al., 2018, Baker et al., 2018, Takeda et al., 2019). Those included two or more combinations of MDTs, CM, and SM. Only one of the four reviews included discharge planning in addition to CM and MDTs as primary interventions (Takeda et al., 2019). The other remaining nine reviews included studies with primarily individual interventions.

8.3.4 Outcomes and Indicators of effectiveness

The outcome measures included in the reviews were summarised in Table 3. Those were divided into three main categories. Across the included reviews, there was a variation in labelling the outcome measures as primary or secondary. Some reviews considered organisational outcomes such as hospital admissions as primary outcomes, whereas other reviews focused on clinical or patient-centred outcomes such as quality of life (Qol) or HbA1c as primary outcomes (Table 4). Besides, some reviews included a mix of different outcomes with or without specifying order or focus. Note that outcomes such as depression and anxiety were labelled as patient-centred as those were assessed in reviews as general and not clinical outcomes (Given that we excluded reviews focusing on mental conditions/illnesses).

Table 2: Characteristics of included reviews

N	Study;	Review type; Study types; n of Studies; n of Databases; n of Participants	Population(s) and Condition(s); Comparator	QA Score; Follow-up	Interventions' Summary; Settings	Main/Common Outcome measures, Primary; Secondary
Self-Management						
1	Zhao et al (2017)	SR and meta-analysis; RCTs; 20; 5; 5802	≥18 years old with T2DM; Usual Care	4.5; 24 weeks-2 years	Education programs with multiple different forms of education and SM theories including empowerment, health belief model (Behavioural), and health motivation; Primary, Community	Qol; HbA1c, BMI, self-efficacy, self-care activities, diabetes knowledge
2	Galdas et al (2015)	SR and meta-analysis; RCTs; 49; 1; N/A	Adults, 18 years or older, diagnosed with one or more LTC; Males receiving SM intervention to Females or mixed-gender groups	3.5; N/A	Distinct SM support interventions with the following elements: Physical activity, education, peer support, and HCP monitoring and feedback all delivered by different HCPs; Primary, Community	HRQoL; depression, anxiety, fatigue
3	Saheb et al (2017)	SR and meta-analysis; RCTs, 1 quasi-experimental study, and 2 observational; 20; 16; 2296	≥18 years old with T2DM; Usual care and other interventions (Except for the two observational studies)	4.5; N/A	Decision aid support presented by personalised patient information on cardiovascular risk factors ("Statin Choice"), and description of five anti-hyperglycemic drugs, their treatment burden, and impact on HbA1c in facilitating SDM regarding diabetes treatment ("Diabetes Medication Choice"); Primary, Secondary, Community	Qol; HbA1C, diabetes knowledge, decision quality, risk perception, patient satisfaction, trust of physician, medication adherence
4	Lenferink et al (2017)	SR and meta-analysis; RCTs; 22; 7; 3854	Adults diagnosed with (COPD); Usual Care	5; 2 days- 12 months	Action plans for exacerbations of COPD within a self-management intervention delivered via face to face sessions with up to 12 months with follow-ups via telephone; Primary, Secondary, Community	HRQoL, Respiratory-related hospital admissions; All-cause hospital admissions, All-cause mortality, Respiratory-related mortality, Dyspnoea, COPD exacerbations, Courses of oral steroids
5	Jolly et al (2016)	SR and meta-analysis; RCTs; 193; 8; Ranged from 10 to 743	Adults diagnosed with (COPD); Usual Care or control receiving no intervention	3.5; 1 to 27 weeks	SM interventions with different educational components, including exercise, breathing technique and management of dyspnea, general education and other components. Primary, Secondary, Community	HRQoL, hospital admissions
6	Peng et al (2019)	SR and meta-analysis; RCTs; 19;	≥18 years old diagnosed with (CKD)	5; 3-60 months	Three types of SM interventions based on Lifestyle modifications (e.g. exercise), Medical-behaviour modifications (e.g. medication	All-cause mortality, progression to ESRD, change in proteinuria excretion, Risk of dialysis;

		8; 2540	Usual Care		adherence), and Multifactorial modifications (combinations of lifestyle and medical behaviour) all delivered face to face or/and via telehealth instruments by different HCPs including nurses; Primary, Secondary, Community	eGFR. BP, CRP, Distance on 6 min walk, HbA1c
7	Harrison et al (2015)	SR and meta-analysis; RCTs; 7; 7; N/A	Adults diagnosed with (COPD) receiving SM during hospitalisation for an AE-COPD or within one month of hospital discharge Usual Care	4; 2 weeks-12 months	Comprehensive education programs delivered by nurses with face to face or/and telephone with follow-ups. Programs included topics on COPD medication management, symptoms and other related educational topics on the disease's management; Primary, Secondary, Community	HRQoL, hospital admissions, mortality; Knowledge, Self-efficacy, Psychologic Morbidity, Primary Care Visits, Behaviour Change, Exercise capacity
8	Howell et al (2017)	Narrative; RCTs; 55; 5; 8084	≥18 years old in the active treatment or survivorship phases of the cancer journey Usual Care or other educational interventions	3.5; 2 weeks-12months	SM interventions (face to face with follow-up) with one or more of the core elements specified by the review which mainly included: self-efficacy and care management, coaching by a trained instructor, facilitation of uptake of health behaviours through goal setting, active development of skills to communicate with health care provider; Primary, Secondary, Community	QoL; Fatigue, pain, depression, anxiety
9	Fryer et al (2016)	SR and meta-analysis; RCTs; 23; 1; 1863	Adults with stroke Usual Care or other interventions	5; 4 weeks- 6 months	SM interventions with multiple components, including goal setting, decision-making, self-monitoring, and problem-solving, delivered face-to-face or/and via telephone with follow-up; Primary, Community	QoL; Self-efficacy
10	Zwerink et al (2014)	SR and meta-analysis; RCTs; 14; 13; 3189	Adults with COPD Usual Care	5; 2-24 months	SM interventions with multiple components, including smoking cessation and diseases knowledge, advice about exercise, and action plans delivered face-to-face or/and via the telephone with follow-up; Primary, Secondary, Community	HRQoL All-cause mortality, All-cause hospital admissions, Respiratory-related hospital admission, Dyspnoea, Exercise capacity, Courses of oral steroids
11	Panagioti et al (2014)	SR and meta-analysis; RCTs; 187; 9; N/A	≥18 years old with LTC Usual Care or other interventions	4; 3-84 months	Different SM interventions with different components to improve disease-specific education, medication adherence and other disease-related management components. Delivered face-to-	Qol, Hospital use

					face or/and via telehealth instruments such as telephones; Primary, Secondary, Community	
12	Van Eikenhorst et al (2017)	SR and meta-analysis; RCTs; 24; 6; 3,610	Adults diagnosed with diabetes excluding gestational diabetes N/A	4; 4-24 months	Multicomponent interventions, which included diabetes education, medication, lifestyle, goal setting and SM skills and other topics delivered by pharmacists via face-to-face individual or group sessions and included home visits and telephone follow-ups; Primary, Community	Qol; Adherence to Medication, Diabetes Knowledge; HbA1C, BGL, BMI, Lipid profile (Cholesterol, HDL, LDL), BP, self-care
13	Jonkman et al (2016)	SR and meta-analysis; RCTs; 47; 5; 10,596	Adults diagnosed with COPD, T2DM, CHF Usual Care	5; 2-8 months	Diverse interventions with different components include goal settings and action plans, SM of symptoms, medication management, exercise and other components. Mode of delivery was heterogeneous and included individual and group sessions, exercise sessions in addition to Telehealth instruments including internet and Telephone contacts; Primary, Secondary, Community	HRQoL
14	Steinsbekk et al (2012)	SR and meta-analysis; RCTs; 26; 5; 2833	Adults diagnosed with T2DM. Routine Treatment	4.5; 6-24 months	Group-based education sessions with or without groups discussion and home visits delivered by one or more members of an MDT (GPs, social workers, nutritionists, nurses) and with or without telephone follow-ups; Primary, Secondary, Community	HbA1C, fasting blood glucose, diabetes knowledge, Qol and self-efficacy. BMI, BP, Lipid profile, Patient satisfaction, and mortality
15	Newham et al (2017)	SR of reviews and meta-analysis; RCTs and Reviews; 26; 3; 3518	Adults diagnosed with COPD Usual care and SM intervention with single components	4; 6-12 months	SM interventions with either one component of symptoms management, management of mental health concerns, management of physical activities or all three together. All delivered either by a single practitioner or multidisciplinary teams, as individual/group(s) single/multiple sessions; Primary, Secondary, Community	ED visits, HRQol
16	Zimbudzi et al (2018)	SR and meta-analysis; RCTs; 8; 4;	Adults diagnosed with T1DM, T2DM and CKD.	4; 3-24 months	SM interventions with the following components: education, provider feedback, provider reminders, patient education, patient reminders, and patient	BP, GFR, HbA1c;

		835	Usual Care		financial incentives with elements that include standardised training, multidisciplinary team, peer contact, keeping logs, goal-setting skills, problem-solving skills, and seeking support. All delivered by single providers or MDTs as group/individual-based sessions; Primary, Secondary, Community	Self-care behaviour, hospital admissions, ED visits, HRQol
17	Ditewig et al (2010)	Narrative; RCTs; 19; 4; 4162	Adults with CHF Usual Care	4; 6-24 months	SM intervention consisting mainly of education components accompanied by self-monitoring of physical conditions, patient diary cards or devices. Interventions were delivered by primary and/or secondary care HCPs via visits or face-to-face in care settings, including hospitals; Primary, Secondary, Community	Mortality, all-cause hospitals readmissions, CHF-hospitalization rate, Qol
18	Gorina et al (2018)	Narrative; RCTs; 20; 7; 15439	Adults with LTCs (T2DM, hypertension, and hypercholester olemia) Usual care and groups who only received education or physical activity as a part of an SM intervention	4; 3 months-3 years	SM interventions with multiple components including diet, physical activity, adherence to medical treatment, self-care and complication prevention and other components. Delivered by nurses or MDTs, face-to-face or/and by telephone and carried out as individual or/and group sessions; Primary, Community	Nutrition habits, Physical activity, adherence to medication, BMI, HbA1c, BP (Only T2DM related outcomes were extracted)
19	Cutler (2018)	Narrative; RCTs, Longitudinal and Qualitative; 19; 3; 2708	Adults with T2DM Other SM interventions components	3; N/A	SM interventions delivered as group sessions with multiple components including lifestyle, physical activity, medication adherence and other components; Primary, Secondary, Community	Self-efficacy, blood glucose, HbA1c, medication adherence.
20	Wang et al (2017)	SR and meta-analysis; RCTs; 25; 11; 13297	Adults with COPD Usual Care	5; 2-48 months	Multiple component SM interventions (Group or individual sessions) which included topics such as smoking cessation, direction to use inhalers, advice on exercise and other components. Interventions were delivered by different HCP, including nurses and pharmacists or MDTs. Primary, Secondary, Community	Qol, COPD-related hospital admission rate, ED visits (COPD-related), Smoking status, Pulmonary functions, Depression, COPD knowledge, BMI, Mortality rate.

21	Hosseinzadeh et al (2019)	Narrative; RCTs; 20; 10; 8998	Adults with COPD Usual Care	3; 6 weeks-4 years	SM interventions with the following educational components: smoking cessation counselling, breathing and coughing skills; mental health education; exacerbation symptoms recognition and management; improving physical activity levels; the correct use of inhalers; and medication compliance, delivered face-to-face or/and via the Telephone by one or more HCP; Primary, Secondary, Community	Qol and hospitalisation rate, COPD knowledge, Self-efficacy, Physical activity, Smoking cessation, Medication adherence and use, depression, and anxiety.
22	Jeong et al (2018)	SR and meta-analysis; RCTs; 37; 3; 5860	Adults with T2DM Usual Care	4; 3 -32 months	Pharmacist-led programs consisted of information on disease and medications, adherence education, survival skills regarding hypo- and hyperglycaemia incidence, and insulin injection skills delivered as face-to-face intervention, telephone counselling, or group appointments, meetings, or education sessions; Primary, Secondary, Community	HbA1c
23	Long et al (2019)	SR and meta-analysis; RCTs; 10; 4; 1959	Adults with COPD Usual care or control	4; 2 weeks - 24months	SM interventions with at least goal setting, motivational interviewing techniques, and COPD-related health education as components. Delivered face-to-face or/and via the Telephone by one or more HCP (Nurse, pharmacist, health coach); Primary, Secondary	HRQoL, All-cause hospital admissions; COPD-related hospital admissions Physical activity, self-care behaviour, and mood
24	Massimi et al (2017)	SR and meta-analysis; RCTs; 29; 4; 10162	>18 years of age with a diagnosis of LTC or multi-morbidity Usual care	5; 2 weeks - 24 months	Nurse-led multicomponent SM interventions with a variety of modes of delivery: face-to-face or face or/and telephone and/or nurse visits; Primary, Community	Qol, HbA1c, BP Mortality
25	Tan et al (2019)	SR and meta-analysis; RCTs; 18; 7; 2,307	Adults with Diabetes or/and hypertension No intervention or other interventions	4.5; 2-36 months	SM educational interventions consisted of individual face-to-face counselling and included educational components on the disease, complications, medication, side effects, adherence, lifestyle changes, self-monitoring and self-management skills. Delivered by pharmacists or nurses; Primary, Secondary, Community	Medication adherence

26	Sakakibara et al (2017)	SR and meta-analysis; RCTs; 14; 4; 2,303	Adults with a history of stroke Usual care, waitlist control, no intervention controls	4; 2 weeks-24 months	SM interventions with the following components: feedback on performance, goal setting/action planning, resource utilization, and problem-solving delivered as an individual or/and group sessions or via telephone or telehealth instruments; Primary, Community	Risk factors of stroke: Alcohol, smoking, cholesterol, diet and nutrition, physical activity, glucose, medication adherence, BP
27	Taylor et al (2014)	Narrative review of reviews; RCTs; 102; 8; N/A	Adults with LTCs N/A	4.5 6 weeks-1 year	A wide variety of SM interventions with different components, including action plans and goal setting, modes of delivery: face-to-face, remote, telehealthcare, web-based, and personnel delivering or facilitating the support, including laypeople and HCPs; Primary, Secondary, Community	BGL, HbA1c, BP, cholesterol, Self-efficacy, HRQol, Qol
28	Majothi et al (2015)	SR and meta-analysis; RCTs; 10; 8; 1,466	Patients with COPD, recently discharged from hospital after an acute exacerbation; Usual Care or other interventions	4; 3-52 weeks	Multi-component SM interventions delivered before or after discharge from the hospital. **Components include:** training on medication adherence, inhaler technique, smoking cessation, nutritional advice, promoted exercise, and management of dyspnea; Primary, Secondary, Community	Primary care consultations, hospital admissions/re-admissions, LoS (Hospital), ED visits, and mortality. HRQoL, self-efficacy, adherence to inhaler treatment and inhaler technique, smoking behaviours, physical activity, knowledge to treat exacerbations, depression score
Case Management						
29	Oeseburg et al (2009)	Narrative; RCTs; 9; 3; 15 746	Community dwelling patients with LTCs; Care without a case management component	3.5; 10–36 months	Home visits and/or telephone calls. Delivered by a case manager (nurse, social worker or nurse practitioner) who was either a member of an MDT or acted independently; Primary, Secondary, Community	Hospital LoS, ED visits, Nursing Home admission
30	Stokes et al (2015)	SR and Meta-analysis; RCTs/CCTs; 36; 6; 23711	Adult patients with LTCs; Care without a case management component	4; 6–60 months	Community-based MDTs responsible for delivering and coordinating services; MDT care plan following a caseworker assessment, case manager constantly available to deal with problems. Delivered by a care manager, nurse, pharmacist, GP collaborating with nurse; Primary, community	Self-assessed health status, mortality, healthcare utilisation (GP visits, social worker visits, nursing visits, ED visits, hospital admissions, Ambulance calls), patient satisfaction

31	**Joo et al (2019)**	Narrative review of reviews; SRs; 7; 5; 46572	Adult patients with LTCs; Usual Care	4; 1 month – 15.9 years	Nurse-led or/ MDTs-led + case managers community- and hospital-based interventions which included assessment and planning, education, transitional services, referrals to primary or other social or health services, and face-to-face or telephone contacts for regular follow-up; Primary, Secondary, Community	Hospital Readmissions, LoS, Nursing home admissions, ED visits, GP visits
32	**Joo and Liu (2017)**	Narrative; RCTs; 10; 5; 7125	Adult patients with LTCs; Usual Care	3.5; 6 months-5 years	Nurse-led or/ MDTs-led continuous coordinated and comprehensive care intervention for participants with chronic illnesses with the following CM services common across the studies included: transitional care services between hospitals and home or other facilities, regular home visits, regular telephone calls, individual assessment and planning at the time of hospital discharge, referral services to social support or health services, education or self-management support, psychosocial supports such as empowerment and motivational encouragement and ongoing assessment until the end of the intervention; Secondary, Community	Hospital Readmissions, LoS, hospital visits; Qol, Self-efficacy
Discharge Management						
33	Echevarria et al (2016)	SR and Meta-analysis; RCTs; 8; 6; 1414	Adults with COPD that were recently discharged from the hospital Usual Care	4.5; N/A	Hospital at Home Early Supported Discharge interventions provided by nurses or/and MDTs, which included plans to manage the patients' conditions at home and after discharge. Interventions mainly included components of home visiting, symptom management, and contacting the patient via the phone; Secondary, Community	Mortality, readmissions
34	Langhorne and Baylan (2017)	SR and Meta-analysis; RCTs; 17; 8; 2422	Adults that have been admitted to hospital with a clinical diagnosis of stroke Usual Care	5; 3-12 months	Two main types of Early supported discharge interventions: 1- ESD service comprised an MDT which co-ordinated discharge from the hospital, post-discharge care and provided rehabilitation and patient care at home or in a community setting. 2- ESD team co-ordination by which discharge home and the immediate post-discharge care	LoS at hospital, hospital, Readmission, death, physical dependency; ADL, Qol, depression score, Patient satisfaction

					were planned and supervised by a coordinated multidisciplinary team, and after discharge care was subsequently handed over to existing community-based agencies who provided continuing rehabilitation and support at home; Secondary, Community	
35	Gonçalves-Bradley et al (2017)	SR and Meta-analysis; RCTs; 32; 6; 4746	Adults with different LTCs Usual Care	4.5; 3-12 months	Early discharge hospital-at-home interventions by which care was provided by a hospital outreach service (By MDTs). In addition, some interventions care was coordinated by a hospital-based stroke team or physician in conjunction with community-based services; Primary, Secondary, Community	Mortality, Hospital readmission, Living in an institutional setting, LoS (hospital), Patient satisfaction.
36	**Yang et al (2017)**	SR and Meta-analysis; RCTs; 31; 3; 6715	Adults with COPD Usual Care	4.5; 3-12 months	Different post-discharge interventions which including home visiting (Mainly by nurses), action plans and telemonitoring, and home base rehabilitation in addition to education; Primary, Community	Readmission rates, mortality, Qol
37	Shepperd et al (2016)	SR and Meta-analysis; RCTs; 16; 5; 1814	Adults with different LTCs Inpatient care	4; 3-12 months	Admission avoidance hospital-at-home interventions which provide active treatment by healthcare professionals (care was provided by single HCPs or MDTs), in the patient's home; Primary, Community	Mortality, hospital readmissions; Living in an institutional setting, Patient satisfaction, LoS at home and/or hospital.
38	**Braet, Weltens and Sermeus (2016)**	SR and Meta-analysis; RCTs; 51; 2; 10-3988 (Median 175)	Adults discharged from a medical or Surgical ward Usual Care, attention controls, other interventions.	5; 4 weeks-3 months	Post or/and pre-discharge interventions categorise based on a taxonomy stated by the review: education, discharge planning, medication intervention, appointment scheduled, rehabilitation, streamlining, home visit, patient empowerment, Transition coach, patient-centred documents, and timely communication. Timely follow-up, Telephone calls, patient hotline, Telemonitoring. Primary, Secondary, Community	Readmissions; ED visits, mortality, patient satisfaction.
39	**Prvu et al., (2012)**	Narrative; RCTs; 62; 4; N/A	Adults with Stroke and MI Usual Care	3; N/A (I could not access the supplementary material	Different types of Transitional care interventions which included hospital initiated (Start at the hospital), Patient and family education, community-based, diseases management provided by	Mortality, patient satisfaction, Qol, Physical activity, depression, anxiety, LoS (hospital), hospital readmissions, Specialist

				provided by this review which included information on follow-ups)	a single HCP or social worker or MDTs with different forms of contact including in-person home or clinic visits and telephone; Primary, Secondary, Community	visits, ED visits, outpatient visits.
40	Roper et al (2017)	Narrative; Observational; 3; 3; 277100	Adults with LTCs No intervention	3; 11-23 months	Transitional care interventions with the following components: high-intensity service for high-risk patients, post-hospital palliative care consultations, home visits by care managers, telehealth management, pre-discharge patient-centred instructions; Primary, Secondary, Community	30 days readmissions (by percentage and by risk groups), Risk of readmission,
41	**Allen et al (2014)**	Narrative; RCTs; 12; 8; 4522	Adult with LTCs Standard Hospital Discharge	3.5; 1-6 months	Transitional care interventions with mainly discharge planning, including health teaching medication and symptoms management (Self-management), post-discharge follow-ups via phone or in-person; Primary, Secondary, Community	Readmission, LoS (Hospital); Depressive symptoms, Qol
42	**Leppin et al (2014)**	SR and Meta-analysis; RCTs; 42; 6; 8401	Older patients and patients with LTCs Usual care and other interventions	4; 2 weeks-1 months	DM interventions which included anywhere from the following: CM, patient education and self-management , home visits delivered by nurses or caregivers and other HCPs; Secondary, Community	30 days readmission
Multidisciplinary Teams						
43	**Hickman et al (2015)**	Narrative; RCTs; 7; 4; 1558	Older Patients with complex needs Usual Care	3; 2-6 months	Different complex MDT interventions with different components, including standard geriatric care criteria and oral and written recommendations, the hospital-initiated tailored exercise program plus 1 home visit post-discharge, & phone calls for maximum 24 weeks, discharge planning (With MDT component), tailored geriatric treatment, daily multidisciplinary geriatric care all with different modes of delivery including telephone and provided by different MDTs;	Hospital readmissions, LoS (Hospital), ED visits

					Primary, Secondary, Community	
44	**Siaw et al (2019)**	SR and Meta-analysis; RCTs; 16; 3; 2422	Adults with T1DM/T2DM Usual Care	4; 3-12 months	Medication review, medication optimisation, and educational counselling delivered by single or multiple care providers as a member of an MDT (Pharmacists, nurses, dietitians, community health workers, health coaches, and peer leaders); Primary, Secondary, Community	BP, HbA1c, LDL Qol, emotional distress (depression and anxiety), Diabetes-related knowledge, self-efficacy, medication adherence, self-management (defined as care activities such as diet, exercise, self-monitoring of blood glucose, foot care, and smoking cessation
45	Shi et al (2018)	SR and Meta-analysis; RCTs, Cohort; 21; 5; 10,284	Adults with CKD Composition of the MDT	3.5; 1-5.7 years	N/A	All-cause mortality, temporal catheterisation, risk of hospitalisation, eGFR
46	Health Quality Ontario (2012)	SR of reviews and Meta-analysis; RCTs; 24; 6; N/A	Adult patients with HF, diabetes, or COPD Usual Care	3.5; N/A	Interventions to provide formalised links between primary and specialist care via disease-specific education, medication review, physical activity and lifestyle counselling, self-care and follow-up. Delivered by intermediate care teams, including GPs, specialists, nurses, social workers, pharmacists, and dieticians. Primary, Secondary, Community	All-cause mortality, Hospitalization, ED visits, HbA1c, BP, cholesterol, Qol
47	Health Quality Ontario (2013)	Narrative; Observational, RCTs and SR; 20; 5; N/A	Adult patients with one or more chronic diseases N/A	3.5; N/A	Informational, management and relational continuity. Assessed by: Duration (length of relationship), Density (number of visits with the same provider in a fixed period), Dispersion (visits with distinct providers), Sequence (order of seeing providers). Primary, Community	All-Cause Mortality, Hospitalization, ED visits, HbA1c
Complex Interventions						
48	Baxter et al (2018)	Narrative; RCTs; 267 (123 quantitative, 101 qualitative, 43 reviews); 11; N/A	All patients including patients with LTCs N/A	4.5; 1-5.7 years	Wide variety of CM and MDT interventions (In addition to ICP which was not focused on in my review); Primary, Secondary, Community	GP appointments, Clinician contact, LoS, unplanned admissions, readmissions, ED visits, Patient satisfaction

49	Flanagan, Damery and Combes (2017)	Narrative; Review of Reviews; 41; 11; 159,134	Adults with LTCs Usual Care	4; 1-60 months	Assessed a wide variety of interventions, including SM, CM, MDT, CCM, and DM. Primary, Secondary, Community	Ool
50	**Valentijn et al (2018)**	SR and Meta-analysis; RCTs; 14; 3; 4693	Adults with CKD Usual Care	4; 3 – ≥12 months	SM, CM, MDTs interventions and SM and CM interventions combined with MDTs; Primary, Secondary, Community	All-cause mortality, HRQol, all-cause hospitalisation, eGFRs, risk of dialysis, BP, creatinine
51	Smith et al (2016)	SR and Meta-analysis; RCTs; 18; 9; 8727	Adults with multimorbidity Usual Care	5; 6 –12 months	SM, MDTs, and CM interventions labelled as patient-oriented or organisational, delivered mainly by nurses through visits and face-to-face with or without telephone follow-ups; Primary, Community	Hb1Ac, BP, Cholesterol, Mortality, Depression scores, Anxiety scores, Qol, Self-efficacy, Hospital admission, Exercise/diet, self- care
52	**Kruis et al (2013)**	SR and Meta-analysis; RCTs; 26; 4; 2997	Adults with COPD Usual care or other interventions	5; 3 –24 months	Integrated Disease management interventions with multiple components (Sub-interventions), including SM, CM, and MDTs; Primary, Secondary, Community	HRQol, Respiratory-related hospital admissions, LoS (Hospital)
53	Murphy et al (2017)	SR and Meta-analysis; RCTs; 42; 4; 11250	Adults with poor control of T2DM Usual care or minor enhanced elements of care	4.5; 3 –36 months	Organisational interventions (Included CM), and patient-centred interventions (Included SM); The review included other single elements and telehealth interventions which is not the focus of my review. Hence, I only focused on the CM and SM interventions included. Primary, Community	HbA1c, BP , lipid control BMI, Depression, Medication adherence
54	**Kastner et al (2018)**	SR and Meta-analysis; RCTs; 25; 5; 12 579	Older patients with multimorbidity Usual care	4.5; 3 –36 months	Care coordination interventions which included combinations of multiple interventions including CM, SM, ED (Separate Education intervention with no other SM components); Primary, Secondary, Community	Depressive symptoms, HbA1c, mortality; Cognitive functioning, Qol
55	**Takeda et al (2019)**	SR and Meta-analysis; RCTs; 47; 4; 10,869	Adults with a history of HF Usual Care	5; 2 –12 months	CM interventions consisting of intense monitoring of patients following discharge from the hospital done by a nurse and typically involves home visits or telephone calls, or both. MDTs with a holistic approach to the individuals' medical, psychosocial, behavioural and financial circumstances and typically involve several different	All-cause mortality, HF-related readmissions, All-cause readmissions; HRQol

					professions working in collaboration; Secondary, Community	
56	Peytremann-Bridevaux, et al (2015)	SR and Meta-analysis; RCTs; 20; 5; 81,746	>16 years dragonised with asthma Usual Care	5; 3 –12 months	Interventions that included three main components: Organisational targeting Patients (CM, and other elements such as structured follow-ups), Organisational targeting healthcare professional and systems (Teamwork, integration of care), Patient-centred education and SM; Primary, Secondary, Community	Asthma-specific quality of life score, hospitalisation, ED visits, Asthma exacerbations, Self-efficacy, Asthma severity score
57	Baker et al (2018)	Narrative; RCTs; 15; 1; 7813	Adults with LTCs and/or multimorbidity No intervention	4.5; 1-36 months	Comprehensive care management interventions with SM and elements of CM such as care plans and care coordination with additional elements such as care navigation. N/A	ED visits, readmissions, outpatient GP visits, HbA1c, BP, BMI, Depression score, Medication adherence
58	Damery, Flanagan and Combes (2016)	Narrative; Review of Reviews; 50; 11; 219 475	Adults with LTCs Usual Care	4.5; 2 weeks-60 months	Assessed a wide variety of interventions, including SM, CM, MDT, CCM, and DM. Primary, Secondary, Community	Admissions, readmissions, LoS, ED visits
59	Mitchell et al (2015)	Narrative; RCTs and Quasi-experimental; 14; 6; 5735 patients	Adults with LTCs Usual Care	4.5; 12-24 months	The review looked at elements of different integrated primary-secondary care models, including combinations of MDTs and SM education elements with communication and information exchange, shared care guidelines or pathways as additional elements to support effectiveness. Primary, Secondary	Clinical outcomes for diabetes, heart failure, and COPD. Readmissions
60	Martínez-González et al (2014)	SR of reviews and meta-analysis; RCTs, SRs; 27; 4; N/A	Patient with LTC N/A	3; 3-52 weeks	Included any interventions based on disease management, case management, managed care, comprehensive care, multidisciplinary care, coordinated care, team care, CCMs. Primary, Secondary, Community	HbA1c, BP, Exercise capacity, Qol, Patient satisfaction, Medication adherence, admissions, readmissions, LoS, Ed visits, mortality, Time between discharge and readmission.

Qol: Quality of Life**, HRQoL:** Health-Related Quality of Life, **HbA1c:** Hemoglobin A1c, **BMI:** Body Mass Index, **ADL:** Activities of Daily Living, **COPD:** Coronary Obstructive Pulmonary Disease, **CKD:** Chronic Kidney Disease, **MI:** Myocardial Infarction, **HF:** Heart Failure, **T1DM/T2DM:** Type 1 or 2 Diabetes Mellitus, **eGFR:** Estimated Glomerular Filtration Rate**, BP:** Blood Pressure**, CRP:** C-reactive protein, **BGL:** Blood Glucose Levels, **ESRD:** End Stage Renal Disease, **LoS:** Length of Stay, **HDL/LDL:** High/Low Density Lipoprotein, **CHF:** Chronic Heart Failure**, ED:** Emergency Department**,** GP: General Practitioner, **SR:** Systematic Review, **CCM:** Chronic Care Model, **CCT:** Controlled Clinical Trial, **RCT:** Randomised Control Trial, **ESD:** Early Supported Discharge, **N/A:** Not Applicable

Table 3: Outcome measures included in the reviews that informed (In addition to availability) the selection outcome measures selected in the main evaluations in the preceding chapters.

Organisational	Clinical, Lifestyle, and Condition-specific	Patient-centred
• Condition-related hospital admissions • All-cause hospital admissions • Risk of Admission • Hospital Readmissions • 30 days readmissions • Risk of readmission • Unplanned admissions • Time between discharge and readmission • All-cause mortality • Condition-related mortality • ED visits • LoS (Home) • LoS (Hospital) • Primary care consultations • Nursing Home admission • GP visits • Social worker visits • Nursing visits • Outpatient visits • Ambulance calls • Living in an institutional setting • Clinician Contact	• Condition-related knowledge • HbA1c • BMI • Foot care • Self-monitoring of blood glucose • Dyspnoea • COPD exacerbations • Pulmonary functions • Distance on 6 min walk • Exercise capacity • Courses of oral steroids • Progression to ESRD • Change in proteinuria excretion • Risk of dialysis • eGFR. • BP • Creatinine • CRP • BGL • Cholesterol • HDL • LDL • Triglycerides • Smoking status • Physical Activity • Behavior Change • Alcohol • Diet and nutrition • Cognitive function • Asthma exacerbations, • Asthma severity score • Asthma-Specific Qol	• Qol • Self-Assessed health status • HRQoL • Subjective Health Status • Patient satisfaction • Self-efficacy • Self-care behaviour/activities • Risk perception • Trust of physician • Physical dependency • Activities of Daily living (ADL) or Extended Activities of Daily living (EADL) • Decision quality • Medication adherence • Depression • Anxiety • Fatigue

8.3.5 Effects by Intervention Type

8.3.5.1 Case Management

Across the 20 outcomes assessed by the reviews which investigated the effectiveness of CM interventions, only eight came out with positive effects (Table 4). Organisational outcomes were the most assessed, with 11 outcomes reported as an uncertain/mixed effect. Although the distribution of uncertain/mixed effects was higher than that of positive effects in total, two reviews showed strong evidence of effectiveness (Table 5) (Joo and Liu, 2017; Joo et al., 2019). Both reviews reported evidence of a reduction in hospital readmissions. These reviews differed from the other two reviews by including studies with interventions consisting of SM components such as education, DM components such as transitional care services, and the CM as a primary intervention (Table 2).

Table 4: Total effects of CM interventions across two categories of outcomes.

CM Interventions' Outcomes	↓ ↑ + +	↔	Total
Organisational	5	11	16
Patient-centred	3	1	4
All Outcomes	8	17	20
Note: Reviews which assessed CM effectiveness only included Organisational and Patient-centred outcomes (See table 4)			

Table 5: CM interventions' effects by Organisational and Patient-centred Outcomes

	Reviews' Findings by all reported Outcomes (CM)														
	Organisational											**Patient-Centred**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Oeseburg et al (2009)				↔	↔	↔									
Stokes et al (2015)	↔		↔	↔			↔	↔	↔		↔		↔	↑ +	
Joo et al (2019)		↓ +		↔	↓ +		↓ +								
Joo and Liu (2017)		↓ +		↓ +	↔							↑ +			↑ +

1. Hospital admissions
2. Hospital Readmissions
3. All-cause mortality
4. ED visits
5. LoS (Hospital)
6. Nursing Home admission
7. GP or outpatient Appointments
8. Social worker visits

9. Nursing visits
10. Outpatient visits
11. Ambulance calls
12. Qol,
13. Self-Assessed health status
14. Patient satisfaction
15. Self-efficacy

8.3.5.2 Discharge Management

Ten reviews that investigated the effectiveness of DM interventions assessed 44 outcomes. There was no substantial difference between uncertain/mixed effects and positive effect counts (Table 6). Patient satisfaction and 30 days hospital readmissions emerged with positive effects in all reviews which reported these outcomes (Table 7). Out of these studies, two were Meta-analyses: 30 days admission: RR 0.82 (95% CI, 0.73-0.91) (Leppin et al., 2014), Patient satisfaction: OR 1.60 (95% CI, 1.08 -2.38) (Langhorne, Baylan, 2017). In this connection, reviews with the most evidence of effectiveness across different outcomes included interventions consisting of anywhere from SM, MDTs, and CM with DM as the primary intervention (Prvu et al., 2012; Braet, Weltens and Sermeus, 2016). However, one review with the same characteristics did not report positive effects (Allen et al., 2014), while other reviews reported positive effects on hospital readmissions with interventions that included education (RR, 0.40,95% CI, 0.27–0.59), and telemonitoring (RR, 0.78, 95% CI, 0.58–0.88) (Yang et al., 2017).

