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Factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults

Kieran Dalton BPharm MPharm MPSI

A thesis submitted to the National University of Ireland, Cork for the degree of Doctor of Philosophy in the School of Pharmacy

September 2019

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# Overview of Contents

Overview of Contents........................................................................................................... i

Declaration.............................................................................................................................. ii

Table of Contents.................................................................................................................. iii

List of Tables......................................................................................................................... xiii

List of Figures......................................................................................................................... xiv

List of Abbreviations............................................................................................................. xv

Publications and Presentations........................................................................................... xix

Acknowledgements................................................................................................................ xxiii

Thesis Abstract..................................................................................................................... 1

**Chapter 1:** Introduction...................................................................................................... 6

**Chapter 2:** Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: a systematic review and meta-analysis................................................................. 48

**Chapter 3:** Factors affecting prescriber implementation of computer-generated medication recommendations in the SENATOR trial – a qualitative study........................................................................................................ 76

**Chapter 4:** Computer-generated STOPP/START recommendations for hospitalised older adults: evaluation of the relationship between clinical relevance and rate of implementation in the SENATOR trial....................................................................................... 105

**Chapter 5:** Prescriber implementation of STOPP/START recommendations for hospitalised older adults: a comparison of a pharmacist approach and a physician approach.......................................................... 123

**Chapter 6:** Factors affecting prescriber implementation of hospital pharmacists’ medication appropriateness recommendations in older adults.................................................................................. 148

**Chapter 7:** Discussion..................................................................................................... 175

References............................................................................................................................. 202

Appendices.......................................................................................................................... 230
Declaration

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Table of Contents

Declaration .......................................................................................................................... ii

List of Tables ...................................................................................................................... xiii

List of Figures ..................................................................................................................... xiv

List of Abbreviations ........................................................................................................ xv

Publications and Presentations ............................................................................................ xix

Peers-reviewed full paper publications ............................................................................ xix

Peers-reviewed published abstracts .................................................................................... xx

Posters and presentations .................................................................................................. xxi

Acknowledgements ........................................................................................................... xxiii

Thesis Abstract .................................................................................................................. 1

Introduction ......................................................................................................................... 1

Methods ............................................................................................................................... 2

Results ................................................................................................................................ 3

Conclusion .......................................................................................................................... 4

Chapter 1: Introduction ..................................................................................................... 6

1.1 Chapter description ....................................................................................................... 6

1.2 The ageing population ............................................................................................... 7

1.3 The complexity of prescribing in older adults ............................................................ 9

1.3.1 Age-related changes in pharmacokinetics and pharmacodynamics ......................... 9

1.3.2 Guidelines .............................................................................................................. 13

1.3.3 Multimorbidity and multiple healthcare providers .................................................. 14
1.3.4 Polypharmacy ........................................................................................................... 16
1.4 Potentially inappropriate prescribing (PIP) in older adults ........................................ 17
  1.4.1 Defining PIP ........................................................................................................... 17
  1.4.2 Prevalence of PIP ............................................................................................... 20
  1.4.3 Consequences of PIP ......................................................................................... 22
1.5 Interventions to reduce PIP in hospitalised older adults ........................................... 24
  1.5.1 Prescribing assessment tools ............................................................................. 24
  1.5.2 Geriatrician-based assessments ......................................................................... 29
  1.5.3 Pharmacist interventions .................................................................................... 31
  1.5.4 Computerised interventions ............................................................................... 33
  1.5.5 Multiple component interventions ..................................................................... 35
1.6 Prescriber implementation of recommendations: a target for behaviour change
  interventions ................................................................................................................... 37
  1.6.1 Prescriber implementation rates of medication appropriateness
       recommendations ........................................................................................................ 37
  1.6.2 Identifying behavioural components affecting implementation ............................ 39
1.7 Summary ..................................................................................................................... 43
1.8 Hypothesis, aims, and objectives .............................................................................. 44
  1.8.1 Hypothesis ......................................................................................................... 44
  1.8.2 Thesis aim and objectives ................................................................................... 44
  1.8.3 Thesis outline ..................................................................................................... 46
Chapter 2: Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: a systematic review and meta-analysis

2.1 Chapter description

2.2 Abstract

2.2.1 Introduction

2.2.2 Methods

2.2.3 Results

2.2.4 Conclusion

2.3 Introduction

2.4 Methods

2.4.1 Eligibility criteria

2.4.2 Study selection

2.4.3 Data extraction

2.4.4 Risk of bias assessments

2.4.5 Data Synthesis

2.5 Results

2.5.1 Search results

2.5.2 Characteristics of included studies

2.5.3 Results of the risk of bias assessments

2.5.4 Reduction in patients with PIMs

2.5.5 Reduction in PIMs prescribed

2.5.6 Implementation rates of computer-generated recommendations
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5.7 Reasons for not implementing recommendations</td>
<td>64</td>
</tr>
<tr>
<td>2.5.8 Clinical outcomes</td>
<td>65</td>
</tr>
<tr>
<td>2.6 Discussion</td>
<td>67</td>
</tr>
<tr>
<td>2.7 Conclusion</td>
<td>70</td>
</tr>
<tr>
<td>2.8 Addendum</td>
<td>71</td>
</tr>
<tr>
<td>2.8.1 Updated search methods</td>
<td>71</td>
</tr>
<tr>
<td>2.8.2 Analysis methods</td>
<td>71</td>
</tr>
<tr>
<td>2.8.3 Updated search results</td>
<td>71</td>
</tr>
<tr>
<td>2.8.4 Updated narrative synthesis and meta-analysis</td>
<td>72</td>
</tr>
<tr>
<td>2.8.5 Discussion</td>
<td>74</td>
</tr>
<tr>
<td>Chapter 3: Factors affecting prescriber implementation of computer-generated medication recommendations in the SENATOR trial – a qualitative study</td>
<td>76</td>
</tr>
<tr>
<td>3.1 Chapter description</td>
<td>76</td>
</tr>
<tr>
<td>3.2 Abstract</td>
<td>77</td>
</tr>
<tr>
<td>3.2.1 Introduction</td>
<td>77</td>
</tr>
<tr>
<td>3.2.2 Methods</td>
<td>77</td>
</tr>
<tr>
<td>3.2.3 Results</td>
<td>77</td>
</tr>
<tr>
<td>3.2.4 Conclusion</td>
<td>78</td>
</tr>
<tr>
<td>3.3 Introduction</td>
<td>79</td>
</tr>
<tr>
<td>3.4 Methods</td>
<td>80</td>
</tr>
<tr>
<td>3.4.1 Context and study setting</td>
<td>80</td>
</tr>
<tr>
<td>3.4.2 Study design and recruitment</td>
<td>81</td>
</tr>
</tbody>
</table>
3.4.3 Data collection ........................................................................................................... 82
3.4.4 Data analysis ............................................................................................................... 84
3.5 Results ................................................................................................................................ 85
  3.5.1 Main themes .................................................................................................................. 86
  3.5.2 Predominant TDF domains .......................................................................................... 94
  3.5.2 Suggestions for future interventions ............................................................................. 97
3.6 Discussion ................................................................................................................................ 98
  3.6.1 Strengths and limitations .............................................................................................. 102
3.7 Conclusion .......................................................................................................................... 104

Chapter 4: Computer-generated STOPP/START recommendations for hospitalised older adults: evaluation of the relationship between clinical relevance and rate of implementation in the SENATOR trial ........................................................................................................... 105

  4.1 Chapter description ........................................................................................................... 105
  4.2 Abstract ............................................................................................................................ 106
    4.2.1 Introduction ................................................................................................................ 106
    4.2.2 Methods ..................................................................................................................... 106
    4.2.3 Results ....................................................................................................................... 106
    4.2.4 Conclusion ................................................................................................................ 107
  4.3 Introduction ....................................................................................................................... 108
  4.4 Methods ............................................................................................................................ 109
    4.4.1 Context and study setting .......................................................................................... 109
    4.4.2 Data collection .......................................................................................................... 110
Chapter 4:~

4.4.3 Data analysis ........................................................................................................ 111

4.5 Results ...................................................................................................................... 111

4.5.1 Clinical relevance evaluation .............................................................................. 112

4.5.2 Prescriber implementation rates ........................................................................ 115

4.5.3 Inter-rater reliability (IRR) results ...................................................................... 115

4.6 Discussion .................................................................................................................. 116

4.7 Conclusion .................................................................................................................. 122

Chapter 5: Prescriber implementation of STOPP/START recommendations for hospitalised older adults: a comparison of a pharmacist approach and a physician approach .......... 123

5.1 Chapter description .................................................................................................. 123

5.2 Abstract .................................................................................................................... 125

5.2.1 Introduction ......................................................................................................... 125

5.2.2 Methods ............................................................................................................. 125

5.2.3 Results ............................................................................................................... 125

5.2.4 Conclusion ......................................................................................................... 126

5.3 Introduction .............................................................................................................. 127

5.4 Methods ................................................................................................................... 128

5.4.1 Study setting and intervention details ................................................................. 128

5.4.2 Data extraction and analysis .............................................................................. 130

5.5 Results ...................................................................................................................... 131

5.5.1 Prescriber implementation of STOPP and START recommendations ............... 131

5.5.2 Number of recommendations made and focus of intervention ....................... 136
6.6 Discussion ........................................................................................................................................... 169

6.6.1 Strengths and limitations .................................................................................................................. 173

6.7 Conclusion ............................................................................................................................................. 174

Chapter 7: Discussion ................................................................................................................................. 175

7.1 Chapter description ............................................................................................................................... 175

7.2 Summary of findings ............................................................................................................................. 176

7.3 Key factors affecting prescriber implementation of medication appropriateness
recommendations in hospitalised older adults .......................................................................................... 183

7.3.1 Clinical relevance of the recommendation ....................................................................................... 184

7.3.2 Method of communication and integration into prescriber workflow .......................................... 185

7.3.3 The hospital environment ................................................................................................................ 187

7.3.4 Prescriber identity ............................................................................................................................ 188

7.3.5 Source of the recommendation ....................................................................................................... 190

7.4 Strengths and limitations ..................................................................................................................... 192

7.5 Implications of findings ....................................................................................................................... 194

7.5.1 Implications for practice ................................................................................................................ 194

7.5.2 Implications for future research .................................................................................................... 198

7.6 Conclusion ............................................................................................................................................. 201

References .................................................................................................................................................... 202

Appendices ................................................................................................................................................ 230

Appendix 1: STOPP/START criteria version 2 ....................................................................................... 231

Appendix 2: Theoretical Domains Framework (version 2) ..................................................................... 241
Topic guide for pharmacists ........................................................................................................300

Topic guide for physicians ........................................................................................................304

Appendix 22: Supplementary Quotations for Chapter 6 .............................................................308
List of Tables

Table 1.1: Prevalence of potentially inappropriate prescribing (PIP) in older adults (≥ 65 years) across healthcare settings in Ireland.................................................................21

Table 2.1: Characteristics of included studies.................................................................57

Table 2.2: Risk of bias assessments................................................................................61

Table 2.3: Implementation rates of computer-generated recommendations..................64

Table 2.4: Studies which assessed clinical outcomes....................................................66

Table 3.1: Acute hospital sites where the SENATOR randomised controlled trial was conducted.................................................................................................................81

Table 3.2: Characteristics of interview participants.......................................................85

Table 3.3: Behavioural determinants affecting implementation of the SENATOR recommendations within the predominant TDF domains.........................................................95

Table 4.1: Prescriber implementation rates of recommendations categorised according to their degree of clinical relevance.................................................................113

Table 4.2: Clinical relevance of total STOPP and total START recommendations.............114

Table 5.1: Prescriber implementation rates for STOPP recommendations: physician versus pharmacist..............................................................................................................132
Table 5.2: Prescriber implementation rates for START recommendations: physician versus pharmacist.................................................................134

Table 5.3: Pharmacist recommendations for “missing medications” identified by medication reconciliation that would have been identified by START criteria........................................139

Table 5.4: Comparable clinical outcomes between interventions.........................................................140

Table 6.1: Sampling Matrix..........................................................................................................................154

Table 6.2: Behavioural determinants affecting implementation of pharmacist recommendations within the predominant TDF domains.................................................................166

List of Figures

Figure 1.1 Thesis Outline..........................................................................................................................47

Figure 2.1: PRISMA flow diagram of search strategy results.................................................................55

Figure 2.2: Forest plot for the odds ratio for the reduction in the proportion of patients prescribed PIMs post-intervention.............................................................................................62

Figure 2.3: PRISMA flow diagram of updated search strategy results.................................................72

Figure 2.4: Forest plot for the odds ratio for the reduction in the proportion of non-recommended doses prescribed post-intervention........................................................................74
# List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE</td>
<td>Angiotensin Converting Enzyme</td>
</tr>
<tr>
<td>ACOVE</td>
<td>Assessing Care of Vulnerable Elders</td>
</tr>
<tr>
<td>ADE</td>
<td>Adverse drug event</td>
</tr>
<tr>
<td>ADR</td>
<td>Adverse drug reaction</td>
</tr>
<tr>
<td>AOU</td>
<td>Assessment of Underutilization of Medication</td>
</tr>
<tr>
<td>APEASE</td>
<td>Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side-effects, Equity</td>
</tr>
<tr>
<td>ARB</td>
<td>Angiotensin Receptor Blocker</td>
</tr>
<tr>
<td>BCT</td>
<td>Behaviour change technique</td>
</tr>
<tr>
<td>BCW</td>
<td>Behaviour Change Wheel</td>
</tr>
<tr>
<td>BPSD</td>
<td>Behavioural and psychological symptoms of dementia</td>
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<tr>
<td>C</td>
<td>Control</td>
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<tr>
<td>CDS</td>
<td>Clinical decision support</td>
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<tr>
<td>CDSS</td>
<td>Clinical decision support system</td>
</tr>
<tr>
<td>CGA</td>
<td>Comprehensive geriatric assessment</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence interval</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
</tr>
<tr>
<td>COREQ</td>
<td>Consolidated Criteria for Reporting Qualitative Research</td>
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<tr>
<td>COX-2</td>
<td>Cyclooxygenase-2</td>
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CPOE  Computerised provider order entry
DDI  Drug-drug interaction
df  Degrees of freedom
DMARD  Disease-modifying anti-rheumatic drug
ED  Emergency department
eGFR  Estimated glomerular filtration rate
EHR  Electronic health record
EPOC  Effective Practice and Organisation of Care
EPR  Electronic prescription record
FEV1  Forced expiratory volume in 1 second
FORTA  Fit fOR The Aged
FYI  For your information
GFR  Glomerular filtration rate
GP  General practitioner
I  Intervention
ICD  International Classification of Diseases
IQR  Interquartile range
IV  Inverse variance
kPa  Kilopascal
MAI  Medication Appropriateness Index
MRC  Medical Research Council
NSAID  Non-steroidal anti-inflammatory drug
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYHA</td>
<td>New York Heart Association</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OPERAM</td>
<td>OPtimising ThERapy to prevent Avoidable hospital admissions in the Multi-morbid elderly</td>
</tr>
<tr>
<td>pCO₂</td>
<td>Partial pressure of carbon dioxide</td>
</tr>
<tr>
<td>PICOS</td>
<td>Participants, interventions, comparisons, outcomes, and study design</td>
</tr>
<tr>
<td>PIM</td>
<td>Potentially inappropriate medication</td>
</tr>
<tr>
<td>PIP</td>
<td>Potentially inappropriate prescribing</td>
</tr>
<tr>
<td>pO₂</td>
<td>Partial pressure of oxygen</td>
</tr>
<tr>
<td>PPI</td>
<td>Proton pump inhibitor</td>
</tr>
<tr>
<td>PPO</td>
<td>Potential prescribing omission</td>
</tr>
<tr>
<td>PRISMA</td>
<td>Preferred Reporting Items for Systematic Reviews and Meta-Analyses</td>
</tr>
<tr>
<td>PROSPERO</td>
<td>International Prospective Register of Systematic Reviews</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised controlled trial</td>
</tr>
<tr>
<td>SaO₂</td>
<td>Oxygen saturation</td>
</tr>
<tr>
<td>SENATOR</td>
<td>Software ENgine for the Assessment &amp; optimization of drug and non-drug Therapy in Older peRsons</td>
</tr>
<tr>
<td>SNRI</td>
<td>Serotonin-noradrenaline re-uptake inhibitor</td>
</tr>
<tr>
<td>SSRI</td>
<td>Selective serotonin re-uptake inhibitor</td>
</tr>
<tr>
<td>START</td>
<td>Screening Tool to Alert to Right Treatment</td>
</tr>
<tr>
<td>STOPP</td>
<td>Screening Tool of Older People’s Prescriptions</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
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<tr>
<td>---------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>TCA</td>
<td>Tricyclic antidepressant</td>
</tr>
<tr>
<td>TDF</td>
<td>Theoretical Domains Framework</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
</tr>
</tbody>
</table>
Publications and Presentations

Peer-reviewed full paper publications

   

2. **Dalton K**, O’Mahony D, Cullinan S, Byrne S. Factors affecting prescriber implementation of computer-generated medication recommendations in the SENATOR trial – a qualitative study. (Chapter 3)
   
   [(Drugs & Aging: accepted subject to revisions)](Drugs & Aging: accepted subject to revisions)

3. **Dalton K**, Curtin D, O’Mahony D, Byrne S. Computer-generated STOPP/START recommendations for hospitalised older adults: evaluation of the relationship between clinical relevance and rate of implementation in the SENATOR trial. (Chapter 4)
   
   [(Age & Ageing: accepted subject to revisions)](Age & Ageing: accepted subject to revisions)

   
Peer-reviewed published abstracts


Posters and presentations


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Thesis Abstract

Introduction

Despite the well-documented association between potentially inappropriate prescribing (PIP) and adverse outcomes for hospitalised older adults, the prevalence of PIP remains unacceptably high. Recommendations to improve medication appropriateness in hospital often come from sources external to the attending prescribing team, such as pharmacists and computerised system alerts. However, these recommendations to minimise PIP are not always implemented by prescribers, meaning that PIP can continue, thereby increasing the risk of adverse drug reactions (ADRs), rehospitalisation, and higher healthcare costs.

Interventions with sufficiently high rates of adherence to medication appropriateness recommendations among prescribers are more likely to result in significantly improved patient outcomes in comparison to those interventions with lower implementation rates, which often show non-significant effects on key outcomes. Thus, it is imperative that prescribing optimisation interventions achieve sufficiently high prescriber implementation rates for these recommendations to be clinically effective. However, it is not always clear which specific intervention components are essential to high implementation rates of prescribing recommendations.

Therefore, the overarching aim of this thesis was to identify the key factors affecting prescriber implementation of recommendations to improve medication
appropriateness in hospitalised older adults, focusing on the factors affecting implementation of i) computer-generated recommendations and ii) pharmacist recommendations.

Methods

Initially, a systematic review and meta-analysis were undertaken to ascertain the effectiveness of computerised interventions in minimising PIP in hospitalised older adults. Secondly, a semi-structured qualitative interview study was conducted alongside the Software ENgine for the Assessment & optimization of drug and non-drug Therapy in Older peRsons (SENATOR) trial to determine the key factors affecting prescriber implementation of the SENATOR software-generated recommendations, which aimed to reduce PIP and ADRs in hospitalised older adults. Based on these qualitative findings, an evaluation of the clinical relevance of SENATOR’s computer-generated recommendations based on Screening Tool of Older People’s Prescriptions (STOPP) and Screening Tool to Alert to Right Treatment (START) criteria (version 2) was performed. Subsequently, the association between the clinical relevance of the recommendations and their implementation by prescribers was assessed. Thereafter, the prescriber implementation rates of STOPP/START recommendations from a physician approach and a pharmacist approach were compared. Finally, a further semi-structured qualitative interview study was conducted to identify the key factors affecting physician prescriber implementation of pharmacist recommendations aimed at optimising medication appropriateness in hospitalised older adults.
Results

The systematic review and meta-analysis showed that computerised interventions can significantly reduce PIP in hospitalised older adults ($p < 0.05$). Of the nine included studies, five reported prescriber implementation rates for the computer-generated recommendations, ranging from 22.5% – 95%, but none of the included studies comprehensively explored the underlying reasons for non-implementation. The qualitative study conducted alongside the SENATOR trial identified four key factors affecting prescriber implementation of the computer-generated recommendations:

i) Computerised output: the clinical relevance and method of provision for the recommendations.

ii) Acute hospital environment: the timing and location of recommendations in a busy and often pressurised clinical setting.

iii) Prescriber role and identity: the responsibility, experience, and specialty of prescribers, as well as their attitude towards research studies.

iv) Patient-specific details: knowing the patient, patient preferences, and their acutely ill status in hospital.

The study evaluating the clinical relevance of the computer-generated SENATOR recommendations showed that nearly three quarters of the 925 computer-generated STOPP/START recommendations generated were judged to be clinically relevant (73.6%), whilst the remainder were judged to be of ‘no clinical relevance’ (21.5%) or of potential ‘adverse significance’ if implemented (4.9%). Recommendations judged to be of higher clinical relevance were significantly more
likely to be implemented than those of lower clinical relevance \((p < 0.05)\), substantiating the findings from the preceding qualitative study that clinical relevance was a key factor affecting implementation.

In the study comparing the implementation of pharmacist-provided and physician-provided STOPP/START recommendations, prescribers implemented a significantly greater proportion of physician recommendations in comparison to pharmacist recommendations \((83.4\% \text{ versus } 37.8\%; p < 0.0001)\). The final qualitative interview study found that the key factors affecting prescriber implementation of pharmacists' medication appropriateness recommendations for hospitalised older adults were:

i) Clinical relevance and complexity of the recommendation.

ii) Interprofessional communication.

iii) Prescriber role and identity.

iv) Knowing each other and developing trusting relationships.

v) Hospital environment.

**Conclusion**

This thesis has made a significant contribution to the understanding of the key factors affecting prescriber implementation of recommendations to improve medication appropriateness in hospitalised older adults. Prescriber non-implementation of these recommendations is not attributable to one easily identifiable cause, and it is likely that a multi-faceted approach will be required in future interventions. The novel studies conducted in this thesis will facilitate the
development of theoretically-informed interventions that result in enhanced prescriber implementation of these recommendations, ultimately with the aims of substantially reducing PIP and improving health outcomes for hospitalised older adults.
Chapter 1: Introduction

1.1 Chapter description

This chapter provides an overview of the literature which informed my research. I begin by discussing the increasingly ageing population and the complexity associated with prescribing in older adults. Secondly, I define what is meant by ‘potentially inappropriate prescribing’ (PIP) in this older patient group, its prevalence, and the associated consequences for patients and healthcare systems.

Following this, I describe the common types of interventions that have been conducted in hospital settings to reduce PIP in older adults. Thereafter, I focus on prescriber implementation of recommendations to optimise prescribing in older adults, and explain how this behaviour can be targeted in future interventions. Finally, I present the hypothesis underpinning my research and an outline of the overall aims and objectives of this thesis.
1.2 The ageing population

Healthier lifestyles, improving socioeconomic conditions, advances in medicine, and greater access to healthcare have contributed to significant gains in life expectancy over time [1]. Within the 36 member countries of the Organisation for Economic Co-operation and Development (OECD), the average life expectancy at birth is now 80.6 years, ten years higher than it was in 1970 [2]. Rising life expectancy in both sexes and decreasing fertility rates mean that older adults comprise an ever-expanding proportion of the global population. The percentage of people aged ≥ 65 years in OECD countries has grown from 10% in 1970 to 17% in 2015, and is predicted to reach 28% by 2050 [3]. Older adults (≥ 65 years) have much higher rates of medication consumption and health services utilisation than their younger counterparts [4]. Thus, healthcare systems worldwide face significant challenges to meet the needs of this increasingly ageing population.

At present, the growing proportion of older adults is placing a substantial burden on already-strained resources in all areas of healthcare. With an ageing population and associated increased workload, general practitioners (GPs), often find that they have increasingly limited time to thoroughly review older patients’ healthcare needs and complex medication regimens [5, 6]. In secondary care, older adults now occupy over half of acute hospital bed days in the United Kingdom (UK) and Republic of Ireland [7, 8]. Discharging these patients from acute care beds is often complicated further by a lack of bed availability in step-down facilities and long-term care facilities, where older adults occupy the majority of beds [9].
However, the challenge facing health services in most developed countries is not simply a matter of increased numbers of older adults. These patients often have multimorbidity, defined by the World Health Organisation (WHO) as the “coexistence of two or more chronic conditions in the same individual” [10], which is increasingly more common with advancing age and complicates their healthcare [11, 12]. A systematic review reported that the prevalence of multimorbidity in older adults ranged from 55% to 98% [13]. Thus, although a 65-year-old in the OECD population could today expect to live an additional 19.5 years on average, only 9 of these are likely to be ‘healthy years’ [14].

Multimorbidity is associated with increased functional decline, cognitive decline, poorer quality of life, greater morbidity, and mortality [15-18]. Not surprisingly, multimorbidity significantly contributes to increased primary care consultations, hospital visits, hospital admissions, as well as escalating the need for specialised care [11, 19-22]. In fact, healthcare utilisation increases significantly with each additional chronic condition in older adults [11, 23]. Moreover, the presence of multimorbidity increases the requirement for multiple medications concomitantly. Medications are the most common form of healthcare intervention worldwide, but despite their many benefits in reducing the progression of chronic diseases in patients by treating and preventing illness, they are also the most common cause of iatrogenic harm [24]. Polypharmacy, most commonly defined as the concurrent use of five or more regular medications [25], is highly prevalent in multimorbid older adults and is associated with negative health outcomes, mostly arising from adverse drug reactions (ADRs) [26, 27]. Older adults are particularly vulnerable to these
medication-related harms due to physiological changes and altered pharmacokinetics and pharmacodynamics associated with advancing age [28]. Therefore, the safe prescribing of medications in older adults presents unique challenges not encountered when prescribing for younger patient populations [29].

1.3 The complexity of prescribing in older adults

Prescribers commonly find a greater degree of heterogeneity amongst our aged population than in the younger adult population, with a spectrum ranging from those who are fit and healthy to those who are frail and multimorbid [30]. Interindividual variability in health, disease, and pharmacotherapy increases significantly with ageing, which adds to the complexity of prescribing and makes it difficult to predict how older adults will respond to different medications.

1.3.1 Age-related changes in pharmacokinetics and pharmacodynamics

With advancing age, the body undergoes several physiological changes which can affect pharmacokinetics and pharmacodynamics. Age-related alterations in pharmacokinetics mean that older adults often have changes in the absorption, distribution, metabolism, and excretion of drugs – which can affect the onset of action, peak concentration, and duration of effect of medications [28, 31]. Moreover, age-related pharmacodynamic changes result in altered drug sensitivity, and can affect older adults’ response to drugs that work at certain receptors or organ systems.
1.3.1.1 Pharmacokinetics

The oral absorption of drugs may be affected by age-related changes in the gastrointestinal tract, including reduced gastric acid secretion, delayed gastric emptying, decreased splanchnic blood flow, as well as prolonged intestinal transit time [32]. However, these changes may more commonly affect the rate of oral drug absorption rather than the extent of absorption [28, 33].

Age-related changes in body composition have a substantial effect on drug distribution. Total body water is reduced by 10% – 15% from age 20 years to age 80 years [34]. Therefore, the volume of distribution for hydrophilic drugs (such as aspirin, lithium, and digoxin) decreases in older adults, leading to higher plasma concentrations, and increasing the risk of toxicity [35]. The decrease in total body water coincides with a reduction in lean body mass, mostly skeletal muscle. This decline in lean body mass contributes to a proportional increase in total body fat. This means that lipophilic drugs have a greater volume of distribution in older adults, and are eliminated more slowly due to their accumulation in adipose tissue. Consequently, lipophilic drugs such as benzodiazepines have prolonged half-lives in older patients, protracting the risk for unwanted side effects, including confusion, drowsiness, and falls. Furthermore, weight loss and frailty may commonly occur in very old individuals, contributing to a decrease in the proportion of body fat. This, in turn, lowers the volume of distribution of lipophilic drugs and results in increased serum drug concentrations [36].

The most clinically significant age-related pharmacokinetic changes involve drug elimination, i.e. primarily through hepatic metabolism and/or renal excretion [37,
In older adults, the liver mass is generally reduced by 20% – 30%, resulting in a decrease in the total number of drug-metabolising enzymes [39]. Thus, hepatic drug metabolism is reduced in advanced age and drug-drug interactions may be more clinically significant. Furthermore, a concomitant reduction in hepatic blood flow by approximately 20% – 50% in older adults means that drugs are presented to the liver at a much slower rate [40, 41]. This is particularly significant for drugs that are extensively extracted from the blood by the liver (e.g. propranolol, morphine, amitriptyline, verapamil); as their metabolism is ‘blood-flow limited’, lower doses are often required in older patients [42].

In addition to a decline in hepatic metabolism, ageing is associated with a reduction in the excretory capacity of the kidney [43]. Renal mass decreases by approximately 25% – 30%, with a 1% reduction in renal blood flow annually in adults from age 50 years and over [39]. Furthermore, the glomerular filtration rate (GFR) declines by an estimated 0.75 ml/minute/year on average in patients between the age of 30 and 90 years [44]. However, longitudinal studies have shown that there may be no significant decrease in GFR in approximately one third of older patients; thus, individual patient comorbidities are key factors affecting renal function with advancing age [44, 45].

Reduced renal clearance in older adults results in elevated drug plasma levels and prolongs the drug’s half-life, thus increasing the risk of ADRs [46]. For example, age-related reductions in renal function and water volume make older adults more susceptible to toxicity from water-soluble drugs, particularly those with a narrow therapeutic index, such as aminoglycosides, lithium, and digoxin [47-49]. However,
in contrast to hepatic elimination, altered drug levels due to age-related changes in renal function can be more easily predicted by calculating GFR [50]. Accordingly, it would be prudent to monitor GFR with the use of renally excreted drugs in older adults, with dose adjustment where appropriate.

1.3.1.2 Pharmacodynamics

In addition to these pharmacokinetic changes, ageing also has an impact on the body’s response to drugs, i.e. pharmacodynamics. At the receptor level, ageing may lead to changes in the number of receptor sites, drug affinity for receptors, or in signal transduction mechanisms. For example, the abundance of dopaminergic receptors in older adults is reduced causing greater blockade with standard doses of metoclopramide at dopamine D2 receptors when compared with younger adults, and increases the risk for parkinsonian side effects [35]. Older adults generally have increased pharmacodynamic sensitivity to drugs, particularly those that act on the central nervous system. For example, increased sensitivity to benzodiazepines, tricyclic antidepressants (TCAs), and antipsychotics can result in increased sedation and augment the risk of falls. Conversely, older adults may have decreased sensitivity to other drug classes; for example, reduced drug binding affinity at β-adrenergic receptors in older adults may lead to a decrease in the sensitivity and clinical response to β-agonists and β-blockers [51, 52].

At an organ system level, older adults may experience accentuated pharmacodynamic responses due to age-related changes in homeostatic mechanisms [53]. An example of this may be seen with volume-depleting drugs such as diuretics, whereby insufficient responses to hypovolaemia are mainly due
to age-related impairments of cardiovascular reflex function. Therefore, this increased pharmacodynamic sensitivity is not due to an increased drug-receptor effect, but rather an exaggerated reaction to the drug’s effect on volume depletion, which may result in orthostatic hypotension and falls in older adults [34]. Furthermore, these patients may be more sensitive to the troublesome anticholinergic effects of some drugs such as dry mouth, constipation, and urinary retention; however, the underlying reason for older adults’ increased sensitivity to some ADRs, such as those mentioned, is not always clear [54].

1.3.2 Guidelines

Best practice would advocate prescribers to comply with evidence-based guidelines when initiating or optimising medications for patients. However, despite being the main users of medications, older adults are often underrepresented in guidelines and in the clinical trials on which the guidelines are based [55]. These trials include patients that are usually selected by strict criteria, often comprising narrow subsets of the population which do not represent the typical patient with the condition [56]. In fact, older adults are commonly excluded from these clinical trials, especially those with multimorbidity [57].

This means that existing clinical practice guidelines are largely focused on single diseases, and many do not consider multimorbidity, despite its high prevalence. However, it should be noted that recent guidelines for some chronic conditions, such as heart failure, chronic obstructive pulmonary disease (COPD), and diabetes mellitus, have attempted to incorporate advice on likely comorbidities [58-60], but these guidelines often only consider one comorbid condition at a time [61].
Therefore, indiscriminate application of prescribing guidelines based on data extrapolated from younger populations may not be justified when prescribing for older adults [26, 62]. Consequently, this often results in healthcare professionals prescribing medications for older patients without a clear evidence base or denying them a treatment they may possibly benefit from [63].

1.3.3 Multimorbidity and multiple healthcare providers

Older patients with complex multimorbidity often attend several different healthcare providers working across multiple sites [64]. With multiple clinicians providing care to older patients with numerous chronic diseases, the number of prescribed medications can accumulate dangerously, particularly as many clinicians may be hesitant to discontinue medications started by fellow prescribers [65]. Furthermore, various prescribers treating the same patient may have different treatment priorities, and commonly a holistic approach to older patient care may be lacking, with each prescriber focusing solely on their area of expertise. This increases the possibility for drug-drug interactions as well as drug-disease interactions, whereby beneficial medications for one condition may be harmful for another (e.g. pioglitazone for diabetes mellitus can exacerbate heart failure) [66]. This emphasises that older patients under the care of multiple prescribers are at a heightened risk of both inappropriate prescribing and ADRs, with each additional prescriber’s influence on a patient’s pharmacotherapy reported to increase the ADR risk by 30% [67, 68].

These negative patient outcomes are frequently due to suboptimal communication between prescribers [69]. This is particularly problematic on transitions of care, but
may also exist between prescribers practising in the same setting [70]. The incomplete transfer of important patient information between prescribers can result in inaccurate patient records, which hinder informed decision-making and predisposes to potentially inappropriate prescribing (PIP). For example, the prescription of duplicate therapies or counter-acting drugs can occur when prescribers are not aware of their peers’ therapeutic plans [71].

This lack of information sharing between prescribers adds to the intricacy of prescribing for older patients. The GP is often consigned the responsibility of managing the patient’s pharmacotherapy and liaising with the various prescribers involved in the patient’s care. However, due to the evolving nature of general practice, older patients may often see more than one GP. This is becoming increasingly more common with a trend towards larger, multi-partner practices [72]. Having multiple prescribers in primary care may impact on continuity of care and prescriber familiarity with individual patient cases [73]. Greater continuity of care is associated with reduced rates of hospitalisation, emergency department (ED) visits, disease complications, as well as lower healthcare costs [74]. Continuity of care and familiarity with individual cases have also been shown to be important in the community pharmacy setting. While most older adults obtain all their prescriptions from one pharmacy, studies have shown that those who use more than one pharmacy are at an increased risk of drug-drug interactions and non-adherence with their medications [75]. However, the issue of multiple healthcare providers is much more problematic in the hospital setting, whereby clinicians with different expertise and varying levels of experience in dealing with multimorbid
older patients are often challenged with complex pharmacotherapy decisions that may be outside of their specialist area for multimorbid older patients that they are not familiar with [76].

1.3.4 Polypharmacy

The presence of multiple prescribers involved in the care of multimorbid older adults has made polypharmacy, and even hyperpolypharmacy (the use of 10 or more regular medications concomitantly), increasingly more prevalent in older adult populations [77-79]. Polypharmacy increases the likelihood of both adverse drug-drug and drug-disease interactions, adding both to the complexity of prescribing and the risk of adverse clinical outcomes in older patients [80].

Despite these potential dangers, polypharmacy is often clinically appropriate when treating older patients with several chronic conditions. Multiple medications are often required in combination to treat, delay the progression of, or ameliorate the symptoms of disease [81], with evidence-based practice guidelines often recommending the use of more than one medication as first-line therapy in some chronic conditions (e.g. heart failure) [58]. Furthermore, the use of appropriate polypharmacy to manage chronic disease can extend patients’ life expectancy, improve their quality of life, and prevent complications such as disability and unnecessary hospitalisations [81, 82]. Given the possibility of both positive and negative outcomes in older adults, it is no surprise that polypharmacy has been termed a ‘necessary evil’ [82]. Balancing the risks and benefits of using a multitude of medications concomitantly remains a significant challenge for prescribers caring for older patients in all care settings.
In summary, reduced drug elimination, coupled with a typically increased sensitivity to medications, renders older adults more susceptible to ADRs. These patients often require lower doses than younger populations, but it is difficult to predict medication response due to interindividual variability in older adults’ drug handling. The paucity of prescribing guidelines for multimorbid older adults with polypharmacy means that increased caution is necessary when initiating medications, along with close monitoring of drug response to ensure both therapeutic efficacy and to prevent PIP and medication-related harm.

1.4 Potentially inappropriate prescribing (PIP) in older adults

1.4.1 Defining PIP

PIP is a term which describes a wide range of suboptimal prescribing practices encompassing, but not limited to, the following:

- Misprescribing, i.e. erroneously prescribing a drug that is needed. This may include prescribing the wrong drug (e.g. because of drug-drug or drug-disease interactions), selecting an inappropriate formulation or route of administration, or the use of drugs lacking cost-effectiveness where equally efficacious cheaper alternatives exist [83-85].

- Overprescribing, i.e. the prescription of medications at a dosage, frequency, or duration in excess of what is clinically needed, or for which no clear clinical indication exists [70, 85].
• Underprescribing, i.e. the prescription of too low a dose to be effective or the failure to prescribe appropriate drug therapy when it may be of benefit to the patient [70, 86].

PIP can often result in the appearance of potentially inappropriate medications (PIMs) in older adults’ pharmacotherapy, where the associated risks may outweigh the benefits, and can often predispose patients to an unacceptably increased risk of ADRs [70]. It is widely acknowledged that certain medications should be used with caution or completely avoided in older adults, particularly when there may be an effective safer alternative [4, 87]. Common examples of PIMs in older adults include the following:

• long-term prescription of benzodiazepines or neuroleptics in patients who are at an increased risk of fall [88], or
• metoclopramide in patients with Parkinson’s disease [88], or
• anticholinergics in patients with delirium or dementia [88].

However, PIP does not only comprise the prescription of PIMs, but also includes potential prescribing omissions (PPOs), i.e. non-prescription of certain medications that older patients may benefit from [89]. PPOs are often highly prevalent in patients with common conditions such as hypertension, heart failure, atrial fibrillation, and osteoporosis [89, 90]. Whilst some PPOs may be unintentionally overlooked by prescribers due to lack of knowledge around evidence-based secondary preventative therapies (e.g. the absence of a bisphosphonate in a patient with osteoporosis), others may be intentionally and inappropriately withheld due to ageist attitudes or other unjustifiable reasons such as therapeutic nihilism or
ignorance of medication benefit to older people in certain circumstances (e.g. the omission of anticoagulation to prevent a cardio-embolic stroke in a patient with known atrial fibrillation) [91].

Polypharmacy is intimately linked with PIP and is one of the principal risk factors for PIM prescription in older adults [92]. Studies have shown an increased likelihood of PIMs with each additional medication prescribed [67, 93]. Furthermore, polypharmacy can exacerbate the risk of a so-called ‘prescribing cascade’ developing, whereby an ADR or side effect of one medication is inadvertently misinterpreted as a new condition, and consequently results in the unnecessary prescription of a new medication to treat it, rather than discontinuation of the causative agent [94]. For example, a patient who develops ankle oedema as a side effect to a calcium channel blocker for hypertension is subsequently prescribed a loop diuretic to manage the oedema, rather than switching to an alternative antihypertensive.

Paradoxically, patients with polypharmacy may also be more susceptible to underprescribing compared to those receiving fewer medications [95]. The negative connotations associated with the term ‘polypharmacy’ may be a causative factor for the underutilisation of potentially beneficial, clinically indicated medications [96]. Prescribers may be reluctant to add to patients’ drug burden for fear of adverse events; however, underprescribing itself is associated with adverse health outcomes [97]. Therefore, it is crucial for prescribers to focus not just on the number of medications prescribed alone, but to distinguish between appropriate polypharmacy and inappropriate polypharmacy in order to facilitate the
deprescribing of PIMs and the optimal utilisation of appropriate medications through detection of PPOs [25].