Table 6: Total effects of DM interventions across two categories of outcomes.

DM Interventions Outcomes	↓ ↑ + +	↔	**Total**
Organisational	15	12	27
Patient-centred	10	7	17
All Outcomes	25	19	44
Note: Reviews which assessed DM effectiveness only included Organisational and Patient-centred outcomes (See table 4)			

Table 7: DM interventions' effects by organisational and Patient-centred Outcomes.

	Reviews' Findings by all reported Outcomes (DM)																	
	Organisational										**Patient-Centred**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Echevarria et al (2016)	↓ +			↓ +														
Langhorne and Baylan (2017)	↔			↔				↓ +				↔		↑ +	↑ +	↑ +	↔	

Gonçalves-Bradley et al (2017)	↔			↔				↓ +		↓ +				↑ +				
Yang et al (2017)	↓ +			↔								↔						
Shepperd et al (2016)	↔			↔			↓ +	↓ +		↓ +				↑ +				
Braet, Weltens and Sermeus (2016)	↓ +			↓ +		↓ +								↑ +				
Prvu et al (2012)	↔			↔	↓ +			↓ +			↑ +	↑ +		↑ +			↔	↔
Roper et al (2017)		↓ +																
Allen et al (2014)	↔							↔				↔		↑ +			↔	
Leppin et al (2014)		↓ +																

1. Hospital Readmissions
2. 30 days readmissions
3. Risk of readmission
4. All-cause mortality
5. Condition-related mortality
6. ED visits
7. LoS (Home)
8. LoS (Hospital)
9. Outpatient visits
10. Living in an institutional setting
11. Physical Activity
12. Qol,
13. Subjective Health Status
14. Patient satisfaction
15. Physical dependency
16. ADL
17. Depression
18. Anxiety

8.3.5.3 Multidisciplinary Teams

MDTs interventions came out with the highest difference in distribution between positive and uncertain/mixed effects (Table 8). All reviews which assessed HbA1c reported a positive decrease (Table 9). Out of those, one was a meta-analysis (MD: – 0.55%, 95% CI – 0.65% to – 0.45%) (Siaw, Lee, 2019). Besides, in terms of distribution and the number of positive effects (Table 9), reviews that included MDTs interventions with an additional DM component, such as discharge planning, or SM components, such as education, were the highest in reporting positive effects (Hickman et al., 2015; Siaw et al., 2019). One review reported higher effects in all-cause mortality in patients with CKD when the staff of the MDT consisted of nephrologists, nurse specialists and professionals from other fields (OR 0.67, 95% CI 0.51-0.88) (Shi et al., 2018). Besides, the same review reported positive effects across the four outcomes assessed, including hospital admissions (RR 0.62, 95% CI 0.46-0.84). Two reviews reported various uncertain/mixed and positive effects across the three categories of outcomes, including hospital readmissions, ED visits, HbA1C, and Qol. (Table 9) (Health Quality Ontario, 2012; Health Quality Ontario, 2013)

Table 8: Total effects of MDTs interventions across three categories of outcomes

MDTs Interventions Outcomes	↓ ↑ + +	↔	Total
Organisational	7	6	13
Clinical, Lifestyle, and Condition-specific Outcomes	7	2	9
Patient-centred	6	0	6
All Outcomes	21	11	32

Table 9: MDTs interventions' effects by organisational, Clinical, Lifestyle, and Condition-specific and Patient-centred Outcomes

	Reviews' Findings by all reported Outcomes (MDTs)																						
	Organisational										**Clinical, Lifestyle, and Condition-specific Outcomes**						**Patient-Centred**						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Hickman et al (2015)	↓ +						↓ +	↓ +															
Siaw et al (2019)									↑ +	↑ +			↓ +	↓ +	↔		↑ +			↑ +	↑ +	↓ +	↓ +
Shi et al (2018)				↓ +	↓ +						↓ +	↓ +											
Health Quality Ontario (2012)				↔			↔						↓ +	↔	↓ +		↓ +						
Health Quality Ontario (2013)				↓ +			↔						↓ +										

1. Hospital Readmissions
2. Condition-specific Admissions
3. 30 days Readmissions
4. Admission
5. All-cause mortality
6. Condition-related mortality
7. ED visits
8. LoS (Hospital)
9. Diabetes knowledge
10. Self-care/management
11. Temporal catheterization
12. eGFR
13. HbA1c
14. BP
15. LDL
16. Cholesterol
17. HRQol / Qol
18. Subjective Health Status
19. Patient satisfaction
20. Self-efficacy
21. Medication adherence
22. Depression
23. Anxiety

8.3.5.4 Self-Management

SM interventions showed a nearly equal number of uncertain/mixed-effects compared to positive effects across the 165 outcomes investigated by all 28 reviews (Table 10). The most frequent outcome category with positive effects was patient-centred, with 35 versus 25 assessed by 26 reviews out of 28. On the other hand, SM interventions showed a lower indication of effectiveness across the 33 organisational outcomes assessed by 15 reviews. Clinical, lifestyle, and condition-specific outcomes showed slightly more indication of effectiveness, with 37 positive outcomes versus 35 assessed by 18 reviews.

Although the results showed organisational outcomes as the category with the slightest indication of effectiveness, all reviews which assessed condition-related hospital admissions reported positive effects (Table 11). Out of these studies, three were meta-analyses: OR 0.46, 95% CI (0.31, 0.69), (Long et al., 2019), RR 0.67 95% (0.56, 0.79), (Wang et al., 2017), OR 0.57 95% (0.43, 0.75) (Zwerink et al., 2014).

Table 10: Total effects of SM interventions across the three categories of outcomes.

SM Interventions' Outcomes	↓ ↑ + +	↔	Total
Organisational	11	22	33
Clinical, Lifestyle, and Condition-specific Outcomes	37	35	72
Patient-centred	35	25	60
All Outcomes	83	82	165

Table 11: SM interventions' effects by organisational outcomes

	Reviews' Findings by Organisational Outcomes (SM)																				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Zhao et al (2017)																					
Galdas et al (2015)																					
Saheb et al (2017)																					
Lenferink et al (2017)	↓ +	↓ +						↔	↔												
Jolly et al (2016)		↓ +																			
Peng et al (2019)								↔													
Harrison et al (2015)		↔						↔									↔				
Howell et al (2017)																					
Fryer et al (2016)																					
Zwerink et al (2014)	↓ +	↓ +						↔													
Panagioti et al (2014)																					↔
Van Eikenhorst et al (2017)																					
Jonkman et al (2016)																					
Steinsbekk et al (2012)								↔													
Newham et al (2017)										↓ +											
Zimbudzi et al (2018)		↓ +								↔											
Ditewig et al (2010)		↔	↔					↔													
Gorina et al (2018)																					
Cutler (2018)																					
Wang et al (2017)	↓ +							↔		↓ +	↓ +										
Hosseinzadeh et al (2019)		↔																			

Jeong et al (2018)																					
Long et al (2019)	↓ +	↔																			
Massimi et al (2017)								↓ +													
Tan et al (2019)																					
Sakakibara et al (2017)																					
Taylor et al (2014)																					
Majothi et al (2015)		↔	↔					↔		↔		↔	↔								

1. **Condition-related hospital admissions**
2. **All-cause hospital admissions**
3. **Hospital Readmissions**
4. **30 days readmissions**
5. **Risk of readmission**
6. **Unplanned admissions**
7. Time between discharge and readmission
8. All-cause mortality
9. Condition-related mortality
10. **ED visits**
11. LoS (Home)
12. **LoS (Hospital)**
13. Primary care consultations
14. Nursing Home admission
15. GP visits
16. Social worker visits
17. Nursing visits
18. Outpatient visits
19. Ambulance calls
20. Living in an institutional setting
21. Hospital Use (General)

Regarding patient-centred outcomes, most reviews reported a positive effect on HRQol (9 out of 11) (Table 12). With this in mind, statistically significant effect sizes (SMD and MD) for this outcome among studies which conducted a meta-analysis ranged between -2.69 and 0.11 (SMD) in six studies (Harrison et al., 2015; Jonkman et al., 2016; Newham et al., 2017; Lenferink et al., 2017; Zimbudzi et al., 2018; Long et al., 2019), and between -3.51 and 3.84 (MD) in three studies (Zwerink et al., 2014; Majothi et al., 2015; Jolly et al., 2016). Also, one review reported three different effect sizes for three different components of an SM intervention, including Physical activity (SMD: 0.38), education (SMD:0.23), and per support (SMD:0.35) (Galdas et al., 2015). Note that effect sizes reported for HRQol were positive effects regardless of being positive or negative in magnitude, depending on the questionnaire used to measure the HRQol. Results across the second outcome category showed a positive increase in condition-related knowledge in all reviews which reported this outcome except one review (Table 13). Statistically significant effect sizes (SMD and MD) among studies which conducted a meta-analysis were: SMD: 0.58, (Zwerink et al., 2014), 0.69, (Steinsbekk et al., 2012), and MD: 2.18 (Wang et al., 2017). Besides, six reviews out of nine reported a positive effect on HbA1c. Statistically significant effect sizes among reviews which pooled their results were: SMD: - 0,22, (Saheb Kashaf, McGill & Berger, 2017), and 0.11, (Harrison et al., 2015), WMD: -0.38, (Zhao et al., 2017), MD, - 0.5 (Zimbudzi et al., 2018), -0.68 (Peng et al., 2019) and -0.71 (van Eikenhorst et al., 2017). Finally, all other outcomes across the three categories were heterogeneous regarding the distribution between positive and uncertain/mixed effects.

Table 12: SM interventions' effects by Patient-centred Outcomes

Reviews' Findings by Patient-centred Outcomes (SM)																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Zhao et al (2017)						↑ +	↑ +										
Galdas et al (2015)			↓ +											↔	↔	↔	
Saheb et al (2017)	↔				↔			↑ +	↔			↑ +	↔				
Lenferink et al (2017)			↓ +														
Jolly et al (2016)			↓ +														
Peng et al (2019)																	
Harrison et al (2015)			↔			↔								↔			
Howell et al (2017)	↑ +													↓ +	↓ +	↓ +	↓ +
Fryer et al (2016)	↑ +					↑ +											
Zwerink et al (2014)			↓ +														
Panagioti et al (2014)	↑ +																
Van Eikenhorst et al (2017)	↔												↑ +				
Jonkman et al (2016)			↓ +														
Steinsbekk et al (2012)	↔				↑ +	↑ +											
Newham et al (2017)			↓ +														
Zimbudzi et al (2018)			↔														
Ditewig et al (2010)	↑ +																
Gorina et al (2018)													↔				

Cutler (2018)						↔							↔				
Wang et al (2017)	↑ +													↔			
Hosseinzadeh et al (2019)	↔					↑ +							↑ +	↑ +	↑ +		
Jeong et al (2018)																	
Long et al (2019)			↓ +				↑ +								↓ +		
Massimi et al (2017)	↔																
Tan et al (2019)														↔			
Sakakibara et al (2017)														↑ +			
Taylor et al (2014)	↔		↓ +			↔											
Majothi et al (2015)			↓ +			↔							↔	↓ +	↓ +		

1. Qol,
2. Self-Assessed health status
3. HRQoL
4. Subjective Health Status
5. Patient satisfaction
6. Self-efficacy
7. Self-care behaviour/activities
8. Risk perception
9. Trust of physician
10. Physical dependency
11. ADL
12. Decision quality
13. Medication adherence
14. Depression
15. Anxiety
16. Fatigue
17. Pain

Table 13: SM interventions' effects by Clinical, Lifestyle, and Condition-specific Outcomes

Reviews' Findings by Clinical, Lifestyle, and Condition-specific Outcomes (SM)																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Zhao et al (2017)	↑ +	↓ +	↔																												
Galdas et al (2015)																															
Saheb et al (2017)	↑ +	↔																													
Lenferink et al (2017)						↓ +	↔				↑ +																				
Jolly et al (2016)																															
Peng et al (2019)		↓ +							↑ +			↓ +	↓ +	↔	↔	↓ +		↓ +													
Harrison et al (2015)	↑ +									↔																↔					
Howell et al (2017)																															
Fryer et al (2016)																															
Zwerink et al (2014)						↓ +					↑ +																				
Panagioti et al (2014)																															
Van Eikenhorst et al (2017)	↔	↓ +	↓ +													↓ +			↔	↓ +	↑ +	↓ +									
Jonkman et al (2016)																															
Steinsbekk et al (2012)	↑ +	↓ +	↔													↔			↓ +	↔	↔	↔	↔								
Newham et al (2017)																															
Zimbudzi et al (2018)		↓ +													↔	↓ +															

Ditewig et al (2010)																															
Gorina et al (2018)		↔	↔													↓ +									↑ +			↑ +			
Cutler (2018)		↓ +																	↑ +												
Wang et al (2017)	↑ +		↔					↔																↔							
Hosseinzadeh et al (2019)	↑ +																							↑ +	↑ +						
Jeong et al (2018)			↓ +																												
Long et al (2019)																															
Massimi et al (2017)		↓ +														↓ +															
Tan et al (2019)																															
Sakakibara et al (2017)																↔			↔	↔				↔	↔			↔	↔		
Taylor et al (2014)			↓ +																↓ +	↔											
Majothi et al (2015)						↔				↔														↔	↔						

1. Condition-related knowledge
2. HbA1c
3. BMI
4. Foot care
5. Self-monitoring of blood glucose
6. Dyspnoea
7. COPD exacerbations
8. Pulmonary functions
9. Distance on 6 min walk
10. Exercise capacity
11. Courses of oral steroids
12. Progression to ESRD
13. Change in proteinuria excretion
14. Risk of dialysis
15. eGFR.
16. BP
17. Creatinine
18. CRP
19. BGL
20. Cholesterol
21. HDL
22. LDL
23. Triglycerides
24. Smoking status
25. Physical Activity
26. Behaviour Change
27. Alcohol
28. Diet and nutrition
29. Cognitive function
30. Asthma exacerbations,
31. Asthma severity score

8.3.5.5 Complex Interventions

The difference in distribution between positive and uncertain/mixed effects was seven across the reviews, which assessed multiple interventions individually or combined (Table 14). Across the four reviews which assessed combined interventions, two came with substantial evidence of positive effects in multiple outcomes, including hospital admissions (Table 15) (Kruis et al., 2013; Kastner et al., 2018). One of the two reviews was an SR and meta-analysis: Admissions: OR 0.68 (95% CI 0.47 to 0.99), LoS hospital: MD -3.78 (95% CI -5.9 to -1.67),HRQol: MD 1.02 (95% CI 0.67 to 1.36) (Kastner et al., 2018). On the other hand, the other two out of four reviews reported a reduction in hospital admissions (RR, 0.38; 95% CI, 0.15 to 0.95) (Valentijn et al., 2018), HF-related readmissions (RR 0.64, 95% CI 0.53 to 0.78), and all-cause mortality (RR 0.78, 95% CI 0.68 to 0.90) (Takeda et al., 2019). Across the nine reviews which assessed different interventions individually, one review reported DM with post-discharge support as the most effective intervention in reducing hospital admissions (Damery, Flanagan and Combes., 2016). Also, the same review reported MDTs interventions as more effective with teams that include condition-specific expertise, specialist nurses and/or pharmacists. Besides, the same review reported that SM interventions were more effective as an adjunct to broader interventions. One review which assessed Qol as the only outcome reported some positive findings regarding CM interventions (Damery, Flanagan and Combes., 2016). However, the same review reported that CM interventions were more likely to be effective when they included more components. Two of the remaining reviews reported uncertain evidence of effectiveness in different outcomes (Smith et al., 2016; Baker et al., 2018). Other reviews varied between positive and uncertain effects in some organisational and patient-centred outcomes (Mitchell et al., 2015; Murphy et al., 2017; Baxter et al., 2018), with one review reporting positive effects across all asthma-related outcomes: asthma-specific quality of life (SMD 0.22, 95% CI 0.08 to 0.37), asthma severity scores (SMD 0.18, 95% CI 0.05 to 0.30), and lung function tests (SMD 0.19, 95% CI 0.09 to 0.30) (Peytremann-Bridevaux et al., 2015).

Table 14: Total effects of Complex interventions across three categories of outcomes

Complex Interventions Outcomes	↓↑ + +	↔	Total
Organisational	18	10	28
Clinical, Lifestyle, and Condition-specific Outcomes	9	14	23
Patient-centred	11	7	18
All Outcomes	38	31	69

Table 15: Complex interventions’ effects by organisational, Clinical, Lifestyle, and Condition-specific and Patient-centred Outcomes

	Reviews’ Findings by all reported Outcomes (C)																																					
	Organisational											Clinical, Lifestyle, and Condition-specific Outcomes																		Patient-Centred								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Valentijn et al (2018)		↓ +				↔															↔	↔	↔			↔				↔								
Kruis et al (2013)	↓ +							↓ +									↑ +													↓ +	↑ +							
Kastner et al (2018)												↓ +															↑ +									↓ +		
Takeda et al (2019)	↓ +			↓ +		↔																								↔								
Peytremann-Bridevaux, et al (2015)		↓ +																						↑ +					↑ +				↑ +					
Baker et al (2018)				↔				↔		↔		↔	↔										↔													↓ +		
Mitchell et al (2015)		↔		↓ +				↓ +																														
Martinez-González et al (2014)		↓ +		↓ +	↓ +	↓ +	↓ +	↓ +				↓ +											↓ +								↑ +	↑ +	↑ +		↑ +			
Murphy et al (2017)												↓ +	↔										↔	↔											↔	↔		
Smith et al (2016)		↔						↔				↔						↔	↔				↔			↓ +					↔		↔		↔	↓ +	↓ +	
Baxter et al (2018)			↓ +	↔			↓ +	↓ +		↔	↓ +																											
Damery, Flanagan, and Combes (2016)	↓ +			↓ +			↓ +	↓ +																														
Flanagan, Damery and Combes (2017)																															↔							

1. Condition-related hospital admissions
2. All-cause hospital admissions
3. Unplanned hospital admissions
4. Hospital Readmissions
5. Time between discharge and readmission
6. All-cause mortality
7. ED visits
8. LoS (Hospital)
9. Outpatient visits
10. GP Appointments
11. Clinician Contact
12. HbA1c
13. BMI
14. Dyspnoea
15. COPD exacerbations
16. Pulmonary functions
17. Distance on 6 min walk
18. Exercise capacity
19. Diet and Nutrition
20. Courses of oral steroids
21. Risk of dialysis
22. eGFR.
23. BP
24. Asthma Specific Qol
25. Cholesterol
26. Creatinine
27. Cognitive function
28. Asthma exacerbations
29. Asthma severity score
30. HRQoL
31. Qol
32. Patient satisfaction
33. Self-efficacy
34. Self-care/management
35. Medication adherence
36. Depression
37. Anxiety
38. Fatigue

8.4 Discussion

The primary objective of this review was to examine the effectiveness of four models of integrated care in improving outcomes of care for patients with chronic conditions. Although the included reviews were heterogeneous regarding study characteristics, my review found some evidently positive trends. SM interventions showed more positive effects in improving patient-centred outcomes, especially condition-related knowledge, HRQol, and HbA1c. Besides, CM interventions showed better effects when combined with other interventions, including DM, SM, and MDT, especially in reducing hospital readmissions. Similarly, DM and MDTs interventions showed more positive effects across the three outcome categories when combined or with other interventions, including CM and SM.

My secondary objective was to identify outcome measures to evaluate IC interventions. As a result, I was able to identify various outcomes, which were classified into three main categories: organisational, patient-centred, and clinical/lifestyle/condition-specific.

8.4.1 Effectiveness

The main finding of my review regarding the effectiveness of the four IC interventions is that they might be more effective as an adjunct to broader interventions. Although there are some evidently positive trends regarding the effectiveness of these interventions as separate models, the combination of the four seemed to be more effective, and three main points can explain this.

First, the overall effects of all interventions across the three categories ranged from low to moderate; however, there was a noticeable variation when effects were examined per review. For example, only 8 out of 20 outcomes assessed by the reviews investigating the effectiveness of CM interventions came out with positive effects. However, when viewed separately, two reviews with interventions consisting of additional SM and DM components showed noticeable effects (Joo and Liu, 2017; Joo et al., 2019). The two reviews accounted mainly for the positive effect frequencies. This trend was visible across all intervention groups. DM as primary intervention showed higher positive effect counts with SM, MDTs and CM, and so did MDTs as a primary intervention. The complex interventions category included the most interventions with combined components. Hence, this trend was more noticeable across this group.

Second, given the variability across the outcome types assessed by different reviews, it can still be argued that the first point might not give a strong indication of more positive effectiveness. However, even in terms of the distribution of effects across the three categories of outcomes, interventions with multiple components showed more positive effects. For example, compared to reviews with interventions consisting of single components, reviews which included interventions with multiple components showed more positive effects in reducing hospital admissions/readmissions. This trend was also visible across many organisational and patient-centred outcomes, including ED visits, LoS at the hospital, and Qol/HRQol. Although the combination of these models might be more effective in general, the components of a broad intervention consisting of two or more of these models might influence effectiveness. In other words, combining specific models seemed more effective with certain outcomes. For instance, across all reviews which included multiple components (Prvu et al., 2012; Kruis et al., 2013; Leppin et al., 2014; Allen et al., 2014; Hickman et al., 2015; Braet, Weltens and Sermeus, 2016; Joo and Liu, 2017; Yang et al., 2017; Kastner et al., 2018; Valentijn et al., 2018; Takeda et al., 2019; Joo et al., 2019), there was uncertainty in evidence regarding hospital readmissions in interventions which did not include CM and MDT components (Prvu et al. 2012; Allen et al., 2014). Besides, interventions that included an additional SM component showed noticeable effects in patient-centred outcomes regarding magnitude and frequency. Given that, even as a separate intervention, SM interventions showed noticeable effects on patient-centred outcomes.

While the combination of multiple ICIs might produce better effects, including higher numbers of combinations could also be more effective. Not all interventions with combinations of two ICIs reduced hospital use. On the other hand, interventions consisting of three ICIs or primary interventions with more than two components of other interventions reduced hospital use across different outcomes (Braet et al., 2014, Leppin et al., 2014, Takeda et al., 2019).

Thirdly, the main aim of IC interventions in reducing fragmentation of care for patients with LTCs might be more feasible to achieve with the combination of multiple models. This can be explained by patients with LTCs often requiring a care plan with multiple elements. In other words, patients with chronic conditions might experience different health-related incidences, which cannot be confined in terms of care in one model. For example, healthcare for patients with COPD might range from simple medication and symptom management to hospitalisations. While an SM model might provide benefits in terms of medication adherence, symptom, and lifestyle management (Smoking cessation, Physical exercise), COPD patients might experience a health-related incidence that might require hospitalisation. As a result, following hospitalisation, a discharge planning element combined with post-discharge SM elements rather than SM alone following discharge might increase the chance of preventing readmission. However, it can still be argued that an SM model can prevent admission in the first place, and this can be explained by the results presented in table 11.

Nevertheless, the aim of complete admissions prevention is not feasible. This argument can also be applied to other models. For instance, patients with CKD were shown to achieve better health outcomes when they received care from multiple HCPs (Shi et al., 2018). As a result, an additional MDTs model to a broad intervention might increase the chance of achieving better outcomes.

Given the variability across health-related incidences, which requires different forms of care, an intervention that could target multiple health-related scenarios across different settings and conditions is required. As a result, a combination of the four ICIs might be able to provide the required coverage. This model could consist of a CM component with case-managers providing care plans to an MDT team which would intervene guided by other interventions (SM and DM) across different settings (Hospital, Home, Clinic).

Achieving a model of care that can address every patient's need and reduce care fragmentation can be difficult. Hence, in addition to combining different ICIs, it is essential to consider the components of these interventions and modes of delivery. While there was a notable variation in components and characteristics in all interventions across the assessed reviews, specific characteristics and components were reported as more effective. DM interventions frequently existed with post-discharge interventions and hospital-initiated interventions continuing after discharge, and interventions involving more individuals in care delivery and supporting patient capacity for self-care were more effective in reducing readmissions (Prvu et al., 2012, Allen et al., 2014, Leppin et al., 2014). Moreover, there was evidence of better effectiveness of DM with post-discharge support with SM components and MDTs interventions as more effective with teams that include condition-specific expertise (Damery et al., 2016).

Some interventions cannot exist without some components by default. For example, MDTs are often characterised by focusing on different action areas, such as case management and health education (Taberna et al., 2016). While those are considered central components of other interventions such as SM or CM, the focus on including components rather than complete interventions with specific characteristics combined could alter the aim of reducing care fragmentations and produce fewer results. Combinations of interventions can establish the necessary coverage of certain additional characteristics needed for specific ICIs (e.g., DM), such as the involvement of more individuals in care delivery (covered by MDTs) and supporting patient capacity total self-care (covered by SM).

8.4.2 Outcome Measures

The secondary objective of this review was to identify potential indicators to measure the effectiveness of ICIs. We were able to identify a variety of outcomes. With this in mind, these indicators could vary in relation to the type of intervention being group/condition specific or targeting general populations with different LTCs. In this regard, while patient-centred and clinical outcomes might serve as good indicators in the case of group/condition-specific interventions, hospital use, and other organisational outcomes might be able to capture effects on the population level.

8.4.3 Knowledge gap

The main gap identified in this review was that population-based interventions were not an area of focus in the included studies. Given the population-based healthcare's nature, implementing, and designing a population-based intervention is crucial. In other words, the studies focused solely on sub-populations of patients with specific LTCs. When it comes to healthcare on the population level, ICM coverage should be broader, thus, combining multiple IC interventions. Accordingly, this emphasises the importance of evaluating and monitoring population-based models to gain insights on how ICMs can benefit a system that provides healthcare to the whole population of patients.

The second gab identified was confined to identifying potential factors that could shape/alter the effectiveness of ICMs. With this in mind, those could include any patient characteristic such as age, gender, and type of LTC. This aligns with evaluating and/or implementing population-based ICMs, which were not an area of focus in the included studies. Such characteristics are critical in risk stratification, a core tool for population-based ICMs' implementation, monitoring, evaluation, and target populations specification (NHS England, 2017). This is related to the fact that this tool aims to identify individuals with the highest risk of unplanned admissions and provide proactive care to prevent adverse events. At the population level, risk stratification is an effective tool for health planning and identifying the distribution of health needs. In figure two in appendix A, to assign the focus of each IC intervention, it is crucial to identify the target population. IC aims to provide proactive care to reduce fragmentation and, by extension, reduce unplanned hospital admission rates. Accordingly, this tool represents a pivotal element in monitoring and shaping IC services and informing commissioning.

Lastly, although this review did not aim to assess or make any conclusion on methods used to evaluate IC interventions, in was clear that RCTs were the most used design. In the context of population-based ICM, randomisation will not be possible; thus, using RCT methods will not be feasible. Besides, predicting the effect of such intervention on hospital activity outcomes, such as admissions, is not plausible. This is related to the phenomenon of the regression to the mean, which occurs with repeated measures. Hence, even without the intervention, the patients might have a lower rate of admissions or readmissions on average. Accordingly, the need to have an outcome-based evaluation model with a different study design and statistical methods for such models would be necessary.

9 CHAPTER 3: THESIS OUTLINE

This thesis aims to give an initial impact evaluation for commissioners and policymakers to analyse the effect of population-based ICMs and determine whether they can meet their initial goals. Fig 2 shows an outline for the research presented in the thesis, which comprises the primary research questions each study is based on. This project was a novel attempt to evaluate a new model of care introduced in the last five years in England and, more recently, in Hillingdon. Evaluating ICMs in England has faced several challenges, especially from the commissioner's perspective (Kumpunen et al., 2019). It was argued that more realistic timeframes and an openness to diverse methods and approaches, including more formative evaluation, are required (Kumpunen et al., 2019).

Regarding population-based ICMs, it is widely known that rapid evaluations are frequently required to discover "quick successes" and accelerate learning within health and social care systems (McCarthy et al., 2019). The NHS's evaluation strategy for the new models of care, including the most recent vanguard programme (Morciano et al., 2020), included rapid evaluations. Accordingly, when we speak about a formative evaluation, there should be an estimation of outcomes in the short and long term. That being said, the first method that comes to mind that could capture those changes in outcomes is interrupted time series (ITS) rather than experimental studies, which are not feasible in the context of such approaches. ITS is the most robust quasi-experimental approach for evaluating the longitudinal effects of interventions (Wagner et al., 2002).

Given the highlighted points, this study adopts an ITS design to evaluate the impact of the Hillingdon ICM. A second objective within the study in relation to the first aim is to evaluate the model in the short term and give indications on its long-term effects to try to overcome the limitation highlighted by McCarthy et al. Two datasets with different data points were acquired. The limitations can be applied to the first dataset and the initial analysis; however, the second dataset included more data points and a control group. This is thought to give a more accurate estimation in the long term and confirm the possibility of short-term effects if similar estimations were obtained.

Nevertheless, regardless of the highlighted limitations, the segmented ITS still have a predictive power to estimate long-term effects. Consequently, this study could provide a systematic method to study the effect of population-based ICMs and understand if they achieved their initial goals. Furthermore, the study could serve as an initial impact evaluation model to capture the short-term and intermediate outcomes and better indicate such models' long-term effects. With this in mind, such indications could be achieved by comparing those models to other contexts.

The emergence of the COVID-19 pandemic and the implementation of the lockdown could have changed hospital activity in Hillingdon regardless of any effects of any intervention. That being said, in addition to the stage two analysis, the last objective concerning the first aim of this study was to assess the impact of COVID-19 lockdown on the intervention impact. In other words, this analysis tried to validate the analysis highlighted earlier.

The last objective of this thesis was to provide the commissioners and policymakers with a predication analysis that can aid in developing a simple risk segmentation criterion for the Hillingdon CCG commissioners. In line with what was highlighted above, this analysis was conducted to add how population-based models could be more effective in achieving better outcomes. Nevertheless, designing a risk segmentation criterion could specify the populations with higher risks of need to be targeted with specific interventions as a part of a whole model. This analysis can open a door for future evaluations of such models with the possibility of conducting cluster analysis. Such cluster analysis can identify what part of the models targets what populations.

Consequently, this might aid in further developing and enhancing population-based ICMs. Furthermore, this analysis can show the extent to which time-varying confounders on any analysis trying to capture an evaluation of an ICM. This can also validate the effect of such factors that were considered in the first analysis. Those can include sociodemographic factors such as gender.

Currently, the QAdmission tool is being used in Hillingdon (Hippisley-Cox and Coupland, 2013). The tool uses an algorithm to predict hospital emergency admissions via a Cox regression analysis. The variables used for prediction include demographics (age, gender, postcode, ethnicity) and information on lifestyle (e.g., smoking status), medical conditions (e.g., Asthma), blood tests (e.g., Haemoglobin), Drugs (e.g., anticoagulants), and BMI. The model calculates the risk of admission as a score that could be converted into a percentage. However, the tool only predicts unplanned hospital admissions risk; thus, the tool might miss some critical groups in population-based models. This is related to the fact that admissions alone could only identify specific risk groups in terms of admissions related to the tool's predictors. Nevertheless, predicting the risk of A&E visits besides LoS at the hospital and non-elective hospital admissions might provide a more straightforward and more effective risk stratification in a general population. This is related to the fact that individuals who visit the A&E could be assigned to different risk groups, including those with the lowest needs.

Moreover, it is still likely for this tool to over -or- underestimate risk stratification concerning care needs as it uses hospital admissions as the only outcome. Although population-based ICMs focus on groups with the highest needs, the model also targets the entire population and aims to reduce outcomes other than non-elective hospital admissions. Second, in the final risk score, precise information on the characteristics of high-risk individuals, such as age, morbidities, and ethnic background, may be lost. All patients in the top stratum have high-risk scores. However, the factors contributing to this high score can vary greatly. These should be considered while implementing and designing interventions to determine which patients are most likely to respond. Accordingly, the study used available data on demographics and LTCs to predict the risk of three hospital activity outcomes, including NEL admission, A&E visits, and LoS at the hospital. With this in mind, once predictors are identified, a simple criterion can be developed, and this could serve as a platform for future population-based integrated care model expansions and developments, including the ones implemented in the context of England.

Fig 2: Thesis Outline

Chapter 1: Introduction

- Why LTCs and MLTCs have been significant challenges, globally and in England?
- Why has the NHS been unable to address these challenges?
- Integrated Care (IC) as anew model of healthcare?
- Introducing the Hillingdon Case

Aims and Objectives of the Thesis

Chapter 2: Reviewing Evidence

Research Questions

- Is IC effective in improving patient care and reducing hospital activity?
- Does combining multiple ICC interventions produce better outcomes?
- What outcomes can be used to predict effectiveness?

Knowledge Gap

Chapter 3: Thesis Outline

Chapter 4: Effects of the Hillingdon ICM on Hospital Activity

Research Questions

- Is the Hillingdon ICM effective in reducing hospital admissions, LoS at the hospital, and A&E visits in the short term?
- Can the Hillingdon ICM, as a multi-component, be more effective than controls (Model with fewer components)?
- Can the Hillingdon ICM produce effects in the long term?

Chapter 5: Evaluating the Impact of COVID-19 lockdown on Hospital Activity

Research Questions

- Did the emergence of COVID-19 pandemic have an impact on the preceding analyses' findings?

Chapter 6: Predictors of Hospital Activity in Hillingdon

Research Questions

- What are the demographic and condition-specific predictors of hospital activity in Hillingdon?

Chapter 7: Discussions and Conclusions

- What are the implications of the findings in this thesis (Hillingdon ICM evaluation) on other contexts and ICMs?
- What does this thesis add?
- What are the limitations of this thesis?

9 CHAPTER 4: EVALUATING THE EFFECTIVENESS OF THE HILLINGDON ICM in reducing Hospital activity.

9.1 INTRODUCTION

While chapter two revealed an existing gap in the literature concerning the implementation and evaluation of population-based ICMs, the primary evaluation of the Hillingdon ICM was introduced in this chapter. The review showed that condition-specific IC intervention was dominating the interests of health policymakers. This probably would have explained why the combination of different IC interventions in one ICM was not introduced. When it comes to population health IC, multiple interventions should be involved. The review showed that combining these interventions might produce better effects; hence, this chapter tested this finding by evaluating a population-based ICM implemented in Hillingdon.

Given the nature of the health system in England, population-based interventions might be the best option to manage populations' health. Several points can explain the rationale behind choosing the population-based approach as the best model of care in this context. First, as highlighted in appendix A, complete/whole system integration is the most ambitious form. This is related to the fact that this integration focuses on the population and not just specific groups. On the other hand, this form combines the population-based and person-centred approach of IC and, thus, focuses on delivering care (Especially for vulnerable groups), improving the population's health, and preventing diseases through health promotion. This form delivery can be guided by risk stratification and dividing the populations into different tiers. This form of integration is applied particularly by population health models. To achieve this, multiple IC interventions should be placed together in an ICM, which can be solely described as population-based. Kaiser Pyramid is the best example of how a population-based approach to IC can be applied (Appendix A, Fig 2).

While the above points explain the rationale behind choosing the population-based approach from a general perspective, how health systems operate in different contexts could be essential in guiding the choice of a suitable IC approach. In England, commissioning is the cornerstone of the NHS's healthcare policy, planning, and monitoring. Commissioning is provided by clinical commissioning groups (CCGs) and NHS England on a local, regional, and national basis, by which all yield on a population level (Adlington et al., 2015). In 2002 a comparison between Kaiser and the NHS health systems found that Kaiser ICM achieved better performance in primary care services with more access to secondary care with lower costs. The paper concluded that better integration throughout the Kaiser system and efficient management of hospital use were the main factors contributing to this difference (Feachem, Sekhri & White, 2002). A study conducted the year after found a better effect on hospital bed utilisation achieved by the Kaiser ICM and suggested that the NHS can learn from Kaiser's integrated approach (Ham et al., 2003). Such evaluations resulted in a shift in the way the NHS delivers healthcare. This is especially true in light of the NHS's five-year plan, which emphasises the NHS's dual role in prevention and lifestyle support and the development of new care models (NHS, 2014). Several evaluations of various ICMs have indicated that people receiving IC services used hospitals more than matched controls, rather than the expected reduction in hospital admissions (Kumpunen et al., 2019). In other evaluations, single disease management models with case management approaches had minor effects on utilisation (Baxter et al., 2018). Problems with model design and targeting the wrong populations were highlighted as a major factor, in addition to the other reasons behind the lack of favourable findings (Kumpunen et al., 2019). Accordingly, given the promising results of the new Vanguard program concerning the above points, it can be argued that the population-based ICM could serve as the best model of choice in the case of England. Even across other contexts, the tendency has been towards broader population-based approaches with the implementation of different models across the whole population (Alderwick, Ham & Buck, 2015).

Reduced hospital activity across multiple hospitals in England, including Hillingdon, might alleviate the workload on services that are rapidly reaching their maximum capabilities, as noted in the opening chapter of this thesis (NHS, 2019). To attain this goal, Hillingdon policymakers needed to offer patients with person-centred and integrated quality of care in various settings, including their homes. This illustrates again the reason for building a model with multiple interventions aimed at the whole Hillingdon neighbourhood. Other ICMs are more likely to concentrate on specific disease management models using case management approaches (Stokes, Checkland & Kristensen, 2016). However, their measures had a minimal impact on hospital use (Baxter et al., 2018). Consequently, there has been a recent trend toward using more comprehensive population-based strategies to deploy various models throughout the population (Alderwick, Ham & Buck, 2015). Scaling up patient-centred and prevention-based techniques is a common theme in such approaches.

Given these points, assessing the impact of such models, including the Hillingdon ICM, in reducing non-elective hospital admissions, A&E visits, and LoS could give an induction if the model produces its designated effect. According to such models, rapid evaluations are frequently required to uncover "quick successes," changes in outcomes, and expedite learning within health and social care systems. (McCarthy et al., 2019).

In this connection, I conducted this principal analysis to evaluate the new population-based ICM implemented in Hillingdon and combine multiple ICIs to reduce hospital activity effectively. The NWL CCG implemented the model in October 2019. Outcomes assessed included: NEL admissions, A&E attendances and length of stay (LoS) at hospitals. The assessment was presented as a short-term effect analysis and was separated into two stages, with two datasets with identical features being analysed in each step. The first stage involved a primary analysis examining the impact on three outcomes at the population and subgroup levels. The second stage was a secondary analysis that looked at the effect on three outcomes at the population level using more data points and a control group to validate stage one findings. The analysis at its first stage was published in BMJ under the Integrated Healthcare Journal (Mansour, Pokhrel, Birnbaum, and Anokye, 2023). On the other hand, the second stage analysis is being prepared for publication in another journal.

9.1.1 Description of The Hillingdon ICM

The HCPP ICM consists of two main models, including the Neighbourhood Teams (NT) and Intermediate Tier (IT) (Fig 3). The NT model is the PACs system or (Primary care network PCN) highlighted earlier. This model consists of eight neighbourhoods with several GP surgeries in each neighbourhood. The model is designed for GPs to work holistically with different teams, including MDTs and care connection teams (CCTs). MDTs consist of multiple HCPs, including pharmacists, mental health practitioners, and social workers, working together with CCTs. These teams are responsible for pro-actively identifying individuals at high risk of A&E attendance and/or hospital admission, providing long-term care, assessing their needs, and developing personalised care plans aiming for self-management (SM) of their conditions. Besides, those teams collaborate to actively 'case manage' the 15% of their patients at greatest risk of future admission, including patients with LTCs. The main aim of the active expansion of case management (CM) is to assess, plan and facilitate service delivery for patients with LTCs. Alongside CM, a high-intensity user (HIU) service was implemented to target the most intensive users of the Hillingdon Hospital emergency department and London Ambulance Service. HIU targets these groups through a health coaching approach, proactively supporting them to understand and address the underlying health and social causes of their frequent requirement for unscheduled care. This model also focuses on providing support services, including smoking cessation, self-care courses, and community assets. Such services target the population with minor needs (Tier 1).

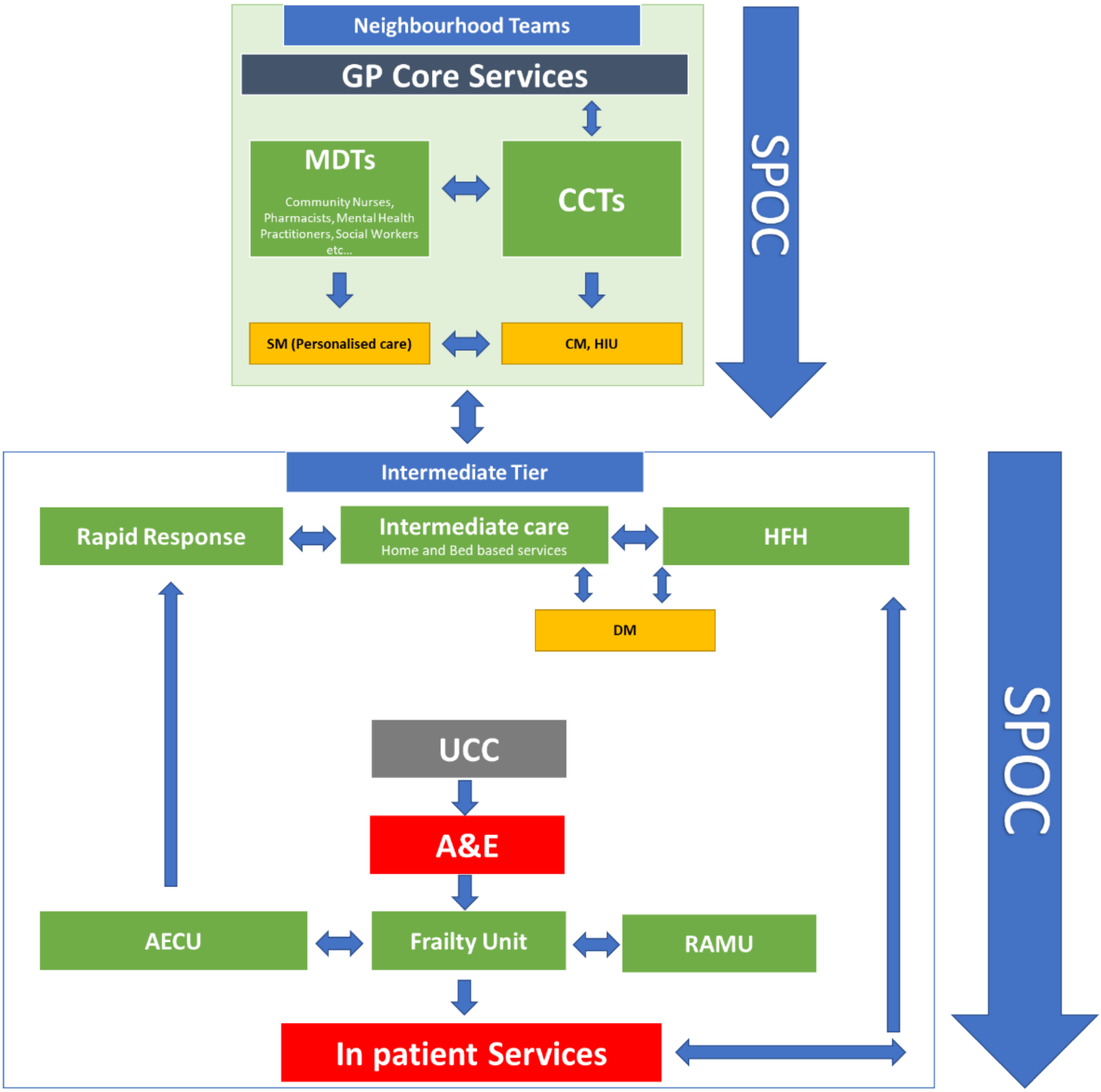
The IT model aims to provide a range of time-limited (up to 6 weeks) integrated health and social care services. Those services can be divided into two main categories: home/community-based and hospital-based. First, the home-based services include a rapid response service staffed by a team of health and social care professionals to provide what is known as 'step up' care: an urgent 2-hour response to a sudden deterioration in a person currently living at home, giving them the maximum opportunity to recover and avoid hospital admission. Second, the Home from Hospital Team (HFH) under integrated line management facilitates discharge and assessment to ensure that frail older people who are medically well enough to leave the hospital are assessed, where appropriate, in their home environment or community setting than on a hospital ward. The intermediate care includes home-based (GP visiting) and community bed-based (specialist beds for acute symptom management and 12 nurses). Both services aim for discharge management (DM), providing early discharge support for people recovering from an illness, fall or post-operation who do not require inpatient treatment and can be cared for in the community or at home. Also, the HFH service aims to reduce the average hospital length of stay and prevent the de-conditioning of older people associated with their over-hospitalisation. Hospital-based services include the Ambulatory Emergency Care Unit (AECU), Rapid Assessment Medical Unit (RAMU), and Frailty Unit. Although the delivery approaches for these services differ, they each aim to streamline intermediate care and hospital ‘front door’ and ‘back door’ services into a coherent service. This service was designed to provide access to rapid multidisciplinary assessment and short-term, time-limited intensive care packages for people at serious risk of admission and to enable people to return home as quickly as possible when they present at the hospital. The AECU is an existing service extended in this model to cover more hours and includes more resources.

On the other hand, RAMU is a new physical location that receives any stable patient unsuitable for AECU. The medical team could see these patients in this new assessment area. The unit could take patients directly from Primary Care, urgent care centre (UCC) & LAS (bypassing emergency department) via a single point of access. Finally, the Frailty Unit is not different from both services except that it uses a multidisciplinary approach and focuses on older patients with a higher risk of hospitalisation.

Lastly, the model includes A 24/7 single point of coordination (SPoC) accessible through a medical information system or by direct dial proposed to assist health and social care professionals in arranging the proper care for all urgent and non-urgent referrals. The SPoC should facilitate better communication between MDTs and GPs across different settings to manage patients with LTCs in the community at the neighbourhood level. Whether discharged from the hospital or being at home, the service aims to provide the necessary care provided by all teams and units in this service to prevent avoidable visits or admissions to the hospital.

The HCPP ICM targets three primary outcomes: non-elective hospital admissions, A&E visits, and length of stay (LoS). The model is expected to reduce these outcomes by providing personalised care plans (MDT, SM and CM) to increase the quality of care to patients, especially those at high risk of admissions (Reduce A&E visits, non-elective hospital admissions). Besides, the model is also expected to provide hospital and home-based integrated health and social care services (DM) to promote faster recovery from illness, prevent unnecessary acute hospital admission, and reduce the LoS at the hospital. Accordingly, the reduction in these three outcomes could be sufficient to indicate the effectiveness of this model.

Fig 3: The Hillingdon ICM (Source: Author conclusions based on meetings with NWL CCG stakeholders)



MDT: Multidisciplinary Teams, **CCTs:** Care Connection Teams, **SM:** Self-Management, **CM:** Case Management, **HIU:** High Intensity Users, **HFH:** Hospital from Home, **DM:** Discharge Management, **UCC:** Urgent Care Centre, **AECU:** Ambulatory Emergency Care Unit , **RAMU:** Rapid Assessment Medical Unit, **A&E:** Accident and Emergency, **SPOC:** Single Point of Coordination

9.2 Data and Methods

9.2.1 Study Design

Interrupted time series (ITS) is the first method that comes to mind for capturing those variations in outcomes. ITS is the most reliable quasi-experimental approach for assessing the longitudinal effects of interventions (Wagner et al., 2002). However, current evidence suggests that ITS may not be the best method for estimating the short-term impacts of such interventions. (McCarthy et al., 2019). This is owing to the fact that datasets used to estimate short-term effects are frequently underpowered due to fewer data points before and after interventions. Furthermore, due to time-varying confounders, such studies' results, particularly those with fewer data points, are prone to bias. (Lopez Bernal, Cummins & Gasparrini, 2018).

While the first stage analysis could provide insight into the initial impact of the Hillingdon ICM on the three outcomes of interest, the second stage analysis could also validate the findings of the earlier analysis by reducing bias and indicating if Hillingdon's current ICM, which includes several integrated care interventions (ICI), was more effective than the control (Ealing). This is because, during the study period, both boroughs shared only two main ICIs in terms of implementation: Neighborhood Teams (NT) and Intermediate Tier (IT). In light of this, the Hillingdon ICM continues to be distinctive regarding extra interventions and integrated care pathways. Besides, in stage two analysis, more data points were included, which might increase power and reduce potential bias, which was highlighted earlier.

In addition to the benefits listed above, ITS can be used as a cut-off approach to understand how outcomes "behave" before and after the deployment of an intervention, which in this case symbolizes the interruption. In other words, the effectiveness in this scenario may be determined by comparing the period prior to implementation (pre-intervention period) to the period following implementation (post-intervention period).

9.2.2 Data

I obtained monthly counts of non-elective hospital admissions, A&E visits, and LoS at the hospital in days from the Whole Systems Integrated Care (WSIC) database provided by the Hillingdon CCG business intelligence team from October 2018 to July 2020 for dataset one (stage one analysis), and to November 2020 for dataset two. In both datasets, data also included demographic characteristics of patients, including age, gender, and ethnicity. Data was provided as an individual-level panel dataset and was analysed as so to prevent aggregation bias (Goodfriend, 1992, Pesaran, 2015). However, data was also analysed in its aggregative form to plot predicted regression curves.

9.2.2.1 Whole Systems Integrated Care (WSIC)

WSIC is a huge database that uses dashboards to connect provider data from four acute, two mental health, and two community trusts across eight CCGs, as well as social care data from eight boroughs and 380 GP practices, to produce an integrated care record. This electronic record can be accessed by various health and social care providers and health professionals involved in a patient's care. The records are transferred to and maintained in a data warehouse, and the North West London Digital ISA, a legal instrument, governs its use. This agreement encourages signatory care providers to share patient information, guaranteeing that personal information is kept private and shared for the intended purpose. Patients are given pseudo ids to minimize the risk of identification.

According to internal stakeholders and North West London CCG BI team, WSIC has implemented data validation and verification methods, which include cross-checking data against external sources and doing periodic data validation exercises. Hence, this could reassure the reliability of this data. Moreover, according to the same source, WSIC data integration techniques include quality control measures to validate, clean, and standardise data. These procedures can also add to reliability and aid in the preservation of data accuracy.

9.2.3 Control Group

The population of Ealing was chosen as the control group for stage two analysis. Three reasons explained choosing this group. The first is data accessibility. Data from the London borough of Ealing was more accessible than data from other boroughs that were unavailable. Second, Ealing is one of the closest boroughs to Hillingdon, having similar population characteristics and service utilisation. As a result, comparing trends in both populations may be able to identify the presence of a potential confounder effect regardless of intervention effects. Lastly, I discussed with the Head of Integration & Delivery in Ealing CCG the statutes of implementation of their ICM. The Ealing ICM is supposed to be the same as the Hillingdon ICM in the long run; however, as confirmed by the head of integration in Ealing, the Neighbourhood part of the model and the Intermediate tier are the only interventions that were in effect at time of interruption in Ealing. As a result, comparing both populations in the second stage analysis could indicate if the ICM in Hillingdon, with its additional intervention, could achieve better effects. In other words, does adding such additional interventions produce better effects?

9.2.4 Ethical Considerations

The analysis was performed in the WSIC de-identified environment (WSIC servers) with no capability to be released from these servers. The dataset was provided in its original form with records linked in these dashboards with pseudo ids. Analysis outcomes, including descriptive statistics, were presented as aggregated data; thus, there was no risk of identification of patients based on their demographic data, which did not include specific identifiable details such as names or postcodes or GP surgeries. The analysis outcomes were released by the WSIC team, who checked for any risk of identification and a consent was given to publish the analysis outcomes (Appendices, Fig 3).

9.3 STATISTICAL ANALYSIS

10.3.1.1 Stage 1:

Multiple imputations (MI) (n=5) by chained equations were used to replace missing data (Young and Johnson, 2015). 'Multiple imputations' is a technique for coping with missing data that entails establishing multiple plausible imputed values for each missing data point and then evaluating these imputed datasets as if they were complete datasets. This method is considered superior to others, such as deletion or single imputation, because it can account for the uncertainty inherent in missing data and result in more accurate and precise estimations of model parameters (van Buuren, Groothuis-Oudshoorn, 2011). Imputation models used ordinal logistic regression to predict missing values in LTC and ethnicity based on the three dependent variables (outcomes), including non-elective admissions, A&E visits, and LoS at the hospital.

Interrupted time series (ITS) Poisson and Negative binomial models (Only for LoS) (Bernal, Cummins & Gasparrini, 2017), with random effects estimator (0.05 significant level), predicted the change in the outcomes controlling for gender, age, ethnicity, and LTC. The inclusion of these factors was chosen due to their well-documented impact on healthcare outcomes (Phelan, Link & Tehranifar, 2010). These variables were included to reduce any confounding effects and improve the study's internal validity.

Robust standard errors (Huber- White) were obtained for the regression parameters to account for potential serial correlation and overdispersion check. I used periodic functions to control for potential seasonality and long-term trends (Bhaskaran et al., 2013). The robust SE estimators informed the choice of the models for each outcome in addition to means and variances (see Appendix B). Generalised linear models (ITS) with Poisson and negative binomial extensions were adopted for plotting regression curves and analysing data in its aggregative form.

To achieve the ITS model, the following segmented regression model was used:

$$\boldsymbol{Y_t} = \beta_0 + \beta_1 \boldsymbol{T} + \beta_2 \boldsymbol{X_t} + \beta_3 \boldsymbol{TX_t}$$

I defined independent variables T_t (from Oct 2018 to Jul 2020) as the time elapsed from the start till the end of the study, and X_t as a dummy variable to indicate the pre-intervention period ($X_t = 0$) or the post-intervention period ($X_t = 1$). T_t=13 (Oct 2019) was defined as the time of implementation of the intervention. Also, the variable T_t represented the change in rate over each month. The β_2 coefficient was defined as the level of change following the intervention and represented the immediate effect (using $\beta_2 X_t$). Using the interaction between T_t and X_t (TX_t) the β_3 coefficient was defined as the level of change following the intervention and represented the effect over time.

I undertook further subgroup analysis to examine the effect of the intervention on the outcomes within diverse populations, with or without LTCs. Groups were defined as: With LTC, Without LTC, Cardiovascular disease (CVD), Hypertension, Asthma, Chronic obstructive pulmonary diseases (COPD), Diabetes, Cancer, Multimorbid (more than one condition), and other conditions (e.g., rheumatoid arthritis, neurological disorders, and thyroid conditions). I also modelled the three outcomes over time before and after implementing the ICM separately to examine trends of change with Poisson and negative binomial models (only for LoS).

Sensitivity analysis examined the effect of missing data replacement by comparing raw and imputed datasets. Also, I examined the effect of potential confounders by removing them from the model. The coefficients estimated for the GLM analysis were also compared to the preliminary modelling results. See appendix B material for sensitivity analysis output.

10.3.1.2 Stage 2:

I adopted the same statistical models from the previous analysis (Multiple groups interrupted time series (ITS) Poisson and Negative binomial models (Only for LoS), (Linden, 2015, Bernal, Cummins & Gasparrini, 2017), with random effects estimator and 0.05 significant level) except that I added extra interactive functions to indicate the control group. Data at this stage had no missing values after recent refreshers from the WSIC team. I controlled for gender, age, ethnicity, and LTC. I also computed robust standard errors (Huber-White) for the regression parameters to account for any serial correlation and overdispersion check. Similarly, I used periodic functions to account for potential seasonality and long-term trends (Bhaskaran et al., 2013). In addition to means and variances, the robust SE estimators influenced the model selection for each outcome. Generalised linear models (ITS) with Poisson and negative binomial extensions were adopted for plotting regression curves and analysing data in its aggregative form.

To achieve the multiple groups ITS model, the following segmented regression model was used:

$$Y_t = \beta_0 + \beta_1 T + \beta_2 X_t + \beta_3 X_t T + \beta_4 Z + \beta_5 Z T + \beta_6 Z X_t + \beta_7 Z X_t T$$

I defined independent variables T (from Oct 2018 to Nov 2020) as the time elapsed from the start till the end of the study, and Xt as a dummy variable to indicate the pre-intervention period (Xt = 0) or the post-intervention period (Xt = 1). T=13 (Oct 2019) was defined as the time of implementation of the intervention. In the current analysis, Z was defined as a dummy variable to denote the cohort assignment (treatment (Hillingdon): Z = 1, or control (Ealing): Z = 0). β_2

(using $\beta 2Xt$) and β3 (using $\beta 3Xt$) coefficients represented the change of outcomes in the control group immediately after the intervention initiation or overtime, respectively. On the other hand, using the interaction between Z, Xt, and T, β_6 and β_7 represented the change of outcomes in the treatment group compared to the control group immediately after the intervention implementation or overtime, respectively.

At this stage, no subgroup analysis was conducted, as this stage analysis aimed initially to validate the results of stage one analysis by including a control group and more data points.

9.4 RESULTS

9.4.1 Stage 1:

9.4.1.1 Description of the Sample:

I analysed a sample of n= 331330 individuals registered in the London borough of Hillingdon, United Kingdom (Table 16). Most individuals were under 65 years of age (84%). Males were more than females by 11%. The population was predominantly White, 48%, followed by Asian (27.82%) and Black (6.50%.). 10.61% of the data in this category was missing.

37% of the population had one or more LTC. Patients with multimorbidity accounted for 14.08% of the population. Like ethnicity, this category also included missing data (7.22%). MI was used to replace missing data in both categories.

Table 16: Sample description and characteristics

		N	%
Pop Hillingdon		331330	100%
Age	> 65 years	52759	16%
	<65 years	278571	84%
Gender			
	Males	162227	49%
	Females	169094	51%
Ethnicity			
	White	151012	45.57%
	Black	21533	6.50%
	Asian	92166	27.82%
	Mixed	9872	2.98%
	Other	21590	6.52%
	Unknown	35157	10.61%
Without LTC		209020	63%
With LTC		122310	37%
	CVD	3112	0.94%
	Diabetes	3216	0.97%
	COPD	415	0.13%
	Asthma	6380	1.93%
	Hypertension	10202	3.08%
	Cancer	1388	0.42%
	Multimorbid	46666	14.08
	Other	27003	8.15%
	Missing/Unknown	23928	7.22%

9.4.1.2 Description of the Outcomes by the Sample:

The total number of non-elective admissions from the start till the end of the study was 43680. Patients with LTCs accounted for most admissions (66.5%) (Table 17). Also, patients with multimorbidities accounted for most admissions, with 36.6% (55% of patients with LTC). The total number of A&E visits was 212180. Individuals with no LTCs accounted for most attendances (52.8%). Similarly, individuals with one or more LTCs accounted for most visits, with 24.5% (52% of patients with LTC). Finally, patients spent 178784 days at the hospital from Oct 2018 to Jul 2020. Patients with LTCs spent around 68% more days at the hospital than individuals without LTCs. Patients with multimorbidities were also the most in spending time at the hospital overall, with 43.1% (51% compared to other LTC groups).

Table 17: Outcome characteristics by sample(s) group

Condition	NEL Admissions		A&E visits		LoS (days)	
	N	%	N	%	N	%
Total	43680	100%	212180	100%	178784	100%
No LTCs	14625	33.4%	112081	52.8%	28388	15.8%
With LTCs	29055	66.5%	100099	47.1%	150396	84.1%
CVD	1185	2.7%	2140	1%	9296	5.2%
Diabetes	527	1.2%	2300	1%	1748	0.9%
COPD	168	0.3%	467	0.22%	753	0.4%
Asthma	870	1.9%	5629	2.65%	1460	0.81%
Hypertension	1473	3.3%	5884	2.77%	5800	3.2%
Cancer	392	0.8%	942	0.44%	1393	0.7%
Multimorbid	15988	36.6%	52068	24.5%	77218	43.1%
Other	4340	9.9%	20589	9.70%	20017	11.1%
Missing/Unknown	4112	9.4%	1000	0.47%	32711	18.2%

9.4.1.3 Effects on Outcomes:

Figure three summarises the change in rates before and after the intervention monthly, together with the predicted regression curves. I observed a gradual decline over time in the three outcomes' rates following an immediate increase in the first month of implementation. The immediate increase in the three outcomes rates, as in rate ratios (RR), was not statistically significant when the data was analysed in its aggregative form (Appendix B). However, this was not the case for the original regression analysis undertaken on the individual-level panel dataset.

Fig 3: Effect of the intervention on outcomes during the study period. Circles and solid lines represent the observed and the predicted rates, respectively. The dashed lines represent the de-seasonalised trend of the three outcomes before and after the intervention.

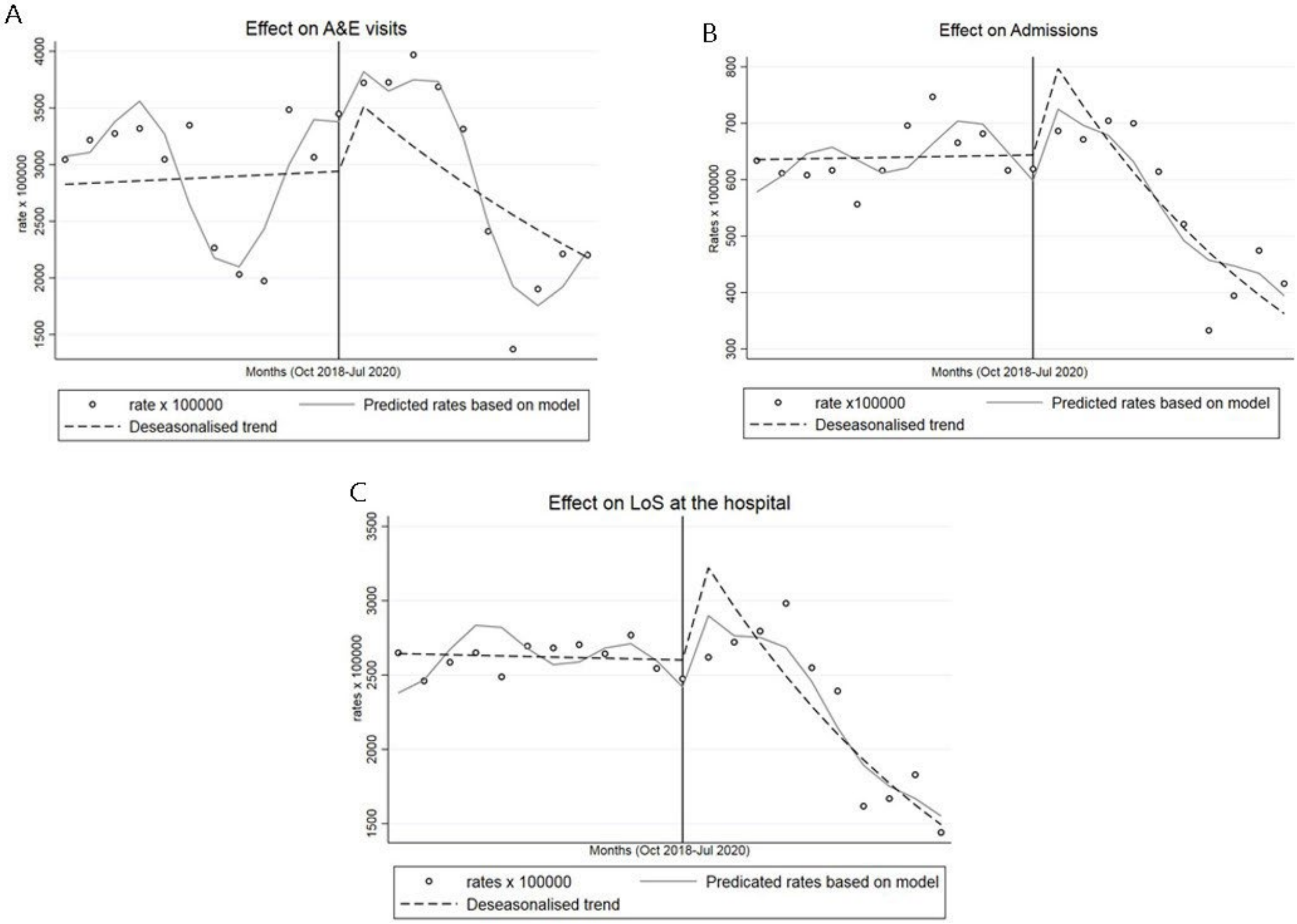


Table 18 summarises the results of the ITS segmented regression model, which was fitted to the individual-level panel data to predict the change of outcomes during and before implementing the Hillingdon ICM model. Among the whole population of Hillingdon, during the first month of implementation, there was an increase of 37% in NEL admissions (RR 1.37, 95% CI 1.25-1.49). Similarly, the other outcomes showed a statistically significant increase during the first month of implementation (Table 20, IE (RR)).

Table 18: Rates of the outcomes of interest during the intervention compared with the pre-intervention period.

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Hillingdon Pop	**1.37*** 1.25-1.49	**0.91*** 0.90-0.92	**1.24*** 1.20-1.32	**0.94*** 0.93-0.95	**1.20*** 1.09-1.33	**0.93*** 0.92-0.94
With LTCs	**1.33*** 1.17-1.52	**0.92*** 0.91-0.93	**1.23*** 1.15-1.30	**0.95*** 0.94-0.96	**1.18*** 1.05-1.33	**0.94*** 0.93-0.95
Without LTCs	**1.44*** 1.24-1.66	**0.90*** 0.88-0.91	**1.27*** 1.20-1.35	**0.93*** 0.92-0.94	**1.27*** 1.05-1.53	**0.92*** 0.90-0.93

IE: Immediate effect, EO: Effect over time (gradual effect), RR: Rate ratio, CI: Confidence intervals, NEL: None-elective, *significant (p<0.05)

Following the first month of implementation, I found evidence of a gradual effect (decrease in rates) on the three outcomes, with a change in the underlying trend in admissions, A&E visits, and LoS among the whole population. The rates of admissions showed a gradual effect of decrease by 9% per month (RR=0.91, 95% CI 0.90-0.92), whereas the rates of A&E Visits and LoS decreased significantly by 6% and 7%, respectively (Table 20, EO (RR)). The effects did not vary in terms of significance and trend among individuals with LTCs compared to those with no LTCs. However, regarding magnitude, the effects on the three outcomes were more among patients with LTCs. Sensitivity analysis did not show a notable change in findings.

Further investigation of the trends of change in the three outcomes over time before and after the intervention showed a decrease in rates after implementing the ICM (Table 19). The rate ratio of admissions for the implementation period (Oct 2019-Jul 2020) among the whole population was 0.93 (95% CI 0.92-0.94). This was approximately the same for the other outcomes in table 21. There was nearly no change in rates of the three outcomes in the pre-implementation period.

Table 19: Change in the outcome of interest over time before and after implementing the intervention (with no interruption).

Outcomes	NEL Admissions	A&E Visits	LoS
Rate vs Time	(RR) 95% CI	(RR) 95% CI	(RR) 95% CI
Before Intervention	**1.01*** 1.00-1.02	**0.99*** 0.98-0.99	**0.99*** 0.98-0.99
After Intervention	**0.93*** 0.92-0.94	**0.91*** 0.90-0.92	**0.93*** 0.92-0.94
*significant (p<0.05)			

9.4.1.4 Effects on Outcomes by LTCs groups

I conducted a subgroup analysis for patients with different LTCs to examine the effect of the model in reducing the three outcomes of interest across these groups. The result of the analysis is summarised in table 20.

Table 20: Rates of the outcomes of interest during the intervention compared with the pre-intervention period among different groups with various LTCs.

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
CVD	1.08 0.62-1.78	**0.88*** 0.82-0.93	0.81 0.53-1.24	**0.91*** 0.86-0.96	1.07 0.63-1.80	**0.85*** 0.81-0.90
Diabetes	1.00 0.43-2.31	0.93 0.87-1.11	1.11 0.64-1.58	0.99 0.95-1.03	0.76 0.30-1.95	1.00 0.91-1.08
COPD	1.17 0.39-3.49	0.89 0.77-1.04	1.23 0.52-2.91	0.99 0.90-1.09	1.33 0.28-6.23	0.93 0.81-1.07
Asthma	1.28 0.71-2.36	**0.87*** 0.81-0.92	**1.32*** 1.01-1.71	**0.91*** 0.89-0.94	2.03 0.86-4.85	**0.90*** 0.83-0.97
Hypertension	**2.69*** 1.69-4.26	**0.89*** 0.86-0.93	**1.30*** 1.01-1.71	**0.91*** 0.89-0.94	**1.85*** 1.07-3.22	**0.95*** 0.89-0.99
Cancer	1.11 0.45-2.69	0.95 0.88-1.04	1.30 0.67-2.55	0.99 0.48-1.05	0.47 0.16-1.40	0.93 0.84-1.02
Multimorbid	**1.27*** 1.10-1.47	**0.91*** 0.90-0.93	**1.19*** 1.09-1.31	**0.95*** 0.94-0.96	1.15 0.98-1.36	**0.94*** 0.93-0.95
Other	**1.69*** 1.30-2.22	**0.90*** 0.87-0.93	**1.43*** 1.23-1.66	**0.95*** 0.93-0.96	**1.39*** 1.02-1.87	**0.91*** 0.89-0.94
*significant (p<0.05)						

Both the IE and EO effects varied in terms of significance and magnetite between groups. The overall pattern of the effects was consistent with the analysis of the whole population, with increased rates during the first month of implementation, followed by a gradual decrease over time. The model did not significantly affect patients with diabetes, COPD, and cancer. However, this was not the case for other groups. Patients with CVD showed a significant decrease of 12%, 9%, and 15% in the three outcomes, respectively (admissions, A&E visits, LoS). Patients with asthma showed similar trends, except that a significant increase of 32% in A&E visits was observed during the first month of implementation (RR 1.32, 95% CI 1.01-1.71). The other groups, including patients with multimorbidities, showed a significant increase in the outcomes during the first month of implementation, followed by a significant decrease over time (Table 22). Sensitivity analysis did not show a notable change of findings (See Appendix B).