1.4.2 Prevalence of PIP

Despite increased awareness about PIP, it remains highly prevalent in older adults globally [98-100]. PIP prevalence can vary between different healthcare settings, but usually rises steadily from primary care through secondary care and further into long-term care settings [89, 92, 101-108]. The median PIP prevalence of community-dwelling older adults across Europe was found to be 22.6% in a systematic review by Tommelein et al. [103]. Moreover, a study from six hospitals in six European countries showed an overall PIM prevalence of 51.3% and an overall PPO prevalence of 59.4% in hospitalised older adults [92]. Furthermore, in older people in the long-term care setting, a recent systematic review comprised of mostly European studies reported a median PIM prevalence of 61.1% and a median PPO prevalence of 48.6% [108]. Examples of reported PIM and PPO prevalence from studies conducted in different healthcare settings in Ireland are illustrated in Table 1.1.
Table 1.1: Prevalence of potentially inappropriate prescribing (PIP) in older adults (≥ 65 years) across healthcare settings in Ireland

<table>
<thead>
<tr>
<th>Healthcare setting</th>
<th>Number of patients</th>
<th>PIM prevalence</th>
<th>PPO prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Ryan <em>et al.</em> [101]</td>
<td>1329</td>
<td>21.4%</td>
<td>22.7%</td>
</tr>
<tr>
<td>- Moriarty <em>et al.</em> [102]</td>
<td>2051</td>
<td>52.7%</td>
<td>38.2%</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Gallagher <em>et al.</em> [104]</td>
<td>715</td>
<td>34.5%</td>
<td>-</td>
</tr>
<tr>
<td>- Barry <em>et al.</em> [89]</td>
<td>600</td>
<td>-</td>
<td>57.9%</td>
</tr>
<tr>
<td>- Hamilton <em>et al.</em> [105]</td>
<td>600</td>
<td>56.2%</td>
<td>-</td>
</tr>
<tr>
<td>Long-term care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Ryan <em>et al.</em> [106]</td>
<td>313</td>
<td>59.8%</td>
<td>42.2%</td>
</tr>
<tr>
<td>- O’Sullivan <em>et al.</em> [107]</td>
<td>732</td>
<td>70.8%</td>
<td>-</td>
</tr>
</tbody>
</table>

PIM: Potentially inappropriate medication  PPO: Potential prescribing omission

It must be acknowledged that the rates of PIP are dependent on the PIP assessment tool utilised to detect prevalence. More recent versions of these tools may be capable of identifying additional instances of PIP in older adults; therefore, the true prevalence rates may be higher than reported [109].

PIP is usually more prevalent in community-dwelling older adults when they are in the hospital setting compared to when they are being managed in primary care. This hospitalised patient cohort are particularly at risk of PIP as they are often acutely unwell, have a wide range of comorbidities, and are often assessed and medicated by multiple prescribers. Furthermore, these patients are especially
susceptible to PIP at points of care transition [76]. However, admission to hospital may provide an opportunity to review older patients’ pharmacotherapy – this is particularly vital when the cause of admission may be medication-related. Laroche et al. observed that hospitalisation in an acute geriatric unit resulted in a significant reduction in PIP from admission to discharge [110]. However, the acute hospital environment is not always conducive to pharmacotherapy optimisation [111]. Moreover, older patients can often be exposed to new and possibly unnecessary medications during hospitalisation [67, 76]. Studies have shown that the prevalence of PIP in older adults may be higher or remain unchanged after hospitalisation in comparison to pre-admission, potentially exposing these patients to an increased risk of medication-related harm [112, 113].

1.4.3 Consequences of PIP

The high prevalence of PIP in older adults is a major public health concern worldwide. In 2017, the WHO launched its third Global Patient Safety Challenge: ‘Medication Without Harm’, aiming to reduce severe avoidable medication-related harm by 50% within 5 years [114]. PIP in older adults can contribute to a wide range of adverse patient outcomes and increased healthcare utilisation. PIP is associated with increased ED visits and unplanned hospitalisations [104, 115-118], prolonged hospital stays [119, 120], as well as increased morbidity and mortality [121, 122]. Many of these adverse outcomes in older adults are related to ADRs, and studies have shown that PIP is one of the main risk factors for ADRs [105, 123].

As well as effects on morbidity and mortality, ADRs can result in exorbitant healthcare costs. In 2002, a study calculated that approximately 76,800 older
people experience an avoidable hospital admission in the Netherlands each year resulting from preventable ADRs, at an average cost of €2,128 per drug-related admission [124]. In addition, it has been reported that ADRs extend hospitalisation by an additional 2 to 4 days on average [125], with the average cost of an in-hospital ADR estimated at €2,250 [126]. Furthermore, PIP in older adults results in superfluous medication costs. Cahir et al. reported the annual cost of PIMs in Ireland to be €45 million, equating to 9% of the total expenditure on pharmaceuticals in those aged ≥ 70 years [127].

Ultimately, PIP results in significant morbidity in older adults and increased healthcare costs, both in terms of greater medication usage and healthcare utilisation requirements to manage negative health consequences. However, certain adverse patient outcomes associated with PIP are potentially preventable. For example, approximately 70% of ADRs may be avoidable, most of which are also predictable [105, 128]. Not all risk factors for ADRs in older adults are amenable to intervention (e.g. age-related changes in pharmacokinetics and pharmacodynamics); however, PIP is one such risk factor that can be identified and targeted by interventions. Therefore, it is not surprising that PIP reduction has been the focus of many hospital-based interventions to prevent ADRs and other medication-related adverse patient outcomes.
1.5 Interventions to reduce PIP in hospitalised older adults

Hospitalisation may provide an opportunity to review the appropriateness of prescribing in a high-risk older adult population. However, without clear evidence of adverse outcomes such as ADRs, it can be difficult to prospectively determine prescribing that is truly inappropriate for older adults [129]. The term ‘PIP’ includes the word ‘potentially’ to emphasise that some PIP instances may not be truly inappropriate in all patient cases, and any pharmacotherapy review should also consider the individual patient’s preferences, goals of care, and life expectancy [130]. This ambiguity can make PIP more difficult to identify in hospitalised older patients, and even more difficult to intervene.

Whilst educational interventions have been a common approach taken to improve prescribing appropriateness in older adults in other healthcare settings [131-142], there are limited studies of this nature in hospitals [143-145]. Henceforth, interventions commonly employed with a more direct approach to minimising PIP in hospitalised older adults, and their associated outcomes, are outlined in the following section.

1.5.1 Prescribing assessment tools

Prescribing assessment tools are used to identify PIP instances in older adults, and are commonly employed in intervention studies to reduce PIP [146-148]. These approaches employ the use of explicit (rule-based) or implicit (judgment-based) criteria, or a combination of both. In 2013, a systematic review by Kaufmann et al. found 46 assessment tools to identify PIP, 28 (61%) of which were explicit, 8 (17%) were implicit, and 10 (22%) used a combined approach. Thirty-six (78%) of these
tools were aimed towards older people, with the remainder not specifying the target age group [149].

1.5.1.1 Explicit criteria

Explicit criteria are clearly defined statements that highlight instances of PIP, typically developed based on published evidence and expert opinions using consensus techniques [70]. These criteria are usually focused on drugs that should be avoided or used with caution in older adults in general or in certain disease states. Whilst they can be applied with little or no judgment, they often do not consider factors such as patient preferences, comorbidities, life expectancy, and quality of life [85].

Explicit criteria have high reliability and reproducibility, and can be readily applied in a structured manner to large cohorts of older patients; therefore, they are commonly deployed in intervention strategies to reduce PIP in hospitalised older adults [83]. A broad spectrum of explicit criterion-based tools has been developed worldwide [87, 88, 150-158]. However, lack of transferability outside the country of origin is a common drawback with many explicit PIM lists [70]. Most significantly, very few of these criteria have been proven to be more effective than standard pharmaceutical care when applied to older patients’ prescriptions in randomised controlled trial (RCT) settings [62].

The explicit PIP tools most commonly utilised and cited in the literature are Beers criteria, Screening Tool of Older People’s Prescriptions (STOPP) criteria, and Screening Tool to Alert to Right Treatment (START) criteria [87, 88]. Beers criteria, first published in 1991, were originally developed to identify PIM use in nursing
home residents [159]. Updated most recently in 2019, and now on their sixth iteration, Beers criteria currently include 30 criteria highlighting medications or medication classes to avoid in older adults, and 16 criteria specifying over 40 medication or medication classes to use with caution or to avoid in certain diseases or conditions [87]. Like many of the other explicit tools, Beers criteria do not assess for underprescribing. Furthermore, there are no RCTs demonstrating that application of Beers criteria to older patients’ prescriptions results in improved clinical outcomes.

The STOPP and START criteria were first published together in 2008 as an explicit screening tool to enable healthcare professionals to appraise older patients’ pharmacotherapy in the context of their concurrent diagnoses [160]. The most recent iteration – STOPP/START version 2 – contains 114 criteria, of which 3 are implicit prescribing rules (Appendix 1) [88]. STOPP criteria identify PIMs and START criteria identify PPOs, and they have been used in tandem as a successful intervention in RCTs to significantly reduce PIP, medication costs, and ADRs in hospitalised older adults [146, 148]. To date, the only other set of explicit prescribing criteria that have been shown in an RCT setting to improve clinical endpoints are the Fit fOR The Aged (FORTA) criteria [161]. In this RCT, Wehling et al. showed that application of FORTA criteria produced significant reductions in overprescribing, underprescribing, ADRs, as well as significant improvements in activities of daily living. The most recent iteration of the FORTA criteria contains 264 medications or medication classes organised into 26 main indication groups, whereby the prescriber is guided to the safest/most effective medications for each
of the common clinical conditions listed, including hypertension, atrial fibrillation, COPD, diabetes mellitus, and dementia [158].

PIP instances identified by explicit criteria-based tools may not always be truly inappropriate. These criteria were developed to complement good clinical judgment, not to replace it. Occasionally, instances of so-called ‘PIP’, as defined by explicit criteria, may be clinically justified, e.g. the use of propranolol to treat benign essential tremor, or the use of amitriptyline to treat severe postherpetic neuralgia (propranolol and amitriptyline being identified as drugs to be avoided at all times in Beers criteria). Patient-specific information is often required to identify true instances of PIP. A recent systematic review has shown that trials deploying criteria requiring detailed patient information, such as STOPP/START and FORTA criteria, are more likely to have a positive impact on clinical endpoints than criteria which are primarily drug-oriented, such as Beers criteria [162]. However, time constraints, particularly in the busy acute hospital setting, may be an obstacle to systematically applying an extensive set of criteria to multimorbid older adults with complex polypharmacy. Digitalisation of such criteria for the purpose of automated rapid deployment may be key in facilitating their routine application in clinical practice [88].

**1.5.1.2 Implicit criteria**

In contrast to the explicit criteria described above, implicit criteria consist of quality indicators of prescribing that are focused on the patient rather than on particular drugs or disease states. The user employs patient-specific information, published evidence, and one’s own pharmaceutical knowledge to make judgments about
appropriateness [76]. Whilst there are several implicit tools in the literature to evaluate prescribing in older adults [163], the most commonly used is the Medication Appropriateness Index (MAI) [164]. This tool contains ten criteria which are used to rate the appropriateness of each medication the patient is prescribed, posing questions such as:

- “Is there an indication for the drug?”
- “Is the medication effective for the condition?”
- “Is the duration of therapy acceptable?”

The sum of all the ratings for each criterion produces a measure of the overall appropriateness for that medication. This procedure is then repeated for each medication. However, the MAI does not assess for underprescribing. Instead, the Assessment of Underutilization of Medication (AOU) tool can be used to implicitly identify PPOs [165], and has been used to complement the application of MAI in measuring prescribing appropriateness [146].

Some implicit criteria-based tools have been deployed as an intervention in primary care, long-term care, and community pharmacy settings [166-168]. In the hospital setting, implicit criteria have primarily been employed to assess prescribing appropriateness as an outcome measure rather than as the sole intervention component [163, 169, 170]. However, the Assessing Care of Vulnerable Elders (ACOVE) criteria – which contain a broad set of quality indicators in caring for older adults, of which 24 (6%) are related to medication [171] – have been applied in the form of an intervention checklist to improve the appropriateness of prescribing thromboprophylaxis in hospitalised older adults [172].
The main advantage of implicit criteria-based tools is that they can focus more on the needs of individual patients. They have been shown to have good inter-rater agreement [163, 164], but successful deployment depends on the users’ levels of knowledge and experience. However, the most significant limitation in applying implicit criteria is their highly time-consuming nature. Thus, their employment has been primarily within the realm of research, with limited applicability to interventions in routine clinical practice.

1.5.2 Geriatrician-based assessments

Given the complexity of prescribing for older adults, it would seem logical that a pharmacotherapy review by a physician specialised in geriatric medicine would be valuable in improving the appropriateness of prescribing in hospitalised older adults. Patients under the care of geriatricians are less likely to have instances of PIP compared to those without specialist geriatrician care [173]. In the hospital setting, it is common for other specialist physicians to ask for a geriatrician’s expert review of older patients’ pharmacotherapy, particularly those with complicated medication regimens relating to complex comorbidity and geriatric syndromes. Studies have shown that recommendations provided by physicians specialised in geriatric medicine can significantly decrease PIP in hospitalised older patients, with reductions in PIMs, PPOs, and ADRs [146, 148, 174].

A comprehensive geriatric assessment (CGA) is a geriatrician-based intervention that enables pharmacotherapy optimisation as part of a more global evaluation of older patients’ healthcare problems, including assessment of their cognitive and physical functional status, quality of life, and life expectancy [175]. CGA
encompasses a thorough and holistic review of an older patient’s healthcare needs by a multidisciplinary team comprising a geriatrician and a number of other healthcare professionals, e.g. nurses, physiotherapists, occupational therapists, nutritionists, and pharmacists [70, 85]. This holistic approach provides an opportunity to utilise the knowledge and expertise of each multidisciplinary team member to make informed decisions in devising comprehensive treatment strategies specifically tailored for individual patients [176].

Several RCTs have proven that CGA in the inpatient hospital setting can be effective in improving prescribing appropriateness [177-179]. Owens et al. reported a significant reduction in ‘inappropriate medication choices’ after CGA compared to usual care in a single-centre RCT [177]. Similarly, a Norwegian study found a significant decrease in anticholinergic drugs, antipsychotics, and drug-drug interactions in the CGA intervention group compared to usual care [178]. Furthermore, Schmader et al. conducted a multi-centre RCT which showed that CGA significantly reduced the prevalence of inpatient PIMs and PPOs compared to usual care; however, there was no significant difference in ADRs between these groups [179]. A recent systematic review and meta-analysis has shown that older adults who receive CGA are more likely to be alive and in their own homes at follow-up than older people who do not receive CGA, but CGA may result in increased costs [180]. Furthermore, no CGA studies to date have shown significant improvements in clinical outcomes directly related to prescribing optimisation in hospitalised older patients (such as reducing ADRs).
Pharmacotherapy review as part of a CGA allows for a multidimensional interdisciplinary approach but may be time-consuming and resource-intensive. With an increasingly ageing population and a limited number of geriatricians, a medication review by a geriatrician as part of a CGA is not a feasible option for all hospitalised older adults, and perhaps is most suitable for those older patients with complex multimorbidity, frailty, or other geriatric syndromes [181].

1.5.3 Pharmacist interventions

With their training and expertise in pharmacotherapy, hospital pharmacists are well positioned to recognise and resolve instances of PIP in older adults, either independently or as part of a multidisciplinary team [169, 182]. Pharmacist initiatives to improve the appropriateness of prescribing in older adults may include practices such as:

i) medication review,

ii) participation in multidisciplinary team meetings and/or ward rounds,

iii) delivery of education sessions, and

iv) provision of patient counselling.

Pharmacist interventions of this nature usually involve a standardised assessment of older patients’ prescriptions, followed by provision of recommendations to the prescriber to optimise pharmacotherapy. These recommendations may be in the form of written communication, verbal communication, or through a combination of approaches. Face-to-face discussion with the prescriber, usually a physician, is highlighted in the literature as the preferred method of communication by pharmacists to resolve pharmacotherapy issues [183].
In previous studies, pharmacist interventions have achieved significant improvements in medication appropriateness in hospitalised older adults [169, 184-186]. Furthermore, a number of RCTs have also illustrated that pharmacist interventions can have a significantly positive impact on patient outcomes. Gillespie et al. showed that pharmacist interventions in hospitalised patients aged 80 years and older resulted in a 16% reduction in all hospital visits, a 47% reduction in ED visits, and an 80% reduction in drug-related readmissions compared to standard care (i.e. without direct involvement of ward-based pharmacists) [187]. O’Sullivan et al. showed that a structured pharmacist review of medication significantly decreased the proportion of older patients experiencing incident ADRs in hospital compared to patients receiving usual hospital pharmaceutical care (13.9% versus 20.7%; \( p = 0.02 \)) [147]. Furthermore, the interventions described in both RCTs were shown to be cost-effective [147, 187]. In fact, most clinical pharmacist interventions have been shown to be cost-effective as implementation costs are generally offset by cost savings associated with the reduction in PIP and ADRs [188-190].

However, not all pharmacists have expertise in geriatric pharmacotherapy. Therefore, intervention delivery and success may depend on the training and experience of the individual pharmacist. The specialisation of hospital pharmacists with further expanded roles may prove beneficial in achieving enhanced patient medication-related outcomes. The advent of pharmacist prescribing in some countries – either as collaborative, supplementary, or independent prescribers – has transformed the manner in which some pharmacists make interventions to improve older patients’ pharmacotherapy. For example, pharmacists making
prescription changes as part of a collaborative prescribing initiative in an Irish hospital has been shown to significantly improve medication appropriateness in older adults [191]. A recent systematic review has provided evidence that hospital pharmacists can prescribe to the same standards as doctors [192]. However, there is limited evidence to date to show that pharmacist prescribing interventions improve both medication appropriateness and clinical outcomes in hospitalised older adults.

1.5.4 Computerised interventions

Most computerised interventions aiming to improve prescribing appropriateness include either computer-based alerts or clinical decision support systems (CDSSs), usually embedded within computerised provider order entry (CPOE) systems to facilitate safer electronic prescribing. CDSSs are software applications designed to assist prescribers regarding drug choice, dosage, monitoring, potential interactions, as well as highlighting instances of PIP.

A fundamental component to the success of these computerised interventions is that they are integrated with patients’ electronic prescription records (EPRs) or electronic health records (EHRs), which may include an EPR as well as clinical data on the patients’ comorbidities and laboratory results. By linking these electronic records to computerised algorithms based on explicit prescribing rules, such as Beers criteria or STOPP/START criteria, detection of PIP and decision support at the point of prescribing can be provided, often in the form of an electronic alert. However, creating computerised algorithms to incorporate the complexity of prescribing for older adults can be profoundly challenging, especially given the
degree and wide range of multimorbidity and polypharmacy that often accompany the age-related changes in pharmacokinetics and pharmacodynamics in older people [193]. If the quality of the computerised algorithms is suboptimal, this can result in the generation of alerts that are of low relevance or the production of too many alerts. This predisposes to the phenomenon of ‘alert fatigue’, whereby clinicians may be overloaded with alerts and clinically important information may be ignored, increasing the risk of patient harm [194].

Despite the increasing deployment of these computerised interventions in hospitals in developed countries [195], their routine use in developing countries is often constrained by limited resources, and thus significant investment would be required [196]. However, once implemented, studies have proven that these interventions can be cost-effective by preventing medication errors, adverse drug events (ADEs), and reducing patients’ hospital length of stay [197].