9.4.2 Stage 2:

9.4.2.1 Description of the Sample and Outcomes:

Table one summarizes the sample description for both treatment and control groups. The Hillingdon sample population did not differ from the previously analysed sample population in terms of distribution by demographics and LTCs (Tables 16 & 21). After excluding groups that relocated and the dead from the current sample, the final number analysed in the current analysis was n= 319015 for the treatment group. The total number difference between Hillingdon and Ealing (Control) was n= 124060.

Table 21: Sample description and characteristics

		Hillingdon		**Ealing** (Control)	
		N	**% From Total**	**N**	**% From Total**
Population		319015	100%	443075	100%
Age	<65 years	279277	89%	398223	90%
	>/= 65 years	39738	11%	44852	10%
Gender	Males	163165	51%	231934	52%
	Females	155850	49%	211141	48%
Ethnicity	White	146204	46%	134000	30%
	Asian	91135	28%	139702	31%
	Black	21661	7%	30673	7%
	Other	50450	3%	111545	25%
	Mixed	9565	16%	27155	7%
Without LTC		221771	70%	316584	71%
With LTC		97244	30%	126491	30%
	Multimorbid	46634	15%	60913	14%
	Other Conditions	26614	8%	33552	8%
	Hypertension	10775	3%	14049	3%

	Asthma	6651	2%	9150	3%
	Diabetes	3219	1%	4932	1%
	CVD	1442	0.5%	1893	0.5%
	Cancer	1462	0.4%	1588	0.4%
	COPD	447	0.1%	402	0.01%

Most individuals were under 65 years of age in both groups. Males were more than females in both groups. The population was predominantly white with 46%, followed by Asian (28%%), and Black (7%.) in the treatment group. A large percentage of people from White, Asian, and mixed ethnicities were found in the control group. Both groups had similar distributions of individuals with and without LTCs. The distribution of groups with LTC was also similar, with multimorbidity accounting for around 14% of the population.

Table two summarises the outcomes per patient group, including different groups with the LTCs categorised as the previous study. Similarly, there was little difference in the distribution of the three outcomes per group compared to the previous Hillingdon sample population. This difference can be explained first by including only registered patients in this analysis, and second by having more registered patients opt-in before the current data was extracted.

Both populations (Treatment and Controls) had similar distributions by demographics, LTCs, and outcomes per patient group (Tables 16 & 21). Accordingly, as highlighted earlier, this explains the reason for choosing the population of Ealing as the control group.

From the beginning through the end of the study, 44721 and 61698 NEL admissions were recorded in the treatment and control groups, respectively. Patients with LTCs accounted for most admissions in both groups (Table 22). Also, patients with multimorbidity accounted for most admissions in total and compared to other LTC groups in both groups. The total number of A&E visits was 238010 and 254158 in the treatment and control groups, respectively. Individuals with no LTCs accounted for most attendances (56% in both groups). Similarly, individuals with multimorbidity accounted for most visits in both groups. Patients with LTC also accounted for most of the days spent at the hospital, with individuals suffering from multimorbidity accounting for the most in both groups.

Table 22: Outcome characteristics by sample(s) group

	Condition	NEL Admissions		A&E visits		LoS (days)	
		N	%	N	%	N	%
Hillingdon	**Total**	**44721**	**100%**	**238010**	**100%**	**145441**	**100%**
	No LTCs	16996	38%	132377	56%	30836	21%
	With LTCs	27731	62%	105633	44%	114605	79%
	CVD	777	2%	1911	1%	3750	3%
	Diabetes	611	1%	2582	1%	1946	1%
	COPD	223	0.5%	551	0.2%	907	1%
	Asthma	1022	2%	6624	3%	1691	1%
	Hypertension	1761	4%	7236	3%	6513	4%
	Cancer	438	1%	1118	0%	1356	1%
	Multimorbid	18418	41%	60650	25%	83940	58%
	Other	4481	10%	24961	10%	14497	10%
Ealing	**Total**	**61698**	**100%**	**254158**	**100%**	**170039**	**100%**
	No LTCs	22162	36%	141618	56%	37109	22%
	With LTCs	39536	64%	112540	44%	132930	78%
	CVD	1405	2%	2625	1%	6248	4%
	Diabetes	981	2%	3158	1%	2301	1%
	COPD	137	0.2%	350	0.1%	450	0.3%
	Asthma	1438	2%	7399	3%	2420	1%
	Hypertension	2448	4%	7752	3%	6628	4%
	Cancer	487	1%	1080	0%	1609	1%
	Multimorbid	26649	43%	65364	26%	99102	58%
	Other	5994	10%	24807	10%	14172	8%

9.4.2.2 Effects on Outcomes:

Figure 4 shows the monthly change in rates before and after the intervention and the predicted regression curves for both treatment and control groups. Following the intervention, I observed comparable trends with a difference in magnitude in both treatment and controls, with an initial decline and then a progressive decrease over time in two outcomes: NEL admissions and LoS at the hospital (Fig 4 A &B). Both groups had a similar pattern before the intervention period, characterised by a progressive increase over time. In the case of A&E visits, however, I observed a monthly decline in the control group, which rose slightly following the intervention period and continued to decrease over time (Fig 4 C). In the treatment group, however, there was an increase prior to the intervention, followed by an immediate modest decline that gradually decreased over time.

Fig 4: Effect of the intervention on outcomes during the period of the study comparing treatment and control at the same scale. Circles and solid lines represent the observed and the predicted rates respectively. The dashed lines represent the de-seasonalised trend of the three outcomes before and after the intervention. Note: Neighbourhood part of the Ealing's model and the Intermediate tier are the only interventions that were in effect at time of interruption.

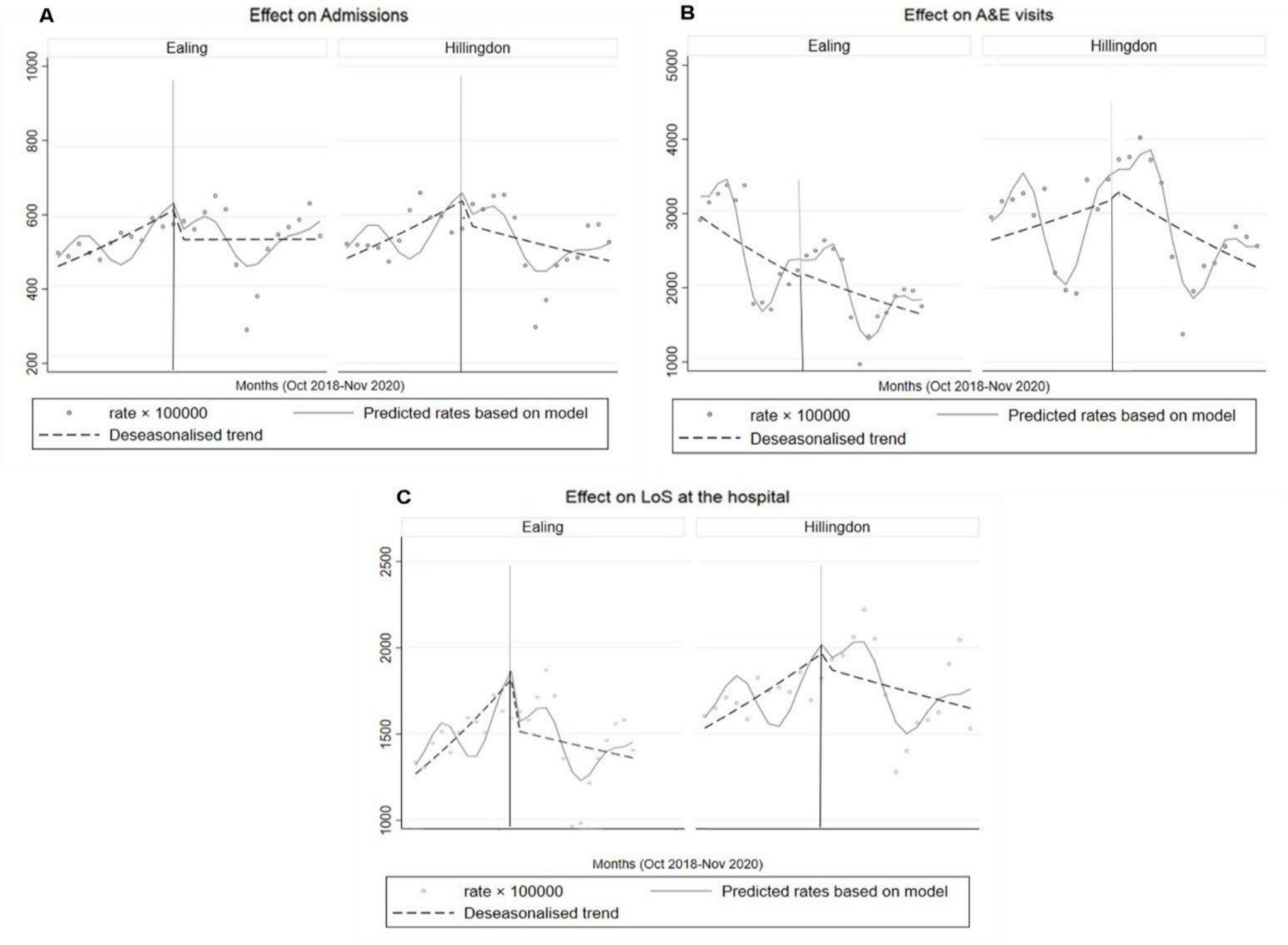


Table 23 summarises the results of the ITS segmented regression model, which was fitted to individual-level panel data to predict changes in outcomes in both groups before and after the Hillingdon ICM model was implemented. Also, the same table included the result of the model that was fitted to predict the effect of the lockdown on the three outcomes of interest in both groups.

After the first month of the ICM implementation, a 16% and17% significant decrease per month in NEL admissions was observed in both treatment and control groups, respectively (Hillingdon: (RR 0.83, 95% CI 0.79-0.88), Ealing: (RR 0.84, 95% CI 0.81-0.88). The model predicted a 3% difference in favor of the control group after the first month of implementation; however, the results were insignificant (RR 1.03, 95% CI 0.98-1.09). Similarly, during the first month of implementation, the model predicted a statistically significant decrease in LoS with approximately the same percentage in both groups, with a 5% non-significant difference favoring the control group. A 3% and 4% significant increase in A&E visits were observed in the control and treatment groups, respectively, with a 1% non-significant difference in favor of the treatment group.

Following the first month of implementation, I found evidence of a gradual decrease over time in NEL admissions in both groups (Hillingdon: (RR 0.95, 95% CI 0.95-0.96), Ealing: (RR 0.97, 95% CI 0.96-0.98). The model predicted a significant 2% difference in favor of the treatment group (RR 0.98, 95% CI 0.97-0.99). On LoS, similar effects were identified; however, there was a non-significant difference of 1% in favor of the control group. While there was an immediate modest rise in A&E visits in the control group (after a continuous drop before the intervention), the model predicted almost no change with a progressive decrease over time (Fig 4, Table 23). On the other hand, the slight immediate decrease of visits in the treatment group was followed by a gradual reduction of 4% per month over time (RR 0.96, 95% CI 0.95-0.97).

Table 23: Rates of outcomes of interest during the intervention compared with the pre-intervention the control, treatment groups, and treatment vs control groups, respectively.

	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Control	**0.84*** 0.81-0.88	**0.97*** 0.96-0.98	**1.03*** 1.01-1.16	**1.007*** 1.004-1.01	**0.82*** 0.78-0.88	**0.96*** 0.95-0.97
Treatment	**0.83*** 0.79-0.88	**0.95*** 0.95-0.96	**1.04*** 1.01-1.07	**0.96*** 0.95-0.97	**0.86*** 0.81-0.92	**0.97*** 0.96-0.98
Treatment vs Controls	1.03 0.98-1.09	**0.98*** 0.97-0.99	0.99 0.96-1.01	**0.95*** 0.94-0.96	1.05 0.99-1.11	1.01 1.00-1.02
IE: Immediate effect, EO: Effect over time (gradual effect), RR: Rate ratio, CI: Confidence intervals, NEL: None-elective, *significant (p<0.05)						

9.5 Discussion

9.5.1 Summary of Findings

I conducted an ITS analysis to evaluate the effectiveness of an ICM in Hillingdon in reducing non-elective hospital admissions, A&E visits, and length of stay at the hospital in two stages.

In the first stage, although the analysis showed an increase in the three outcomes during the first month of implementation, the model showed signs of effectiveness over time with a significant gradual decrease in the three outcomes ranging between 7 to 9%. The model also showed similar effects across the different LTCs groups, including patients with multimorbidities. In an independent analysis, modelling of the outcomes over time with no interruption showed a decrease in the three outcomes after the implementation compared to nearly no change in the previous period.

In stage two analysis, I found similar trends ranging between a 3% to 5% decrease in EO on the three outcomes; however, the increase in the first month of implementation was only found in A&E visits. Those effects were nearly similar in both treatment and control groups, with a slight difference in magnitude. However, differences were not statistically significant in multiple outcomes except for EO in NEL Admissions and A&E Visits.

9.5.2 Finding's Interpretation

It is well known that ICMs are complex systems rather than comparable to clinical interventions (Edwards, 2019). Consequently, these models are not straightforward and are not expected to work immediately after implementation. With this in mind, the increase in the three outcomes observed during the first month of implementation does not necessarily indicate a lack of effectiveness of the model. This is related to the fact that the increase was followed by a significant decrease that continued over time (Fig 5). This continuation might indicate that the model could have effectively achieved its aims, at least to a certain extent. Although the high immediate increase during the first month might indicate that the implementation was not fully achieved or the model was not fully operational across all the interventions (Fig 3), it can also indicate the presence of certain factors that might have potentially biased the results. With this in mind, the stage two analysis indicated that the exclusion of groups that relocated and the dead from the sample had changed these immediate increases (except for A&E visits; however, the increase in magnitude was massively less (See tables 18 and 23)) potentially controlling for the first analysis bias.

The separate analysis conducted without interruption at stage one might further validate this argument concluded from stage two. This is related to the fact that the overall change over time in the post-implementation period did show a decrease over time.

Regardless of the stage two analysis, the differential analysis in stage one on individuals with and without LTCs separately showed similar trends compared to the whole population analysis. For example, the rate of A&E visits among individuals with no LTCs during the study period was 33828 per 100000 (5.6% higher than the patients with LTC). My results showed a gradual decrease of 5% in monthly rates in this group (1691 per 100000), with similar trends in other outcomes. These findings might indicate the importance of implementing population-based ICMs rather than models focusing on patients with LTC alone. While the A&E visits among individuals with no LTCs were higher than patients with LTC, targeting those populations would be necessary. In addition, the findings summarised in Table 17 show that individuals with no LTC might constitute a notable percentage of the total number of all three outcomes.

The Hillingdon ICM model also showed a noticeable effect on patients with LTC. Those patients accounted for most percentages of the total hospital admissions and LoS at the hospital. Patients with multimorbidity had the highest admissions rate during the study period (4825 per 100000), and the analysis showed a 9% decrease over time (equivalent to 434 per 100000/ month). This effect was similar in other groups except for patients with COPD, Cancer, and Diabetes. However, the absence of effect might be explained statistically by the low sample sizes and frequency of outcomes across these groups (Tables 16 &17).

Nevertheless, the model did show a noticeable effect on patients with LTCs overall (Table 20), considered the model's primary targets. This might indicate that the model might have effectively achieved its aims. In other words, if the model works on patients most vulnerable to being admitted to or staying at the hospital, it might have met its causal assumptions.

Stage two analysis was conducted to validate the findings in stage one. Multiple arguments can be postulated at this stage. First, the slight difference in effects in both populations (Hillingdon and Ealing) in most outcomes was due to chance; hence, there was no noticeable effect of the ICM in Hillingdon on outcomes. Second, the minor differences in some outcomes indicate that the Hillingdon ICM outweighs the Ealing model's effectiveness to a certain extent. Lastly, effects observed in both populations were not a result of the model itself but an external factor, particularly the COVID-19 emergence.

Regardless of the third argument, the results of stage two analysis lean more towards accepting the second argument, and multiple pieces of evidence can explain this. The differences in RRs comparing both groups were not insignificant in all outcomes and durations, including EO for NEL admissions and A&E visits (Table 23). This might indicate that these differences, although small in magnitude, were mainly associated either with the ICM model in Hillingdon itself or implementation and operational differences in both models in favor of the Hillingdon ICM. This can be supported by trends observed in Fig 4. For A&E visits, there was only a level change in the trend. This means that before the implementation of the interventions, there was a continuous decrease in A&E visits in Ealing which increased slightly after implementation and then continued to decrease overtime.

On the other hand, this was not the case in Hillingdon as visits were increasing and suddenly increased immediately after implementation and continued to decrease over time with higher magnitude compared to Ealing. Regarding NEL Admissions, trends after and before intervention were the same, although the effect overtime seemed to be more constant in terms of trend in Ealing (Fig 4), and this can be supported statistically by the significant difference compared to that of Hillingdon (Table 23). Although the difference in EO on LoS was insignificant, this could still indicate effectiveness as hospital-based models were implemented in both boroughs. Accordingly, it is possible that both populations had similar effects due to similarities in some integrated care compartment implementations. Lastly, where trends were similar, there was no statistical significance. In other words, the differential RR was insignificant, whereas the IE RR were nearly similar in both groups. In contrast, a significant differential effect (In EO) was observed where a difference was noticed.

All these pieces of evidence validate the stage one analysis to a certain extent. However, an external effect on these outcomes cannot be ignored. After the post-intervention period, the COVID-19 pandemic emerged. Accordingly, there is a possibility that those results were biased. Hence, the effect of lockdown on these outcomes, especially NEL admissions and A&E visits, should be examined. In the next chapter, this analysis was introduced.

9.6 Comparison with existing evidence and meaning of the study

The findings of this study were partly consistent with recent evaluations of new ICMs in England piloted under the “Vanguard” initiative (Morciano et al., 2020). These evaluations suggested a slowed rise in emergency admissions in Vanguard sites compared to a substantial increase in emergency admissions among non-Vanguard sites. The study evaluated two main outcomes, including NEL admissions and LoS at hospitals (no reduction in total bed-days (LoS) was reported). My overall evaluation of the Hillingdon ICM found a substantial decrease in the same outcomes in addition to A&E visits compared to the pre-intervention period.

My study had some strengths compared to the recent evaluations of the NHS vanguard programs. Reducing A&E visits is an official objective of NHS England's new integrated care models (NHS, 2021). Besides, this outcome is an outcome of interest when evaluating ICMs (Damery, Flanagan & Combes, 2016; Baxter et al., 2018). Accordingly, considering this outcome in my evaluation is the first strength recognised. Secondly, assessing the effect of the Hillingdon ICM on different populations with various LTCs could also be considered a major strength of my study. Exploring the effects on such groups might guide in assessing the requirement of further interventions targeting such groups specifically. For example, implementing disease or condition-specific interventions as a part of population-based ICM might be required to achieve better outcomes in such groups. Thirdly, my control for some potential confounders such as age, gender, and ethnic category to reduce confounding bias could be another strength to add. With this in mind, there is evidence of the effects of such factors on hospital unitisation in patients with different conditions (Krasnik et al., 2002; Robbins & Webb, 2006). Finally, the approached adopted in my analysis to treat missing values might be more accurate than discarding missing values and analysing balanced samples. This being said, my sensitivity analysis in stage one could indicate the precision of my MI model and increase the precision of the estimates compared to the vanguard program evaluation study. On the other hand, in stage two, no missing values were reported, which might add to the precision of the estimates. However, my study still has some weaknesses and limitations compared to other evaluations discussed in the next section.

Even after considering limitations with studies assessing the new ICM in England, either my evaluation or other assessments, these studies still have meanings in the context of the effectiveness of population-based ICMs. These evaluations might highlight the advantage of population-based ICMs on other models to achieve their aim of reducing hospital utilization. Compared to other models which showed minor effects on utilisation (Baxter et al., 2018), this study's findings and those recent evaluations might suggest that population-based ICMs might provide better effects. This is related to the fact that such models aim towards a complete system integration, considered the most ambitious. This form of integration usually combines a population-based and person-centred approach of integrated care and, thus, focuses on delivering care (Especially for vulnerable groups), improving the population's health, and preventing diseases through health promotion. To achieve this form of integration, an ICM should combine multiple integrated care interventions to form a model of care that can be solely described as population-based. Consequently, while new ICMs focused on single disease management models with case management approaches (Stokes, Checkland & Kristensen, 2016), population-based ICM might be considered a better model of choice to reduce care fragmentation and, by extension, hospital utilisation.

10 CHAPTER 5: EVALUATING THE IMPACT OF COVID-19 LOCKDOWN ON HOSPITAL ACTIVITY.

10.1 INTRODUCTION

Pandemics/epidemics have been found to significantly impact hospital utilization, resulting in increased hospitalizations, NEL admissions, LoS, and A&E visits, in addition to other outcomes such as increased use of mechanical ventilation. For example, the H1N1 influenza pandemic raised the demand for hospital services and strained healthcare worker resources (Tsubokura et al., 2010, Rubinson et al., 2013). A 2009 study published in the Journal of the American Medical Association (JAMA) discovered a significant rise in hospital admissions for influenza-like illness during the peak of the H1N1 influenza pandemic (Jain et al., 2009).

The impact of pandemics/epidemics is not only related to illness-related cases but also can affect the service level and utilisation associated with other conditions. For instance, some evidence was reported that the 2002-2003 severe acute respiratory syndrome (SARS) outbreak caused a decline in hospital activity and service utilization and in the number of patients seeking care for other health conditions (Man et al., 2003).

Like other pandemics, the 2019 new coronavirus illness (COVID-19) impacted hospital unitisation globally and in England. England's health system faced and still faces unprecedented challenges since the overbreak of the severe acute respiratory syndrome coronavirus two (SARS-CoV-2) and the global spread of COVID-19. As a result, COVID-19 had an impact on the uptake of hospital-based care across the country after the lockdown, with a noticeable decrease in Accident and Emergency visits (A&E), planned/unplanned hospital admission rates (NEL Hospital Admissions), and an increase in hospital length of stay (LoS) in some patient groups, including COVID-19 patients, all compared to national averages before lockdown. (Ball et al., 2020, Thornton, 2020, Mulholland et al., 2020, Gemma Green et al., 2021, NHS, 2021b).

Like other pandemics, COVID-19 also had an impact on non-Covid care. This is related to the fact that many hospitals had to cancel or postpone elective procedures, such as surgeries, to free up capacity for Covid-19 patients. This led to a backlog of non-Covid patients needing care, which the NHS is still working to clear (NHS, 2021b). Besides, there was a decline in the number of non-Covid inpatient admissions during the first wave of the pandemic and in the number of outpatient appointments and diagnostic tests. This decline in activity was partly due to the cancellation of elective procedures to free up capacity for Covid-19 patients, but it was also likely due to patients being reluctant to seek care due to fear of infection.

The effect of covid on non-covid care can rationalise how pandemics can affect IC outcomes. As the number of COVID-19 patients increased throughout the pandemic, there was a change in emphasis on delivering acute care and hospital services (NHS, 2021b). This resulted in fewer primary care and community-based services being provided and fewer patients seeking care for non-COVID-related diseases. Besides, the increased use of virtual consultation can decrease hospitalisation (Stamenova et al., 2022).

In this connection, this explains the rationale behind what was suggested in the previous chapter concerning the effects shown in both populations to be associated with the pandemic rather than the ICM model. In this chapter, I analysed the impact of COVID-19 on the previous findings highlighted in chapter 4.

10.2 Methods

For ease of access, key elements of data and methods are being repeated here. Data for this analysis came from the same source as the previous analysis (WSIC) and was by nature the same (Same coding (except for study duration), same control group (Ealing)). I used the same statistical models as in the previous study (Multiple groups interrupted time series (ITS) Poisson and Negative binomial models (Only for LoS), (Linden, 2015, Bernal, Cummins, & Gasparrini, 2017), with random effects estimator, and also added extra interactive functions to indicate the control group. As highlighted earlier in stage 2 analysis in chapter 4, following recent WSIC team refreshers, data at this level had no missing values. Gender, age, ethnicity, and LTC were all controlled for. I also estimated robust standard errors (Huber-White) for the regression parameters to account for serial correlation and overdispersion checks. Similarly, I used periodic functions to account for probable seasonality and long-term patterns (Bhaskaran et al., 2013).

To achieve the multiple groups ITS model, the following segmented regression model was used:

$$\boldsymbol{Y}_t = \beta_0+\beta_1\boldsymbol{T}+\beta_2\boldsymbol{X}_t + \beta_3\boldsymbol{X}_t\boldsymbol{T} + \beta_4\boldsymbol{Z}+ \beta_5\boldsymbol{ZT}+ \beta_6\boldsymbol{ZX}_t + \beta_7\boldsymbol{ZX}_t\boldsymbol{T}$$

I defined independent variables T (from July 2019 to Nov 2020) as the time elapsed from the start till the end of the study, and X_t as a dummy variable to indicate the pre-lockdown period

(Xt = 0) or the post-lockdown period (Xt = 1). T=9 (March 2020) was defined as the time of implementation of the lockdown measure in England. Similar to previous stage 2 analysis, Z was defined as a dummy variable to denote the cohort assignment (treatment (Hillingdon): Z = 1, or control (Ealing): Z = 0). β_2 (using $\beta_2 X_t$) and β_3 (using $\beta_3 X_t$) coefficients represented the change of outcomes in the control group immediately after the lockdown initiation or overtime respectively. On the other hand, using the interaction between Z, X_t, and T, β_6 and β_7 represented the change of outcomes in the treatment group compared to the control group immediately after the lockdown measure implementation or overtime respectively.

In this analysis, the duration of the study was from July 2019 to Nov 2020. Time of interruption was set to March 2020 (Time of implementation of the lockdown measure in England). I confined the duration of the study to this time interval to make the period before and after the interruption (Lockdown) equal.

10.3 Results

10.3.1 Sample Characteristics

Despite the variations in time frames between this analysis and the preceding one in chapter 4 (Stage 2), the sample of this analysis has similar features. Regarding distribution by demographics and LTCs, the Hillingdon sample population did not differ from the previously examined sample population (Chapter 4: Tables 16 & 21). After subtracting relocated and deceased groups from the current sample, the total number analysed in the current study was n= 319015 for Hillingdon. The total number difference between Hillingdon and Ealing was n= 124060. At the time of this analysis, no missing data was observed which was related to the fact that WSIC created a new refresh and update of their data.

The total number of NEL admissions during the study period was 41195 in Ealing and 28973 in Hillingdon. Besides, LoS and A&E visits in Ealing and Hillingdon were 112026 bed days, 146726 visits, and 96560 bed days, 158316 visits, respectively. Before lockdown, Ealing showed 21226 admissions, 59529 bed days, and 82698 visits. On the other hand, 19969 admissions, 52497 bed days, and 64028 visits occurred after the lockdown. In Hillingdon, 15477 admissions, 49782 bed days, and 91340 visits occurred before lockdown, while 13496 admissions, 46778 bed days, and 66976 visits occurred after.

10.3.2 Effects on Outcomes

Figure 5 shows the monthly change in rates before and after the lockdown in March 2020 and the predicted regression curves for both the treatment and control groups. Both control and treatment showed similar trends in NEL admissions and A&E visits with different magnitudes, with a rapid drop that gradually proceeded over time. Regarding LoS, both groups had differing trends before lockdown, with Ealing experiencing a decline over time and Hillingdon experiencing an increase. Both populations experienced an abrupt drop in bed days after the lockdown. In Hillingdon, however, the decline continued gradually, but Ealing shifted to a progressive increase over time (Fig 5 C).

Fig 5: Effect of the lockdown on outcomes during the period of the study comparing treatment and control at the same scale. Circles and solid lines represent the observed and the predicted rates, respectively. The dashed lines represent the de-seasonalised trend of the three outcomes before and after the lockdown in March 2020.

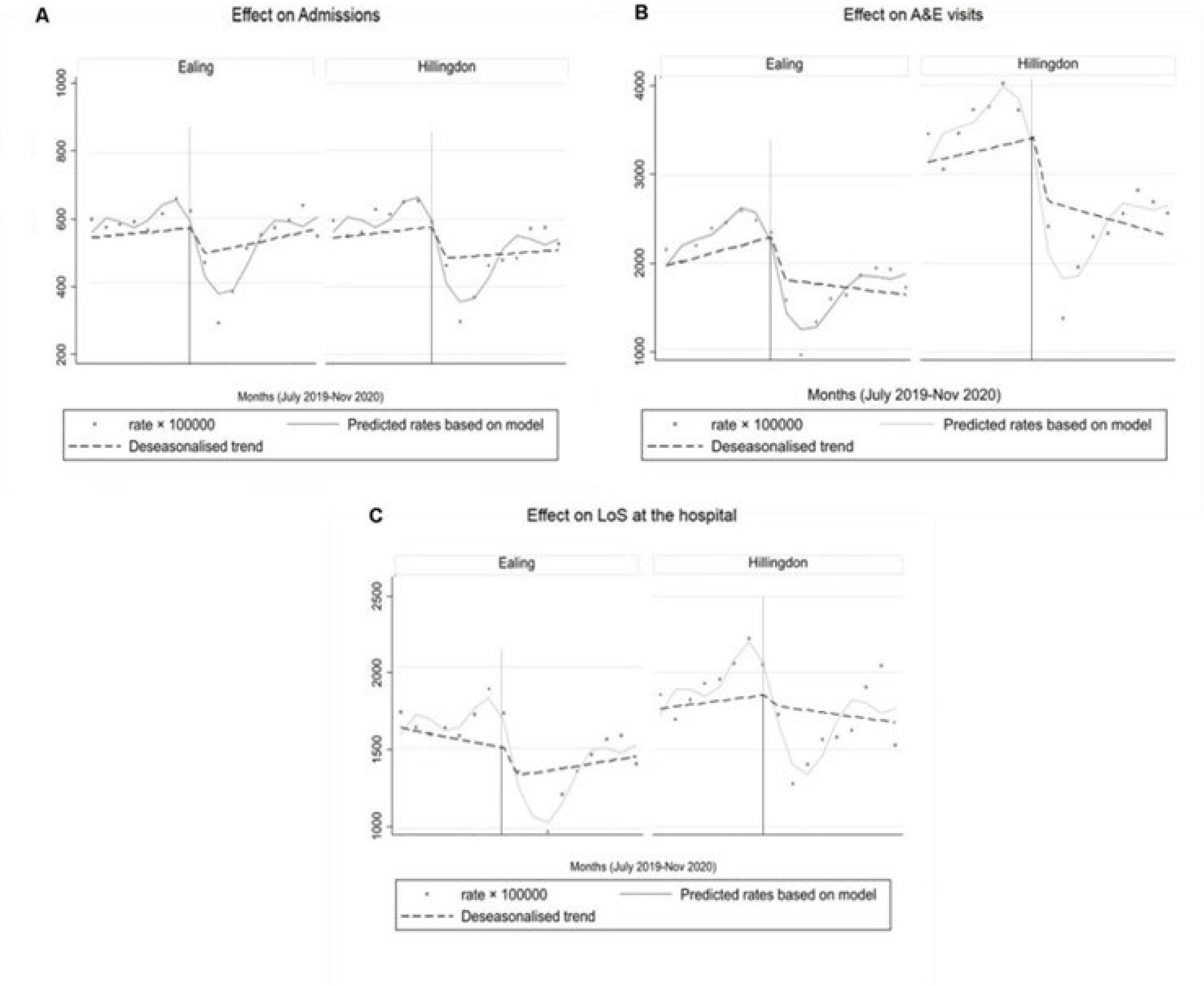


Table 24 summarises the results of the ITS segmented regression model, which was fitted to individual-level panel data to predict changes in outcomes in both groups before and after the lockdown was implemented in March 2020 in the UK. after the first month, a 23% and19% significant decrease per month in A&E visits was observed in both Hillingdon and Ealing populations, respectively (Hillingdon: (RR 0.77, 95% CI 0. 0.73-0.81), Ealing: (RR 0.81, 95% CI 0.76-0.86). The model predicted nearly no difference between both populations after the first month of implementation; however, the results were insignificant (RR 1.01, 95% CI 0.96-1.04). The decrease continued over time in both populations with nearly equal percentages but with less magnitude than the immediate effect. Similarly, the model predicted almost no difference between both populations with a non-significant effect. A significant immediate 13% decrease in NEL admissions following lockdown was observed in Ealing compared to a 10% non-significant decrease in Hillingdon. A 5% non-significant difference was predicted, favouring Hillingdon. Over time, there was nearly no change in both populations, with a slight increase in Ealing, although the results were not statistically significant. Exact predictions as NEL admissions were noted for LoS for immediate and overtime effects, with all effects being statistically non-significant.

Table 24: Rates of outcomes of interest during the lockdown compared to the pre-lockdown period in the control, treatment, and treatment vs control groups, respectively.

	NEL Admissions		**A&E Visits**		**LoS**	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Ealing	**0.87*** 0.80-0.95	1.01 0.98-1.02	**0.77*** 0.73-0.81	**0.96*** 0.94-0.97	0.95 0.86-1.01	1.01 0.99-1.03
Hillingdon	0.90 0.80-1.01	1.00 0.98-1.02	**0.81*** 0.76-0.86	**0.97*** 0.96-0.98	0.99 0.90-1.05	0.99 0.97-1.02
Hillingdon vs Ealing	0.95 0.89-1.02	0.99 0.97-1.00	1.01 0.96-1.04	1.01 0.99-1.02	1.04 0.96-1.13	0.99 0.97-1.01
IE: Immediate effect, EO: Effect over time (gradual effect), RR: Rate ratio, CI: Confidence intervals, NEL: None-elective, *significant						

10.4 Discussion

I evaluated the impact of COVID-19 lockdown measure in England on hospital activity in both Hillingdon and Ealing. The findings suggest the presence of an impact on hospital activity in Ealing more than in Hillingdon. The effect was observed predominantly on A&E visits. I found no effect regarding admissions and LoS in Hillingdon. On the other hand, Ealing showed an IE on admissions.

10.4.1 Interpretation of findings

The main aim of this chapter was to evaluate the impact of the lockdown measure on hospital activity to validate the results in the previous chapter. Accordingly, the lockdown seemed to have a noticeable effect on A&E visits rather than the other outcomes. This can be considered convincing evidence validating the previous chapter's findings, and a few points can explain this.

Regarding trends, both populations seemed to have similar changes visually (Fig 5). Compering the numbers of the three outcomes between both hospitals might also indicate an equal impact of the lockdown on both (See sample characteristics in the result section of this chapter). While this might indicate the presence of an equal effect of the lockdown on both hospitals, this can be denied statistically by the results in table 24. Two main related statistical patterns were observed, which can explain minimal effects on some outcomes.

First, when comparing the current analysis with the previous stage 2 analysis in Chapter 4 regarding significance, similar effects should be observed in both populations after the intervention and the lockdown. In other words, if the lockdown had an effect, significance should not be affected in the current analysis. "Significant" and "magnitude" are both statistical findings and their interpretation could indicate different things. For example, the difference in magnitude in the previous analysis between Ealing and Hillingdon could be due to the partially implemented ICM in Ealing since no difference in statistical significance was observed. On the other hand, a difference in significance between this analysis and the previous one could indicate the absence of the lockdown's direct impact on most outcomes. This is related to the fact that both analyses overlap in time, and considering both interruptions, the significance should not be impacted.

Second, the absence of EO, which was shown to be statistically insignificant (Except for A&E visits), could indicate that the lockdown did not significantly impact the outcomes over time rather than the intervention, which has shown significance in effect over time. In other words, the absence of EO could imply that even if the lockdown had an immediate effect during the first weeks, the insignificant EO could imply that the decrease showed after was unrelated to the lockdown itself rather than the intervention.

Although this analysis showed some evidence of the minimal impact of COVID-19 lockdown on LoS and NEL admissions, it did show a noticeable impact on A&E visits. Consequently, this can question the previous analysis outcomes regarding the effects on A&E visits and emphasise the importance of conducting more evaluations in the future. Moreover, this can also question the potential effects of the model on NEL admissions observed.

The available evidence clearly shows that A&E visits are one of the most outcomes affected by the COVID pandemic generally (NHS, 2021a). According to this data, A&E attendances fell by 37% in April 2020 compared to the same month in 2019. Similarly, the number of NEL admissions from the A&E fell by 25% during the same period. This data could suggest a possibility that the observed decrease in NEL admissions was shaped by this decrease in A&E visits, given that a noticeable percentage of NEL admissions come from the A&E department. With this in mind, this can suggest that the absence of effect of the lockdown on admissions was due to not being a direct factor itself. Although this argument can be falsified by the fact that not all NEL admissions come for the A&E department, most NEL admissions come from this source. Other potential sources might include GP referrals, outpatient clinics, ambulance services, and community services (Morse, 2013). However, all these sources have also shown drops in rates following the COVID-19 pandemic emergence, including Ambulance services as the most source that can 'produce' such admissions (NHS, 2021a).

Although these arguments might suggest that the COVID lockdown or other measures did impact hospital activity outcomes assessed in this thesis, one could still argue that the impact of the intervention on the outcomes is still feasible. This is related to the fact that the COVID-19 measures in the UK started to be lifted in June 2021. However, during this time, those outcomes were still statistically significantly decreasing (Stage 2 analysis). This might still suggest that there might have been still some effects of this model, especially since the model compartments were still operating at this time virtually. Telemedicine/virtual healthcare during the pandemic period was shown to decrease hospital activity (Nittari et al., 2022).

This analysis cannot fully ignore the impact of the COVID-19 pandemic on the findings of the previous analysis. This is related to the fact that the current analysis did not consider other factors which could have played a role in biasing the previous finding estimates. For example, acquiring data on COVID-related admissions or A&E visits was impossible. Controlling for COVID-related activity could be a change in the previous analysis findings. Consequently, the findings must be considered cautiously, and further analyses are required.

11 Chapter 6: Predictors of Hospital Activity in Hillingdon

11.1 Introduction

Sociodemographic factors, such as age, ethnicity, and location, are known to interfere with the effectiveness, evaluation, and monitoring of IC (Baicker, Chandra, 2004). All these factors interact with health outcomes and factors such as LTCs to shape how IC can provide its benefits. For example, older adults are more prone to chronic diseases requiring non-elective care. ICMs aimed at this group may need to prioritise meeting the specific healthcare needs of older persons, such as geriatric care and end-of-life care (Anderson, Horbar, 2002). On the other hand, racial and ethnic minorities are more likely to have health inequalities and have less access to primary care. Integrated care approaches to improve access to care for these populations may need to address cultural and linguistic obstacles and health inequities. Furthermore, People living in rural areas may face different challenges regarding access to care, transportation, and communication compared to those living in urban areas. Integrated care models in rural areas may need to address the unique challenges that rural populations face regarding access to care (Baicker, Chandra, 2004).

In this connection, sociodemographic factors can also be related to hospital utilisation and alter how health services could be used. For example, older adults are more likely to use hospital services due to age-related health issues. Additionally, certain racial and ethnic groups may have higher rates of certain health conditions, leading to higher utilization of hospital services.

With these connections in mind, such factors can also shape how IC should operate and what target populations it should focus on. Within ICMs, personalisation and patient-centred care became an important goal in the NHS long-term plan (NHS, 2020). People who receive individualised care have a say in how their care is organised and provided. It is based on what is important to them, their unique needs, and their strengths. This occurs within a framework that maximises individuals, families, and communities' knowledge, abilities, and potential to produce better results and experiences. SM interventions, an essential element of ICMs, serve as a solid representation of this framework. For such interventions, personalization represents an important desirable goal. While a new interaction between individuals, professionals, and the health and care system are represented by personalised care, other compartments of ICMs, such as MDTs and CMs, also represent an essential element that could contribute to the personalisation of care. This can explain why combining multiple IC interventions within one ICM could provide better outcomes, a prominent finding in chapter 2 of this thesis.

While CM and care coordination delivered by other interventions are considered key components within ICMs, targeting the right populations would contribute to achieving better outcomes on all levels. Risk stratification (RS) is specifically mentioned when we discuss targeting the appropriate populations. RS is a systematic method that can be used for commissioning that stratifies a population's risk for an inevitable outcome, such as NEL admissions, a primary outcome considered in this study. With this in mind, this could also highlight why RS is essential before and after the implementation and evaluations of ICMs. On the other hand, SM interventions work on personalisation of specific individuals within those groups. This emphasizes the importance of combining multiple IC interventions within one model when it comes to population-based targeting, a main finding in the review in chapter 2.

Although the primary analysis in chapter 4 did consider time-varying confounders such as age and gender, and LTC, the extent to which such characteristics shape hospital activity and impact ICM effect distribution on different patients' population is not well known. The review in chapter 2 did show the scarcity of evidence concerning such factors. Accordingly, this emphasises the importance of assessing the effects of such factors that might act as predictors of hospital activity and thus predict the effect of such outcomes on ICM effectiveness evaluations. Besides, such analyses can have implications for policy formulation regarding ICM implementation and monitoring.

In this chapter, I present this analysis that predicted the hospital activity sociodemographic factors in addition to LTCs. This analysis would add further to the previous analysis by validating the effect of such factors on evaluating ICMs and emphasising controlling for them as confounders. Additionally, this analysis can be a cornerstone for future ICMs designs, evaluation, implementation, and monitoring, especially in Hillingdon.

11.2 Data and Methods

11.2.1 Data

The data from the preceding two chapters, particularly stage 2 analysis in chapter 4, were utilised in this analysis. From its initial longitudinal form, data was aggregated and clustered. Table 21 in chapter 4 contains descriptive statistics for the analysed sample.

11.2.2 Statistical analysis

Since this analysis questioned the predictors of hospital activity, NEL admissions, LoS, and A&E visits were defined as the dependent variables in the statistical model adopted for this analysis. Age, Ethnicity, Gender, LTC, and GP practice were defined as the independent variables (Predictors). Because many patients did not have hospital activity for some time, the data contained an excess of zeros. To handle excessive zeros in count, zero-inflated multiple Poisson and Negative binomial models (Only for LoS) predicted the risk of the three outcomes (NEL admissions, A&E visits, and LoS) by age (Coded into groups), gender, ethnicity, LTC, and GP practice.

The zero-inflated multiple Poisson (ZIMP) regression is considered the best method to handle excessive zeros in count data because it addresses two crucial issues often present in count data: overdispersion and modelling the probability of zero observations (Czado, 2012). Count data often exhibit more variation than would be expected under a Poisson distribution. The ZIMP model allows for overdispersion by modelling the count data with a Poisson distribution and the excess zeros with a zero-inflation model (Czado, 2012).

11.2.3 Variables

The requirement to improve the accuracy and comprehensiveness of the prediction model drives the selection of specific factors for predicting hospital admissions in Hillingdon. Currently, Hippisley-Cox and Coupland's QAdmission tool, released in 2013, uses an algorithm based on Cox regression analysis to evaluate the risk of emergency hospital admissions.

In this context, several key variables have been chosen for inclusion in the predictive model. Driven by the QAdmission tool and the availability of data. These variables encompass demographic information such as age, gender, and ethnicity, which play a pivotal role in understanding the diverse characteristics of the local population.

The rationale behind this careful selection of variables is multifaceted. First and foremost, these variables are deemed to be critical determinants of an individual's health and potential risk of hospitalization. By encompassing a wide range of factors, the model can account for the complex interplay between demographic attributes and health status, thus rendering a more holistic view of patient risk.

However, it is important to note that the QAdmission tool, in its current form, exclusively focuses on the prediction of unplanned hospital admissions. This limited scope may overlook certain segments of the population who exhibit different types of healthcare needs and utilization patterns. As a result, the tool may not provide a complete representation of healthcare risk in the general population.

Recognizing this limitation, it is imperative to explore the extension of the predictive model to encompass additional aspects of healthcare utilization. These aspects may include the prediction of Accident & Emergency (A&E) visits, Length of Stay (LoS) at the hospital, and non-elective hospital admissions. By doing so, a more comprehensive and effective risk stratification approach can be achieved. This broader perspective acknowledges that individuals who visit the A&E department may belong to diverse risk groups, including those with the lowest acuity needs. In this way, the expanded model seeks to provide a more nuanced understanding of healthcare risk within the community, thereby better equipping healthcare providers to meet the needs of their diverse patient population.

11.3 Results

11.3.1 Description of the Sample:

Table 21 in Chapter 4 lists the descriptive characteristics of the analysed sample. The distribution of patients' percentages per PCN and the number of patients by GP surgery are shown in Fig. 8 below. Forty-three surgeries with a total population of n=319015 (Table 21) were examined in this analysis. Nine surgeries had more than 10,000 patients registered, with three of them—Central Uxbridge Surgery, HESA Medical Center, and Hayes Medical Center—having more than 16,000. The remaining 23 registered between 5000 and 9000 people, while Lady Gate Lane Medical Center and Acrefield Surgery had the fewest—roughly 2000 patients each. The HH collaborative had the greatest population registered in percentage distribution across PCN, while the other groups varied from 12 to 19%. Fig 9 shows the frequencies of individuals with and without LTC by GP practice. With this in mind, surgeries with the highest frequencies of patients with LTC had the highest number of registered populations (e.g., Central Uxbridge surgery).

For example, around 11000 were registered in Brunel medical centre, although; number of admissions were relatively lower compared to surgeries with similar number of registered populations, and same applies to the other two outcomes. The Highest number of NEL admissions and A&E visits were noted for Central Uxbridge surgery and HESA Medical Centre. On the other hand, the top three surgeries with the highest bed days recorded were

Central Uxbridge surgery, Harefield Health Centre, and Otterfield Medical Centre.

12.3.2 Description of Outcomes by the Sample:

A total of 44721 NEL admissions, 238010 A&E visits, and 145441 bed days (Table 22) were distributed to GP surgeries and PCN, as Fig 6 shows. Generally, outcomes were proportional in distribution to the number of populations per surgery, with few exceptions.

Fig 6: Distribution of Hillingdon's population by GP surgery and PCN.

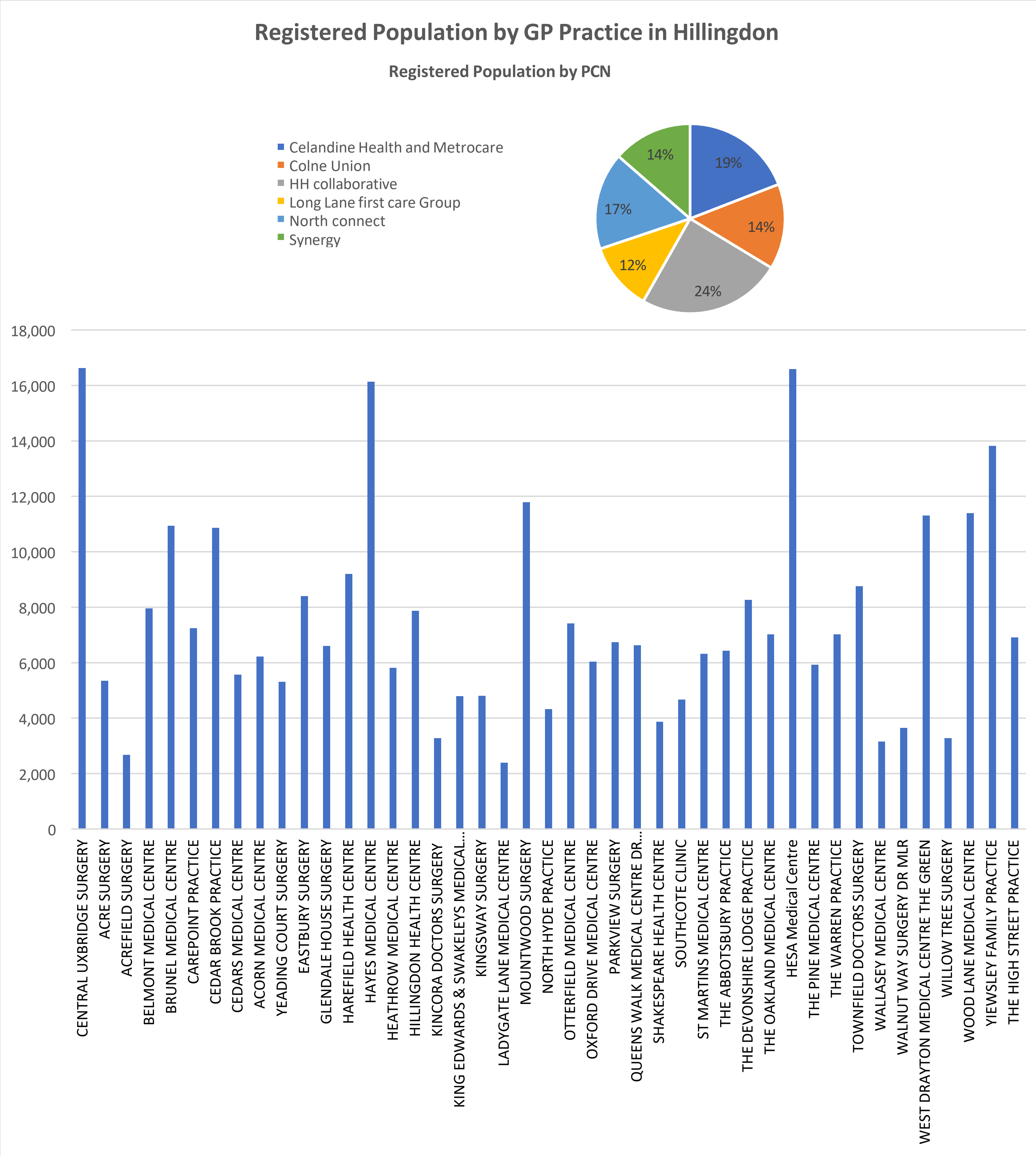


Fig 7: Frequencies of Patients with and without LTC by GP Surgery

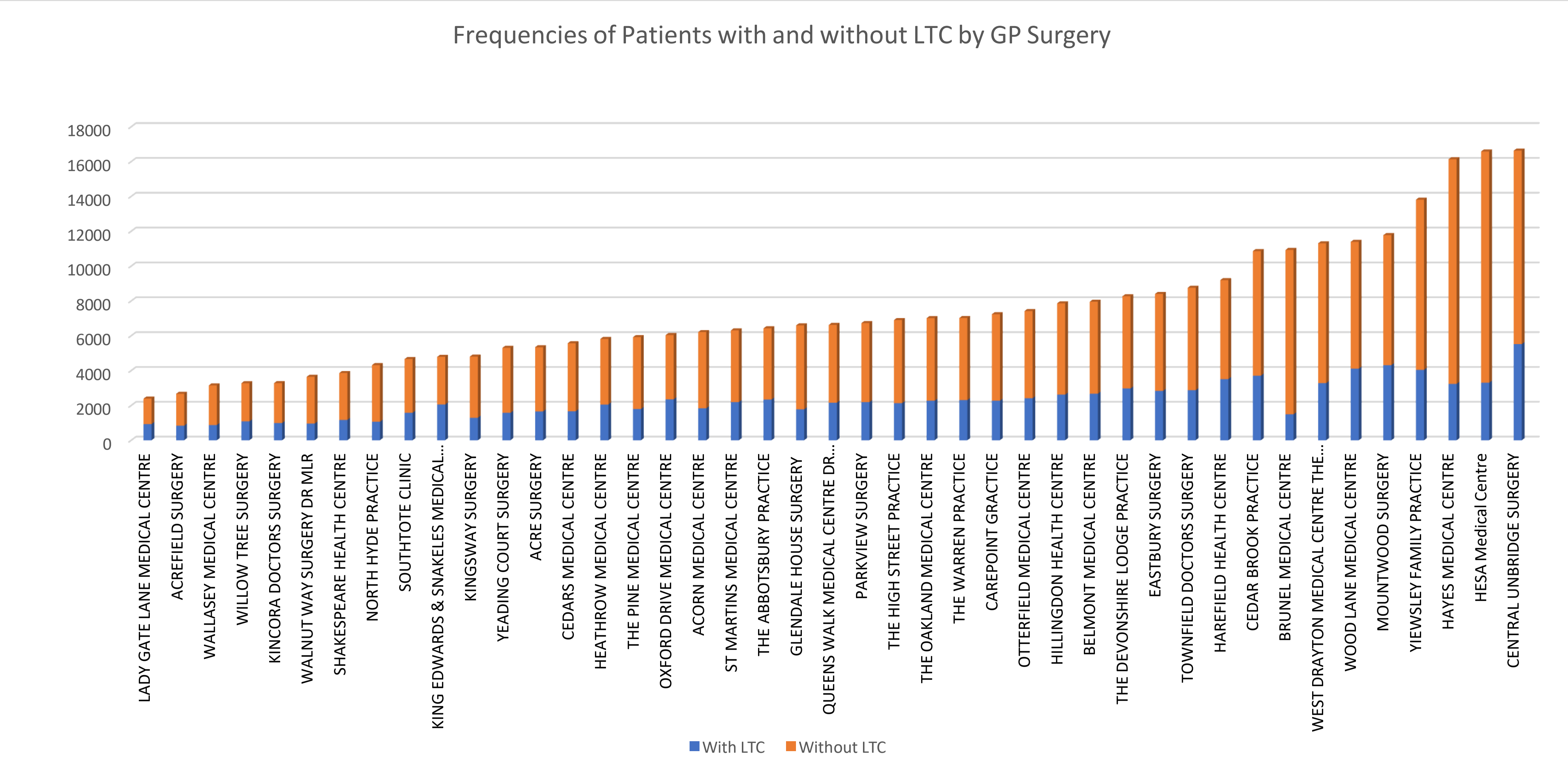
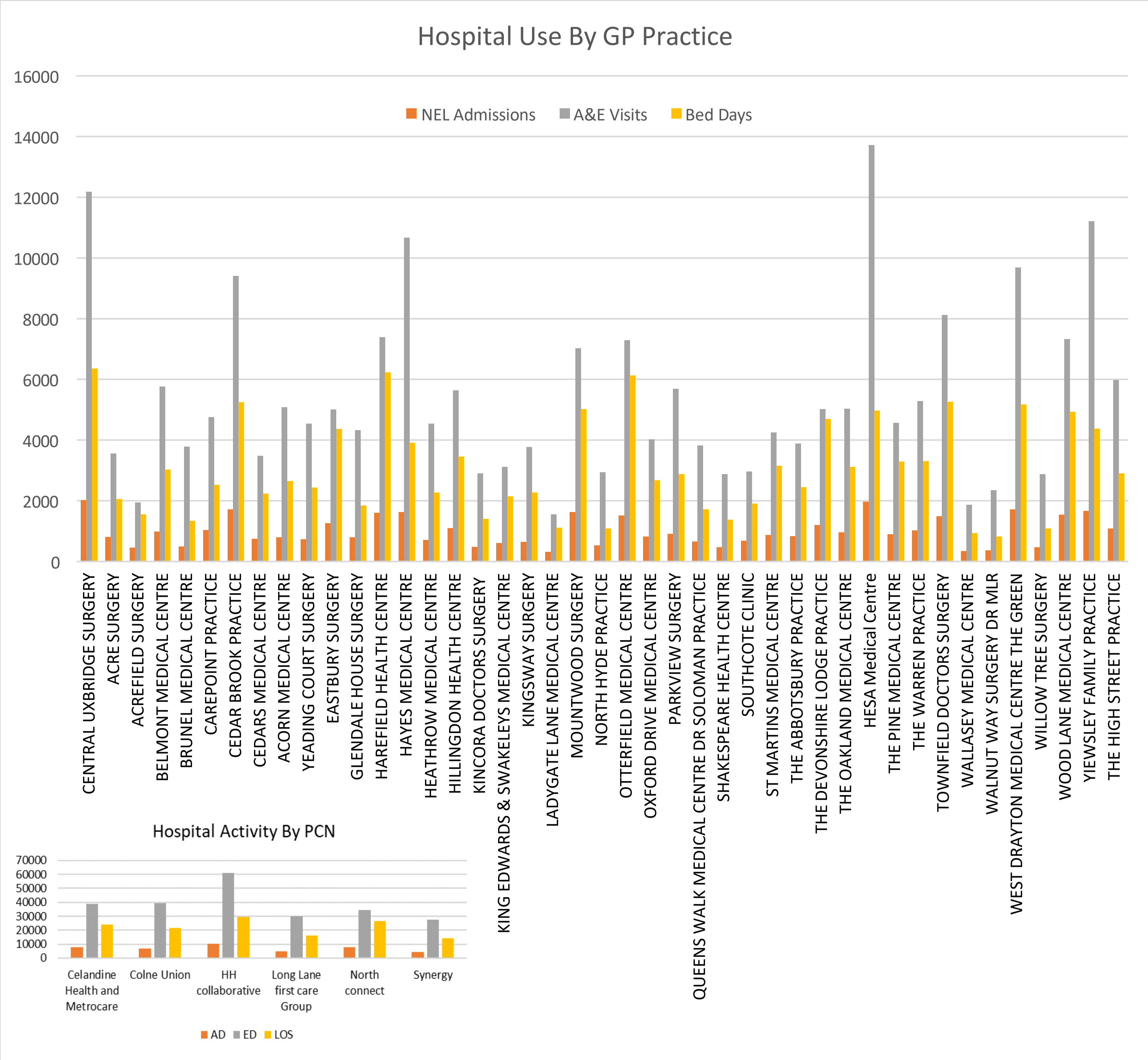


Fig 8: Distribution of the outcomes by GP surgery and PCN.



12.3.3 Predictors of Hospital Activity:

Table 25 shows the regression analysis results conducted to predict the risk of the three outcomes of interest by demographics (age, gender, and ethnicity), LTC, and GP practice. Fig 11 represents tree maps plotted to enhance the visuality of one part of the results.

12.3.3.1 GP Practices

GP surgeries exhibited various effects, including an increased and decreased chance of patients needing a NEL admission, an A&E visit, or more hospital bed days. A higher risk of patients needing a NEL admission was seen in 31 surgeries compared to Central Uxbridge Surgery (the practice with the highest frequency of outcomes overall, also taking population size into account), with nine statistically non-significant effects (Range RR: 1.04-1.18). Two surgeries had the highest risks, including Otterfield Medical Centre (RR: 1.50 95% CI: 1.36-1.67) and Acrefield Surgery (RR: 1.42 95% CI: 1.23-1.65), out of the other 22 practices (Range: 1.13-1.50), with 17 being at greater risk ranging from 20 to 50%. Ten practices showed a decreased risk of having patients requiring a NEL admission. From these, only four were significant (Range RR: 0.59-0.98), with Brunel Medical Centre being the lowest.

Thirty surgeries revealed an elevated likelihood of patients needing extra hospital bed days. Among these, 19 had RRs between 1.0 and 1.20 that were statistically insignificant. The risk for the subsequent 11 surgeries ranged from 27 to 59%. (RR: 1.27-1.59). The highest rates of patients at risk of spending more extended time in the hospital were found at Acrefield Surgery (RR: 1.59 95% CI: 1.04-2.45), Shakespeare Health Centre (RR: 1.52 95% CI: 1.13-2.06), and Otterfield Medical Centre (RR: 1.25 95% CI: 1.13-1.84). Only two of the 12 practices that demonstrated a decreased risk (n=12) were statistically significant: Walnut Way Surgery (RR: 0.72 95% CI: 0.55-0.94) and Brunel Medical Centre (RR: 0.65 95% CI: 0.48-0.88). Both emerged at the same time with the lowest risks.

Twenty-five practices (Range RR: 0.53-0.99) emerged with decreased risk of having patients visiting the A&E, with only five being statistically insignificant. The lowest risk (Equivalent to – 47% decreased risk) was seen in Brunel Medical Centre (RR: 0.53 95% CI: 0.50-0.56). Seventeen surgeries showed an increased risk of having patients visiting the A&E (Range RR: 1.02-1.24) with Otterfield Medical Centre (RR: 1.24 95% CI: 1.17-1.31), Kincora Doctors Surgery (RR: 1.21 95% CI: 1.10-1.33), Townfield Doctors Surgery (RR: 1.20 95% CI: 1.14-1.28) being the highest. Among the 17, 6 had insignificant effects (The six lowest effects-RR) ranging between 2 to 8%.

12.3.3.2 Long Term Conditions

The included long-term conditions had a significantly increased chance of experiencing any of the three outcomes compared to individuals without LTC (omitted variable). For NEL admissions, patients with COPD were at 182% risk of having an unplanned admission (RR:2.82 95% CI: 2.23-3.56), followed by CVD patients (RR:2.43 95% CI: 2.06-2.87), and patients with more than one conditions combined (RR:2.64 95% CI: 2.45-2.85). The rest of the conditions ranged between 1.35 and 2.15. For A&E visits, the same LTC groups with showed the highest risk of visiting the A&E with an RR ranging between 1.85 and 2.31 (Multimorbid patients were at the highest risk). Other LTC groups ranged between RR:1.24 to1.51. The results were not different for LoS at the hospital; patients with CVD showed a risk of 4.83, followed by COPD patients (RR: 3.70), and then patients with multimorbidities (RR:3.00). Other LTC groups ranged between RR: 1.25 to 2.60.

12.3.3.3 Demographics

All age groups younger than 60 years were significantly lower in risk of having a NEL admission. Individuals between 30-39 years old were 40% less likely to require an admission (RR:0.60 95% CI: 0.56-0.63) compared to the older population (>60 years). On the other hand, individuals belonging to the 40-49 age group had the lowest risk (RR:0.59). Other age groups ranged between 12% (<19) and 39% (20-29), with less likelihood of requiring an admission. The younger population were significantly the highest in the possibility of visiting the A&E (RR:1.51), followed by 20-29 years (RR:1.28) and 30-39 years (RR:1.07). The older population in the 50-59 group had a significantly lower chance of visiting the emergency department (RR:0.95 95% CI: 0.92-0.98), while the 40-49 years group came with no significant difference. Regarding gender, there was no significant difference in the chance to require a NEL admission compared to females, while the chance to visit the A&E was significantly less by 3%, and the chance of requiring more stay at the hospital was significantly more by 20%.

Compared with individuals from a white background, Asians were significantly less likely to require any of the three outcomes (Range RR: 0.80 to 0.83). On the other hand, patients from black backgrounds were 5% more likely to visit the A&E and 31% more likely to stay at the hospital after admission, with no significant difference in the chance of having or requiring a NEL admission. No significant difference was observed for individuals from a mixed background, while all the other ethnic groups showed less chance of requiring or having any of the outcomes except LoS at the hospital.

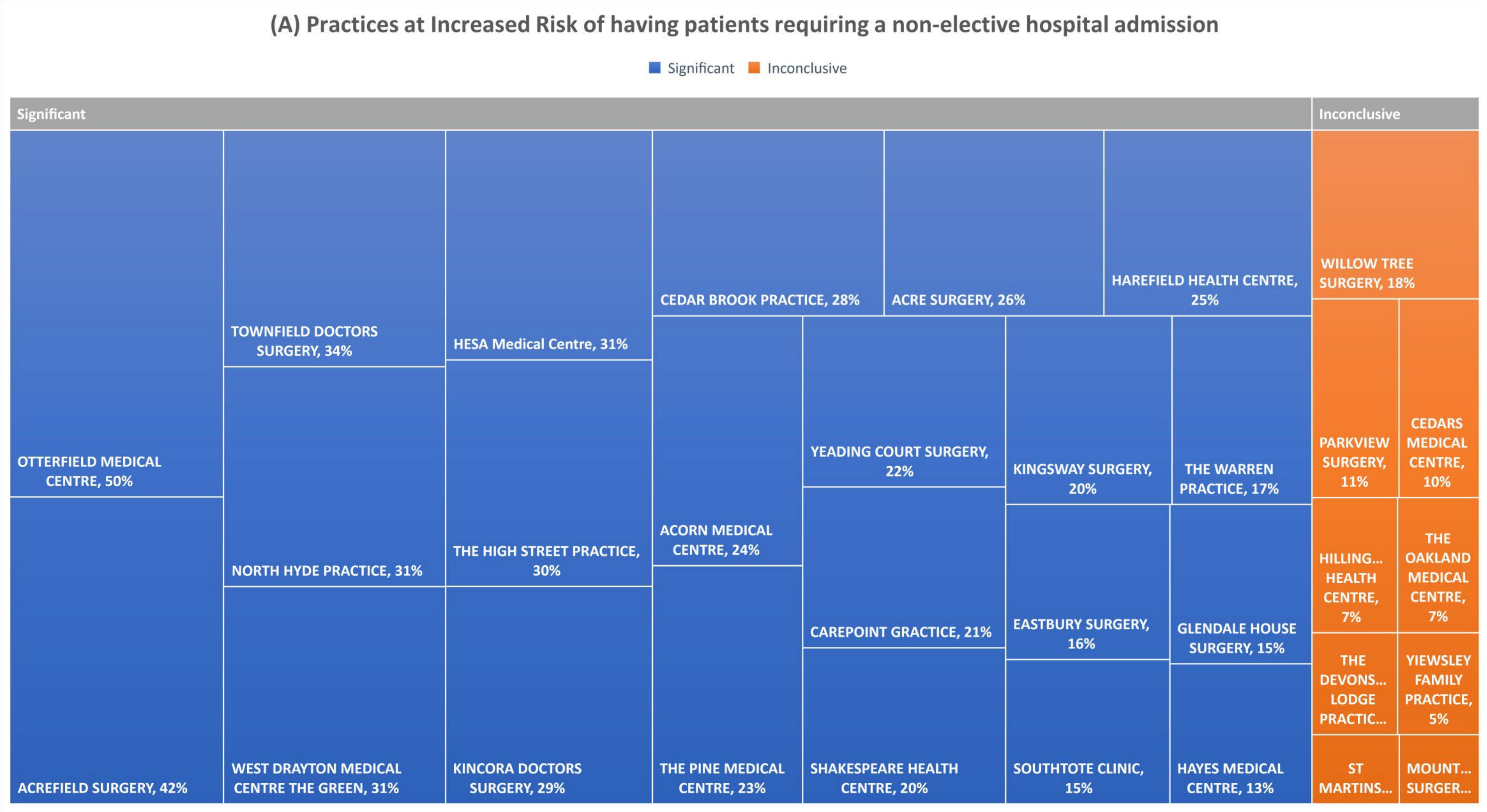
Table 25: Predicted risk of hospital activity (NEL admissions, A&E visits and LoS) in Hillingdon by background variables

	NEL Admissions	A&E Visits	LoS
	RR 95% CI	**RR** 95% CI	**RR** 95% CI
GP Practice			
Acre Surgery	**1.26*** 1.11-1.44	**0.88*** 0.82-0.94	1.02 0.79-1.33
Acrefield Surgery	**1.42*** 1.23-1.65	0.97 0.89-1.06	**1.59*** 1.04-2.45
Belmont Medical Centre	1.00 0.89-1.12	**0.93*** 0.88-0.99	1.02 0.83-1.26
Brunel Medical Centre	**0.59*** 0.51-0.67	**0.53*** 0.50-0.56	**0.65*** 0.48-0.88
Carepoint Practice	**1.21*** 1.08-1.36	**0.88*** 0.83-0.93	0.91 0.74-1.12
Cedar Brook Practice	**1.28*** 1.14-1.43	**1.10*** 1.05-1.17	**1.38*** 1.11-1.73
Cedars Medical Centre	1.10 0.96-1.27	**0.80*** 0.75-0.86	1.18 0.88-1.57
Acorn Medical Centre	**1.24*** 1.10-1.40	**1.18*** 1.11-1.26	**1.44*** 1.13-1.83
Yeading Court Surgery	**1.22*** 1.07-1.39	**1.15*** 1.08-1.24	**1.45*** 1.07-1.97
Eastbury Surgery	**1.16*** 1.04-1.31	**0.81*** 0.76-0.86	1.10 0.88-1.37
Glendale House Surgery	**1.15*** 1.02-1.29	**0.92*** 0.86-0.99	1.06 0.84-1.34
Harefield Health Centre	**1.25*** 1.13-1.38	1.02 0.96-1.08	**1.35*** 1.11-1.65
Hayes Medical Centre	**1.13*** 1.02-1.24	0.99 0.94-1.04	1.20 0.98-1.48
Heathrow Medical Centre	0.98 0.85-1.14	1.04 0.97-1.11	1.07 0.82-1.40
Hillingdon Health Centre	1.07 0.96-1.20	**0.94*** 0.89-0.99	1.03 0.83-1.28
Kincora Doctors Surgery	**1.29*** 1.11-1.50	**1.21*** 1.10-1.33	1.16 0.80-1.69
King Edwards & Snakeles Medical Centre	**0.82*** 0.71-0.95	**0.78*** 0.73-0.84	0.83 0.63-1.10
Kingsway Surgery	**1.20*** 1.02-1.42	1.08 1.00-1.17	**1.34*** 1.04-1.73
Lady Gate Lane Medical Centre	0.96 0.80-1.14	**0.81*** 0.74-0.88	0.87 0.64-1.18
Mountwood Surgery	1.04 0.94-1.14	**0.79*** 0.75-0.84	0.87 0.72-1.05
North Hyde Practice	**1.31*** 1.04-1.66	0.99 0.90-1.09	1.10 0.81-1.50
Otterfield Medical Centre	**1.50*** 1.36-1.67	**1.24*** 1.17-1.31	**1.52*** 1.25-1.84
Oxford Drive Medical Centre	0.97 0.86-1.09	**0.82*** 0.76-0.87	1.08 0.80-1.46
Parkview Surgery	1.11 0.98-1.26	**1.12*** 1.05-1.20	1.13 0.90-1.41
Queens Walk Medical Centre Dr Soloman	**0.84*** 0.74-0.95	**0.76*** 0.72-0.81	0.87 0.66-1.15
Shakespeare Health Centre	**1.20*** 1.02-1.42	1.06 0.98-1.14	**1.52*** 1.13-2.06
Southtote Clinic	**1.15*** 1.01-1.31	**0.82*** 1.76-0.88	0.91 0.72-1.15
St Martins Medical Centre	1.04 0.92-1.16	**0.87*** 0.81-0.93	1.06 0.84-1.33
The Abbotsbury Practice	0.99 0.88-1.11	**0.81*** 0.76-0.86	0.86 0.67-1.12
The Devonshire Lodge Practice	1.06 0.94-1.18	**0.79*** 1.74-0.84	1.11 0.90-1.38
The Oakland Medical Centre	1.07 0.96-1.20	0.95 0.89-1.02	1.02 0.82-1.25