Reviews have shown that computerised interventions can be successful in improving prescribing appropriateness for older adults in different healthcare settings [198, 199]. Two controlled studies have shown improved health-related outcomes with significant reductions in ADEs and inpatient falls respectively arising from application of such computerised interventions [200, 201]. However, most of the interventions in the literature are single-centre studies and do not routinely show improvements in patients’ health-related outcomes. Two European multi-centre RCTs have recently been completed which deployed the STOPP/START criteria (version 2) in computerised interventions – Software ENgine for the Assessment & optimization of drug and non-drug Therapy in Older peRsons
(SENATOR) and OPTimising ThERapy to prevent Avoidable hospital admissions in the Multimorbid elderly (OPERAM) [202, 203]. The SENATOR RCT’s primary aim was to reduce in-hospital ADRs, and the primary aim of the OPERAM RCT to reduce drug-related rehospitalisations. The results from both RCTs have not been published yet, but future interventions of this kind must demonstrate improved patient outcomes if they are to be utilised routinely in clinical practice.

1.5.5 Multiple component interventions

Given the complexity associated with optimising prescribing for older adults in an acute hospital environment, many research groups have conducted multiple component interventions which incorporate one or more of the elements described in the interventions above. Two studies have shown that a pharmacist medication review in combination with applying STOPP/START criteria or an adjusted STOPP tool have resulted in significant reductions in PIP, ADRs, ED visits without subsequent hospitalisation, as well as a significant improvement in patient quality of life [147, 185]. In addition, collaborative approaches between pharmacists and physicians have been shown to significantly improve the appropriateness of prescribing in hospitalised older patients, with significant reductions in ED visits [182, 187, 204]. Furthermore, some research groups have utilised computerised interventions in combination with other components to reduce PIP in this older patient group. Stevens et al. showed that combining a CDSS intervention with education and individual provider feedback can significantly reduce the number of PIMs in older adults in the ED [205]. Similarly, Cossette et al. have shown that pharmacist review of alerts from a computerised system in combination with CGA...
and education can also significantly decrease PIM use [206]. However, when multiple component interventions are successful in reducing PIP, it is not always clear which elements were effective, thus making replication problematic.

In summary, many of the interventions described throughout this section have shown significant reductions in PIP, but few studies produce significant improvements in clinical outcomes for hospitalised older patients. Even with the success of some initiatives, many of these interventions have been conducted in single centres or in a specific context that may not be transferable to other settings. Furthermore, few studies have demonstrated sustainable reductions in PIP, and therefore PIP prevalence remains unacceptably high. It has been hypothesised that low prescriber implementation rates of recommendations to improve appropriateness of prescribing may be maintaining this high prevalence of PIP, and potentially contributing to avoidable ADRs [147, 187]. Given the clear link between PIP, adverse patient outcomes, and increased healthcare costs, it is surprising that these low rates of prescriber implementation have not been extensively investigated in the literature to date.
1.6 Prescriber implementation of recommendations: a target for behaviour change interventions

1.6.1 Prescriber implementation rates of medication appropriateness recommendations

From the interventions described above, it is clear that many of the recommendations to improve the appropriateness of prescribing in older adults come from sources external to the prescribing team, for example: from geriatricians, pharmacists, and computerised systems (e.g. CDSSs or computerised alerts). Most geriatrician reviews of this nature are requested by other specialist physicians, and therefore their pharmacotherapy recommendations are highly likely to be implemented. However, recommendations from other external sources that have not been specifically requested by the prescribing team are less likely to be followed. The implementation rates of recommendations from pharmacist-based and computerised interventions to improve prescribing appropriateness in hospitalised older adults generally range from 39% – 69% [169, 186, 187, 207-209] and 29.3% – 95% [200, 201, 210, 211] respectively. If these pharmacotherapy recommendations are not implemented, it means that the high prevalence of PIP continues in these older patients, augmenting the risk of ADRs, rehospitalisation, and increased healthcare costs.

Pharmacist interventions with higher prescriber implementation rates for medication appropriateness recommendations [186, 187] are more likely to result in significantly improved patient outcomes in comparison to those with lower
implementation rates, which often show non-significant patient outcomes [207, 208]. However, O’Sullivan et al. showed that a structured pharmacist intervention in 361 patients with only 38.5% of medication appropriateness recommendations implemented can still result in a clinically significant 6.8% absolute risk reduction in patients with ADRs compared with standard pharmaceutical care \((p = 0.02)\) [147, 169]. Moreover, as the authors suggested, an enhanced implementation rate may have generated a further reduction in ADRs.

A narrative review on computerised interventions in various healthcare settings has suggested that computer-generated recommendations can be successful in improving prescribing appropriateness in older adults, but there is limited evidence showing how their implementation affects important patient outcomes such as hospital length of stay, rehospitalisation, and mortality [198]. Nevertheless, studies have shown significant reductions in both in-hospital falls and ADEs with relatively low implementation rates of 31% and 29% respectively [200, 201]. Further research is clearly required to assess the effectiveness, implementation rates, and patient outcomes specifically associated with computer-generated recommendations to improve the appropriateness of prescribing in hospitalised older adults.

In studies with pharmacist and computer-generated recommendations, the reported implementation rate is merely a quantitative measure of the intervention’s success. Many of these studies do not provide sufficient information on how the recommendations were communicated, how the intervention integrated into practice, or any specific barriers encountered. Therefore, it is important that quantitative and qualitative research be used in tandem to inform
the design of future intervention strategies targeting medication appropriateness in older adults.

**1.6.2 Identifying behavioural components affecting implementation**

Interventions based on medication appropriateness recommendations with high implementation rates are more likely to translate into improved clinical outcomes for hospitalised older patients compared to interventions with low implementation rates. Therefore, it would seem logical that future interventions should aim to attain high uptake rates for these recommendations. However, it is not always clear for researchers which specific intervention components contribute to achieving high implementation rates. Robust qualitative research is required to ascertain the key factors affecting prescriber behaviours concerning implementation of these recommendations. By identifying the pertinent barriers and facilitators, future interventions can be targeted towards changing practice to increase the implementation of recommendations.

**1.6.2.1 Behaviour change in healthcare interventions**

The UK Medical Research Council (MRC) framework advocates the incorporation of a theoretical basis into the development of complex interventions [212]. However, previous systematic reviews of interventions designed to change professional practice have shown that limited numbers of studies report using theory to inform intervention design [213, 214], even though the evidence from the literature demonstrates that theory-based behaviour change interventions are more effective than those without a theoretical base [215]. There are many different health psychology theories that could be utilised to inform and develop interventions
While the use of a single theory may be justified, it is preferable to utilise a more comprehensive approach to increase the likelihood of identifying all relevant factors underpinning a specific behaviour [217]. The Theoretical Domains Framework (TDF) is one such validated tool that has been synthesised using 33 behaviour change theories [217]. The TDF, now on its second iteration, is comprised of 14 domains based on 84 theoretical constructs related to behaviour change (Appendix 2). This integrative framework makes behaviour change theory more accessible to healthcare researchers, particularly those without a background in health psychology [218]. As a result, the TDF has been widely used by healthcare researchers to explain practice implementation problems and to inform interventions [219-223].

Whilst the TDF can be applied to quantitative data (e.g. from questionnaires), it is most commonly employed in qualitative studies (e.g. using interviews or focus groups). Even though no formal guidelines have been established on how to apply the TDF to qualitative interview studies, formulating topic guides based on the TDF is a well-established approach to ensure that intervention development is theory-based [224]. This allows exploration of interviewees’ perceptions on how each domain may affect the target behaviour, which provides greater clarification on the TDF-related barriers and facilitators that could be targeted by an intervention [225]. Thereafter, the transcripts are usually coded into the theoretical domains, with the most relevant domains or overarching themes representing the factors that predominantly influence the target behaviour [224]. The TDF is commonly employed with the Behaviour Change Wheel (BCW) (Appendix 3) to inform the
Having identified the relevant theoretical domains, these can then be mapped to the BCW to identify intervention functions as well as several behaviour change techniques (BCTs) that may be appropriate in addressing the target behaviour [226, 227].

1.6.2.2 Informing the development of interventions with enhanced prescriber implementation rates

In developing behaviour change interventions to optimise prescribing, one must be clear on the behaviour(s) being targeted. Hence, it is important now to distinguish between the behaviours of ‘prescriber acceptance’ and ‘prescriber implementation’ of medication appropriateness recommendations. Whilst many prescribers may agree with these recommendations and accept that action may be required, issues such as forgetting (due to distraction in the busy clinical setting) or patient preference can be problematic and prevent their implementation. The term ‘prescriber implementation’ demonstrates that the recommendation has been actively executed, and studies have shown large discrepancies between rates of prescriber acceptance and prescriber implementation of medication recommendations [228, 229]. Therefore, TDF-related qualitative studies in this research area should specifically explore the barriers and facilitators to successful implementation of medication recommendations provided to prescribers, and not just their acceptance of them.

The TDF has been used previously to explore the influences on prescriber behaviour regarding appropriate prescribing for older adults in different healthcare settings, with the subsequent identification of possible intervention types that may be
suitable in future studies using the BCW [111, 230, 231]. Going beyond this, the TDF and BCW have been exploited successfully to develop interventions to improve prescribing. Cadogan et al. have shown that an intervention developed using the TDF to improve appropriate polypharmacy for older people in primary care is feasible and acceptable to stakeholders [232]. Furthermore, Elouafkaoui et al. have shown that a TDF-informed intervention can be successful in significantly improving antibiotic prescribing practices of dentists [233]. Therefore, it would seem reasonable to expect that the TDF could also be employed in a similar fashion i) to explore the behavioural determinants underpinning prescriber implementation of medication appropriateness recommendations for older adults in the hospital setting, and ii) to use these findings to inform the development of future interventions to improve prescribing.

To date, the TDF has not been used to specifically assess factors affecting prescriber implementation of medication appropriateness recommendations from sources such as pharmacists and computer systems in the hospital setting. Therefore, these represent significant gaps in our knowledge and evidence base. By identifying the key barriers and facilitators to implementation of medication appropriateness recommendations from robust qualitative research methods, interventions can be tailored to address issues affecting prescriber implementation, and ultimately to improve medication appropriateness in hospitalised older adults.
1.7 Summary

PIP in older adults remains a significant healthcare problem worldwide. Despite the myriad of interventions that have been evaluated, there is still no widely accepted optimal strategy for reducing PIP in older hospitalised patients. Many interventions in hospital settings consist of recommendations from sources external to the prescribing team. However, these recommendations to improve the appropriateness of older patients’ pharmacotherapy are not always implemented by hospital prescribers, despite the abundant quantity of evidence highlighting the adverse outcomes that PIP may cause in this patient population.

Rather than maintaining a continued focus on conducting further interventions that may not be evidence-based, a clear gap in the evidence base must be addressed first, i.e. the key underlying factors affecting prescriber implementation of these medication appropriateness recommendations in the hospital setting. In addressing this knowledge gap, future theoretically-informed interventions can be designed that tackle the issue of non-implementation, thus improving medication appropriateness and patient outcomes.
1.8 Hypothesis, aims, and objectives

1.8.1 Hypothesis

The basis of this research is the knowledge that prescriber non-implementation of prescribing recommendations to improve medication appropriateness results in PIP continuation in older adults, thereby increasing the risk for adverse clinical outcomes. Robust research is required to investigate the reasons behind non-implementation of prescribing recommendations in order to inform the design of future interventions to effectively minimise PIP in hospitalised older adults.

1.8.2 Thesis aim and objectives

The overarching aim of this thesis is to identify the key factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults, focusing on the factors affecting implementation of i) computer-generated recommendations and ii) pharmacist recommendations.

Firstly, two definitive objectives were formed ab initio to achieve the aim of identifying the factors affecting prescriber implementation of these computer-generated recommendations:

1. To systematically review the literature in order to establish the effectiveness of computerised interventions designed to improve medication appropriateness in hospitalised older adults, the implementation rate of the computer-generated recommendations, and their associated clinical outcomes (Chapter 2).
2. To determine the key factors affecting prescriber implementation of computer-generated recommendations in the multi-centre SENATOR RCT using semi-structured interviews with physician prescribers and trial researchers (Chapter 3).

Thereafter, based on the findings from Chapter 3, a third objective was defined in order to achieve this aim:

3. To systematically evaluate the clinical relevance of the computer-generated recommendations in the SENATOR trial and to determine if the relevance of recommendations was associated with their rate of implementation (Chapter 4).

Furthermore, two specific objectives were defined in order to achieve the aim of identifying the key factors affecting prescriber implementation of pharmacist recommendations to improve the appropriateness of prescribing in hospitalised older adults:

1. To compare the prescriber implementation rates of STOPP/START recommendations between a pharmacist approach and a physician approach in the same hospital, and to identify components within the intervention approaches that may have affected the implementation rates (Chapter 5).

2. To explore the key factors affecting prescriber implementation of pharmacist recommendations in the hospital setting using semi-structured interviews with physician prescribers and pharmacists (Chapter 6).
1.8.3 Thesis outline

Each of the five objectives outlined above are associated with a specific study chapter (Chapters 2 – 6), which are then followed by an overarching discussion chapter (Chapter 7). Figure 1.1 illustrates how the individual studies undertaken as part of this doctoral research address the thesis aims and objectives and, when combined, these chapters provide a comprehensive investigation into the key factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults.
Overarching Aim:
- To identify the key factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults.

Aim i)
- To identify the key factors affecting prescriber implementation of computer-generated recommendations.

Aim ii)
- To identify the key factors affecting prescriber implementation of pharmacist recommendations.

Chapter 2:
To systematically review the literature on the effectiveness of computer-generated recommendations to improve medication appropriateness in hospitalised older adults.

Chapter 3:
To identify the factors affecting prescriber implementation of computer-generated STOPP/START recommendations in the SENATOR trial using semi-structured interviews.

Chapter 4:
To evaluate the clinical relevance of the computer-generated STOPP/START recommendations in the SENATOR trial, and to examine if the relevance of recommendations was associated with their implementation.

Chapter 5:
To compare prescriber implementation rates of STOPP/START recommendations between a physician intervention and a pharmacist intervention, and to identify the intervention components that may have affected implementation.

Chapter 6:
To identify the factors affecting prescriber implementation of hospital pharmacist recommendations using semi-structured interviews.

Discussion (Chapter 7):
To synthesise the findings from each chapter which may be used in the future development of theoretically-informed interventions to sustainably minimise inappropriate prescribing in hospitalised older adults and improve patient outcomes.
Chapter 2: Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: a systematic review and meta-analysis

2.1 Chapter description

In Chapter 1, I explained how hospitalised older adults are particularly vulnerable to PIP, and how computerised interventions may be effective in identifying PIP in this patient group. In this chapter, I conduct a systematic review and meta-analysis to examine the effectiveness of computerised interventions in minimising PIP in hospitalised older adults, with a secondary focus on the implementation rates of these computer-generated recommendations. An addendum is provided at the end of this chapter with a discussion of up-to-date search results.

The work of this chapter has been published as: Dalton K, O’Brien G, O’Mahony D, Byrne S. Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: a systematic review and meta-analysis. Age Ageing. 2018 Jun 8;47(5):670-8.
2.2 Abstract

2.2.1 Introduction

Computerised interventions have been suggested as an effective strategy to reduce PIP for hospitalised older adults. This systematic review and meta-analysis examined the evidence for efficacy of computerised interventions designed to reduce PIP in this patient group.

2.2.2 Methods

An electronic literature search was conducted using eight databases up to October 2017. Included studies were controlled trials of computerised interventions aiming to reduce PIP in hospitalised older adults (≥ 65 years). Risk of bias was assessed using Cochrane’s Effective Practice and Organisation of Care (EPOC) criteria.

2.2.3 Results

Of 653 records identified, eight studies were included - two randomised controlled trials, two interrupted time series analysis studies, and four before-after studies. Included studies were mostly at a low risk of bias. Overall, seven studies showed either a statistically significant reduction in the proportion of patients prescribed a PIM (absolute risk reduction 1.3% – 30.1%), or in PIMs ordered (absolute risk reduction 2% – 5.9%). It was only possible to include three studies in the meta-analysis for one of the primary outcomes – which demonstrated that intervention patients were less likely to be prescribed a PIM (odds ratio 0.6; 95% confidence interval [CI] 0.38, 0.93). No computerised intervention targeting PPOs was
identified. There is insufficient evidence thus far to suggest that these interventions can routinely improve patient-related outcomes.

2.2.4 Conclusion

This systematic review concludes that computerised interventions are capable of statistically significantly reducing PIMs in hospitalised older adults. Future interventions should strive to target both PIMs and PPOs, ideally demonstrating both cost-effectiveness data and clinically significant improvements in patient-related outcomes.
2.3 Introduction

Prescribing medications for older adults is a challenging process due to age-related alterations in pharmacokinetics and pharmacodynamics, often coupled with multimorbidity and polypharmacy [13, 28, 77]. In the hospital setting, older patients are commonly exposed to new medications under the care of multiple prescribers in the management of acute illness; this increases the risk for drug-drug interactions, drug-disease interactions, PIP, and ADRs [76].

Computerised interventions have been suggested as an effective strategy to support healthcare professionals’ decision-making and improve medication appropriateness for hospitalised older adults [85]. However, given the complexity associated with prescribing in this patient group, distinct challenges arise in designing software algorithms to generate patient-specific recommendations by factoring in all pertinent patient information [193], e.g. which may include a wide range of comorbidities, medications, and laboratory parameters.

In hospital settings, electronic prescribing and CPOE systems have been shown to reduce prescribing errors and aid in the prevention of ADEs [234, 235]. However, no review has yet summarised the evidence regarding the impact of computerised interventions in hospital to reduce PIP specifically in older adults. Therefore, the primary aim of this study was to collect all currently available evidence of prospective controlled studies that have utilised computerised interventions capable of independently identifying PIP and which aimed to improve the appropriateness of prescribing in hospitalised older adults (≥ 65 years). Second, it
2.4 Methods

This systematic review and meta-analysis were reported in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [236], and the PRISMA checklist is provided in Appendix 4. The inclusion criteria, exclusion criteria, and methods for the analysis were established in advance and documented in a protocol, which was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the identification number CRD42017059795.

A comprehensive electronic search of the literature was conducted using the following eight databases from inception up to and including October 2017: PubMed, EMBASE, Medline (via Ovid), Web of Science, CINAHL, Cochrane Central Register of Controlled Trials, PsycInfo and ClinicalTrials.gov. The search strategy was developed in PubMed using a combination of key words and Medical Subject Headings (as shown in Appendix 5). For each of the remaining databases, the search strategy was modified to suit their specific search capabilities if necessary. Additionally, the hand search involved scrutinising the bibliographies of i) any review papers that looked at computerised interventions in reducing PIP in older adults across different healthcare settings and ii) all papers that were included at the full text review stage to ensure no other relevant studies were missed.
2.4.1 Eligibility criteria

Studies were eligible if they described a controlled intervention in which an objective was to reduce PIP in hospitalised older adults (≥ 65 years) using computer-generated recommendations. The primary outcomes of interest for this review were: reductions in PIP or patients with PIP. The secondary outcomes of interest were patient outcomes and implementation rates of recommendations. As determined a priori, studies involving a multifaceted intervention would be included only if the effect of the computerised intervention on reducing PIP could be clearly determined. No date or language restrictions were applied.

2.4.2 Study selection

For the first stage of study selection, one reviewer screened titles to eliminate papers that were clearly not relevant to the research question. Secondly, two reviewers independently screened titles and abstracts to identify potentially pertinent full texts. The last stage involved papers being read in full and their suitability for inclusion was determined independently by two reviewers. Two authors were contacted to supply any additional information required to decide on inclusion of the full texts [237, 238]. Consensus on inclusion was reached by discussion between reviewers, with arbitration by a senior supervisor if necessary.

2.4.3 Data extraction

Data extraction was performed by one reviewer and verified by another. A data extraction form was piloted on two papers and adjusted thereafter where necessary. All authors of the included papers were contacted to provide supplementary information where required.
2.4.4 Risk of bias assessments

Two review authors independently assessed risk of bias for the included studies according to Cochrane’s Effective Practice and Organisation of Care (EPOC) risk of bias criteria [239]. Consensus on the assessments was reached by discussion, with advice from a senior supervisor if required. This tool was used to determine if any of the included studies were at a high risk of bias which may impact the findings from the narrative summary or meta-analysis.