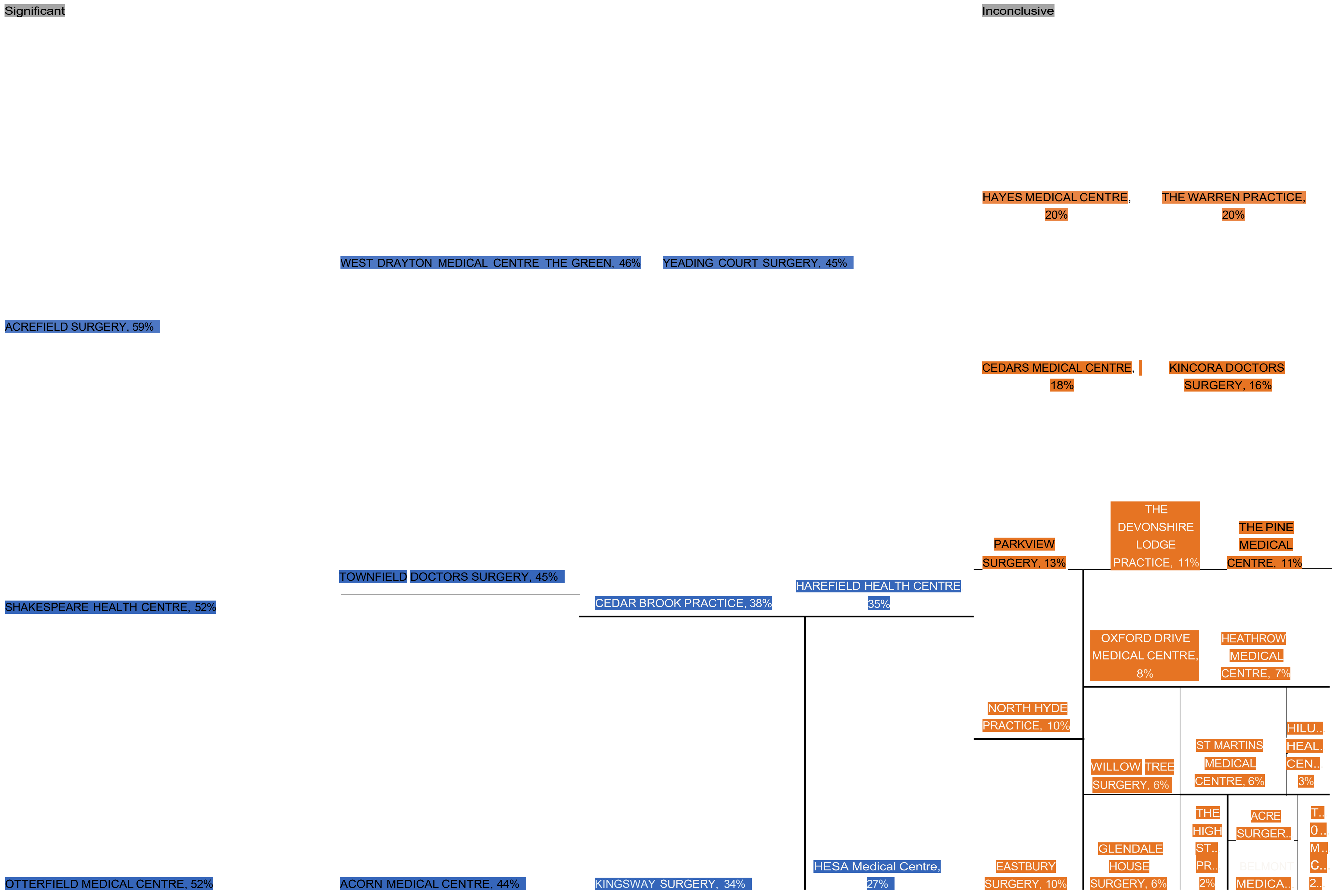
HESA Medical Centre	**1.31*** 1.18-1.44	**1.17*** 1.12-1.24	**1.27*** 1.05-1.53
The Pine Medical Centre	**1.23*** 1.08-1.40	1.03 0.95-1.11	1.11 0.89-1.39
The Warren Practice	**1.17*** 1.04-1.32	0.99 0.94-1.07	1.20 0.96-1.51
Townfield Doctors Surgery	**1.34*** 1.20-1.50	**1.20*** 1.14-1.28	**1.45*** 1.15-1.82
Wallasey Medical Centre	0.95 0.79-1.15	**0.82*** 0.75-0.89	0.93 0.63-1.37
Walnut Way Surgery Dr MLR	0.91 0.78-1.07	**0.89*** 0.81-0.97	**0.72*** 0.55-0.94
West Drayton Medical Centre The Green	**1.31*** 1.17-1.46	**1.13*** 1.07-1.20	**1.46*** 1.13-1.87
Willow Tree Surgery	1.18 0.98-1.42	1.13 0.95-1.33	1.06 0.79-1.44
Wood Lane Medical Centre	0.96 0.86-1.06	**0.81*** 0.75-0.88	0.84 0.68-1.04
Yiewsley Family Practice	1.05 0.96-1.17	1.04 0.99-1.09	0.93 0.77-1.12
The High Street Practice	**1.30*** 1.16-1.46	**1.11*** 1.04-1.19	1.02 0.83-1.27
LTC			
CVD	**2.43*** 2.06-2.87	**1.85*** 1.65-2.07	**4.83*** 3.71-6.29
Diabetes	**1.54*** 1.33-1.79	**1.49*** 1.36-1.63	**2.60*** 1.91-3.53
COPD	**2.82*** 2.23-3.56	**2.22*** 1.87-2.63	**3.70*** 2.57-5.32
Asthma	**1.26*** 1.14-1.40	**1.48*** 1.41-1.55	**1.24*** 1.03-1.48
Hypertension	**1.12*** 1.02-1.24	**1.24*** 1.17-1.30	**1.25*** 1.06-1.48
Cancer	**2.15*** 1.77-2.61	**1.38*** 1.24-1.53	**2.41*** 1.87-3.10
Multimorbid	**2.64*** 2.45-2.85	**2.31*** 2.21-2.41	**3.00*** 2.70-3.32
Other Conditions	**1.35*** 1.23-1.48	**1.51*** 1.45-1.58	**1.38*** 1.17-1.62
Ethnicity			
Asian	**0.83*** 0.80-0.86	**0.88*** 0.85-0.89	**0.80*** 0.73-0.86
Black	1.00 0.94-1.06	**1.05*** 1.02-1.09	**1.31*** 1.15-1.49
Mixed	0.91 0.77-1.06	0.99 0.91-1.07	0.92 0.68-1.22
Other	**0.88*** 0.82-0.96	**0.97*** 0.93-0.99	0.94 0.83-1.06
Age Groups			
	0.88* 0.81-0.95	**1.51*** 1.46-1.57	**0.41*** 0.35-0.48
20-29	**0.61*** 0.57-0.65	**1.28*** 1.23-1.32	**0.36*** 0.30-0.42
30-39	**0.60*** 0.56-0.63	**1.07*** 1.04-1.11	**0.34*** 0.30-0.39
40-49	**0.59*** 0.56-0.62	1.00 0.97-1.03	**0.35*** 0.31-0.40
50-59	**0.63*** 0.59-0.66	**0.95*** 0.92-0.98	**0.43*** 0.39-0.48
Gender			
Males	0.98 0.94-1.02	**0.97*** 0.95-0.99	**1.20*** 1.11-1.30

CI: Confidence intervals, ***significant**, Omitted variables: **GP Practice**: Central Uxbridge surgery, **LTC:** Patients with No LTC**, Ethnicity:** White, **Age:** >60 years, **Gender:** Females

Fig 9: Practices at increased risk of NEL admission **(A)**, A&E visit **(B)**, and bed days **(C)** in Hillingdon (in %). The risk increases as the area of each square increases. Figures (A) and (B) have invisible percentages or names in the bottom left corner. **(A):** Mountwood Surgery and St Martin Medical Centre=4%, The Devonshire Lodge Practice=6%, **(B):** The High Street Practice, The Oakland Medical Centre, Belmont Medical Centre, and Acre Surgery=2%, Hillingdon Health Centre=3%.



(B) Practices at Increased Risk of having patients requiring more bed days at the hospital



(C) Practices at Increased Risk of having patients visitng A&E

12.4 Discussion

12.5 Summary of Findings

Using three outcomes—NEL admissions, A&E visits, and LoS at the hospital—I analysed the predictors of hospital activity in Hillingdon. The analysis showed that LTCs, particularly COPD, CVD, and multimorbidity, are significant components that can predict hospital activity.

The three outcomes were significantly affected by demographic factors. Compared to younger populations, which showed a lower chance of needing a NEL admission or more bed days, older people exhibited a greater risk of developing or needing any of the outcomes. In contrast, people under the age of 39 were more likely to attend the A&E than people over 50, and individuals in the age range of 50 to 59 were less likely to do so than individuals over 60. Additionally, compared to white race (omitted variable), Asian groups appeared less prone to anticipate any of the three outcomes. On the other hand, Hillingdon's black community appeared more prone to visit the A&E and needed lengthier hospital stays after admission. Finally, compared to females, males showed a lower likelihood of visiting the A&E and a higher likelihood of needing more bed days.

GP practices exhibited a diversity of outcomes. The risk of patients needing a NEL admission and additional bed days after admission was highest at Otterfield Medical Centre and Acrefield Surgery. The surgery with the lowest likelihood of patients needing any of the three outcomes was found to be at Brunel Medical Centre.

12.6 Interpretation of Findings

Numerous predictors of hospital activity in the London borough of Hillingdon were established through this analysis. Given this, those variables may be considered predictors that help set up populations according to their likelihood of needing any of the three outcomes examined in this study. To adopt various interventions within population-based integrated care models that can assist in reducing hospital activity and, in turn, cut costs and ease pressure on health services, it is essential to identify risk groups given the rising demand for hospitals in England. This could have a significant impact on commissioning in Hillingdon.

There are two perspectives from which to examine those predictors. To determine which Hillingdon GP surgeries are most likely to experience an increase in patients who might need one of the three outcomes, commissioners and policymakers can first examine those practices.

At this level, one might argue that commissioners can focus solely on the number of patients who may necessitate one of the three outcomes each surgery incorporates. Looking at the results of my investigation, some practices appeared to have a higher risk of hospital use, even if they had smaller populations or hospital usage frequencies. For example, compering Otterfield Medical Centre (RR: 1.50 95% CI: 1.36-1.67, Population: 7419, With LTC: 2414 NEL admissions: 1505) to Wood Lane Medical Centre (RR: 0.96 95% CI: 0.86-1.06, Population: 11396, With LTC: 4113, NEL admissions: 1535). This also applies to outcomes such as A&E visits (Comparing Brunel Medical Centre to Shakespeare Health Centre and Kingsway surgery: See Figs 8 to 9). As a result, this could point to other elements that may or may not have been considered in my analysis. Given this, it would be simpler to observe the geographic distribution of risk, which in this case is reflected by a GP practice, rather than taking a population-level look at such elements.

While predicting risk, considering GP surgery could be regarded as a valuable tool for commissioners to risk stratify population, LTC and demographics could also help in this regard. Predicting risk based on LTC could aid in risk stratification and implementing necessary interventions, such as condition-specific interventions targeting those at risk. While logically speaking, a patient with multimorbidity could have a higher risk of hospital usage, the findings of this study showed a greater risk for patients with COPD or CVD. This can emphasize the importance of prioritising those patient groups and patients with multimorbidities as targets of condition-specific interventions. This could also apply to ethnicity, although the focus would be on the community level. For example, areas or GP surgeries with most Black populations could be a target for general interventions such as SM.

Having an increased risk of visiting the A&E in the younger population is an important finding in this study. In opposition to what could be expected, A&E visits could be costly. On the other hand, it is frequently argued that many visits might have been avoided and that these patients could have received better care elsewhere, most frequently in a primary care setting (Parkinson et al., 2020). With that being said, this could also be another focus for policymakers in the new modern models of care.

In addition, the data showed that those over the age of 60 with Chronic Obstructive Pulmonary Disease (COPD) and Cardiovascular Disease (CVD) have greater rates of NEL, which is consistent with the frequency of chronic diseases in older age groups. A&E visits are more common among people over the age of 19, as well as those who are black, multimorbid, and female, indicating potential inequities in healthcare access and sociodemographic characteristics. In terms of LoS, black males with CVD have longer stays, followed by those with COPD, highlighting the need to investigate the particular reasons contributing to protracted hospitalisation in these groups.

Overall, this study's findings can be considered an essential assumption for factors influencing hospital usage. On the other hand, it can be used to risk stratify the population by commissioners, policymakers, and health providers to determine the appropriate level of care and services for various patient groupings. When it comes to population health, identifying practical strategies that can enhance healthcare outcomes and reduce inequities is crucial. With this in mind, the study provides a platform for establishing targeted interventions, particularly ICMs, customised to the unique requirements of demographic groups identified in the analysis by understanding the underlying causes and limits. This stage is critical for ensuring that any changes implemented are evidence-based and beneficial.

12 CHAPTER 7: DISCUSSION AND FINAL COMMENTS

12.1 INTRODUCTION

In the current situation of increased demands on hospital use and pressure on NHS services, this thesis aimed to contribute to the understanding of the evaluation of population-based ICMs by taking the Hillingdon ICM as a case study. In the context of such models, multiple-component interventions seemed more effective in reducing hospital use, a prominent finding in the review conducted in chapter 2. With this in mind, the primary rapid impact evaluation in two stages was consistent with this finding. The population-based ICM in Hillingdon effectively reduced hospital activity to a certain extent. However, the implementation of this model and the time of evaluation were significant challenges for this thesis resulting in (a). massive delays, and

(b). higher chance of bias in the estimates. This led to the analysis in chapter five of this thesis that considered the impact of COVID-19 lockdown and found minimal impacts, especially on NEL admissions and bed days.

Although the impact of COVID-19 generally, and other potential time cofounding factors and issues related to implementation evaluation still cannot be ignored. This emphasises the importance of focusing on other types of evaluations in the future that could focus more on implementation analysis, fidelity, reach, and more. This type of analysis might give better indications of effectiveness and provide a framework that would improve such models and enhance their focus and impact. In the same context, and without the capability to apply this method in this thesis, chapter 6 was a novel attempt to create a background for future evaluation and improvement in such models by identifying some predictors of hospital use outcomes in Hillingdon.

The following sections of this chapter summarised the thesis' contributions to knowledge by discussing its findings and their policy relevance. Besides, other sections discussed its limitations and challenges, suggestions for further research, and concluding remarks.

12.2 CONTRIBUTIONS OF THE THESIS AND ITS RELEVANCE TO POLICY

12.3 Summary

This thesis contributes to the continuing discussion about the complexities of healthcare approaches by advocating for a nuanced, trial-and-error approach to understanding the adaptability of Integrated Care Models (ICMs) across varied contexts. The thesis expands on its theoretical base by defining and investigating Integrated Care (IC) in response to the problems provided by an ageing population and the prevalence of Long-Term Conditions (LTCs) in England. Notably, Chapter 2 emphasises the potential effectiveness of a population-based strategy that integrates several interventions, which is consistent with broader discussions in the literature, particularly (Morciano et al., 2020) (See chapter 4).

The systematic review in Chapter 2 expands on the contributions by identifying knowledge gaps and emphasising the importance of comprehensive interventions, supporting the argument that combining four IC interventions in a population-based model is critical for effectively managing general populations with LTCs. Chapter 4 empirically tests this, using the Hillingdon ICM as a case study, and repeatedly demonstrates the efficacy of such a combination in lowering hospital utilisation, particularly in general populations.

Chapter 6 extends the contributions by finding risk segmentation determinants of hospital activity in Hillingdon. The risk stratification discussion is consistent with the previous literature (Hippisley-Cox and Coupland, 2013), emphasising its significance in optimising resources, prioritising interventions, and improving outcomes. The use of GP practises as a risk stratification tool provides fresh insights, incorporating risk segmentation into the design of primary care networks.

A Deeper Dive into Thesis Contributions

Understanding IC, in addition to evaluating it, is a very complex task. It is well known that evaluating ICMs is not straightforward and requires understanding the interactions between different parts of models (Edwards, 2019). The complexities stem from the different types, concepts, forms, and levels of IC, making it difficult to determine what is appropriate for given settings. This thesis asserts that care fragmentation, greater patient needs, and increased expenditures stem from England's growing older population and Long-Term Conditions (LTCs). While integration can take many forms and levels, the thesis implies that using a complete approach—addressing specific interventions, forms of integration, and levels of integration all at once—might be the best way to manage population healthcare. The thesis calls for whole-system integration through the use of a population-based model with different interventions.

The thesis presents essential questions to determine the practicality of such an approach: Will it work, and are there similar models? These investigations are especially important for policymakers in England and Hillingdon who are establishing Integrated Care Models (ICMs). In Chapter two, an in-depth examination of the evidence was done to answer these questions. The systematic review of reviews highlighted gaps in knowledge and gave a comprehensive understanding of the effectiveness of IC. Notably, the study discovered a scarcity of research examining the combined effectiveness of the four IC treatments on general populations with LTCs in all settings at the same time. The majority of existing interventions were disease or condition specific. According to the thesis, such approaches may not deliver the expected results within the NHS framework in England. The thesis specifically states that combining the four IC interventions is critical for developing an effective ICM addressing broad populations with LTCs. In other words, the review in chapter two of this project emphasizes the need for a comprehensive approach, contrasting disease-specific interventions prevalent in the literature with the theoretical proposition of combining multiple interventions for general populations with LTCs.

The primary focus of the NHS's new models of care is on general populations across various boroughs in England, including the London borough of Hillingdon. Notably, the Hillingdon ICM stands out by encompassing all four IC interventions evaluated in chapter 2. This unique characteristic of the Hillingdon model raises the possibility that it might be particularly effective in achieving its designated outcomes. Furthermore, the findings of this review hold potential significance for policymakers in diverse contexts, offering insights into the design of comprehensive Integrated Care Models (ICMs) targeting general populations with a range of Long-Term Conditions (LTCs). The implication is that a holistic approach, as demonstrated by the Hillingdon model, is more likely to yield positive results in managing healthcare for diverse populations. However, this needed to be tested. The same chapter showed how unique the Hillingdon ICM is in terms of design in relation to the highlighted scarcity of studies focusing on the combined effectiveness of the four IC interventions on general populations.

Using the Hillingdon ICM as a case study, Chapter 3 studied the impact of combining four IC interventions within a population-based model to reduce hospital utilisation. The conclusions of the chapter were consistent with the review of reviews. Notably, it showed the ICM's ability to produce population-level benefits more effectively. This was demonstrated by a decrease in A&E visits, even among individuals who did not mainly represent patients with LTC. These findings show that IC may be able to fulfil its goals of reducing major outcomes, including admissions to hospitals and visits, more effectively when directed at general populations rather than exclusively vulnerable groups. This finding, however, does not rule out the possibility of including condition-specific modalities within an ICM.

In chapter 2, condition-specific interventions showed their effectiveness in multiple contexts and with various outcomes. This was also the case with the subgroup analysis in chapter 3 (Stage 1). In the appendices of this thesis, the 'Kaiser Permanente' (Appendices, Fig 2) was presented. The pyramid clearly shows that the population can be divided according to risk or care needs. While the whole model can benefit the whole population (As shown in chapter 3), condition-specific interventions could operate on the other three top levels (As shown in Chapter 2 and Chapter 3 (subgroup analysis)). This highlights how population-based interventions are expected to deliver their expected benefits in reducing hospital use.

While the Hillingdon ICM evaluation focused on hospital use outcomes, the findings of chapter 2 showed indications of improvement in patient-centred and clinical outcomes with ICMs consisting of multiple models. Accordingly, it can still be argued that population-based ICMs, such as the one in Hillingdon, are still expected to improve such outcomes. However, further evaluations in this regard are needed.

Mentioning the first three groups shown in the Kaiser pyramid, and in the absence of a process evaluation, identifying those at risk is extremely important for ICM effectiveness. In order to know what to do, we should identify whom to target. While Chronic patients can be easily identified through records, those at high risk and with severe complications need to be explicitly identified. In other words, the more specific and systematic the healthcare providers, policymakers, and commissioners are in their targets, the more benefits they can claim. When we speak about being systematic, risk stratification comes.

In healthcare, risk segmentation is a systematic technique that emphasises resource optimisation, intervention prioritisation, and improved outcomes. This method is based on the efficient allocation of limited resources, which enables healthcare providers to prioritise interventions for individuals or groups at higher risk, ensuring that resources are used adequately. Risk stratification allows for a proactive approach by identifying individuals who are predisposed to adverse outcomes and permitting preventive actions and early interventions. Furthermore, it adds to personalised care plans customised to a population's various risk levels, improving the overall effectiveness of interventions. Risk-based segmentation enhances cost-effectiveness in the healthcare system by focusing resources on high-risk individuals, potentially reducing the overall burden of preventable consequences. This technique also connects with population health management goals, allowing for targeted public health initiatives, outreach programmes, and education efforts to promote community health in a systematic manner. Accordingly, chapter 5 in this thesis identified different predictors of hospital activity in Hillingdon, which can aid in stratifying the first three levels in the pyramid.

Chapter 5 also contributed to knowledge by presenting GP practices as an effective tool that can be used to risk stratify populations. Given the neighbourhood compartment of the Hillingdon ICM explained in chapter 4, such predictions can form an essential tool for commissioners to amend their primary care network. This can be considered by combining surgeries in PCN according to their risks rather than just their geographic location.

Concerning GP surgeries, the findings in this chapter indicate a significant variation among GP surgeries in terms of their impact on hospital activity, with some practices having an increased risk of patients requiring NEL admission, more extended hospital stays, and A&E visits, while others have a decreased risk. These disparities could be attributed to various factors, including variations in patient demographics, healthcare services, and the level of care offered by GP surgeries. According to the findings, some GP surgeries may be more effective at managing patients' health requirements and minimising unnecessary hospitalisations and A&E visits.

In terms of IC, these findings emphasise the need to encourage collaborative and coordinated care among various healthcare providers, including some GP surgeries (e.g., those with increased risk of having patients requiring more hospital activity) and hospitals. This could entail better collaboration between GP practices and hospital care teams, sharing patient data and medical records, and more proactive outreach to patients at high risk of hospitalisation in some surgeries. Furthermore, these data show that focused interventions and quality improvement measures may be required in specific GP surgeries to address the factors contributing to increased rates of hospital activity. This could include training and assistance for primary care clinicians to better manage chronic illnesses and avoid unnecessary hospitalisations and measures to promote patient engagement and access to healthcare services.

This chapter also highlighted the importance of considering factors other than LTCs while stratifying populations. Age groups were significantly identified as a predictor of A&E visits. The analysis showed that younger age groups were at higher risk of visiting the A&E. With this in mind, this can also emphasise that although ICMs have patients with LTC as their main targets, they are also expected to claim benefits within the general population including the younger age groups. On the other hand, this also highlights the importance of evaluating integrated urgent care services, such as the NHS 111. Such services have an important role in preventing patients from visiting the A&E by providing the necessary advice to patients via telephone consultations.

In the same chapter, ethnic background as a predictor showed that ethnic discrepancies in hospital activity exist. Asian patients were less likely to require any of the three outcomes, whereas black patients were more likely to visit A&E and remain in the hospital following admission. This could have been due to a variety of reasons, including cultural customs and values, socioeconomic level, and access to healthcare. In terms of IC, these findings emphasise the significance of addressing these differences and providing culturally sensitive and appropriate care to patients of various ethnicities. These could include customised health education and outreach initiatives, language interpretation services, and community-based care models addressing social determinants of health. This is primarily related to the conclusions in Chapter 2 regarding the importance of SM interventions as a part of population-based ICMs.

This thesis can be regarded as a novel attempt to deliver a framework that can be considered while a—Designing ICMs, b—implementing ICMs, and c—Evaluating ICMs, especially in the contexts were population-based models are becoming the cornerstone of health policy-making. While ICMs have become the cornerstone of the policy response in different countries, including England, to relieve the pressure on health services, these models have become an essential goal in the NHS long-term plan (NHS, 2020). The plan is leaning towards creating

Integrated Care Systems everywhere, building on the progress already made. ITS design is considered a powerful tool to evaluate the impact of interventions implemented in healthcare settings (Ewusie et al., 2020). Accordingly, an indication of the Hillingdon ICM impact on the three outcomes of interest is a major strength of this thesis. The study could provide the policymakers in Hillingdon CCG with the first steps to understand whether their model was and is working and, more importantly, question what they can do better. This is all related to how this thesis tried to answer different questions to aid this understanding. While chapter 2 indicated what could work best, chapter 3 tested that.

Before 2019, numerous evaluations of various ICMs had not resulted in the anticipated decreased hospital admissions; in some instances, it has even been discovered that patients receiving integrated care use hospitals more frequently than controls (Kumpunen et al., 2019). In a briefing explaining the potential causes of this, a group of researchers identified the underuse of process evaluation as a potential issue contributing to (a). not being able to identify what is missing in the model, and (b) not knowing whom to target. While conducting a process evaluation was not possible in this study, I introduced my risk segmentation analysis in chapter 6, which could not fulfil (a) but addressed (b). Stratifying populations by risk could form an explainable build-up for commissioners and ICM designers, implementers, and evaluators on what to focus on, which interventions could be helpful, and which groups are the most at risk.

12.4 LIMITATIONS AND CHALLENGES OF THESIS AND FUTURE RESEARCH

Despite its considerable contributions to knowledge, this thesis came with several limitations and challenges. The results of this project should therefore be handled with caution.

The review in chapter two synthesised the evidence narratively and did not attempt a quantitative synthesis, despite the moderate to high quality of the included reviews. This was mainly related to the heterogeneity of the included studies. Due to the nature and purpose of the review and it's aims, I refrained from commenting on or drawing conclusions regarding the methods followed to evaluate the effectiveness of the interventions or the specific settings in which they were put into practice. This was related to the fact that attempting to consider methods to evaluate complex interventions could be complex, especially if those were regarded as being recent.

The analysis in Chapter 3 included several limitations related to the nature of the dataset provided. First, the subgroup analysis of patients of LTCs in stage one might have been subjected to some biases. Patients with a particular LTC were assigned to a particular group. However, it was clear from the data that some patients had additional LTCs in different durations. For example, a patient might be assigned to the hypertension group from Oct 2018 to Sep 2019 and then develop diabetes in Sep 2019. However, analysing the data on the individual level in two stages might have accounted somehow to the potential bias that might have occurred concerning this point. Besides, although MI was used to replace missing data in the LTC group, I still expect some biases in the subgroup analysis, given the known limitations of such methods (Jakobsen et al., 2017).

Nevertheless, my sensitivity analysis did provide a valid indication of the negligible effect of missing values on the analysis. On the other hand, the absence of missing values in the stage 2 analysis might have also accounted for this bias. It is also possible that some data regarding the three outcomes were not recorded or missed in WSIC.

Although the choice of the control group was reasonable to a certain extent with what was available, the estimate could have been more accurate if a group with no intervention in place was found. This would have accounted more for potential time-varying confounders and given more indications of the effectiveness of such models.

The analyses in chapters 3 to 5 were confined only to three outcomes related to hospital activity. A wide range of outcomes can add to the analysis and make the estimation of effectiveness more accurate, as highlighted in chapter 2. 30 days readmissions could significantly indicate the DM's effectiveness in preventing readmission. On the other hand, outcomes such as patient-centred and condition-specific could add more to the subgroup analysis. It can, for example, assess whether patients with diabetes can manage their HbA1c.

Furthermore, assessing the effects of factors such as local services, transportation, schools, and other community factors on the outcomes mentioned in chapters 3–5, is crucial. The scope of study must be expanded beyond the immediate healthcare context. Understanding the contextual influences on health outcomes and the success of Integrated Care Models (ICMs) requires evaluating the broader environmental variables. Investigating the connections between healthcare interventions and local services, transportation accessibility, and the educational environment can provide useful insights into the multidimensional character of health outcomes. For instance, understanding how transportation limitations may effect patient adherence to follow-up appointments or how local schools contribute to health education and preventive measures could expand the study and provide a more holistic assessment of the intervention's impact.

The assessment of intervention effectiveness was too broad. Although the aim was to capture any benefits for the general population, it is crucial to evaluate what part of the intervention was the most or the least beneficial. This form of analysis can greatly indicate implementation succession. That being said, the analysis in chapter 3 in its two stages was fully impact based; thus, no process evaluation or any of its compartments was attempted in this thesis. Although rapid outcome-based evaluations are crucial when evaluating ICMs, process evaluations are better tools for capturing the effectiveness of complex interventions. By examining the quantity and quality of what was delivered and measuring the generalisability of its effectiveness by understanding the impact of context, process evaluation swings toward providing higher confidence in findings of effectiveness (Moore et al., 2015). Implementation research should go into the intricacies of how the intervention was provided, verifying that the planned model was followed. Examining the number and quality of services delivered, potential changes in implementation across different contexts, and the extent to which the intervention reached its target population are all part of this approach. Fidelity assessments would reveal whether the intervention was carried out faithfully and whether any variations influenced outcomes. Furthermore, understanding the extent of the intervention's penetration throughout the community and identifying any inequities in access is critical. Collectively assessing the implementation process, fidelity, and reach contributes to a more nuanced view of intervention success within the larger socio-ecological environment (Moore et al., 2015).

Although questions about implementation are a crucial aspect of Integrated Care Models (ICMs), what remains uncertain is the degree to which the cumulative evidence-based interventions of ICMs affect health outcomes. Ideally, both the effectiveness of ICMs (addressed in this thesis) and how to enhance their practical implementation (implementation science) should be examined. However, the unforeseen emergence of COVID-19 prevented the latter investigation, yet it holds promise for future research in this field and could significantly enhance our current understanding.

Adding to the limitations of chapter 3, the power of this analysis can still be regarded as low to moderate. With ITS, more data points mean more power. The duration of the study can still be considered insufficient to estimate the model's short time impact. ICMs can take time to work, and the emergence of COVID-19 at the time of the study can make the findings of this evaluation questionable.

In chapter 4, assessing the impact of COVID-19 could have been more accurate if data on COVID-related admissions, A&E visits, and bed days were provided. Excluding these outcomes from the analysis could provide better direct estimates of COVID impact on hospital activity regardless of COVID-related outcomes. Moreover, other data related to other health services, such as GP referrals, self-referral, and Ambulance services, could have given more accurate estimations. This is related to the fact that data from these services can identify the primary sources of NEL admissions and thus give more indications on the impact of COVID-19 on hospital activity outcomes. The inability to dig further into the practical deployment of ICMs is acknowledged in light of the unforeseen problems brought by the COVID-19 outbreak. However, this setback provides an opportunity for future study to investigate the interaction between ICMs and external factors, taking into account the dynamic nature of healthcare delivery in the face of unexpected events. Future research might focus on the resilience and adaptation of ICMs in the face of external shocks, providing useful insights into ways for improving the practical implementation and sustainability of such models in the face of unexpected challenges.

Moreover, it is essential to note that the effectiveness of telemedicine in facilitating integrated care services may vary depending on the context and the specific needs of patients. Future evaluations of integrated care models that incorporate telemedicine interventions should consider the specific challenges and opportunities presented by this approach, and assess its impact on outcomes such as patient satisfaction and its role in IC.

Considering more predictors in chapter 5 would have added more to its analysis. Risk stratification is complex as patients could possess risks differently and concerning different factors. There is still a possibility that those predictors might still not be enough. For example, postcodes could increase the accuracy of predicting the indirect effects of GP practices on hospital usage.

12.4.1 Challenges

Despite its contributions to knowledge, this thesis faced many challenges that played an important role in its progress.

COVID-19 placed considerable pressure on multiple things that slowed down the progress of this thesis and possessed multiple limitations highlighted earlier. Data access took an enormous amount of time, and at the same time, it was not available daily. Access to the WSIC environment was disrupted multiple times and required many communications. This also led to a failure in conducting any further analysis, including some qualitative synthesis with the stakeholders and policymakers as a part of a process evaluation. A process evaluation would have been an enormous contribution to this thesis.

On the other hand, personally, I faced multiple health issues and was diagnosed with a new condition. My energy levels were highly effected, and this caused significant delays in my progress. Financial pressure was another thing that I faced which also had equal ramifications. COVID-19 also greatly affected my personal health, especially my mental health.

Despite all these challenges and pressures, I completed this project. I understand that I could have done better, yet: arriving late is better than not arriving at all.

12.5 Future Research

Future evaluations of ICM, especially the one in Hillingdon, should be built on the limitations in this thesis. Process evaluation should be the first aim for evaluators. Understanding what was delivered and what can be done better is crucial for success in delivering integrated care. Outcomes related to patients' care should also be considered. Integrated care is not only about reducing hospital usage and costs but also about patient care and satisfaction. More data in this context could mean more power. Increasing data points could hugely give better estimates of effects. On the other hand, more outcomes in the evaluation and predicting effects on outcomes could better understand patients' needs and the effects of ICMs.

More clustering analysis could also contribute more to improving IC and patient care. Patients could benefit differently from IC. Understanding what is posing better effects and what is not and who is benefiting is crucial for IC. Micro evaluations in different settings can achieve such benefits.

Assessing organisational outcomes, such as communications between different members of MDTs can give more indications in implementation evaluations. For IC to work, it should be assessed if it is delivered correctly. This can also be applied to other interventions, such as DM.

Future reviews can include qualitative synthesis. This can highly contribute to the finding of Chapter 2 regarding the better effects of a multicomponent intervention. Cost-effectiveness analysis is vital to assess efficiency in different contexts, including Hillingdon. Future research should also examine contextual factors, implementation mechanisms, and methods used to evaluate the effectiveness of similar IC interventions. While new evaluations of population-based ICMs are being published yearly, it is crucial to assess methodological approaches to evaluate such models in the future. Such complex models are very new, and this project can be considered one of the most recent impact evaluations of population-based ICMs in England and consequently can be regarded as a massive contribution in this context.

12.6 Concluding Comments

The overarching purpose of this thesis has been to contribute to understanding integrated care effectiveness and its evaluation. Interventions with multiple components were most likely to be effective, especially in reducing hospital admissions. Outcomes that can be assessed in the case of such interventions could include organisational outcomes such as unplanned hospital admissions/ED visits/LoS at the hospital, patient-centred such as Qol, and clinical outcomes such as HbA1C in subgroup analysis. The assessment of the effectiveness of an ICM implemented in the London borough of Hillingdon in the UK showed indications of effectiveness in reducing non-elective hospital admissions, A&E visits, and LoS. This project also found evidence of a reduction in the three outcomes across diverse populations with various LTCs. The results could also indicate that Hillingdon's model seemed more effective in reducing hospital activity than Ealing's in a case-control analysis. Two reasons could have accounted for this difference: including more compartments in the model and better implementation. The assessment of the impact of COIVD-19 lockdown on hospital activity comparing both Hillingdon and Ealing hospitals populations found minimal effect on all outcomes accept A&E visits. The comparison between different analyses could indicate that the effects of the intervention observed were not notably affected by lockdown measures, at least to a certain extent. Accordingly, it can be argued that the Hillingdon ICM could have still produced promising effects in reducing hospital activity. Numerous predictors of hospital activity in the London borough of Hillingdon were established through a risk prediction analysis. Given this, those variables, including GP practices, LTCs, and demographics may be considered predictors that help set up populations according to their likelihood of needing any of the three outcomes examined in this project. To adopt various interventions within population-based integrated care models that can assist in reducing hospital activity and, in turn, cut costs and ease pressure on health services, it is essential to identify risk groups given the rising demand for hospitals in England. This could have a significant impact on commissioning in Hillingdon.

Given the limitations of this study, the results need to be interpreted cautiously. Further research should include more data with more data points to increase power. ICM effect on other outcomes, such as condition-related knowledge, should also be evaluated. A process evaluation assessing facilitators and barriers to effectiveness and implementation could add more to this thesis. Moreover, clustering analysis could be recommended by assessing effects based on the interaction of specific groups with interventions within the model. This might be able to capture mechanisms of impact and if adding group-specific interventions is required.

Despite the challenges and constraints, to the best of my knowledge, this thesis is one of the first attempts in England to examine population-based integrated care models. As a result, this study could serve as a benchmark for healthcare providers, commissioners, and policymakers in England who want to make speedy improvements and need the most up-to-date evidence synthesis pertinent to their situation.

In summary, this thesis has significantly contributed to understanding population-based ICMs and their effectiveness in reducing hospital use. Despite the challenges encountered during the implementation and evaluation of the Hillingdon ICM, my findings suggest that multiple-component interventions can effectively reduce hospital activity to a certain extent. It is essential to recognize the impact of COVID-19 and other time-confounding factors in future evaluations of ICMs. Additionally, focusing on other types of evaluations, such as implementation analysis, fidelity, and reach, can provide a more nuanced understanding of ICM effectiveness and help improve their focus and impact. Finally, the predictors of hospital use outcomes identified in chapter 6 can inform future research and policy decisions in this area, ultimately contributing to better patient healthcare outcomes.

13 REFERENCES (INCLUDING APPENDICES)

Adlington, K., Finn, R., Ghafur, S., Smith, C.R. & Zarkali, A. 2015, *Commissioning What's the big deal?*, NHS England.

Alderwick, H., Ham, C. & Buck, D. 2015, Feb 23,-last update, *Population health systems: going beyond integrated care*. Available: https://www.kingsfund.org.uk/publications/population-health-systems [2021, 28/01/].

Allen, J., Hutchinson, A.M., Brown, R. & Livingston, P.M. 2014, "Quality care outcomes following transitional care interventions for older people from hospital to home: a systematic review", *BMC Health Services Research,* vol. 14, pp. 346.

Anderson, G.A. & Horbar, J.D. 2002, "Integrated care for premature infants and their families", *Pediatrics,* vol. 6, no. 109, pp. 1222-1228.

Armitage, G.D., Suter, E., Oelke, N.D. & Adair, C.E. 2009, "Health systems integration: State of the evidence", *International journal of integrated care,* vol. 9, no. 2, pp. e82.

Baek, H., Cho, M., Kim, S., Hwang, H., Song, M. & Yoo, S. 2018, "Analysis of length of hospital stay using electronic health records: A statistical and data mining approach", *PLOS ONE,* vol. 13, no. 4, pp. e0195901.

Belbasis, L., Bellou, V. & Ioannidis, J.P.A. 2022, "Conducting umbrella reviews", *BMJ medicine,* vol. 1, no. 1, pp. e000071.

Baicker, K. & Chandra, A. 2004, "Medicare Spending, The Physician Workforce, And Beneficiaries' Quality Of Care", *Health affairs (Millwood, Va.),* vol. 23, pp. W184-W4197.

Baker, J.M., Grant, R.W. & Gopalan, A. 2018, "A systematic review of care management interventions targeting multimorbidity and high care utilization", *BMC Health Services Research,* vol. 18, no. 1, pp. 65.

Ball, S., Banerjee, A., Berry, C., Boyle, J.R., Bray, B., Bradlow, W., Chaudhry, A., Crawley, R., Danesh, J., Denniston, A., Falter, F., Figueroa, J.D., Hall, C., Hemingway, H., Jefferson, E., Johnson, T., King, G., Lee, K.K., McKean, P., Mason, S., Mills, N.L., Pearson, E., Pirmohamed, M., Poon, M.T.C., Priedon, R., Shah, A., Sofat, R., Sterne, J.A.C., Strachan, F.E., Sudlow, C.L.M., Szarka, Z., Whiteley, W. & Wyatt, M. 2020, "Monitoring indirect impact of COVID-19 pandemic on services for cardiovascular diseases in the UK", *Heart (British Cardiac Society),* vol. 106, no. 24, pp. 1890-1897.

Baxter, S., Johnson, M., Chambers, D., Sutton, A., Goyder, E. & Booth, A. 2018a, "The effects of integrated care: a systematic review of UK and international evidence", *BMC health services research,* vol. 18, no. 1, pp. 350.

Baxter, S., Johnson, M., Chambers, D., Sutton, A., Goyder, E. & Booth, A. 2018b, "Understanding new models of integrated care in developed countries: a systematic review", *Health services and delivery research,* vol. 6, no. 29, pp. 1-132.

Baxter, S., Johnson, M., Chambers, D., Sutton, A., Goyder, E. & Booth, A. 2018c, "Understanding new models of integrated care in developed countries: a systematic review", .

Bernal, J.L., Cummins, S. & Gasparrini, A. 2017, "Interrupted time series regression for the evaluation of public health interventions: a tutorial", *International journal of epidemiology,* vol. 46, no. 1, pp. 348-355.

Bhaskaran, K., Gasparrini, A., Hajat, S., Smeeth, L. & Armstrong, B. 2013, "Time series regression studies in environmental epidemiology", .

Blunt, I. 2014, *Focus on:*

A&E attendances, Nuffieldtrust.

Braet, A., Weltens, C. & Sermeus, W. 2016, "Effectiveness of discharge interventions from hospital to home on hospital readmissions: a systematic review", *JBI Database of Systematic Reviews & Implementation Reports,* vol. 14, no. 2, pp. 106-173.

Brunner-La Rocca, H., Fleischhacker, L., Golubnitschaja, O., Heemskerk, F., Helms, T., Hoedemakers, T., Allianses, S.H., Jaarsma, T., Kinkorova, J., Ramaekers, J., Ruff, P., Schnur, I., Vanoli, E., Verdu, J. & Zippel-Schultz, B. 2016, "Challenges in personalised management of chronic diseases-heart failure as prominent example to advance the care process", *The EPMA Journal,* vol. 7, no. 1, pp. 1-9.

Business Performance Team Residents Services 2019, *Hillingdon Borough Profile*.

Charles, A. 2021, *Integrated care systems explained: making sense of systems, places and neighbourhoods*, The King's Fund, London, England.

Contandriapoulos, A.P., Denis, J.L., Touati, N. & Rodriguez, C. 2003, "The integration of health care: dimensions and implementation.", *Groupe de recherche interdisciplinaire en santé.*, .

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I. & Petticrew, M. 2008, "Developing and evaluating complex interventions: the new Medical Research Council guidance", *BMJ,* vol. 337, no. 7676, pp. 979-983.

Cutler, S. 2018, "Effectiveness of Group Self-Management Interventions for Persons with Chronic Conditions: A Systematic Review", *MEDSURG Nursing,* vol. 27, no. 6, pp. 359-367.

Czado, C. 2012, *Zero-inflated generalized Poisson regression: Asymptotic theory and applications*.

Damery, S., Flanagan, S. & Combes, G. 2016, "Does integrated care reduce hospital activity for patients with chronic diseases? An umbrella review of systematic reviews", *BMJ Open,* vol. 6, no. 11.

Damery, S., Flanagan, S. & Combes, G. 2016, "Does integrated care reduce hospital activity for patients with chronic diseases? An umbrella review of systematic reviews", *BMJ open,* vol. 6, no. 11, pp. e011952.

Diederichs, C., Berger, K. & Bartels, D.B. 2011, "The measurement of multiple chronic diseases—a systematic review on existing multimorbidity indices", *The journals of gerontology. Series A, Biological sciences and medical sciences,* vol. 66, no. 3, pp. 301-311.

Ditewig, J.B., Blok, H., Havers, J. & van Veenendaal, H. 2010, "Effectiveness of self-management interventions on mortality, hospital readmissions, chronic heart failure hospitalization rate and quality of life in patients with chronic heart failure: a systematic review", *Patient education and counseling,* vol. 78, no. 3, pp. 297-315.

Dueñas-Espín, I., Vela, E., Pauws, S., Bescos, C., Cano, I., Cleries, M., Contel, J.C., de Manuel Keenoy, E., Garcia-Aymerich, J., Gomez-Cabrero, D., Kaye, R., Lahr, M.M.H., Lluch-Ariet, M., Moharra, M., Monterde, D., Mora, J., Nalin, M., Pavlickova, A., Piera, J., Ponce, S., Santaeugenia, S., Schonenberg, H., Störk, S., Tegner, J., Velickovski, F., Westerteicher, C. & Roca, J. 2016, "Proposals for enhanced health risk assessment and stratification in an integrated care scenario", *BMJ Open,* vol. 6, no. 4, pp. e010301.

Echevarria, C., Brewin, K., Horobin, H., Bryant, A., Corbett, S., Steer, J. & Bourke, S.C. 2016, "Early Supported Discharge/Hospital At Home For Acute Exacerbation of Chronic Obstructive Pulmonary Disease: A Review and Meta-Analysis", *COPD,* vol. 13, no. 4, pp. 523-533.

Edwards, N. 2019, "Lessons from integrated care pilots in England", *Journal of integrated care (Brighton, England),* vol. 28, no. 1, pp. 2-6.

Ewusie, J.E., Soobiah, C., Blondal, E., Beyene, J., Thabane, L. & Hamid, J.S. 2020, "Methods, Applications and Challenges in the Analysis of Interrupted Time Series Data: A Scoping Review", *Journal of Multidisciplinary Healthcare,* vol. 13, pp. 411-423.

Feachem, R.G.A., Sekhri, N.K. & White, K.L. 2002, "Getting More For Their Dollar: A Comparison Of The NHS With California's Kaiser Permanente", *BMJ: British Medical Journal,* vol. 324, no. 7330, pp. 135-141.

Flanagan, S., Damery, S. & Combes, G. 2017, "The effectiveness of integrated care interventions in improving patient quality of life (QoL) for patients with chronic conditions. An overview of the systematic review evidence", *Health And Quality Of Life Outcomes,* vol. 15, no. 1, pp. 188.

Fryer, C.E., Luker, J.A., McDonnell, M.N. & Hillier, S.L. 2016, "Self management programmes for quality of life in people with stroke", *Cochrane Database of Systematic Reviews,* , no. 8.

Galdas, P., Fell, J., Bower, P., Kidd, L., Blickem, C., McPherson, K., Hunt, K., Gilbody, S. & Richardson, G. 2015, "The effectiveness of self-management support interventions for men with long-term conditions: a systematic review and meta-analysis", *BMJ Open,* vol. 5, no. 3, pp. e006620.

Gemma Green, Sarah Abbott, Yiannis Vyrides, Irrum Afzal, Deiary Kader & Sarkhell Radha 2021, "The impact of the COVID-19 pandemic on the length of stay following total hip and knee arthroplasty in a high volume elective orthopaedic unit", *Bone & joint open,* vol. 2, no. 8, pp. 655-660.

Goddard, M.K. & Mason, A. 2017, "Integrated Care : A Pill for All Ills?", .

Gonçalves-Bradley, D.C., Iliffe, S., Doll, H.A., Broad, J., Gladman, J., Langhorne, P., Richards, S.H. & Shepperd, S. 2017, "Early discharge hospital at home", *Cochrane Database of Systematic Reviews,* , no. 6.

Goodfriend, M. 1992, "Information-Aggregation Bias", *The American economic review,* vol. 82, no. 3, pp. 508-519.

Goodwin, N., Sonola, L., Thiel, V. & Kodner, D.L. 2013, *Co-ordinated care for*
people with complex
chronic conditions
Key lessons and markers
for success, The King's Fund, London.

Gorina, M., Limonero, J.T. & Álvarez, M. 2018, "Effectiveness of primary healthcare educational interventions undertaken by nurses to improve chronic disease management in patients with diabetes mellitus, hypertension and hypercholesterolemia: A systematic review", *International journal of nursing studies,* vol. 86, pp. 139-150.

Ham, C., York, N., Sutch, S. & Shaw, R. 2003, "Hospital bed utilisation in the NHS, Kaiser Permanente, and the US Medicare programme: analysis of routine data", *BMJ,* vol. 327, no. 7426, pp. 1257-1260.

Ham, C., Dixon, A. & Brooke, B. 2012, "Transforming the Delivery of Health and Social Care: The case for fundamental change", *The King's Fund,* .

Harrison, S.L., Janaudis-Ferreira, T., Brooks, D., Desveaux, L. & Goldstein, R.S. 2015, "Self-management following an acute exacerbation of COPD: a systematic review", *Chest,* vol. 147, no. 3, pp. 646-661.

Health Quality Ontario 2013, "Continuity of care to optimize chronic disease management in the community setting: an evidence-based analysis", *Ontario health technology assessment series,* vol. 13, no. 6, pp. 1-41.

Health Quality Ontario 2012, "Specialized community-based care: an evidence-based analysis", *Ontario health technology assessment series,* vol. 12, no. 20, pp. 1-60.

HHCP 2018, *Hillingdon Health and Care Partners (HHCP) Integrated Care System Update,* London, Hillingdon.

Hickman, L.D., Phillips, J.L., Newton, P.J., Halcomb, E.J., Al Abed, N. & Davidson, P.M. 2015, "Multidisciplinary team interventions to optimise health outcomes for older people in acute care settings: A systematic review", *Archives of Gerontology and Geriatrics,* vol. 61, no. 3, pp. 322-329.

Hillingdon Health and Wellbeing Board 2018, *Hillingdon Health and Wellbeing Strategy 2018-21,* Hillingdon London Borough Council, London.

Hippisley-Cox, J. & Coupland, C. 2013, "Predicting risk of emergency admission to hospital using primary care data: derivation and validation of QAdmissions score", *BMJ open,* vol. 3, no. 8, pp. e003482.

Hosseinzadeh, H. & Shnaigat, M. 2019, "Effectiveness of chronic obstructive pulmonary disease self-management interventions in primary care settings: a systematic review", *Australian Journal of Primary Health,* vol. 25, no. 3, pp. 195-204.

Howell, D., Harth, T., Brown, J., Bennett, C. & Boyko, S. 2017, "Self-management education interventions for patients with cancer: a systematic review", *Supportive Care In Cancer: Official Journal Of The Multinational Association Of Supportive Care In Cancer,* vol. 25, no. 4, pp. 1323-1355.

Imperial College 2021, , *Imperial College Health partners: Discover now project.* Available: https://imperialcollegehealthpartners.com/discover-now/ [2021, 28/06/].

Jain, S., Kamimoto, L., Bramley, A.M., Schmitz, A.M., Benoit, S.R., Louie, J., Sugerman, D.E., Druckenmiller, J.K., Ritger, K.A., Chugh, R., Jasuja, S., Deutscher, M., Chen, S., Walker, J.D., Duchin, J.S., Lett, S., Soliva, S., Wells, E.V., Swerdlow, D., Uyeki, T.M., Fiore, A.E., Olsen, S.J., Fry, A.M., Bridges, C.B. & Finelli, L. 2009, "Hospitalized patients with 2009 H1N1 influenza in the United States, April-June 2009", *The New England Journal of Medicine,* vol. 361, no. 20, pp. 1935-1944.

Jakobsen, J.C., Gluud, C., Wetterslev, J. & Winkel, P. 2017, "When and how should multiple imputation be used for handling missing data in randomised clinical trials - a practical guide with flowcharts", *BMC medical research methodology,* vol. 17, no. 1, pp. 162.

Jeong, S., Lee, M. & Ji, E. 2018, "Effect of pharmaceutical care interventions on glycemic control in patients with diabetes: a systematic review and meta-analysis", *Therapeutics And Clinical Risk Management,* vol. 14, pp. 1813-1829.

Joint Strategic Needs Assessment, (. 2014, *Older People In Hillingdon: Health and Long Term Illness.*

Jolly, K., Majothi, S., Sitch, A.J., Heneghan, N.R., Riley, R.D., Moore, D.J., Bates, E.J., Turner, A.M., Bayliss, S.E., Price, M.J., Singh, S.J., Adab, P., Fitzmaurice, D.A. & Jordan, R.E. 2016, "Self-management of health care behaviors for COPD: a systematic review and meta-analysis", *International Journal Of Chronic Obstructive Pulmonary Disease,* vol. 11, pp. 305-326.

Jonkman, N.H., Schuurmans, M.J., Groenwold, R.H.H., Hoes, A.W. & Trappenburg, J.C.A. 2016, "Identifying components of self-management interventions that improve health-related quality of life in chronically ill patients: Systematic review and meta-regression analysis", *Patient education and counseling,* vol. 99, no. 7, pp. 1087-1098.

Joo, J.Y. & Liu, M.F. 2017, "Case management effectiveness in reducing hospital use: a systematic review", *International nursing review,* vol. 64, no. 2, pp. 296-308.

Joo, J.Y. & Huber, D.L. 2019, "Case Management Effectiveness on Health Care Utilization Outcomes: A Systematic Review of Reviews", *Western journal of nursing research,* vol. 41, no. 1, pp. 111-133.

Juhnke, C. 2012, "Clinical and service integration. The route to improved outcomes", *International journal of integrated care,* vol. 12, no. 8.

Kastner, M., Cardoso, R., Lai, Y., Treister, V., Hamid, J.S., Hayden, L., Wong, G., Ivers, N.M., Liu, B., Marr, S., Holroyd-Leduc, J. & Straus, S.E. 2018, "Effectiveness of interventions for managing multiple high-burden chronic diseases in older adults: a systematic review and meta-analysis", *CMAJ: Canadian Medical Association Journal = Journal De L'association Medicale Canadienne,* vol. 190, no. 34, pp. E1004-E1012.

Kodner, D. 2009, "All Together Now: A Conceptual Exploration of Integrated Care", *Healthcare quarterly (Toronto, Ont.),* vol. 13, no. SP1, pp. 6-15.

Kodner, D.L. & Spreeuwenberg, C. 2002, "Integrated care: meaning, logic, applications, and implications – a discussion paper", .

Krasnik, A., Norredam, M., Sorensen, T.M., Michaelsen, J.J., Nielsen, A.S. & Keiding, N. 2002, "Effect of ethnic background on Danish hospital utilisation patterns", *Social science & medicine (1982),* vol. 55, no. 7, pp. 1207-1211.

Kruis, A.L., Smidt, N., Assendelft, W., Gussekloo, J., Boland, M., Rutten-van Mölken, M. & Chavannes, N.H. 2013, "Integrated disease management interventions for patients with chronic obstructive pulmonary disease", *Cochrane Database of Systematic Reviews,* , no. 10.

Kumpunen, S., Edwards, N., Georghiou, T. & Hughes, G. 2019a, "Evaluating integrated care: Why are evaluations not producing
the results we expect?", *Nuffieldtrust,* .

Kumpunen, S., Edwards, N., Georghiou, T. & Hughes, G. 2019b, *Evaluating integrated care: why are evaluations not producing the results we expect?,* Nuffield Trust.

Langhorne, P. & Baylan, S. 2017, "Early supported discharge services for people with acute stroke", *Cochrane Database of Systematic Reviews,* , no. 7.

Lenferink, A., Brusse-Keizer, M., van, d.V., Frith, P.A., Zwerink, M., Monninkhof, E.M., van, d.P. & Effing, T.W. 2017, "Self-management interventions including action plans for exacerbations versus usual care in patients with chronic obstructive pulmonary disease", *Cochrane Database of Systematic Reviews,* , no. 8.

Leppin, A.L., Gionfriddo, M.R., Kessler, M., Brito, J.P., Mair, F.S., Gallacher, K., Wang, Z., Erwin, P.J., Sylvester, T., Boehmer, K., Ting, H.H., Murad, M.H., Shippee, N.D. & Montori, V.M. 2014, "Preventing 30-day hospital readmissions: a systematic review and meta-analysis of randomized trials", *JAMA Internal Medicine,* vol. 174, no. 7, pp. 1095-1107.

Leutz, W.N. 1999, "Five Laws for Integrating Medical and Social Services: Lessons from the United States and the United Kingdom", *The Milbank quarterly,* vol. 77, no. 1, pp. 77-110.

Lewis, R.Q., Rosen, R., Goodwin, N. & Dixon, J. 2010, *Where next for integrated care organisations in the English NHS ?,* Nuffield Trust, Londres.

Lewis, R.Q., Rosen, R., Goodwin, N. & Dixon, J. 2010, *Where next for integrated care organisations in the English NHS?,* The King's Fund, London.

Linden, A. 2015, "Conducting Interrupted Time-series Analysis for Single- and Multiple-group Comparisons", *The Stata journal,* vol. 15, no. 2, pp. 480-500.

Long, H., Howells, K., Peters, S. & Blakemore, A. 2019, "Does health coaching improve health-related quality of life and reduce hospital admissions in people with chronic obstructive pulmonary disease? A systematic review and meta-analysis", *British Journal Of Health Psychology,* vol. 24, no. 3, pp. 515-546.

Lopez Bernal, J., Cummins, S. & Gasparrini, A. 2018, "The use of controls in interrupted time series studies of public health interventions", *International journal of epidemiology,* vol. 47, no. 6, pp. 2082-2093.

Majothi, S., Jolly, K., Heneghan, N.R., Price, M.J., Riley, R.D., Turner, A.M., Bayliss, S.E., Moore, D.J., Singh, S.J., Adab, P., Fitzmaurice, D.A. & Jordan, R.E. 2015, "Supported self-management for patients with COPD who have recently been discharged from hospital: a systematic review and meta-analysis", *International Journal Of Chronic Obstructive Pulmonary Disease,* vol. 10, pp. 853-867.

Man, C.Y., Yeung, R.S., Chung, J.Y. & Cameron, P.A. 2003, "Impact of SARS on an emergency department in Hong Kong", *Emergency medicine (Fremantle, W.A.),* vol. 15, no. 5-6, pp. 418-422.

Mansour, M.H.H., Pokhrel, S. & Anokye, N. 2022, "Effectiveness of integrated care interventions for patients with long-term conditions: a review of systematic reviews", *Integrated Healthcare Journal,* vol. 4, no. 1, pp. e000083.

Mansour, M.H.H., Pokhrel, S., Birnbaum, M. & Anokye, N. 2022, "Effectiveness of a population-based integrated care model in reducing hospital activity: an interrupted time series analysis", Integrated Healthcare Journal, vol. 4, no. 1, pp. e000104.

Martínez-González, N.A., Berchtold, P., Ullman, K., Busato, A. & Egger, M. 2014, "Integrated care programmes for adults with chronic conditions: a meta-review", *International Journal for Quality in Health Care,* vol. 26, no. 5, pp. 561-570.

Massimi, A., De Vito, C., Brufola, I., Corsaro, A., Marzuillo, C., Migliara, G., Rega, M.L., Ricciardi, W., Villari, P. & Damiani, G. 2017, "Are community-based nurse-led self-management support interventions effective in chronic patients? Results of a systematic review and meta-analysis", *Plos One,* vol. 12, no. 3, pp. e0173617.

McCarthy, A., McMeekin, P., Haining, S., Bainbridge, L., Laing, C. & Gray, J. 2019, "Rapid evaluation for health and social care innovations: challenges for "quick wins" using interrupted time series", *BMC health services research,* vol. 19, no. 1, pp. 964.

McKeown, A., Cliffe, C., Arora, A. & Griffin, A. 2019, "Ethical challenges of integration across primary and secondary care: a qualitative and normative analysis", *BMC Medical Ethics,* vol. 20, no. 1, pp. 42.

Merriam, S.B. 1998, *The Case Study as a Research Method,* New Directions for Adult and Continuing Education.

Mitchell, G.K., Burridge, L., Zhang, J., Donald, M., Scott, I.A., Dart, J. & Jackson, C.L. 2015, "Systematic review of integrated models of health care delivered at the primary-secondary interface: how effective is it and what determines effectiveness?", *Australian Journal of Primary Health,* vol. 21, no. 4, pp. 391-408.

Moore, G.F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., Moore, L., O'Cathain, A., Tinati, T., Wight, D. & Baird, J. 2015, "Process evaluation of complex interventions: Medical Research Council guidance", *BMJ : British Medical Journal,* vol. 350, no. mar19 6, pp. h1258.

Morciano, M., Checkland, K., Billings, J., Coleman, A., Stokes, J., Tallack, C. & Sutton, M. 2020, "New integrated care models in England associated with small reduction in hospital admissions in longer-term: A difference-in-differences analysis", *Health policy (Amsterdam)*, vol. 124, no. 8, pp. 826-833.

Morse, A. 2013, *Report by the Comptroller and Auditor General on Department of Health: Emergency admissions to hospital: managing the demand*.

Mulholland, R.H., Wood, R., Stagg, H.R., Fischbacher, C., Villacampa, J., Simpson, C.R., Vasileiou, E., McCowan, C., Stock, S.J., Docherty, A.B., Ritchie, L.D., Agrawal, U., Robertson, C., Murray, J.L., MacKenzie, F. & Sheikh, A. 2020, "Impact of COVID-19 on accident and emergency attendances and emergency and planned hospital admissions in Scotland: an interrupted time-series analysis", *Journal of the Royal Society of Medicine*, vol. 113, no. 11, pp. 444-453.

Murphy, M.E., Byrne, M., Galvin, R., Boland, F., Fahey, T. & Smith, S.M. 2017, "Improving risk factor management for patients with poorly controlled type 2 diabetes: a systematic review of healthcare interventions in primary care and community settings", *BMJ Open*, vol. 7, no. 8, pp. e015135.

National Audit Office 2017, *Health and social care integration*.

Newham, J.J., Presseau, J., Heslop-Marshall, K., Russell, S., Ogunbayo, O.J., Netts, P., Hanratty, B. & Kaner, E. 2017, "Features of self-management interventions for people with COPD associated with improved health-related quality of life and reduced emergency department visits: a systematic review and meta-analysis", *International Journal Of Chronic Obstructive Pulmonary Disease*, vol. 12, pp. 1705-1720.

NHS 2021, , *Integrated care in action – urgent care*. Available: https://www.england.nhs.uk/integratedcare/resources/case-studies/integrated-care-in-action-urgent-care/ [2021, 28/04/].

NHS 2020, , *NHS Long Term Plan*. Available: https://www.longtermplan.nhs.uk/online-version/overview-and-summary/ [2021, 22/02/].

NHS 2015, *Using case finding and risk stratification: A key service component for personalised care and support planning*.

NHS 2014, *NHS Five Years Forward view*, NHS England.

NHS England 2021a, , *A&E Attendances and Emergency Admissions*. Available: https://www.england.nhs.uk/statistics/statistical-work-areas/ae-waiting-times-and-activity/ae-attendances-and-emergency-admissions-2019-20/ [2021, May16,].

NHS England 2021b, Sep ,-last update, *COVID-19 Hospital Activity*. Available: https://www.england.nhs.uk/statistics/statistical-work-areas/covid-19-hospital-activity/ [2021, 06/09/].

NHS England 2017, "Risk stratification: Learning and Impact Study", *Operational Research and Evaluation Unit, NHS England*, .

NICE 2018, "Chapter 38 Integrated care: NICE publish emergency and acute medical care in over 16s: service delivery & organisation guidance", .

Nittari, G., Savva, D., Tomassoni, D., Tayebati, S.K. & Amenta, F. 2022, "Telemedicine in the COVID-19 Era: A Narrative Review Based on Current Evidence", *International journal of environmental research and public health*, vol. 19, no. 9, pp. 5101.

Oeseburg, B., Wynia, K., Middel, B. & Reijneveld, S.A. 2009, "Effects of case management for frail older people or those with chronic illness: a systematic review", *Nursing research,* vol. 58, no. 3, pp. 201-210.

Office for National Statistics 2017, *Overview of the UK population.*

ONS 2020, Mar 24,-last update, *Subnational population projections for England: Office for National Statistics (ONS).* Available: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/subnationalpopulationprojectionsforengland/2018based [2021, 27/01/].

Ouwens, M., Wollersheim, H., Hermens, R., Hulscher, M. & Grol, R. 2005, "Integrated care programmes for chronically ill patients: A review of systemic reviews", *International Journal for Quality in Health Care,* vol. 17, no. 2, pp. 141-146.

Ouwens, M., Wollersheim, H., Hermens, R., Hulscher, M. & Grol, R. 2005, "Integrated care programmes for chronically ill patients: a review of systematic reviews", *International journal for quality in health care,* vol. 17, no. 2, pp. 141-146.

Panagioti, M., Richardson, G., Murray, E., Rogers, A., Kennedy, A., Newman, S., Small, N. & Bower, P. 2014, "Reducing Care Utilisation through Self-management Interventions (RECURSIVE): a systematic review and meta-analysis", .

Parkinson, B., Meacock, R., Checkland, K. & Sutton, M. 2020, "How sensitive are avoidable emergency department attendances to primary care quality? Retrospective observational study", *BMJ quality & safety,* vol. 30, no. 11, pp. 884-892.

Phelan, J.C., Link, B.G. & Tehranifar, P. 2010, "Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications", *Journal of health and social behavior,* vol. 51, no. 1_suppl, pp. S28-S40.

Peng, S., He, J., Huang, J., Lun, L., Zeng, J., Zeng, S., Zhang, L., Liu, X. & Wu, Y. 2019, "Self-management interventions for chronic kidney disease: a systematic review and meta-analysis", *BMC Nephrology,* vol. 20, no. 1, pp. 142.

Pesaran, M.H. 2015, *Time Series and Panel Data Econometrics,* First edition edn, Oxford University Press, Oxford.

Peytremann-Bridevaux, I., Arditi, C., Gex, G., Bridevaux, P.O. & Burnand, B. 2015, "Chronic disease management programmes for adults with asthma", *Cochrane Database of Systematic Reviews,* , no. 5.

Pieper, D., Antoine, S., Mathes, T., Neugebauer, E.A.M. & Eikermann, M. 2014, "Systematic review finds overlapping reviews were not mentioned in every other overview", *Journal of Clinical Epidemiology,* vol. 67, no. 4, pp. 368-375.

Prvu Bettger, J., Alexander, K.P., Dolor, R.J., Olson, D.M., Kendrick, A.S., Wing, L., Coeytaux, R.R., Graffagnino, C. & Duncan, P.W. 2012, "Transitional care after hospitalization for acute stroke or myocardial infarction: a systematic review", *Annals of Internal Medicine,* vol. 157, no. 6, pp. 407-416.

Rebekah Young & David R. Johnson 2015, "Handling Missing Values in Longitudinal Panel Data With Multiple Imputation", *Journal of marriage and family,* vol. 77, no. 1, pp. 277-294.

Robbins, J.M.M. & Webb, D.A. 2006, "Hospital Admission Rates for a Racially Diverse Low-Income Cohort of Patients With Diabetes: The Urban Diabetes Study", *American journal of public health (1971),* vol. 96, no. 7, pp. 1260-1264.

Roper, K.L., Ballard, J., Rankin, W. & Cardarelli, R. 2017, "Systematic Review of Ambulatory Transitional Care Management (TCM) Visits on Hospital 30-Day Readmission

Rates", *American Journal Of Medical Quality: The Official Journal Of The American College Of Medical Quality,* vol. 32, no. 1, pp. 19-26.

Rubinson, L., Mutter, R., Viboud, C., Hupert, N., Uyeki, T., Creanga, A., Finelli, L., Iwashyna, T.J., Carr, B., Merchant, R., Katikineni, D., Vaughn, F., Clancy, C. & Lurie, N. 2013, "Impact of the Fall 2009 Influenza A(H1N1)pdm09 Pandemic on US Hospitals", Medical care, vol. 51, no. 3, pp. 259-265.

Saheb Kashaf, M., McGill, E.T. & Berger, Z.D. 2017, "Shared decision-making and outcomes in type 2 diabetes: A systematic review and meta-analysis", *Patient education and counseling,* vol. 100, no. 12, pp. 2159-2171.

Sakakibara, B.M., Kim, A.J. & Eng, J.J. 2017, "A Systematic Review and Meta-Analysis on Self-Management for Improving Risk Factor Control in Stroke Patients", *International Journal of Behavioral Medicine,* vol. 24, no. 1, pp. 42-53.

Sara Shaw, Rebecca Rosen & Benedict Rumbold 2011, *What is integrated care? An overview of integrated care in the NHS*, Nuffieldtrust.

Shaw, S., Rosen, R. & Rumbold, B. 2011, *What is Integrated Care ? An overview of integrated care in the NHS.*

Shepperd, S., Iliffe, S., Doll, H.A., Clarke, M.J., Kalra, L., Wilson, A.D. & Gonçalves-Bradley, D.C. 2016, "Admission avoidance hospital at home", *Cochrane Database of Systematic Reviews,* , no. 9.

Shi, Y., Xiong, J., Chen, Y., Deng, J., Peng, H., Zhao, J. & He, J. 2018, "The effectiveness of multidisciplinary care models for patients with chronic kidney disease: a systematic review and meta-analysis", *International urology and nephrology,* vol. 50, no. 2, pp. 301-312.

Siaw, M.Y.L. & Lee, J.Y. 2019, "Multidisciplinary collaborative care in the management of patients with uncontrolled diabetes: A systematic review and meta-analysis", *International journal of clinical practice,* vol. 73, no. 2, pp. e13288.

Smith, S.M., Wallace, E., O'Dowd, T. & Fortin, M. 2016, "Interventions for improving outcomes in patients with multimorbidity in primary care and community settings", *Cochrane Database of Systematic Reviews,* , no. 3.

Stamenova, V., Chu, C., Pang, A., Fang, J., Shakeri, A., Cram, P., Bhattacharyya, O., Bhatia, R.S. & Tadrous, M. 2022, "Virtual care use during the COVID-19 pandemic and its impact on healthcare utilization in patients with chronic disease: A population-based repeated cross-sectional study", *PloS one,* vol. 17, no. 4, pp. e0267218.

Stein, K.V., Goodwin, N. & Miller, R. 2020, "From Crisis to Coordination: Challenges and Opportunities for Integrated Care posed by the COVID-19 Pandemic", *International Journal of Integrated Care,* vol. 20, no. 3, pp. 7.