2.4.5 Data Synthesis

Quantitative analysis was conducted if at least two studies had a common comparable primary outcome measure, and if pooling their results was deemed appropriate. Study heterogeneity was assessed qualitatively by reviewing the differences in the interventions and study design, whereas statistical heterogeneity was assessed using the $I^2$ statistic. Review Manager 5.3 software was employed to determine the pooled estimate of effect and 95% confidence intervals (CIs), with $p < 0.05$ considered statistically significant. When it was not possible to combine primary outcome data due to the variability in results reporting across studies, or simply due to lack of data available, a narrative summary was provided.

2.5 Results

2.5.1 Search results

A total of 653 studies were identified after duplicates were removed. After the exclusion of records based on their titles and abstracts, 20 full texts were assessed
for eligibility. Eight papers were suitable for inclusion in the systematic review. A PRISMA flow diagram describes the flow of studies in the review [236] and details the reasons for exclusion of full texts reviewed (Figure 2.1).

Figure 2.1: PRISMA flow diagram of search strategy results

2.5.2 Characteristics of included studies

The included studies’ characteristics and outcomes are provided in Table 2.1. A more detailed summary of each intervention is provided in Appendix 6. In four of
the studies, the intervention utilised clinical decision support within a CPOE system [200, 201, 210, 240]. In three other studies, the intervention consisted of alerts or reminders embedded into a CPOE system [211, 241, 242]. The remaining study involved the use of INTERcheck® software, a ‘computerised prescription support system’ which aimed to reduce PIMs, potentially severe drug-drug interactions, and anticholinergic burden [238]. The medications on admission were reviewed using the computerised tool and changed according to the INTERcheck® indication. This was the only included intervention not conducted at the point of PIM prescribing. In total, there were 18,507 control patients and 24,535 intervention patients across 6 of the studies [201, 210, 211, 238, 240, 241]. One study did not report the total number of patients – primary author contacted: data no longer available [242]. The remaining study reported patient visits only [200].

Six of the eight included studies utilised computerised alerts or reminders incorporated into a CPOE system, which appeared in various forms to notify healthcare professionals of PIP instances at the time a PIM was ordered [200, 210, 211, 240-242]. While some alerts simply provided information to the healthcare professional to guide prescribing [200, 242], others provided recommendations that required acceptance or rejection at the time of medication ordering [240]. Five of the six studies that utilised alerts or reminders suggested an alternative to PIM use [200, 210, 211, 240, 242]. The study by Lester et al. was the exception to this; they stated that the suggested alternative may also be inappropriate for certain older patients, thus forcing the prescriber to think for themselves regarding treatment options and the health status of individual patients [241].
### Table 2.1: Characteristics of included studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Country</th>
<th>Setting</th>
<th>Study Design</th>
<th>Aim of study</th>
<th>Intervention</th>
<th>Number of patients</th>
<th>Reduction in % of patients with PIMs</th>
<th>Reduction in % of PIMs</th>
<th>% Implementation rate of recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agostini et al. [211]</strong></td>
<td>USA</td>
<td>Adult inpatient service in a teaching hospital.</td>
<td>Before-after study</td>
<td>To develop a feasible, inexpensive, point-of-care computerised reminder to improve sedative-hypnotic prescribing in hospitalised older people.</td>
<td>Computerised reminder in a CPOE system aiming to minimise use of diphenhydramine and diazepam, and directing physicians to either a non-pharmacological sleep protocol or to an alternative medication, such as trazodone or lorazepam.</td>
<td>C: 12,356</td>
<td>I: 12,153</td>
<td>Total: 24,509</td>
<td>Prescribing of diphenhydramine and diazepam decreased from 18% in pre-intervention patients to 15% post-intervention.</td>
</tr>
<tr>
<td><strong>Boustani et al. [240]</strong></td>
<td>USA</td>
<td>Medical ward at a university-affiliated, public hospital.</td>
<td>Randomised controlled trial</td>
<td>To evaluate the efficacy of a CDSS to improve the quality of care for patients with cognitive impairment.</td>
<td>If a physician ordered any one of 18 inappropriate anticholinergic medications in a CPOE system, a CDSS interruptive alert recommended to discontinue the medicine, dose modification, or suggested an alternative.</td>
<td>C: 225</td>
<td>I: 199</td>
<td>Total: 424</td>
<td>Not stated.</td>
</tr>
<tr>
<td><strong>Ghibelli et al. [238]</strong></td>
<td>Italy</td>
<td>Acute geriatric ward in an academic urban hospital.</td>
<td>Before-after study</td>
<td>To evaluate the applicability of INTERcheck® as a means of reviewing older patients’ medicines. To evaluate the effectiveness of INTERcheck® in reducing PIMs, potentially severe DDIs, and anticholinergic burden.</td>
<td>The physician utilised a computerised prescription support system (INTERcheck®) to identify PIMs and potential drug-drug interactions, as well as aiming to reduce anticholinergic load and adjust doses in patients with renal impairment.</td>
<td>C: 74</td>
<td>I: 60</td>
<td>Total: 134</td>
<td>Between admission and discharge, the intervention resulted in a reduction in patients with PIMs (41.7% versus 11.6%).</td>
</tr>
<tr>
<td>Author</td>
<td>Country</td>
<td>Setting</td>
<td>Study Design</td>
<td>Aim of study</td>
<td>Intervention</td>
<td>Number of patients</td>
<td>Reduction in % of patients with PIMs</td>
<td>Reduction in % of PIMs</td>
<td>% Implementation rate of recommendations</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------</td>
<td>--------------------------</td>
<td>--------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------</td>
<td>-----------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Griffey et al. [201]</td>
<td>USA</td>
<td>Urban academic tertiary care emergency department.</td>
<td>Interrupted time series</td>
<td>To evaluate the impact of a CDS tool on physician ordering behaviour and ADEs.</td>
<td>When one of the study medications was ordered in a CPOE system for patients ≥ 65 years, a clinical decision support tool modified one or more of the following parameters: medication selection, default dosage, or default frequency. The physician could then choose to accept or override the recommendation. The tool was alternated ‘OFF’ and ‘ON’ in consecutive blocks during the study period.</td>
<td>C: 668 I: 739 Total: 1,407</td>
<td>Not stated.</td>
<td>During intervention periods, 69% of initial orders were not consistent with recommendations (potentially inappropriate) versus 77% during control periods.</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Lester et al. [241]</td>
<td>USA</td>
<td>University-affiliated hospital.</td>
<td>Before-after study</td>
<td>To evaluate the impact of “geriatric alerts” in the CPOE on ordering patterns of diphenhydramine, metoclopramide, and antipsychotics.</td>
<td>Informational alerts popped up when a PIM was ordered in the CPOE system. The physician was required to acknowledge the alert, before deciding on whether to cancel their order or continue prescribing the medication.</td>
<td>C: 3,259 I: 9,591 Total: 12,850</td>
<td>Pre-alert versus post-alert: patients prescribed diphenhydramine (26.9% versus 20%) and metoclopramide (16.7% versus 12.5%). There was no decrease in patients prescribed antipsychotics (8.8% versus 9.2%).</td>
<td>Not stated.</td>
<td>Not applicable.</td>
</tr>
<tr>
<td>Mattison et al. [242]</td>
<td>USA</td>
<td>Urban teaching hospital.</td>
<td>Before-after study</td>
<td>To determine whether a CPOE drug warning system can decrease orders for PIMs in hospitalised older patients.</td>
<td>The CPOE system alerted prescribers when a PIM was ordered by providing a medication-specific warning that advised alternative medication or dose reduction.</td>
<td>Not stated.</td>
<td>The authors state “a decline in the number of patients exposed to a subset of potentially problematic medications”. Specific figures are not reported, but the authors do state a reduction in the number of PIMs ordered per patient per day (0.07 versus 0.054).</td>
<td>The mean rate of non-recommended medicines (PIMs) ordered decreased from 11.56 to 9.94 orders per day post-intervention.</td>
<td>Not applicable.</td>
</tr>
</tbody>
</table>

Table 2.1: (continued) Characteristics of included studies
<table>
<thead>
<tr>
<th>Author</th>
<th>Country</th>
<th>Setting</th>
<th>Study Design</th>
<th>Aim of study</th>
<th>Intervention</th>
<th>Number of patients</th>
<th>Reduction in % of patients with PIMs</th>
<th>Reduction in % of PIMs</th>
<th>% Implementation rate of recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peterson et al. [200]</td>
<td>USA</td>
<td>Medical, surgical, neurology, and gynaecology services in a tertiary care hospital.</td>
<td>Interrupted time series</td>
<td>To encourage more conservative initial dosing and better psychotropic drug selection among hospitalised older patients.</td>
<td>A decision support tool altered the default dose and frequency for psychotropic medications for patients ≥ 65 years, and suggested an alternative medication when prescribers ordered one of 12 psychotropic medications known to be poorly tolerated in older patients. The support tool was activated for 2 of 4 six-week study periods in an off-on-off-on pattern.</td>
<td>C: 2,515 patient visits I: 2,647 patient visits Total: 5,162</td>
<td>Not stated.</td>
<td>The intervention reduced the prescription of non-recommended drugs (10.8% versus 7.6% of total orders)*.</td>
<td>29.3% - 29.3% of prescriptions for psychotropics agreed with system recommendations.</td>
</tr>
<tr>
<td>Terrell et al. [210]</td>
<td>USA</td>
<td>Emergency department in a university-affiliated urban public hospital.</td>
<td>Randomised controlled trial</td>
<td>To evaluate the effectiveness of CDS in reducing PIP in older adults</td>
<td>Nine high-use and high impact PIMs, selected by an expert panel consisting of two doctors of pharmacy, two physician information technology experts, three geriatricians, and three emergency physicians.</td>
<td>C: 1,925 I: 1,793 Total: 3,718</td>
<td>There were significantly fewer patients prescribed PIMs by the intervention physicians compared with the control physicians (2.6% versus 3.9%)*.</td>
<td>Lower proportion of inappropriate medications in the intervention group (3.4% versus 5.4%)*.</td>
<td>43% - Decision support was provided 114 times to physicians, who accepted 49 (43%) of the recommendations.</td>
</tr>
</tbody>
</table>

USA: United States of America, CPOE: Computerised physician order entry, C: Control, I: Intervention, CDSS: Computerised decision support system, PIM: Potentially inappropriate medication, DDI: Drug-drug interaction, CDS: Clinical decision support, PIP: Potentially inappropriate prescribing * Statistically significant difference, † No statistically significant difference.
Results of the risk of bias assessments

The results of the risk of bias assessments are shown in Table 2.2. All of the included studies were found to be at a low risk of bias overall, with one exception where the risk of bias was deemed unclear [242]. Both RCTs recognise that they may have been at risk of contamination [210, 240]. However, the potential for contamination in these studies, if present, would tend to bias against finding an effect of the intervention.

According to Cochrane’s EPOC criteria [239], the before-after studies must be deemed ‘high risk’ with regard to the two selection bias domains. Three of the four before-after studies did not provide enough information to confirm that the baseline characteristics and outcome measurements were similar [211, 241, 242], and thus the risk of bias was deemed ‘unclear’.
Table 2.2: Risk of bias assessments

<table>
<thead>
<tr>
<th>Author (RCTs* and before-after studies)</th>
<th>Selection Bias</th>
<th>Detection Bias</th>
<th>Attrition Bias</th>
<th>Reporting Bias</th>
<th>Other Bias</th>
<th>Overall Risk of Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random sequence generation</td>
<td>Allocation concealment</td>
<td>Baseline outcome measurements similar</td>
<td>Baseline characteristics similar</td>
<td>Free of contamination</td>
<td>Outcome assessment</td>
</tr>
<tr>
<td>Agostini et al. [211]</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Boustani et al. [240]*</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Ghibelli et al. [238]</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Lester et al. [241]</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Mattison et al. [242]</td>
<td>-</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Terrell et al. [210]*</td>
<td>+</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Author (Intermittent time series analysis studies)</th>
<th>Was the intervention independent of other changes?</th>
<th>Was the shape of the intervention effect pre-specified?</th>
<th>Was the intervention unlikely to affect data collection?</th>
<th>Was the knowledge of the allocated interventions adequately prevented during the study?</th>
<th>Were incomplete outcome data adequately addressed?</th>
<th>Was the study free from selective reporting?</th>
<th>Other risks of bias</th>
<th>Overall risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Griffey et al. [201]</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Peterson et al. [200]</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Judgments are categorised as ‘Low Risk’ of bias (+), ‘High Risk’ of bias (-) or ‘Unclear Risk’ of bias (?)

* RCTs: Randomised controlled trials
2.5.4 Reduction in patients with PIMs

2.5.4.1 Quantitative analysis

Three of the eight studies had data available on the exact number of patients that were prescribed PIMs as an outcome, and so were amenable to quantitative analysis [210, 211, 238]. In these three studies, there were a total of 29,791 patients/patient visits (14,860 and 14,931 in the intervention and control arms respectively). Given the heterogeneous types of intervention and considerable statistical heterogeneity between the study results ($I^2 = 82\%; p = 0.004$), a random-effects model was performed to provide a pooled estimate of effect. The meta-analysis found that patients in the intervention group were less likely to be prescribed PIMs post-intervention (odds ratio 0.6; 95% CI: 0.38, 0.93) (Figure 2.2).

These three studies were found to be at a low risk of bias, so one can be reasonably confident in the results of this meta-analysis.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Events</th>
<th>Total</th>
<th>Control Events</th>
<th>Total</th>
<th>Weight</th>
<th>Odds Ratio IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agustini et al.</td>
<td>1832</td>
<td>12153</td>
<td>2268</td>
<td>17950</td>
<td>48.5%</td>
<td>0.82 (0.78, 0.87)</td>
</tr>
<tr>
<td>Chibnall et al.</td>
<td>17</td>
<td>69</td>
<td>25</td>
<td>60</td>
<td>15.3%</td>
<td>0.16 (0.07, 0.47)</td>
</tr>
<tr>
<td>Terrell et al.</td>
<td>99</td>
<td>2647</td>
<td>98</td>
<td>2515</td>
<td>38.2%</td>
<td>0.69 (0.48, 0.98)</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>14180</td>
<td>14301</td>
<td>100.0%</td>
<td></td>
<td></td>
<td>0.60 (0.38, 0.93)</td>
</tr>
<tr>
<td>Total events</td>
<td>1900</td>
<td>2332</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.11; \chi^2 = 11.25, df = 2 (P = 0.004); I^2 = 82\%$

Test for overall effect: $Z = 2.26 (P = 0.02)$

Figure 2.2: Forest plot for the odds ratio for the reduction in the proportion of patients prescribed PIMs post-intervention
2.5.4.2 Narrative summary

Four of the included studies reported results on the effect the intervention had on the proportion of patients prescribed PIMs, all of which showed a statistically significant reduction \( (p < 0.05) \) for this outcome [210, 211, 238, 241]. Where it was possible to calculate, there was an absolute risk reduction of 1.3% – 30.1% [210, 211, 238], and a relative risk reduction of 16.7% – 72.2% [210, 211, 238, 241] in patients prescribed PIMs across the studies.

2.5.5 Reduction in PIMs prescribed

Due to the variability in which the results were reported, a meta-analysis could not be performed for this primary outcome. Where it was possible to calculate, there was an absolute risk reduction of 2% – 5.9% [200, 210, 238], and a relative risk reduction of 14% – 77.6% [200, 210, 238, 242] in PIMs prescribed across the studies. Overall, six studies showed a reduction in the number of PIMs prescribed when comparing the intervention and control groups, with five studies demonstrating statistically significant reductions \( (p < 0.01) \) [200, 240, 242]. The only exception to this was the study by Boustani et al., whereby the intervention group still had a greater discontinuation rate in anticholinergic drug orders versus the control group, but the difference was not statistically significant (48.9% versus 31.2%; \( p = 0.11 \)) [240]. As previously mentioned, contamination may have been an issue in this study which may have reduced the difference found between the groups. Given the overall low risk of bias in these studies, one can be reasonably confident in the results provided.
2.5.6 Implementation rates of computer-generated recommendations

Four of the included studies have data on implementation rates or levels of agreement with the computer’s recommendations (Table 2.3) [200, 201, 210, 211].

Table 2.3: Implementation rates of computer-generated recommendations

<table>
<thead>
<tr>
<th>Author</th>
<th>Intervention type</th>
<th>Medications involved</th>
<th>% Implementation Rates or Agreement with Recommendations (intervention arm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agostini et al. [211]</td>
<td>Computerised reminder</td>
<td>Diazepam and diphenhydramine</td>
<td>95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95% of patients were successfully directed to a non-pharmacological sleep protocol, or to a safer sedative-hypnotic drug.</td>
</tr>
<tr>
<td>Terrell et al. [210]</td>
<td>Computerised decision support</td>
<td>Nine high-use and high impact PIMs</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Decision support was provided 114 times to intervention physicians, who accepted 49 (43%) of the recommendations.</td>
</tr>
<tr>
<td>Griffey et al. [201]</td>
<td>Computerised decision support</td>
<td>Benzodiazepines, NSAIDs, opiates, sedative-hypnotics</td>
<td>31%; 7.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Of initial medicine orders: 403/1283 (31%) were consistent with the computerised recommendations for medication dosage/frequency. 7.5% of suggestions for alternatives were accepted (4/53).</td>
</tr>
<tr>
<td>Peterson et al. [200]</td>
<td>Computerised decision support</td>
<td>Seventy-two medications chosen by expert panel</td>
<td>29.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>29.3% of prescriptions for psychotropics were in agreement with system recommendations.</td>
</tr>
</tbody>
</table>


2.5.7 Reasons for not implementing recommendations

Three studies identified reasons why prescribers did not accept or may have overridden the computerised recommendations [201, 210, 242]. A patient having previously tolerated a PIM was the most common reason for non-implementation of recommendations in two of the studies [201, 210], while it remained the second
most common in the remaining study after the reason that the prescriber felt that the regimen was clinically indicated [242]. This perhaps suggests a degree of inertia with regard to addressing PIP in the acute hospital setting.

Some of the other reasons given in these three studies included:

i) On the advice of a consultant, the medicine is not to be changed [201].

ii) No good substitute exists for the medication [210].

iii) The patient insists on the medication [210].

iv) Interaction noted, regimen clinically indicated, will closely monitor [242].

v) Warning noted, will use smaller dose and monitor for side effects [242].

2.5.8 Clinical outcomes

Three of the included studies assessed clinical outcomes [200, 201, 240]. Griffey et al. demonstrated a statistically significant reduction in ADEs (3.4% versus 7.1%; \( p = 0.02 \)) [201] and Peterson et al. showed a statistically significant reduction in inpatient falls (0.28 versus 0.64 falls per 100 patient-days; \( p = 0.001 \)) [200]. However, there was no statistically significant difference in the remaining fifteen clinical outcomes identified, such as hospital length of stay, readmission rates, or mortality rates (Table 2.4).
Table 2.4: Studies which assessed clinical outcomes

<table>
<thead>
<tr>
<th>Author</th>
<th>Description of Clinical Outcomes</th>
</tr>
</thead>
</table>
| Boustani et al. [240] | All clinical outcomes with no statistically significant difference (0/9)  
No statistically significant effects on health outcomes including:  
- the mean days of hospital stay (intervention: 7.7 days versus usual care: 6.8, \( p = 0.12 \)),  
- 30-day mortality rate (intervention: 6% versus usual care: 5.8%, \( p = 0.69 \)),  
- home discharge (intervention: 43.2% versus usual care: 36.9%, \( p = 0.13 \)),  
- 30-day readmission rates (intervention: 18.6% versus usual care: 16.4%, \( p = 0.53 \)),  
- hospital-acquired complications (intervention: 47.2% versus usual care: 44.9%, \( p = 0.94 \)).  
The hospital-acquired complications included:  
- incidence of delirium (intervention: 33.7% versus usual care: 31.1%, \( p = 0.78 \)),  
- the presence of ICD-9 codes of pressure ulcer at discharge (intervention: 12.1% versus usual care: 11.1%, \( p = 0.77 \)),  
- the presence of ICD-9 code for fall or injury at discharge (intervention: 4.5% versus usual care: 4.9%, \( p = 0.88 \)),  
- orders for physical restraints or patients observed to be physically restrained (intervention: 11.1% versus usual care: 7.6%, \( p = 0.54 \)). |
| Griffey et al. [201] | One clinical outcome with statistically significant difference* (1/5)  
No significant differences were observed in: admission rate, reversal drug administration, number of 10-fold orders, or emergency department length of stay.  
*ADEs: There were 39 ADEs identified, distributed as 8/237 patients (3%; 95% CI: 1% – 6%) during ON periods and 31/436 patients (7%; 95% CI 5% – 9%) during OFF periods (\( p = 0.02 \)). |
| Peterson et al. [200] | One clinical outcome with statistically significant difference† (1/3)  
No difference between control and intervention for length of stay or altered mental status.  
†The rate of falls continued to be significantly less (0.28 versus 0.64 falls per 100 patient-days; \( p = 0.001 \)). |

ICD: International Classification of Diseases; ADE: Adverse drug event; CI: Confidence interval.
2.6 Discussion

This systematic review and meta-analysis showed that computerised interventions can reduce PIP in hospitalised older adults. Although seven of the eight included studies showed a statistically significant reduction in PIMs ordered or the proportion of patients prescribed PIMs, it is important to note that all of these were single-centre studies. Furthermore, all the included studies in this review were conducted in the United States of America (USA), except for one study conducted in Italy [238], and therefore this may impact on the generalisability of the review findings for other countries.

The implementation rates of the computer-generated recommendations varied highly across the studies that measured this outcome (Table 2.3). These findings suggest that interventions that target a smaller number of PIP instances may have greater recommendation implementation rates than those targeting a wider range of PIP instances. One reason for this may be that prescribers could become overwhelmed by the complexity of information provided in broader interventions [243]. It is interesting to note that Agostini et al. achieved a 95% success rate in switching to a safer alternative to a PIM, whereas only 4/53 (7.5%) recommendations for alternatives were accepted in Griffey et al. [201, 211]. Thus, providing a recommendation for an alternative does not necessarily mean that prescribers will accept this and discontinue the PIM in question. Further qualitative research is required to identify factors affecting implementation of computer-generated recommendations of this kind.
Autonomy is very important when encountering computerised interventions such as these; prescribers should be capable of bypassing recommendations where clinically appropriate [211]. While overrides are often justified, they can be associated with serious adverse events (or even death) if clinically significant information is unintentionally ignored [244]. A common reason for overrides may be due to ‘alert fatigue’, whereby prescribers may pay less attention if they are encountering repeated or inappropriate alerts, or are being inundated by a large quantity of alerts [241, 244]. Customisation of alerts for individual institutions may improve their specificity, and potentially reduce the occurrence of this phenomenon [245].

The results of this systematic review are in keeping with that of previous reviews, which have shown that computerised interventions may be effective in improving the appropriateness of prescribing in older adults. One review assessed the use of electronic prescribing and other forms of technology in reducing PIP and polypharmacy in older adults [198], and an older review evaluated computer decision support to improve medication prescribing in older adults [199]; however, both studies broadly looked at interventions across different healthcare settings. This is the first systematic review to focus specifically on computerised interventions which aimed to reduce PIP for older adults in the hospital setting.

It should be noted that only two of the included studies in this review were RCTs, which are considered the most robust way of identifying if a cause-effect relationship exists between an intervention and outcome [246]. The studies included in the meta-analysis were at a low risk of bias; however, the pooled
estimate of effects may have been biased as incomplete reporting in some papers meant that these were the only studies which allowed comparison of one of the primary outcomes (data retrieval bias) [247]. Even though the other studies that assessed this outcome showed a statistically significant reduction in the proportion of patients prescribed PIMs, the pooled estimate may not accurately represent the true effect that these computerised interventions can have on reducing PIP in hospitalised older adults, especially when you consider that the meta-analysis contained studies that were not RCTs. Despite these limitations, this review is valuable for healthcare professionals as it shows that computerised interventions can be implemented in hospital settings to reduce instances of PIP for older patients.

This systematic review aimed to identify computerised interventions targeting PIMs and PPOs. However, the included studies in this review only targeted PIMs, and did not identify medication underuse, i.e. PPOs which older patients may benefit from. Despite the comprehensive search strategy, it is still possible that all relevant papers may not have been identified. A systematic review by Meid et al. recommended that future interventions targeting PIP should utilise explicit criteria, such as START, alone or in combination with implicit reasoning, to screen for medication underuse in older people [248]. Thus, if possible, computerised interventions should strive to target PPOs and not just PIMs.

With the increasing prevalence of electronic prescribing and CPOE worldwide, it should be noted that implementing these systems does not always result in positive patient outcomes [249]. Hospital managers and other key stakeholders will have to
devise strategies to allow for successful integration with clinical workflows and with other technologies already in place. All but one of the interventions in this review were conducted at the point of prescribing, which may be a key feature for designing future studies. The advantage of this is that prescribers are prompted in real time to address medication appropriateness issues to reduce the risk of ADE at the earliest possible point.

Hospital managers will also have important roles in assigning funding to these computerised systems. It has been demonstrated that the extra costs associated with the implementation of CPOE with a CDSS are acceptable in the prevention of medication errors and preventable ADEs [250]. Further research should aim to identify how best to integrate these new computerised systems into routine clinical practice, and to explore the factors affecting implementation of computer-generated recommendations.

2.7 Conclusion

Overall, these findings demonstrate that computerised interventions can be effective in significantly reducing PIMs in hospitalised older adults. Larger scale multi-centre RCTs, at national and international levels, are required to further demonstrate the benefit of these interventions across different institutions, ideally showing both cost-effectiveness data and clinically significant improvements in patient outcomes.
2.8 Addendum

2.8.1 Updated search methods

An updated search of the eight electronic databases was conducted in August 2019 to search for all potentially relevant articles published since October 2017, the date of the latest search prior to publication of the systematic review and meta-analysis [251]. Once duplicates were removed, records were excluded based on screening their titles and abstracts. Thereafter, potentially relevant articles were read in full to decide on their inclusion. Authors were contacted to provide any additional information that was necessary to decide on their eligibility for inclusion and/or to provide relevant data based on this review’s outcome measures [252-255].

2.8.2 Analysis methods

Quantitative analysis was conducted on the additional studies from the updated search if they had a common comparable primary outcome measure with at least one other study, and if combining their results was considered appropriate. Review Manager 5.3 software was utilised to determine the pooled estimate of effect and 95% confidence intervals (CIs), with $p < 0.05$ considered statistically significant. Where it was not possible or not appropriate to pool primary outcome data, a narrative synthesis was provided. Risk of bias in the additional studies was assessed using Cochrane’s EPOC criteria [239].

2.8.3 Updated search results

A total of 234 records were screened after the removal of duplicates, of which 214 records were excluded based on their titles and abstracts. Where available, the full
texts of the remaining records were assessed for inclusion. This resulted in one article meeting the eligibility criteria, which was included in the updated systematic review, as shown in Figure 2.3.

Figure 2.3: PRISMA flow diagram of updated search strategy results

2.8.4 Updated narrative synthesis and meta-analysis

The article from Kim et al. was the only one deemed eligible for inclusion after the updated literature search [255]. The aim of this additional study was to identify the effect of the introduction of a CPOE template that altered the default dose listed for
opioids, benzodiazepines, and non-steroidal anti-inflammatory drugs (NSAIDs) for all older adults (aged ≥ 65 years) in the emergency departments of two university-affiliated hospitals in the USA [255]. The primary outcome measure in this study was the difference in frequency of the medications of interest with the recommended starting dose in older adults between two 4-month time periods: from May – August 2015 and May – August 2016, before and after the implementation of a modified CPOE template, which was introduced in both hospitals in September 2015. Pre-intervention, 2561 doses were administered to 1002 patients, of which 1863 were not in line with the recommended dose (72.7%). Post-intervention, 2700 doses were administered to 944 patients, whereby physician prescribers implemented 22.5% of default starting dose recommendations, meaning that 1823 doses that were not in line with the recommended dose (67.5%). The absolute risk reduction and relative risk reduction in non-recommended doses were 5.2% and 7.2% respectively. This reduction in PIP was found to be statistically significant (67.5% versus 72.7%; \( p < 0.001 \)). However, it should be noted that a statistically significant difference was reported in one of the hospital sites (a 9% improvement in recommended dosing) but not in the other. Kim et al. did not investigate the effect of the intervention on patient outcomes, and this additional study was judged to have a low risk of bias overall.

No data was available on the reduction of the proportion of patients with PIMs from the Kim et al. article. Therefore, the study results were not amenable for inclusion in the previously published meta-analysis. However, the nature of the intervention and results reporting in Kim et al. were very similar to that of one of
the original eight included studies (the one conducted by Griffey et al.) [201], which meant it was possible to pool these results together for a new meta-analysis (Figure 2.4). This meta-analysis found that non-recommended doses were less likely to be prescribed in the intervention group (odds ratio 0.72; 95% CI: 0.61, 0.86).

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Events</th>
<th>Control Events</th>
<th>Odds Ratio IV, Random, 95% CI</th>
<th>Odds Ratio IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Griffey et al.</td>
<td>860</td>
<td>1283</td>
<td>0.80(0.64, 0.78)</td>
<td></td>
</tr>
<tr>
<td>Kim et al.</td>
<td>1823</td>
<td>2700</td>
<td>0.76(0.60, 0.90)</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>2703</td>
<td>3676</td>
<td>0.72(0.61, 0.86)</td>
<td></td>
</tr>
<tr>
<td>Total events</td>
<td>2703</td>
<td>2722</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity: $\tau^2=0.01$, $\chi^2=2.81$, df = 1, ($P = 0.11$), $I^2=62%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: $Z = 2.67$, $P = 0.0002$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.4: Forest plot for the odds ratio for the reduction in the proportion of non-recommended doses prescribed post-intervention**

### 2.8.5 Discussion

The study from Kim et al. showed a significant reduction in the number of non-recommended doses of high-risk medications in hospitalised older adults. These findings are line with the studies from the initial search, whereby seven of the eight interventions were found to significantly reduce PIP in this patient group. The 5.2% absolute risk reduction in non-recommended doses (i.e. PIMs prescribed) post-intervention is at the higher end of the range found in the original systematic review (2% – 5.9%), but the 7.2% relative risk reduction for this outcome is below the range from the original included studies (14% – 77.6%) [251]. In the Kim et al. study, prescribers implemented 22.5% of default starting dose recommendations from the computer, which was below the range of 29.3% – 95% found in the original articles, and no reasons were provided for prescribers’ non-implementation of recommendations.
With the addition of the Kim et al. paper after the updated search, eight of the nine included studies were conducted in the USA, which impacts on the generalisability of the findings to hospital settings in other countries. In addition, the transferability of the findings could also be questioned given that a statistically significant reduction in PIP was found in only one of the two hospital settings in the Kim et al. study, despite having the ‘same’ computerised intervention. As with the majority of the original included articles, Kim et al. did not investigate the effect of the intervention on patient outcomes. Given that this updated systematic review has shown that computerised interventions significantly reduce PIP in hospitalised older adults, it is imperative that future studies focus on demonstrating significant improvements in patient outcomes, and not just on reducing PIP.

Due to time constraints, this update to the previously published systematic review was conducted solely by the primary researcher. Hence, it is possible that relevant studies were unintentionally omitted. Therefore, I recommend that an updated systematic review and meta-analysis be conducted by multiple researchers prior to dissemination of the findings.

Please note that Chapters 3 & 4 (pp. 76-122) are unavailable due to a restriction requested by the author.
Chapter 5: Prescriber implementation of STOPP/START recommendations for hospitalised older adults: a comparison of a pharmacist approach and a physician approach

5.1 Chapter description

In Chapter 4, I evaluated the clinical relevance of computer-generated medication appropriateness recommendations, and the findings showed that clinical relevance was a significant factor affecting their implementation by prescribers in the SENATOR trial. However, medication appropriateness recommendations provided by a healthcare professional, such as a pharmacist or physician, are likely to be clinically relevant. Whilst the degree of relevance may still influence implementation, it is likely that there are other factors at play.

In this chapter, I compare the prescriber implementation rates of STOPP/START recommendations from similar pharmacist and physician interventions to help identify factors affecting prescriber implementation of medication appropriateness recommendations in the hospital setting, which could then be explored in depth using qualitative research methods in future.
The work of this chapter has been published as: Dalton K, O’Mahony D, O’Sullivan D, O’Connor MN, Byrne S. Prescriber implementation of STOPP/START recommendations for hospitalised older adults: a comparison of a pharmacist approach and a physician approach. Drugs Aging. 2019 Mar 8;36(3):279-88
5.2 Abstract

5.2.1 Introduction

Two RCTs conducted simultaneously in the same acute university teaching hospital in the Republic of Ireland have shown that provision of recommendations based on STOPP/START criteria to attending prescribers can reduce in-hospital ADRs in older adults (≥ 65 years). One of the RCT interventions was conducted by a physician and the other by a pharmacist. The aims of the present study were to compare the prescriber implementation rates of STOPP/START recommendations between the physician approach and the pharmacist approach in these two RCTs and to provide a narrative summary of the comparable clinical outcomes.

5.2.2 Methods

Data were extracted from the two RCT published papers and their associated computerised databases to calculate the percentage prescriber implementation rates for the STOPP/START recommendations. The chi-square test was used to quantify the differences in prescriber implementation rates, with differences considered statistically significant where \( p < 0.05 \).

5.2.3 Results

Prescriber implementation rates of the STOPP and START recommendations made by the physician were 81.2% and 87.4% respectively, significantly higher than those made by the pharmacist (39.2% and 29.5% respectively), \( p < 0.0001 \). A greater absolute risk reduction in patients with ADRs was shown with the physician’s intervention compared to the pharmacist’s intervention (9.3% versus 6.8%).
5.2.4 Conclusion

This study shows that the methods of communication and the medium through which the STOPP/START recommendations are delivered significantly affect their implementation. Non-implementation of some pharmacist-delivered recommendations may be contributing to preventable ADRs in older adults. Thus, future research should aim to identify the factors influencing prescriber implementation of pharmacist recommendations in order to inform the design of more effective pharmacist interventions in optimising older patients’ pharmacotherapy.
5.3 Introduction

The STOPP and START criteria are well recognised tools for aiding identification of PIP in older adults, and have been utilised in a range of healthcare settings worldwide [88, 308]. Used in tandem, the criteria can be routinely applied to older patients’ pharmacotherapy and concurrent diagnoses to identify PIMs (via STOPP criteria) and PPOs (via START criteria). Studies deploying these criteria as part of the intervention routinely result in improvements in medication appropriateness [146, 174]. Two RCTs conducted in the same large acute university teaching hospital in the Republic of Ireland demonstrated a clinically significant absolute risk reduction in incident ADRs in multimorbid older adults arising from physician-delivered and pharmacist-delivered pharmacotherapy recommendations to attending prescribers [147, 148]. Both RCTs included the primary researcher (physician or pharmacist) providing recommendations based on STOPP/START criteria version 1 (Appendix 17) [7] to attending physician prescribers caring for hospitalised older adults.

The primary aim of the present study was to compare the prescriber implementation rates of STOPP and START recommendations from these two RCTs conducted simultaneously in the same Irish university teaching hospital, where the recommendations were delivered by a physician in one trial and by a pharmacist in the other trial [147, 148]. Secondary aims were to identify components within the interventions that may have affected prescriber implementation, to compare the prescriber implementation of the pharmacist’s STOPP/START recommendations with other pharmacist-delivered recommendations, and to provide a narrative summary of comparable clinical outcomes in the two RCTs.
5.4 Methods

5.4.1 Study setting and intervention details

Both RCTs were conducted in Cork University Hospital, an 810-bed tertiary referral centre in the Munster province of the Republic of Ireland. Participants were enrolled within 48 hours of their presentation to hospital with acute illness. The interventions in both RCTs primarily aimed to reduce non-trivial in-hospital ADRs in older adults (≥ 65 years), and are briefly summarised below.

In both RCTs [147, 148], the primary researcher applied the STOPP/START criteria (version 1) [7] at a single time point to the medication list of intervention patients within 48 hours of hospital admission, and placed a printed report in the patient’s clinical records with STOPP/START-based recommendations. The primary researcher in each trial verbally notified the attending prescribers of the recommendations and answered any clarifying questions that they may have had.

In RCT 1, the physician verbally notified the attending prescribers of the STOPP/START-based recommendations for all patients [148]; in RCT 2, the pharmacist verbally notified the attending prescribers of the recommendations for approximately one third of patients, but provided mobile phone contact details on the printed report in case prescribers wanted verbal clarification on the pharmacist’s advice [147]. In RCT 2, the pharmacist’s STOPP/START-based recommendations were provided in conjunction with recommendations based on other medication appropriateness issues, i.e. including drug-drug interactions, need for renal and hepatic dose adjustments, and other PIP instances identified utilising
Beers criteria (version 3) [309] and PRISCUS criteria [156], as well as issues based on medication reconciliation, which has been defined as the “process of identifying the most accurate list of all medications a patient is taking - including name, dosage, frequency, and route - and using this list to provide correct medications for patients anywhere within the health care system” and “involves comparing the patient’s current list of medications against the physician’s admission, transfer, and/or discharge orders” [310]. The medication reconciliation issues in RCT 2 were primarily due to medications omitted and incorrect doses prescribed on admission [169]. In RCT 1, the physician was a specialist registrar (i.e. senior resident) in geriatric medicine with 3 years of specialist clinical experience [148]. In RCT 2, the pharmacist was fully registered with 4 years of postgraduate experience in providing pharmaceutical care to older adults.

Both trials used a cluster randomised design. In each RCT, two lists of attending consultant prescribers were created such that the combined rates of ADRs in these groups were known to be comparable from previous work undertaken by this group [85]. Having finalised the lists, one group of attending consultant prescribers was assigned as the intervention arm of the study and the other was assigned as the control arm. The intervention clusters in both RCT 1 and RCT 2 included individuals admitted under the care of specialists in cardiology, respiratory medicine, endocrinology, renal medicine, and orthopaedics. The intervention cluster in RCT 1 also consisted of patients admitted under the care of specialists in radiation oncology, whilst the intervention cluster in RCT 2 also included patients admitted under the care of specialists in rheumatology, general and vascular surgery, and
general internal medicine. To avoid potentially biased enrolment of patients into either arm of the study, the primary researcher in each RCT approached prospective trial participants in the order of their admission to the hospital’s emergency department to assess their eligibility for the trial. RCT 1 was conducted from May 2011 to May 2012. RCT 2 was conducted from June 2011 to July 2012. No patient in either RCT received the intervention from the other RCT. Patients in the intervention and control groups in both RCTs received standard medical and pharmaceutical care from physicians and pharmacists who routinely work in the hospital. Implementation of recommendations was assessed by the primary researcher at day 7 – 10 or at the point of hospital discharge (whichever came first). Further details (e.g. such as study design and patient characteristics) can be found in the published papers describing these RCTs [147, 148, 169].

5.4.2 Data extraction and analysis

As part of this secondary data analysis, data were extracted from the papers based on the RCTs [147, 148, 169], and their associated computerised databases, stored locally in Microsoft® Access. The percentage prescriber implementation rates for the STOPP and START recommendations were calculated for both RCTs. The chi-square test was used to compare the prescriber implementation rates of the STOPP and START recommendations in the pharmacist and physician intervention groups, as well as to quantify any differences between the implementation of STOPP/START recommendations and other recommendations included in the pharmacist’s intervention. Differences were considered statistically significant where \( p < 0.05 \).
5.5 Results

5.5.1 Prescriber implementation of STOPP and START recommendations

Tables 5.1 and 5.2 show the prescriber implementation rates of STOPP and START recommendations from the physician and pharmacist respectively, divided according to the relevant physiological systems.