Steinsbekk, A., Rygg, L.Ø, Lisulo, M., Rise, M.B. & Fretheim, A. 2012, "Group based diabetes self-management education compared to routine treatment for people with type 2 diabetes mellitus. A systematic review with meta-analysis", *BMC Health Services Research,* vol. 12, pp. 213.

Stokes, J., Checkland, K. & Kristensen, S. 2016, "Integrated care: theory to practice", .

Stokes, J., Panagioti, M., Alam, R., Checkland, K., Cheraghi-Sohi, S. & Bower, P. 2015, "Effectiveness of Case Management for 'At Risk' Patients in Primary Care: A Systematic Review and Meta-Analysis", *Plos One,* vol. 10, no. 7, pp. e0132340.

Takeda, A., Martin, N., Taylor, R.S. & Taylor, S. 2019, "Disease management interventions for heart failure", *Cochrane Database of Systematic Reviews,* , no. 1.

Tan, J.P., Cheng, K.K.F. & Siah, R.C. 2019, "A systematic review and meta-analysis on the effectiveness of education on medication adherence for patients with hypertension, hyperlipidaemia and diabetes", *Journal of advanced nursing,* .

Taylor, S.J.C., Pinnock, H., Epiphaniou, E., Pearce, G., Parke, H.L., Schwappach, A., Purushotham, N., Jacob, S., Griffiths, C.J., Greenhalgh, T. & Sheikh, A. 2014, "A rapid synthesis of the evidence on interventions supporting self-management for people with long-term conditions: PRISMS – Practical systematic Review of Self-Management Support for long-term conditions", .

The King's Fund 2018, , *Long-term conditions: The challenge for the NHS*. Available: https://www.kingsfund.org.uk/publications/long-term-conditions-challenge-nhs.

Thielke, S., Vannoy, S. & Unützer, J. 2007, "Integrating Mental Health and Primary Care", *Primary care,* vol. 34, no. 3, pp. 571-592.

Thornton, J. 2020, "Covid-19: A&E visits in England fall by 25% in week after lockdown", *BMJ,* vol. 369, pp. m1401.

Tsubokura, M., MD, Nakada, H., JD, Matsumura, T., MD, Kodama, Y., RN & Kami, M., MD 2010, "The impact of H1N1 influenza A virus pandemic on the emergency medical service in Kobe", The American Journal of Emergency Medicine, vol. 28, no. 2, pp. 248-251.

Valentijn, P.P., Pereira, F.A., Ruospo, M., Palmer, S.C., Hegbrant, J., Sterner, C.W., Vrijhoef, H.J.M., Ruwaard, D. & Strippoli, G.F.M. 2018, "Person-Centered Integrated Care for Chronic Kidney Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials", *Clinical Journal Of The American Society Of Nephrology: CJASN,* vol. 13, no. 3, pp. 375-386.

Valentijn, P.P. 2016, "Rainbow of Chaos: A study into the Theory and Practice of Integrated Primary Care", *International Journal of Integrated Care,* vol. 16, no. 2.

van Buuren, S. & Groothuis-Oudshoorn, K. 2011, "mice: Multivariate Imputation by Chained Equations in R", *Journal of Statistical Software,* vol. 45, no. 3.

van Eikenhorst, L., Taxis, K., van Dijk, L. & de Gier, H. 2017, "Pharmacist-Led Self-management Interventions to Improve Diabetes Outcomes. A Systematic Literature Review and Meta-Analysis", *Frontiers In Pharmacology,* vol. 8, pp. 891.

Vuik, S.I., Mayer, E. & Darzi, A. 2016, "Enhancing risk stratification for use in integrated care: a cluster analysis of high-risk patients in a retrospective cohort study", *BMJ open,* vol. 6, no. 12, pp. e012903.

Wagner, A.K., Soumerai, S.B., Zhang, F. & Ross-Degnan, D. 2002, "Segmented regression analysis of interrupted time series studies in medication use research", *Journal of clinical pharmacy and therapeutics,* vol. 27, no. 4, pp. 299-309.

Wagner, A.K., Soumerai, S.B., Zhang, F. & Ross-Degnan, D. 2002, "Segmented regression analysis of interrupted time series studies in medication use research", *Journal of clinical pharmacy and therapeutics,* vol. 27, no. 4, pp. 299-309.

Wang, T., Tan, J., Xiao, L.D. & Deng, R. 2017, "Effectiveness of disease-specific self-management education on health outcomes in patients with chronic obstructive pulmonary disease: An updated systematic review and meta-analysis", *Patient education and counseling,* vol. 100, no. 8, pp. 1432-1446.

WHO 2019, , *Integrated chronic disease prevention and control* [Homepage of World Health Organization], [Online]. Available: https://www.who.int/chp/about/integrated_cd/en/ [2019, Sep 15,].

WHO 2002, *The World Health Report: Reducing Risks, Promoting Healthy Life*, World Health Organisation, Switzerland.

WHO Regional Office for Europe 2016, "Integrated care models: an overview", *Health Services Delivery Programme, Division of Health Systems and Public Health, .*

Wistow, G., Gaskins, M., Holder, H. & Smith, J. 2015, *Putting integrated care into practice: the North West London experience: Evaluation of the Whole Systems Integrated Care programme*, Nuffield Trust, London.

World Health Organization 2018, , *Long-term conditions*. Available: https://www.who.int/news-room/fact-sheets/detail/long-term-conditions.

Yang, F., Xiong, Z., Yang, C., Li, L., Qiao, G., Wang, Y., Zheng, T., He, H. & Hu, H. 2017, "Continuity of Care to Prevent Readmissions for Patients with Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis", *COPD,* vol. 14, no. 2, pp. 251-261.

Zhao, F., Suhonen, R., Koskinen, S. & Leino - Kilpi, H. 2017, "Theory-based self-management educational interventions on patients with type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials", *Journal of Advanced Nursing (John Wiley & Sons, Inc.),* vol. 73, no. 4, pp. 812-833.

Zimbudzi, E., Lo, C., Misso, M.L., Ranasinha, S., Kerr, P.G., Teede, H.J. & Zoungas, S. 2018, "Effectiveness of self-management support interventions for people with comorbid diabetes and chronic kidney disease: a systematic review and meta-analysis", *Systematic Reviews,* vol. 7, no. 1, pp. 84.

Zwerink, M., Brusse-Keizer, M., van, d.V., Zielhuis, G.A., Monninkhof, E.M., van, d.P., Frith, P.A. & Effing, T. 2014, "Self management for patients with chronic obstructive pulmonary disease", *Cochrane Database of Systematic Reviews,* , no. 3.

14 APPENDICES:

14.1 APPENDIX A: GENERAL CONCEPTS

14.1.1 Defining integrated care

Integrated care (IC) is a term that is now widely known across the world, but there is still a persistent and lasting 'linguistic barrier' when it comes to defining it (Kodner, 2009). It is well known that the term "integrated care" has been defined in various ways (Armitage et al., 2009). This is related to the fact that different stakeholders within care systems with various backgrounds have guided this diversity in defining it. For instance, this may be influenced by different professional perspectives (e.g., clinical versus managerial) or from the observer's disciplinary viewpoint (e.g., public health versus social science) (Contandriapoulos et al., 2003). Consequently, there are four main definitions of IC that are used from these diverse perspectives, including health system-based, managers'-based, social science-based, and a person-centred coordinated care-based definition. Given this thesis's context and aims, and objectives (See chapter 2), the health system-based definition could be presented as the most applicable definition. With this in mind, the health system-based definition describes IC as health services that are managed and delivered to reduce care fragmentation by providing a continuum of disease prevention, diagnosis and treatment, diseases management and health promotion, rehabilitation and recovery, and palliative care services, coordinated across different settings and sites (Contandriapoulos et al., 2003).

The health system-based definition could demonstrate two main characteristics of IC as a principle. First, the term 'to integrated' would imply combining from a whole. If this implication is applied in the context of healthcare delivery, this must involve putting together crucial elements of fragmented care systems. Second, the term 'care' would refer to providing people who require medical attention with the necessary assistance or treatment.

It is crucial to understand the difference between integration and integrated care when contemplating the understanding of IC. IC is a care delivery organising principle aimed at improving patient care by greater integration of services provided. On the other hand, integration refers to a set of procedures, processes, and models aimed at improving care management. As a result, where attempts to increase integration positively impact patient groups, the outcome is referred to as IC (Kodner, Spreeuwenberg, 2002).

14.1.2 Taxonomies of integration

Complexity is a hallmark of IC. However, a variety of conceptual structures and taxonomies have been created to aid in understanding it. Taxonomies of IC can be differentiated using the definitions highlighted earlier.

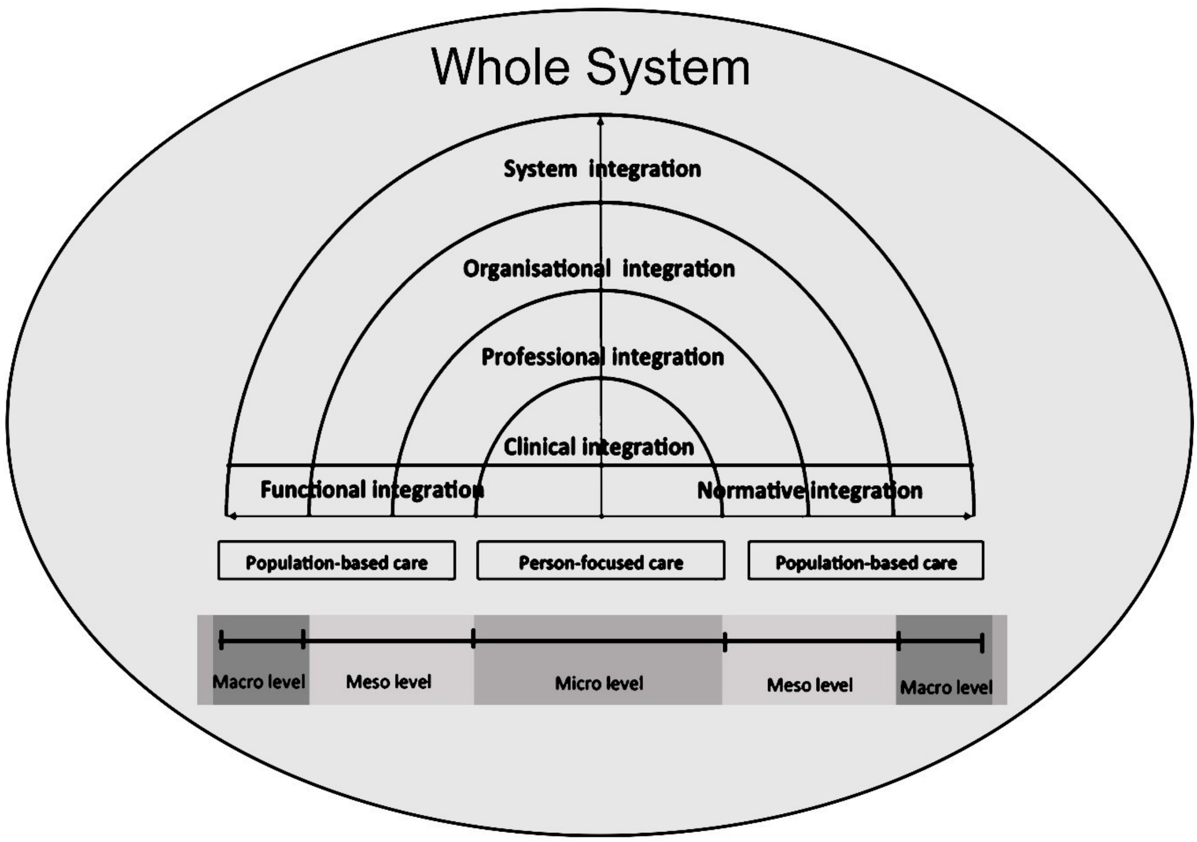
14.1.2.1 Typologies and levels of integration

There are four known types of integration (Fig 1): systems, organisational, service (Also referred as professional), and clinical (Lewis et al., 2010, Valentijn, 2016, McKeown et al., 2019). Organisational integration is the process of putting together several organisations through provider networks and mergers that are orchestrated. Integration of various health programmes and/or healthcare professionals (HCPs) at an organisational level is referred to as service or professional integration. Clinical integration combines treatment into a single, cohesive process within/or through professions using common standards and protocols. The highest level of integration is systems integration with all types of integration are put together to form an integrated care system. On the other hand, any form of integration can be guided by two types of integration including functional and normative. Functional integration means, for instance, sharing electronic patient records to integrate non-clinical and back-office functions, while normative integration implies that actors share a common frame of reference as well as values and aims for providing services (Valentijn, 2016).

Integration can also take multiple forms by which different procedures and processes can describe each form across different settings (Leutz, 1999, Valentijn, 2016). With this in mind, those include mainly, Patient-centred integration, and Whole-system integration. Patient-centred integration focuses on empowering the patients through health education, supported self-management and decision making. On the other hand, Whole-system integration combines both the population-based and person-centred approach of IC. This form of IC focuses on the population as a whole and not just a specific group of patients with specific diseases or condition, and it is considered the most ambitious. This form of integration also combines multiple systems and approaches and can be referred to as all forms, types, and levels of integration in one whole system.

There are three known levels of integration that can occur as macro, meso, and micro (Juhnke, 2012, Valentijn, 2016). Integration at the micro-level aims to provide an individual with a seamless treatment experience, which can be achieved by personalised care planning. Meso-level integration seeks to provide IC for a specific care community or groups with similar diseases or conditions. In contrast, at the macro level, integration can provide comprehensive treatment to an entire population by stratifying needs and tailoring services to meet those needs. The breadth of integration overlaps with levels of integration in terms of definitions. However, the breadth of integration is more general, referring to providing IC either to a group with a specific disease/condition or the entire population.

Fig 1: Typologies and levels of integration (Source: Authors summary based on (Leutz, 1999, Lewis et al., 2010, Juhnke, 2012, Valentijn, 2016, McKeown et al., 2019))



14.1.3 Models and interventions of IC

Like IC as a concept, referring to IC as a model or intervention seemed to have similar diversities. The literature does not seem to differentiate between the two terminologies in terms of definitions. Although, in some studies, IC was referred to as an intervention (Damery, Flanagan and Combes, 2016), while a scoping review from the world health organisation (WHO) described IC as models (WHO, 2016). Besides, a systematic review from National Institute for Health and Care Excellence (NICE) used both terminologies (NICE, 2018). The diversities in these reviews might indicate that referring to IC as a model or an intervention might depend on how IC operates, mainly depending on the breadth of integration. For example, five primary interventions of IC were defined and studied in the review of Damery et al (Table 1). On the other hand, the scoping review from the WHO described three main types of models, including population-based, individual-based, and disease or condition-specific based.

Some interventions were identified as models by themselves in table one, while others were reported as interventions as a part of a broad, integrated care model (ICM). For example, Case management (CM) was identified as an individual model in the same review, while it was referred to as an intervention in Damery et al's review. On the other hand, Self-management, and Multidisciplinary teams (MDT) were not identified as models by themselves in the WHO review but as an intervention in a broad model such as the Chronic care model (CCM). This might indicate that if the breadth of integration was more expansive than the individual level (Disease-specific or population-based), most IC interventions, though not exclusively, become a part of a whole model. It is not clear why interventions such as SM or MDT were not considered as models by themselves. However, "Integration" might be used in various contexts, such as characterising interventions that improved care or quality assurance but did not require personnel to operate in novel ways (Baxter et al; 2018). As a result, this might describe why SM can be referred to as ICM or IC interventions.

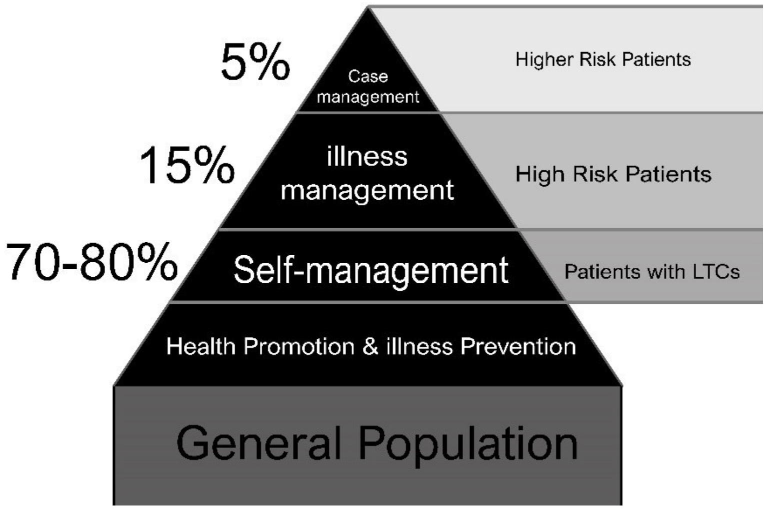
Table 1: Intervention groupings with description (Adapted from the work of (Damery, Flanagan and Combes, 2016)

Category	Description of intervention
Self-management (SM)	"Interventions designed to provide patient support, typically via tailored education to inform the patient about their condition(s), recognising signs and symptoms of disease exacerbation, dietary and lifestyle advice and/or condition-specific education supporting medication adherence"
Case management (CM)	"Based on the implementation of a collaborative process between one or more care coordinators or case managers and the patient, to assess, plan and facilitate service delivery for patients with chronic diseases, particularly when transitions across healthcare settings are required"
Discharge management (DM)	"Interventions designed to facilitate effective transitions from hospital care to other settings. Typically includes a pre-discharge phase of support, transitional care for the move between the hospital and community/home setting and post-discharge follow-up and monitoring, often incorporating rehabilitation or reablement support"
Multidisciplinary teams (MDT)	"Interventions comprising teams composed of multiple health and/or social care professionals working together to provide care for people with complex needs. Teams typically included condition-specific expertise, nurses, occupational therapists, physiotherapists, social workers, GPs and occasionally pharmacists or case managers"
Chronic care model (CCM)	"Model that identifies six modifiable elements of healthcare systems: (1) organisational support, addressing organisational culture and leadership, (2) clinical information systems to organise patient, population and provider data, (3) delivery system design to address composition and function of the care team and follow-up management, (4) decision support to increase provider access to evidence-based

	guidelines and specialists for collaboration, (5) self-management support to provide tailored education, skills training, psychosocial support and goal-setting and (6) community resources to provide peer support, care coordination and community-based interventions”

The scoping review by the WHO gave multiple examples of different models other than the ones specified above as interventions (WHO, 2016). On the individual level, individual care planning was identified as a model. With this in mind, this review dealt with CM and individual care planning as separate approaches, while care planning could be combined with CM. The Patient-centred medical home was another individual-based model described. The model combines both SM and MDT approaches to deliver care for patients. In terms of disease or condition-specific based models, CCM was presented as a core model. The review also defined an IC model for elderly and frail patients consisting of CM and MDT as baseline models. Health and social care coordinators are employed in this model, and they serve as a central point of contact for each team. Disease-specific models were defined broadly with the aim of linking primary, secondary, and community settings through multiple interventions, including MDT (With General practitioners (GPs) serving as care coordinators) and SM. Finally, population-based models were presented with multiple interventions, including CM, MDT, SM, and DM. These models usually work by case managing patients with severe complications and illness management for high-risk patients with collaboration between multiple health care professionals (HCPs) as a part of MDTs. Besides, the model focuses on promoting self-management within the patients with chronic conditions and promoting health and prevention for the general population. The most common model with such characteristics is known as 'Kaiser Permanente’ (Fig 2).

Fig 2: The Extended Kaiser Pyramid (Source: author summary based on WHO, 2016)



14.2 APPENDIX B: SUPPLEMENTARY MATERIAL

14.2.1 Material for chapter 2:

14.2.1.1 Scoping Review

14.2.1.1.1 Search Terms (In Scopus):

(TITLE-ABS-KEY ("integrated care") AND TITLE-ABS-KEY (chronic*) AND TITLE-ABS-KEY (outcomes OR "quality of life" OR health* OR effectiveness) AND TITLE-ABS-KEY ("systematic review" OR "meta-analysis ")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (LANGUAGE , "English")).

14.2.1.1.1.1 Results of Scoping Review

Table 2: Results of my Scoping Review

Study	Study Title	Databases	Key Search Terms
(Flanagan, Damery and Combes, 2017)	The effectiveness of integrated care interventions in improving patient quality of life (QoL) for patients with chronic conditions. An overview of the systematic review evidence	MEDLINE, Embase, ASSIA (Applied Social Sciences Index and Abstracts), PsycINFO, Health Management Information Consortium database (HMIC), CINAHL, Cochrane library (including the Health Technology Assessment (HTA) database, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effectiveness—DARE), EPPI-Centre library, TRIP database and the Health Economic Evaluations Database (HEED)	chronic OR "long term" OR Multimorb* OR morbidit* MeSH terms for the 11 specific chronic diseases identified from scoping searches: Hypertension Diabetes Mellitus Cardiovascular Diseases Coronary Disease Stroke Ischemic Attack, Transient Pulmonary Disease, Chronic Obstructive Neoplasms Cancer Depression Dementia Arthritis Model OR integrat* OR "Case management", "patient centred"
(Damery, Flanagan and Combes, 2016)	Does integrated care reduce hospital activity for patients with chronic diseases? An umbrella review of systematic reviews	Same as above (Flanagan, Damery and Combes, 2017)	Same as above (Flanagan, Damery and Combes, 2017)
(Martínez-González et al., 2014)	Integrated care programmes for adults with chronic conditions: A meta-review	MEDLINE, CINAHL Embase, The Cochrane Database of Systematic Reviews	Chronic*, integra*, health planning*, care, healthcare or health care, "mental disorders", HIV, depression, disorder*
(Ouwens et al., 2005)	Integrated care programmes for	Medline and Cochran	'disease management', 'patient care management', 'patient-centred

chronically ill patients: a review of systematic reviews	care', 'health planning', 'delivery of health care integrated'

14.2.1.2 Search Strategy

The most common search term used by the reviews of reviews in Table 2 were selected. We selected the terms based on the PICO framework below:

Population: Patients with Chronic diseases or long-term conditions

Keywords: Chronic, long term, Multimorbidity, complex needs

Search terms: Chronic OR "long term" OR Multimorb* OR complex

Intervention: Integrated business case (Combined integrated care interventions)

Keywords: integrated care Program/intervention, complex intervention/program, multidisciplinary intervention/program.

Comparator: single integrated care interventions (Based on single models), or usual care

Keywords: Case management, Multidisciplinary teams, Self-management, discharge-management.

Search Terms for comparator and intervention: integrat* OR multidisciplinary OR management OR discharge OR comprehensive OR continuity OR collaborative OR continuum OR shared OR transitional OR "community based"

AND Program OR Intervention* OR Care OR healthcare OR "health care" OR planning

Outcome: Reduction in hospital admissions, increase in quality of care and health outcomes, increase in quality of life,

Keywords: hospitalisation, hospital care, hospital admissions, quality of life, quality of care, health outcomes.

Search Terms: hospital* OR “quality of life” OR Qol OR outcomes OR effect* OR admissions OR re?admissions OR Rehabilitation OR reduc* OR prevention

Comprehensive Search Terms:

CINAHL Plus and MEDLINE via EBSCO:

1- Chronic OR “long term” OR Multimorb* OR complex (ALL FIELDS)

2- **AND** integrat* **OR** multidisciplinary **OR** management **OR** discharge **OR** comprehensive **OR** continuity **OR** collaborative **OR** continuum **OR** shared **OR** transitional **OR** “community based” **OR** Primary **OR** “Primary care homes” OR “patient activation” OR “Patient centred” OR personalised OR personalized (ALL FIELDS)

3- **AND** Program **OR** Intervention* **OR** Care **OR** healthcare **OR** “health care” **OR** planning (ALL FIELDS)

4- **AND** hospital* **OR** “quality of life” **OR** Qol **OR** outcomes **OR** effect* **OR** admissions **OR** re?admissions **OR** Rehabilitation **OR** reduc* **OR** prevention (ALL FIELDS)

5- **AND** "systematic review" **OR** "meta-analysis" AND Review (TITLE)

6- **NOT** protocol **OR** "cost effec*" (TITLE)

Cochrane Database of Systematic Reviews:

1- Chronic OR “long term” OR Multimorb* OR complex (Title Abstract Keyword)

2- **AND** integrat* **OR** multidisciplinary **OR** management **OR** discharge **OR** comprehensive **OR** continuity **OR** collaborative **OR** continuum **OR** shared **OR** transitional **OR** “community based” **OR** Primary **OR** “Primary care homes” OR “patient activation” OR “Patient centred” OR personalised OR personalized (Title Abstract Keyword)

3- **AND** Program **OR** Intervention* **OR** Care **OR** healthcare **OR** “health care” **OR** planning (Title Abstract Keyword)

4- **AND** hospital* **OR** “quality of life” **OR** Qol **OR** outcomes **OR** effect* **OR** admissions **OR** re?admissions **OR** Rehabilitation **OR** reduc* **OR** prevention (Title Abstract Keyword)

Boolean/Phrase (EBSCO):

TX (Chronic OR “long term” OR Multimorb* OR complex) AND TX (integrat* OR multidisciplinary OR management OR discharge OR comprehensive OR continuity OR collaborative OR continuum OR shared OR transitional OR “community based” OR Primary OR “Primary care homes” OR “patient activation” OR “Patient centred” OR personalised OR personalized) AND TX (Program OR Intervention* OR Care OR healthcare OR “health care” OR planning) AND TX (hospital* OR “quality of life” OR Qol OR outcomes OR effect* OR admissions OR re?admissions OR Rehabilitation OR reduc* OR prevention) AND TI ("systematic review" OR "meta-analysis" AND Review) NOT TI (protocol OR "cost effec*")

Boolean/Phrase (Cochrane):

Chronic OR “long term” OR Multimorb* OR complex in Title Abstract Keyword AND integrat* OR multidisciplinary OR management OR discharge OR comprehensive OR continuity OR collaborative OR continuum OR shared OR transitional OR “community based” OR Primary OR “Primary care homes” OR “patient activation” OR “Patient centred” OR personalised OR personalized in Title Abstract Keyword AND Program OR Intervention* OR Care OR healthcare OR “health care” OR planning in Title Abstract Keyword AND hospital* OR “quality of life” OR Qol OR outcomes OR effect* OR admissions OR re?admissions OR Rehabilitation OR reduc* OR prevention

Databases: We selected the most common databases used by the reviews included in table 2. As a result, we decided to include: MEDLINE, CINAHL, and the Cochrane Database of Systematic Reviews.

14.2.1.3 Quality Assessment Tool

Table 3: Centre for Evidence-Based Medicine (CEBM) tool for critical appraisal of systematic reviews

15.2.1.3.1.1.1.1 What question (PICO) did the systematic review address?	
What is best?	Where do I find the information?
The main question being addressed should be clearly stated. The exposure, such as a therapy or diagnostic test, and the outcome(s) of interest will often be expressed in terms of a simple relationship.	The ***Title, Abstract*** *or final paragraph of the* ***Introduction*** should clearly state the question. If you still cannot ascertain what the focused question is after reading these sections, search for another paper!
This paper: Yes □ No □ Unclear □ Comment:	
F - Is it unlikely that important, relevant studies were missed?	
What is best?	Where do I find the information?
The starting point for comprehensive search for all relevant studies is the major bibliographic databases (e.g., Medline, Cochrane, EMBASE, etc) but should also include a search of reference lists from relevant studies, and contact with experts, particularly to inquire about unpublished studies. The search should not be limited to English language only. The search strategy should include both MESH terms and text words.	The ***Methods*** section should describe the search strategy, including the terms used, in some detail. The ***Results*** section will outline the number of titles and abstracts reviewed, the number of full-text studies retrieved, and the number of studies excluded together with the reasons for exclusion. This information may be presented in a figure or flow chart.
This paper: Yes □ No □ Unclear □ Comment:	
15.2.1.3.1.1.1.2 A - Were the criteria used to select articles for inclusion appropriate?	
What is best?	Where do I find the information?
The inclusion or exclusion of studies in a systematic review should be clearly defined a priori. The eligibility criteria used should specify the patients, interventions or exposures and outcomes of interest. In many cases the type of study design will also be a key component of the eligibility criteria.	The ***Methods*** section should describe in detail the inclusion and exclusion criteria. Normally, this will include the study design.
This paper: Yes □ No □ Unclear □ Comment:	

15.2.1.3.1.1.1.2.1 *A - Were the included studies sufficiently valid for the type of question asked?*	
What is best?	Where do I find the information?
The article should describe how the quality of each study was assessed using predetermined quality criteria appropriate to the type of clinical question (e.g., randomization, blinding and completeness of follow-up)	The ***Methods*** section should describe the assessment of quality and the criteria used. The ***Results*** section should provide information on the quality of the individual studies.
This paper: Yes □ No □ Unclear □ Comment:	

15.2.1.3.1.1.1.2.2 *T - Were the results similar from study to study?*	
What is best?	Where do I find the information?
Ideally, the results of the different studies should be similar or homogeneous. If heterogeneity exists the authors may estimate whether the differences are significant (chi-square test). Possible reasons for the heterogeneity should be explored.	The ***Results*** section should state whether the results are heterogeneous and discuss possible reasons. The forest plot should show the results of the chi-square test for heterogeneity and if discuss reasons for heterogeneity, if present.
This paper: Yes □ No □ Unclear □ Comment:	

14.2.2 Material for chapters 4 , 5, and 6:

Table 3: Main Analysis with no imputations

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Pop Hillingdon	**1.15*** **1.06-1.23**	**0.91*** **0.90-0.92**	**1.06*** **1.02-1.10**	**0.94*** **0.93-0.95**	**1.11*** **1.02-1.22**	**0.93*** **0.92-0.94**
With LTC	**1.11*** **1.01-1.22**	**0.92*** **0.91-0.93**	**0.98** **0.93-1.04**	**0.96*** **0.95-0.97**	**1.11*** **1.00-1.23**	**0.94*** **0.93-0.95**
Without LTC	**1.19*** **1.06-1.34**	**0.89*** **0.88-0.91**	**1.12*** **1.07-1.18**	**0.93*** **0.92-0.94**	1.13 0.97-1.32	**0.91*** **0.89-0.93**

Table 4: Analysis with no imputations (LTC groups)

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
CVD	1.12 0.74-1.69	**0.88*** **0.83-0.94**	1.31 0.94-1.84	**0.88*** **0.84-0.93**	1.05 0.69-1.61	**0.87*** **0.82-0.92**
Diabetes	1.25 0.65-2.38	0.94 0.87-1.01	0.89 0.62-1.27	1.00 0.95-1.04	0.91 0.42-1.99	1.02 0.93-1.11
COPD	1.09 0.39-3.03	0.90 0.78-1.04	1.20 0.54-2.69	0.97 0.87-1.07	0.63 0.1-2.00	0.98 0.84-1.14
Asthma	**2.13*** **1.30-3.5**	**0.89*** **0.83-0.95**	1.22 0.98-1.53	**0.93*** **0.91-0.96**	**3.44*** **1.68-7.04**	**0.91*** **0.83-0.98**
Hypertension	1.18 0.79-1.78	**0.88*** **0.84-0.92**	1.21 0.96-1.52	**0.95*** **0.92-0.97**	142 0.90-2.25	**0.90*** **0.86-0.95**
Cancer	1.13 0.55-2.31	0.97 0.89-1.06	0.99 0.57-1.71	1.03 0.96-1.10	1.02 0.44-2.35	0.99 0.91-1.09
Multimorbid	1.08 0.96-1.22	**0.92*** **0.91-0.93**	0.96 0.89-1.03	**0.96*** **0.95-0.97**	1.05 0.93-1.20	**0.95*** **0.93-0.96**
Other	1.06 0.84-1.34	**0.90*** **0.88-0.93**	0.91 0.80-1.03	**0.96*** **0.95-0.97**	1.16 0.91-1.50	**0.92*** **0.89-0.94**

Table 5: No confounding control included.

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Pop Hillingdon	**1.15*** **1.07-1.24**	**0.91*** **0.90-0.92**	**1.07*** **1.03-1.11**	**0.94*** **0.94-0.95**	**1.13*** **1.04-1.22**	**0.93*** **0.92-0.94**

Table 6: Analysis of data in its aggregated form

Outcomes	NEL Admissions		A&E Visits		LoS	
Effect	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI	IE (RR) 95% CI	EO (RR) 95% CI
Pop Hillingdon	1.24 0.82-1.86	**0.91* 0.88-0.95**	1.19 0.76-1.84	**0.94* 0.90-0.98**	1.21 0.88-1.65	**0.92* 0.90-0.95**
With LTC	1.24 0.78-1.99	**0.91* 0.88-0.95**	1.19 0.90-1.74	**0.95* 0.92-0.99**	1.24 0.89-1.73	**0.92* 0.90-0.95**
Without LTC	1.23 0.84-1.80	**0.91* 0.88-0.94**	1.19 0.72-1.98	**0.93* 0.89-0.98**	1.14 0.80-1.64	**0.91* 0.88-0.94**

Table 7: Robust Standard errors

Outcomes	NEL Admissions		A&E Visits		LoS	
	IE	EO	IE	EO	IE	EO
Pop Hillingdon	0.036	0.004	0.018	0.0023	0.041	0.004
With LTC	0.045	0.005	0.025	0.003	0.048	0.005
Without LTC	0.061	0.007	0.028	0.003	0.009	0.015

Table 8: Means and Variances

Outcomes	NEL Admissions		A&E Visits		LoS	
	Mean	Variance	Mean	Variance	Mean	Variance
Pop Hillingdon	0.006	0.007	0.03	0.05	0.02	0.30
With LTC	0.01	0.01	0.04	0.06	0.06	0.73
Without LTC	0.003	0.004	0.02	0.04	0.006	0.057

Table 9: Modelling Zeros

	NEL Admissions	**A&E Visits**	**LoS**
	β P value 0.05	**β** P value 0.05	**β** P value 0.05
LTC	**-17.00*** <0.001	**-1.00*** <0.001	**-0.16*** <0.001
Ethnicity	**0.56*** 0.034	**0.36*** 0.000	**0.32*** 0.004
Gender	**0.25*** 0.000	**0.59*** <0.001	**0.16*** <0.001
Age	**0.01*** 0.001	**0.02*** <0.001	**0.01*** <0.001
GP Practice	-0.02 0.625	**-0.01*** 0.040	**-0.04*** 0.008

Fig 3: Consent for Publishing analysis outcomes related to Hillingdon CCG

Re: consent for publishing

GS

GOODMAN, Ian (MOUNTWOOD SURGERY) <ian.goodman@nhs.net>
12/04/2023 15:24

To: Mohammad Hussein Mansour (Doctoral Researcher)

Hi Mohammad

I have been given the all clear from the IG lead and also from Kavitha who heads up WSIC

She does stress that small numbers should be suppressed i.e. if you have any tables showing numbers less than 5 then that should be shown as <5 rather than the actual number.

Regards
Professor Ian Goodman
NHS Hillingdon CCG Lead