In 360 intervention patients in RCT 1, the physician made 292 STOPP recommendations (0.81/patient) and 159 START recommendations (0.44/patient), i.e. a total of 1.25 STOPP/START recommendations per patient. Attending prescribers implemented 237 of the physician’s 292 STOPP recommendations (81.2%) and 139 of the physician’s 159 START recommendations (87.4%). In 361 intervention patients in RCT 2, the pharmacist made 255 STOPP recommendations (0.71/patient), and 44 START recommendations (0.12/patient), i.e. a total of 0.83 STOPP/START recommendations per patient. Attending prescribers implemented 100 of the pharmacist’s 255 STOPP recommendations (39.2%) and 13 of the pharmacist’s 44 START recommendations (29.5%).
### Table 5.1: Prescriber implementation rates for STOPP recommendations: physician versus pharmacist

<table>
<thead>
<tr>
<th>STOPP criteria</th>
<th>Physician</th>
<th>Pharmacist</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular System</strong></td>
<td>22/26 (84.6%)</td>
<td>14/26 (53.9%)</td>
<td>0.0162*</td>
</tr>
<tr>
<td>Digoxin at a long-term dose &gt; 125µg per day with impaired renal function</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Loop diuretic for dependent ankle oedema only</td>
<td>4/6</td>
<td>1/2</td>
<td></td>
</tr>
<tr>
<td>Loop diuretic as first-line monotherapy for hypertension</td>
<td>4/4</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td>Non-cardioselective β-blocker with COPD or asthma</td>
<td>9/9</td>
<td>2/7</td>
<td></td>
</tr>
<tr>
<td>β-blocker in combination with verapamil</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcium channel blockers with chronic constipation</td>
<td>2/4</td>
<td>9/11</td>
<td></td>
</tr>
<tr>
<td>Use of aspirin and warfarin in combination without histamine H₂ receptor antagonist or PPI (high risk of gastrointestinal bleeding)</td>
<td>-</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>Aspirin at dose &gt; 150mg day</td>
<td>-</td>
<td>1/1</td>
<td></td>
</tr>
<tr>
<td>Aspirin without coronary, cerebral, or peripheral arterial symptoms or occlusive arterial event</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Central Nervous System</strong></td>
<td>37/46 (80.4%)</td>
<td>15/33 (45.5%)</td>
<td>0.0012*</td>
</tr>
<tr>
<td>Tricyclic antidepressants with dementia</td>
<td>3/3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Tricyclic antidepressants with glaucoma</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Tricyclic antidepressants in chronic constipation</td>
<td>3/3</td>
<td>3/4</td>
<td></td>
</tr>
<tr>
<td>Tricyclic antidepressants in combination with an opiate or calcium channel blocker</td>
<td>1/1</td>
<td>6/8</td>
<td></td>
</tr>
<tr>
<td>Long-term (&gt; 1 month) use of long-acting benzodiazepines</td>
<td>16/25</td>
<td>4/16</td>
<td></td>
</tr>
<tr>
<td>Long-term (&gt; 1 month) use of neuroleptics as hypnotics</td>
<td>4/4</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Long-term (&gt; 1 month) use of neuroleptics in those with parkinsonism</td>
<td>2/2</td>
<td>1/1</td>
<td></td>
</tr>
<tr>
<td>Phenothiazines in patients with epilepsy</td>
<td>-</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td>SSRIs with a history of clinically significant hyponatraemia</td>
<td>5/5</td>
<td>1/1</td>
<td></td>
</tr>
<tr>
<td>Prolonged use (&gt; 1 week) of 1st generation antihistamines</td>
<td>2/2</td>
<td>0/2</td>
<td></td>
</tr>
<tr>
<td><strong>Gastrointestinal System</strong></td>
<td>85/96 (88.5%)</td>
<td>39/118 (33%)</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>Prochlorperazine or metoclopramide with parkinsonism</td>
<td>-</td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>PPI for peptic ulcer disease at full therapeutic dose for &gt; 8 weeks</td>
<td>85/96</td>
<td>38/115</td>
<td></td>
</tr>
<tr>
<td><strong>Respiratory System</strong></td>
<td>-</td>
<td>1/3</td>
<td>-</td>
</tr>
<tr>
<td>Theophylline as monotherapy for COPD</td>
<td>-</td>
<td>1/1</td>
<td>(33.3%)</td>
</tr>
<tr>
<td>Nebulised ipratropium with glaucoma</td>
<td>-</td>
<td>0/2</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.1 (continued): Prescriber implementation rates for STOPP recommendations: physician versus pharmacist

<table>
<thead>
<tr>
<th>Musculoskeletal System</th>
<th>15/20 (75%)</th>
<th>5/13 (38.5%)</th>
<th>0.0358*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSAID with history of peptic ulcer disease or gastrointestinal bleeding unless with concurrent H₂ receptor antagonist, misoprostol or PPI</td>
<td>2/2 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSAID with moderate-severe hypertension</td>
<td>4/6 3/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSAID with heart failure</td>
<td>1/1 0/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term (&gt; 3 months) use of NSAIDs for symptom relief in mild osteoarthritis</td>
<td>6/9 1/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warfarin and NSAID together</td>
<td>- 1/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSAIDs with chronic renal failure</td>
<td>2/2 -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Urogenital System</th>
<th>9/12 (75%)</th>
<th>3/7 (42.9%)</th>
<th>0.1612</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder antimuscarinic drugs with dementia</td>
<td>4/7 1/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antimuscarinic drugs with glaucoma</td>
<td>1/1 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antimuscarinic drugs with chronic constipation</td>
<td>3/3 2/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha-blockers in males with frequent incontinence (≥ 1 episode daily)</td>
<td>1/1 -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endocrine System</th>
<th>- 0/1 (0%)</th>
<th>-</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>β-blockers in those with diabetes mellitus and frequent hypoglycaemic episodes</td>
<td>- 0/1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drugs that adversely affect those prone to falls</th>
<th>30/46 (65.2%)</th>
<th>12/36 (33.3%)</th>
<th>0.0042*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzodiazepines</td>
<td>19/27 10/26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuroleptic drugs</td>
<td>3/5 1/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st generation antihistamines</td>
<td>2/2 0/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vasodilator drugs in those with persistent postural hypotension</td>
<td>1/1 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term opiates</td>
<td>5/11 1/4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analgesic drugs</th>
<th>16/18 (88.9%)</th>
<th>7/9 (77.8%)</th>
<th>0.4436</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular opiates for &gt; 2 weeks in those with constipation without concurrent laxatives</td>
<td>12/14 7/9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of long-term powerful opiates as first line therapy for mild-moderate pain</td>
<td>2/2 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term opiates in those with dementia unless indicated for palliative care or moderate-severe chronic pain syndrome</td>
<td>2/2 -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duplicate drug class prescriptions</th>
<th>23/28 (82.1%)</th>
<th>4/9 (44.4%)</th>
<th>0.0267*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>237/292 (81.2%)</td>
<td>100/255 (39.2%)</td>
<td>&lt; 0.0001*</td>
</tr>
</tbody>
</table>

COPD: Chronic obstructive pulmonary disease      PPI: Proton pump inhibitor      SSRI: Selective serotonin re-uptake inhibitor
NSAID: Non-steroidal anti-inflammatory drug     * Statistically significant difference observed (p < 0.05).
Table 5.2: Prescriber implementation rates for START recommendations:physician versus pharmacist

<table>
<thead>
<tr>
<th>START criteria</th>
<th>Physician</th>
<th>Pharmacist</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular System</strong></td>
<td>29/37</td>
<td>4/15</td>
<td>0.0005*</td>
</tr>
<tr>
<td>Warfarin with chronic atrial fibrillation</td>
<td>15/18</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Aspirin with chronic atrial fibrillation where warfarin is contraindicated</td>
<td>2/3</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td>Aspirin or clopidogrel with a documented history of atherosclerotic coronary, cerebral or peripheral vascular disease in patients with sinus rhythm</td>
<td>0/2</td>
<td>2/5</td>
<td></td>
</tr>
<tr>
<td>Antihypertensive therapy where systolic blood pressure consistently &gt; 160 mmHg</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Statin therapy with history of coronary, cerebral, or peripheral artery disease without contraindication</td>
<td>8/9</td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>ACE inhibitor with chronic heart failure</td>
<td>3/4</td>
<td>1/4</td>
<td></td>
</tr>
<tr>
<td>ACE inhibitor following acute myocardial infarction</td>
<td>-</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td>β-blocker with chronic stable angina</td>
<td>-</td>
<td>0/1</td>
<td></td>
</tr>
<tr>
<td><strong>Gastrointestinal System</strong></td>
<td>1/1 (100%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proton Pump Inhibitor with severe gastro-oesophageal acid reflux disease or peptic stricture requiring dilatation</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Musculoskeletal System</strong></td>
<td>97/109 (89%)</td>
<td>6/19 (31.6%)</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>Bisphosphonates in patients taking maintenance oral corticosteroid therapy</td>
<td>14/18</td>
<td>1/10</td>
<td></td>
</tr>
<tr>
<td>Calcium and vitamin D supplementation in patients with known osteoporosis, fragility fracture or dorsal kyphosis</td>
<td>83/91</td>
<td>5/9</td>
<td></td>
</tr>
<tr>
<td><strong>Endocrine System</strong></td>
<td>12/12 (100%)</td>
<td>3/10 (30%)</td>
<td>0.0004*</td>
</tr>
<tr>
<td>Metformin with type 2 diabetes mellitus +/- metabolic syndrome</td>
<td>1/1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ACE inhibitor or angiotensin 2 receptor blocker in patients with diabetes and nephropathy</td>
<td>7/7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Antiplatelet therapy in those with diabetes mellitus and one or more major cardiovascular risk factors</td>
<td>2/2</td>
<td>1/1</td>
<td></td>
</tr>
<tr>
<td>Statin therapy in patients with diabetes mellitus and one or more major cardiovascular risk factors</td>
<td>2/2</td>
<td>2/9</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>139/159 (87.4%)</td>
<td>13/44 (29.5%)</td>
<td>&lt; 0.0001*</td>
</tr>
</tbody>
</table>

ACE: Angiotensin Converting Enzyme  * Statistically significant difference observed (p < 0.05).
In total, attending prescribers implemented 83.4% of the physician’s STOPP/START recommendations (376/451) compared to 37.8% of the pharmacist’s STOPP/START recommendations (113/299). When comparing the physician and pharmacist interventions, there was a statistically significant difference between prescriber implementation rates of the total STOPP, total START, and total STOPP/START-combined recommendations ($p < 0.0001$).

Of the ten categories of STOPP criteria, recommendations were made by both physician and pharmacist across eight of these categories. The physician achieved higher implementation rates than the pharmacist for recommendations across all eight STOPP categories, with the absolute differences ranging from 11.1% to 55.5%. The largest absolute difference observed was for recommendations based on the gastrointestinal system. This was primarily due to the low implementation rate of pharmacist recommendations to deprescribe PPIs (38/115), which was the most common type of STOPP/START recommendation provided in both RCTs. There were statistically significant differences in the implementation rates of recommendations across six of the eight STOPP categories, with the exceptions being recommendations based on urogenital system drugs and analgesic drugs. Of the six categories of START criteria, recommendations were made by both physician and pharmacist across three of these categories. The physician achieved statistically significantly higher implementation rates than the pharmacist for recommendations across all three START categories, with the absolute differences ranging from 51.7% to 70%.
Of the 65 individual STOPP criteria, recommendations based on 22 of these were prevalent in both RCTs. The physician achieved higher implementation rates than the pharmacist for recommendations based on 19 of these 22 STOPP criteria, as shown in Table 5.1. The pharmacist achieved a higher implementation rate than the physician for recommendations based on one of the STOPP criteria – STOPP rule A8: “Calcium channel blockers with chronic constipation (may exacerbate constipation)”. Of the 22 individual START criteria, recommendations based on 8 of these criteria were prevalent in both RCTs. The physician achieved higher implementation rates than the pharmacist for recommendations linked to 6 of these 8 START criteria, as shown in Table 5.2. The pharmacist achieved a higher implementation rate than the physician for recommendations based on one of the START criteria – START rule A3: “Aspirin or clopidogrel with a documented history of atherosclerotic coronary, cerebral or peripheral vascular disease in patients with sinus rhythm”.

5.5.2 Number of recommendations made and focus of intervention

Of the 360 patients randomised to the intervention arm in RCT 1, the physician made 451 recommendations in 233 patients (1.94 recommendations per patient). Of the 361 patients randomised to the intervention arm in RCT 2, the pharmacist made 1000 recommendations in 296 patients (3.38 recommendations per patient). Thus, for patients where pharmacotherapy recommendations were provided, the pharmacist provided 1.44 more recommendations per patient in comparison to the physician.
In RCT 2, the pharmacist’s STOPP/START recommendations represented almost 30% of the total number of recommendations (299/1000), and 51.8% (299/577) of the medication appropriateness recommendations (i.e. including drug-drug interactions, need for renal and hepatic dose adjustments, and other PIP instances identified utilising Beers criteria version 3 [309] and PRISCUS criteria [156]) [169]. The remainder of the pharmacist’s recommendations concerned issues with medication reconciliation (n = 423), of which 326 were implemented (77.1%). The implementation rate of the pharmacist’s recommendations concerning medication reconciliation recommendations was approximately double the rate of those concerning STOPP/START criteria (77.1% versus 37.8%; p < 0.0001).

5.5.3 Pharmacist medication reconciliation recommendations based on START criteria

On initial viewing of the START recommendations in both RCTs, it is evident that the physician made 3.67 times more START recommendations per patient in RCT 1 compared to the pharmacist in RCT 2 (0.44 START/patient versus 0.12 START/patient). The physician did not conduct medication reconciliation, whereas the pharmacist did. Therefore, as part of the pharmacist’s intervention, there were 322 recommendations to prescribe “missing medications” (i.e. medications that were prescribed prior to admission but omitted from the patient’s list of medications on admission), of which 71 (22.0%) would have been identified by the START criteria based on the patients’ lists of prescribed medications on admission and comorbidities (Table 5.3). Fifty-eight of these recommendations were implemented (81.7%). Prescribers were therefore substantially more likely to
implement a recommendation from a pharmacist to initiate a START criteria-based drug if it had previously been prescribed by a physician rather than based on the pharmacist’s recommendation alone (81.7% versus 29.5%; \( p < 0.0001 \)).

If the 71 recommendations to prescribe START criteria-based “missing medications” were factored in to the comparison between implementation of physician-delivered and pharmacist-delivered STOPP/START recommendations (Appendix 18), the physician would still achieve statistically significantly higher implementation rates for:

i) the total START recommendations: 139/159 (87.4%) versus 71/115 (61.7%); \( p < 0.0001 \), and

ii) the total STOPP/START recommendations: 376/451 (83.4%) versus 171/370 (46.2%); \( p < 0.0001 \).
Table 5.3: Pharmacist recommendations for “missing medications” identified by medication reconciliation that would have been identified by START criteria

<table>
<thead>
<tr>
<th>START-based medication reconciliation recommendations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular System</strong></td>
<td>22/27</td>
</tr>
<tr>
<td>Warfarin with chronic atrial fibrillation</td>
<td>2/3</td>
</tr>
<tr>
<td>Aspirin with chronic atrial fibrillation where warfarin is contraindicated</td>
<td>4/4</td>
</tr>
<tr>
<td>Aspirin or clopidogrel with a documented history of atherosclerotic coronary, cerebral or peripheral vascular disease in patients with sinus rhythm</td>
<td>7/9</td>
</tr>
<tr>
<td>Statin therapy with history of coronary, cerebral, or peripheral artery disease without contraindication</td>
<td>8/9</td>
</tr>
<tr>
<td>ACE inhibitor with chronic heart failure</td>
<td>0/1</td>
</tr>
<tr>
<td>β-blocker with chronic stable angina</td>
<td>1/1</td>
</tr>
<tr>
<td><strong>Respiratory System</strong></td>
<td>16/20</td>
</tr>
<tr>
<td>Regular inhaled β₂ agonist or anticholinergic agent for mild to moderate asthma or COPD</td>
<td>5/7</td>
</tr>
<tr>
<td>Regular inhaled corticosteroid for moderate-severe asthma or COPD, where predicted FEV1 &lt; 50%</td>
<td>11/13</td>
</tr>
<tr>
<td><strong>Central Nervous System</strong></td>
<td>4/4</td>
</tr>
<tr>
<td>Antidepressant drug in the presence of moderate-severe depressive symptoms lasting at least three months</td>
<td>4/4</td>
</tr>
<tr>
<td><strong>Musculoskeletal System</strong></td>
<td>8/12</td>
</tr>
<tr>
<td>Disease-modifying anti-rheumatic drug (DMARD) with active moderate-severe rheumatoid disease lasting &gt; 12 weeks</td>
<td>0/1</td>
</tr>
<tr>
<td>Bisphosphonates in patients taking maintenance oral corticosteroid therapy</td>
<td>1/2</td>
</tr>
<tr>
<td>Calcium and vitamin D supplementation in patients with known osteoporosis, fragility fracture or dorsal kyphosis</td>
<td>7/9</td>
</tr>
<tr>
<td><strong>Endocrine System</strong></td>
<td>8/8</td>
</tr>
<tr>
<td>Metformin with type 2 diabetes mellitus +/- metabolic syndrome</td>
<td>2/2</td>
</tr>
<tr>
<td>ACE inhibitor or angiotensin 2 receptor blocker in patients with diabetes and nephropathy</td>
<td>1/1</td>
</tr>
<tr>
<td>Antiplatelet therapy in those with diabetes mellitus and one or more major cardiovascular risk factors</td>
<td>1/1</td>
</tr>
<tr>
<td>Statin therapy in patients with diabetes mellitus and one or more major cardiovascular risk factors</td>
<td>4/4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>58/71</td>
</tr>
</tbody>
</table>

ACE: Angiotensin Converting Enzyme    FEV1: Forced expiratory volume in 1 second
5.5.4 Clinical outcomes

The comparable clinical outcomes from the two RCTs are displayed in Table 5.4. The physician’s intervention resulted in an absolute reduction of 9.3% in the proportion of patients who experienced a non-trivial in-hospital ADR in comparison to the control group, compared to the pharmacist’s intervention which resulted in an absolute reduction of 6.8% for this same outcome. The corresponding relative risk reductions for this outcome were 44.3% and 32.9% respectively. Neither intervention resulted in significant differences in median length of hospital stay or mortality when compared to controls.

Table 5.4: Comparable clinical outcomes between interventions

<table>
<thead>
<tr>
<th>Clinical Outcome Measure</th>
<th>Physician</th>
<th>Pharmacist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adverse Drug Reactions (ADRs):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Patients with ADRs (%)</td>
<td>78 (21)</td>
<td>78 (20.7)</td>
</tr>
<tr>
<td>Intervention Patients with ADRs (%)</td>
<td>42 (11.7)</td>
<td>50 (13.9)</td>
</tr>
<tr>
<td>Absolute Risk Reduction in patients with ADRs</td>
<td>9.3%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Relative Risk Reduction in patients with ADRs</td>
<td>44.3%</td>
<td>32.9%</td>
</tr>
<tr>
<td><strong>Median Length of Hospital Stay:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Patients (IQR)</td>
<td>8 days (4 – 14)</td>
<td>9 days (5 – 16)</td>
</tr>
<tr>
<td>Intervention Patients (IQR)</td>
<td>8 days (4 – 14)</td>
<td>8 days (5 – 13.5)</td>
</tr>
<tr>
<td>Significance level</td>
<td>Not stated</td>
<td>( p = 0.444 )</td>
</tr>
<tr>
<td><strong>Mortality:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Patients; Intervention Patients</td>
<td>11; 9</td>
<td>17; 17</td>
</tr>
<tr>
<td>Significance level</td>
<td>( p = 0.6 )</td>
<td>( p = 0.9 )</td>
</tr>
</tbody>
</table>

IQR: Interquartile range

“in-hospital deaths”

“died during their index hospital stay”
5.6 Discussion

There is a paucity of research comparing pharmacists and physicians in the provision of pharmacotherapy recommendations in hospitalised older adults. This is the first study to compare prescriber implementation rates of STOPP/START recommendations from one approach by a trained clinical pharmacist and another approach by a trained physician in geriatric medicine. These results have shown that the source of the STOPP/START recommendations and the communication methods through which they are provided may have a substantial impact on their implementation – it was found that physician prescribers in this particular hospital in the Republic of Ireland were statistically significantly more likely to implement STOPP/START recommendations from the physician’s approach than from the pharmacist’s approach in these two RCTs. There was a greater disparity between the two approaches in the implementation of START recommendations (87.4% versus 29.5%) compared to the implementation of STOPP recommendations (81.2% versus 39.2%).

A small sample size may have prevented showing statistically significant differences in the prescriber implementation rates of certain STOPP or START recommendations between physician and pharmacist. Nevertheless, this study has demonstrated that the physician obtained statistically significantly higher implementation rates than the pharmacist for 10 of the 30 individual STOPP/START recommendations present in both interventions, including recommendations to deprescribe benzodiazepines and proton pump inhibitors. In recent years, there has been extensive research on deprescribing of these drugs in particular [311-314].
The present study is consistent with previous findings that geriatricians may be more effective than other healthcare professionals with deprescribing in hospitalised older adults [313, 315].

It is acknowledged that differences between the interventions, other than the individual healthcare professionals, may have had an influence on prescriber implementation rates, such as:

i) The pharmacist provided other recommendations, not just STOPP/START recommendations like the physician did.

ii) Both the pharmacist and physician provided all of the recommendations in written form. The physician also communicated all recommendations verbally, whereas the pharmacist verbally communicated approximately one third of these recommendations.

iii) The physician had previously worked in the hospital prior to RCT commencement, whereas the pharmacist had not.

The physician-delivered intervention was narrowly focused on providing recommendations based on the STOPP/START criteria only, whereas the pharmacist’s intervention involved the provision of recommendations based on STOPP/START as well as a wider range of drug-related problems. As previously stated, the pharmacist provided 1.44 more recommendations on average per patient than the research physician to attending prescribing teams. A recent systematic review suggests that computerised interventions which target a broader range of PIP issues in older adults may contribute to information overload, and consequently result in fewer recommendations being implemented [251]. Thus, in
the present study, the greater complexity of the pharmacist intervention compared to the physician intervention may have resulted in a lower implementation rate of pharmacotherapy recommendations by attending prescribers.

Previous studies have shown that pharmacists and physicians prefer the use of verbal or face-to-face recommendations when working in collaboration to review pharmacotherapy [183, 316]. Recommendations communicated in this way are usually implemented at a higher rate than those provided by written means alone [317-320]. This suggests that the pharmacist might have achieved higher implementation rates if he had provided verbal reinforcement to prescribers regarding all the recommendations in the printed report. However, the high implementation rate of the pharmacist’s medication reconciliation recommendations (77.1%) suggests that the mode of delivery of the pharmacist’s recommendations may not have been the primary cause of the observed difference in STOPP and START recommendation implementation rates between the pharmacist and physician. Moreover, the contrast in implementation between pharmacist medication reconciliation recommendations and STOPP/START recommendations is noteworthy. This difference suggests that there may be an impediment to prescriber implementation of pharmacist interventions relating to prescribing appropriateness in older patients, and that physicians may be more accepting of the pharmacist’s role in medication reconciliation as distinct from prescribing appropriateness alterations.

Both the pharmacist and the physician were highly familiar with the STOPP/START criteria prior to the start of the two RCTs. Previous studies have demonstrated that
IRR amongst pharmacists and physicians is high when provided with the same clinical information [321, 322]. Therefore, identification of PIP by either healthcare professional should not have been different. A key factor in achieving implementation of prescribing recommendations may be who provides them, and how they are delivered to prescribers. Physicians may be more likely to implement recommendations from fellow physicians, as this is customary practice in healthcare systems worldwide. Physicians may be less likely to implement pharmacists’ recommendations but the reasons for this are not fully understood. A qualitative study by Hughes et al. found that some pharmacists felt that doctors considered them to be subordinate on a professional level in relation to medication issues [323]. In that study, hierarchical differences were implicit in the doctors’ comments as they questioned the role of pharmacists in certain areas, such as having greater involvement with prescribing decisions, which some doctors viewed to be solely within the professional domain of the doctor. The same study suggested that this may be because of some doctors’ lack of awareness of pharmacist training, as well as some doctors feeling that greater pharmacist involvement would encroach on their prescribing role. Most of the studies in this area of research are focused on the relationships between pharmacists and physicians in primary care, and there appears to be limited research into exploring the factors affecting physician implementation of pharmacist recommendations in secondary care settings [323-325].

Prior to commencement of the RCTs, the research physician had previously worked in the same hospital training in geriatric medicine at specialist registrar level. As a
result, this particular physician may have already established a good professional rapport with some of the attending prescribers prior to RCT 1. This, in turn, may have contributed to an increased implementation of the STOPP/START recommendations offered by the research physician. In contrast, whilst the research pharmacist was experienced in providing pharmaceutical care for older adults, he had not previously worked in the hospital where the RCTs were conducted. Previous research has highlighted that key components to physician-pharmacist collaboration are trust and knowing each other [326], and that pharmacists who work closely with physicians are more likely to be successful in optimising geriatric pharmacotherapy [70]. These interprofessional barriers may have contributed to the observed lower implementation rate of the pharmacist’s STOPP/START recommendations described in this study.

Published studies providing details on prescriber implementation of pharmacist and physician STOPP/START recommendations are limited. An earlier RCT conducted by a physician in the same hospital (where medication appropriateness was the primary outcome measure) demonstrated a very high level of prescriber implementation of both the STOPP (91%) and START (97%) recommendations [146]. Although this intervention took place in the hospital where the STOPP/START criteria were developed, it is unlikely that this is the reason for the high implementation rates as the criteria are not routinely applied to older patients there due to resource constraints. The implementation rates of the pharmacist’s STOPP and START recommendations in this present study seem to be lower than those described in the literature to date (STOPP: 44% – 94% and START: 58%) [209,
Therefore, these results support previous findings which indicate that a lower proportion of pharmacist-provided STOPP/START recommendations are implemented by prescribers in comparison to those provided by physicians.

There are some limitations to this study. Firstly, although both the original pharmacist and physician interventions encompass STOPP and START recommendations, they were not designed to be directly compared. Differences between the interventions cannot be ruled out as possible contributing factors to the difference in outcomes observed. Secondly, this was a single-centre comparison between the prescriber implementation rates of recommendations provided by one pharmacist and one physician. Evaluating implementation of STOPP and START recommendations from a larger sample of pharmacists and physicians in a multi-centre RCT setting would provide a more accurate comparison of the professions on this matter, as it is acknowledged that different personalities and communication styles also vary between individuals, which may impact on the implementation rates.

A cost-effectiveness analysis of the pharmacist intervention has shown that it was cost-effective [148]. However, a more recent cost-effectiveness analysis indicates that the physician intervention was unlikely to be cost-effective [328], even though it was associated with a greater absolute risk reduction in patients with ADRs compared to the pharmacist intervention. The present study suggests that a higher prescriber implementation rate of STOPP recommendations in particular is associated with lower rates of incident ADRs in hospitalised older adults. Therefore, it could be argued that the lower implementation rate of some of the pharmacist’s
recommendations resulted in a higher rate of incident ADRs in the pharmacist RCT intervention cohort. Studies have consistently shown that pharmacists contribute to reductions in healthcare costs in the hospital setting [188]. If physicians are less likely to be cost-effective in conducting interventions of this type, it is important that other ways to enhance the implementation of pharmacist recommendations are identified, which reliably lead to further reductions in ADRs, and subsequently lower healthcare costs.

5.7 Conclusions

This study has shown that the methods of communication and the medium through which the STOPP/START recommendations are provided may have a significant impact on their implementation. Qualitative research is necessary to identify the key factors affecting prescriber implementation of hospital pharmacists’ medication appropriateness recommendations, along with possible ideas for future intervention, as non-implementation of these recommendations may be contributing to preventable ADRs occurring in hospitalised older adults.

Please note that Chapter 6 (pp. 148-174) is unavailable due to a restriction requested by the author.

CORA Cork Open Research Archive [http://cora.ucc.ie](http://cora.ucc.ie)
Chapter 7: Discussion

7.1 Chapter description

This chapter firstly presents a summary of the thesis findings, focusing on the novel aspects of the research. Following this, an overview is provided of the key factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults, with a discussion of these findings in the context of the published literature. Thereafter, the overall strengths and limitations associated with this body of work will be described. Finally, the implications for practice and future research will be discussed.
7.2 Summary of findings

In the introduction to this thesis, it was highlighted that there is no accepted optimal strategy to minimise PIP in hospitalised older adults. Consequently, the prevalence of PIP remains unacceptably high, placing these older patients at significant risk of adverse outcomes. A large number of intervention studies have been conducted which involved the provision of recommendations to hospital prescribers aiming to reduce PIP in older adults. From these studies, it is evident that interventions with higher prescriber implementation rates of these recommendations are more likely to result in significant improvements in both medication appropriateness and patient outcomes [186, 187, 207, 208]. Irrespective of the impact of these interventions, most studies with low prescriber implementation rates have not investigated the reasons underlying the reduced uptake of recommendations with any rigour [207, 208]. With this gap in the literature, this doctoral research investigated the key determinants underlying prescriber implementation of medication appropriateness recommendations related to older patients’ pharmacotherapy, focusing primarily on the implementation of pharmacist-provided and computer-generated recommendations.

The first novel outcome of this thesis was the production of a systematic literature review and meta-analysis on the effectiveness of computerised interventions designed to minimise PIP in hospitalised older adults [251]. Previous reviews had gathered evidence across different healthcare settings [198, 199], but the systematic review described in Chapter 2 has filled an important knowledge gap in
the literature as it was the first conducted specifically related to interventions in the hospital setting. The main finding was that these interventions can significantly reduce PIP in hospitalised older adults compared to control ($p < 0.05$). However, the systematic review also showed that computerised interventions do not routinely result in significantly improved patient outcomes. Three of the nine included studies assessed the intervention’s impact on patient outcomes, with statistically significant improvements in two of seventeen patient outcomes assessed – one study showing a reduction in ADEs and the other a reduction in inpatient falls.

Five studies reported the prescriber implementation rates of the computer-generated recommendations, ranging widely from 22.5% to 95%. Interestingly, it was more common for interventions that targeted fewer PIMs to have higher implementation rates. Although not extensively investigated in any of the included studies, three articles provided reasons for prescriber non-implementation of recommendations to discontinue PIMs, including:

i) patient was tolerating the PIM,

ii) PIM was clinically indicated, or

iii) no suitable alternative available (to the PIM).

This systematic review allowed for a greater understanding of the particular research area in advance of conducting the studies related to computer-generated recommendations, as described in Chapters 3 and 4. In particular, the description of the computerised interventions and the reasons for prescriber non-implementation of computer-generated recommendations helped inform the development of the topic guides for the semi-structured interview study described in Chapter 3. This
qualitative study utilised the TDF to help ascertain the key factors that affected prescriber implementation of the SENATOR trial intervention’s recommendations.

In Chapter 3, interview participants revealed that implementation of recommendations depended on some individual prescriber characteristics, such as prescriber experience, specialty, and the prescriber’s attitude towards research studies. Implementation was facilitated by provision of the recommendations to a ‘decision-maker’ in the prescribing team. In addition, the interviewees asserted that the hospital environment played a role in the low implementation rates. Recommendations were often not acted upon due to the patient’s acutely ill status in the hospital setting, and that it may be preferable to make changes in a non-acute setting when the patient is more stable. Furthermore, the recommendations were mostly not provided to prescribers at the time of patient review, thus hindering their implementation.

The most pervasive perception among the interviewees was that the clinical relevance of the computer-generated SENATOR recommendations was a key factor affecting their implementation. Quite simply, if recommendations were not considered relevant, they would not be implemented. Furthermore, recommendations of low relevance contributed to prescriber fatigue with the intervention. This meant that even recommendations of greater relevance may have been ignored, preventing their implementation.

In comparison to the other key factors affecting implementation of the SENATOR recommendations, the clinical relevance of recommendations can be measured. Thus, the findings from Chapter 3 led us to conduct a retrospective evaluation of
the clinical relevance of computer-generated STOPP/START recommendations from the SENATOR intervention, and thereafter assess for any association between relevance and the rate of implementation. As part of this study, as described in Chapter 4, the clinical relevance of all STOPP/START recommendations that were provided to prescribers caring for the 204 intervention patients in Cork University Hospital, the lead site in the SENATOR trial, were evaluated. This study was novel in that it was the first study to:

i) evaluate the clinical relevance of computer-generated STOPP/START recommendations, and

ii) use a validated scale to assess the clinical relevance of computer-generated medication appropriateness recommendations for hospitalised older adults.

In this study, it was found that nearly three quarters of the recommendations were clinically relevant (73.6%), with the remainder judged to be either of ‘no clinical relevance’ (21.5%) or of potential ‘adverse significance’ (4.9%) if implemented. However, of the clinically relevant recommendations, nearly half of these were of ‘possibly low relevance’ (47%). Furthermore, when examining the association between clinical relevance and implementation, it was found that recommendations of higher clinical relevance were significantly more likely to be implemented than those of lower clinical relevance ($p < 0.05$). Therefore, this chapter corroborated the qualitative findings from Chapter 3, whereby the clinical relevance of recommendations was deemed a significant factor affecting prescriber implementation.
The second aim of this thesis (as shown in Figure 1.1) was to identify the key determinants influencing prescriber implementation of pharmacist-provided recommendations to improve medication appropriateness in hospitalised older adults. Prior to undertaking qualitative research to investigate this issue (as detailed in Chapter 6), I compared two similar interventions – one pharmacist-led and the other physician-led – that involved the provision of STOPP/START recommendations to prescribers aiming to reduce PIP and associated ADRs in hospitalised older patients. This study, as described in Chapter 5, was the first to compare implementation rates of STOPP/START recommendations between a pharmacist and a physician [280].

Prescriber implementation of physician-provided STOPP/START recommendations was found to be significantly higher than those provided by a pharmacist (83.4% versus 37.8%; \( p < 0.0001 \)). Furthermore, these results suggested that higher implementation rates of recommendations may be associated with better patient outcomes – the physician’s intervention had a higher proportion of STOPP/START recommendations implemented and resulted in a greater absolute risk reduction in patients with ADRs in comparison to the pharmacist’s intervention (9.3% versus 6.8%). This study also identified intervention components that may have influenced the prescriber implementation rates of pharmacist recommendations, namely the method of communication utilised, the type of the recommendation made, and personal acquaintance with the prescriber. These findings were used to inform the topic guide development for the semi-structured interviews with hospital pharmacists and physicians conducted in Chapter 6.
Although several studies have explored interprofessional relationships between pharmacists and physicians [323-325], the final research chapter is novel in that it describes the first study to explicitly elucidate the factors affecting prescriber implementation of hospital pharmacist medication appropriateness recommendations. The findings in this study echo some of those described in Chapter 3, reaffirming that environmental barriers (e.g. communications methods utilised and intervention timing), individual prescriber characteristics (e.g. experience, specialty, and personality), and the clinical relevance of the prescribing advice all significantly affect the implementation of medication appropriateness recommendations by hospital physician prescribers.

It was suggested in Chapter 5 that one reason contributing to non-implementation of pharmacist recommendations was lack of personal acquaintance with the physician. This hypothesis was supported by interviewees in Chapter 6, who indicated that although knowing each other is not essential, it does however greatly enhance rapport and the likelihood of recommendation uptake. In addition, the findings in Chapter 6 emphasised the important influence that the medical hierarchy has on implementation of pharmacist recommendations. Junior physicians are likely to seek advice from their senior physician colleagues as part of the decision-making process to implement pharmacist recommendations. This implies that physicians often trust their colleagues’ advice over that of pharmacists, which perhaps further explains the significantly lower implementation rate of pharmacist-provided recommendations in comparison to physician-provided recommendations found in Chapter 5.
Six TDF domains appeared as predominant in influencing prescriber implementation of medication appropriateness recommendations in each of the qualitative studies (Chapters 3 and 6). Five of these predominant domains were common to both studies, namely: ‘Environmental Context and Resources’, ‘Social/Professional Role and Identity’, ‘Memory, Attention and Decision Processes’, ‘Knowledge’, and ‘Goals’. By mapping these predominant domains to the BCW, this may help identify intervention functions that could be utilised to enhance prescriber implementation of recommendations to improve medication appropriateness.

The ‘Social Influences’ domain appeared as predominant in influencing prescriber implementation of pharmacist recommendations, but this was not the case for the computer-generated SENATOR recommendations. This is perhaps unsurprising due to the importance that has been previously attributed to the interpersonal processes between pharmacists and physician prescribers [360, 361]. Conversely, the ‘Intentions’ domain appeared as predominant in affecting prescriber implementation of the SENATOR recommendations, but not for the pharmacist recommendations in Chapter 6. As highlighted in Chapter 3, this may be due to prescribers’ lack of intrinsic motivation to engage with a research trial intervention, whereas there may be greater intentions to engage with pharmacist interventions as they have been proven to be effective in improving the appropriateness of prescribing in hospitalised older adults [184].
7.3 Key factors affecting prescriber implementation of medication appropriateness recommendations in hospitalised older adults

The factors identified by this body of doctoral research to be key in affecting prescriber implementation of medication appropriateness recommendations are as follows:

i) Clinical relevance of the recommendation.

ii) Method of communication and integration into prescriber workflow.

iii) The hospital environment.

iv) Prescriber identity.

v) Source of the recommendation.

Whilst the quantitative research components of this thesis allowed us to make statistical inferences on specific factors affecting implementation, the deeper insights into these issues are primarily underpinned by the two qualitative studies described in Chapters 3 and 6. Given the complexity associated with prescribing for older adults in the hospital setting, this thesis aimed to robustly identify the salient factors affecting implementation of these recommendations, as it would be impossible to detail each underlying determinant of this issue. The factors outlined above contain elements that are inextricably interlinked, and will now be discussed as to how each of these elements affects implementation.
7.3.1 Clinical relevance of the recommendation

Participants in both qualitative studies (Chapters 3 and 6) emphasised that the clinical relevance of the recommendations was key to implementation. Recommendations that are important in the clinical context of the patient are more likely to be implemented; for example, if they are related to the acute admission and/or would undoubtedly prevent or ameliorate medication-related harm. Similarly, it was suggested that the low implementation rate observed in the pharmacist intervention described in Chapter 5 may have been due to recommendations that were of low relevance at the time of the intervention [169].

Whilst previous studies have assessed the clinical relevance of pharmacist recommendations or computer-generated recommendations [289, 293-295, 307], very few studies actually prove that clinical relevance is the likely reason for non-implementation. However, in this thesis, the participant insights from the interview studies have been corroborated by the novel quantitative findings in Chapter 4, whereby the clinical relevance was shown to significantly influence the implementation rate, i.e. recommendations of higher clinical relevance were significantly more likely to be implemented than those of lower clinical relevance ($p < 0.05$).

However, recommendations of low clinical relevance can also have an effect on the implementation of recommendations of high clinical relevance. Large numbers of recommendations of low relevance may cause prescribers to experience fatigue with the intervention – for computerised interventions, this is a well-documented phenomenon called ‘alert fatigue’ [194], possibly resulting in clinically important
recommendations being ignored. This may have been the case with the findings in Chapter 4, as it was observed that even recommendations judged to be of ‘possibly very important relevance’ were still not implemented approximately 30% of the time.

7.3.2 Method of communication and integration into prescriber workflow

As indicated above, these factors affecting implementation are often interconnected. With regard to pharmacist interventions, it should be noted that the clinical relevance of the recommendation often dictates the method of communication used to contact the prescriber [317]. Recommendations of high importance that require urgent resolution will necessitate swift communication, usually using verbal methods – via telephone, or preferably face to face if the prescriber is present. There is less urgency to resolve issues of lower relevance; this may result in the pharmacist providing the recommendation in writing or delaying the recommendation until the next opportunity to discuss with the prescriber. As written recommendations usually have lower implementation rates than verbal recommendations [317, 318], this may be a confounding factor affecting the implementation of recommendations of lower relevance. Thus, one reason postulated for significantly reduced implementation rates for recommendations of lower relevance may be the method of communication used.

In Chapter 5, it was suggested that the proportion of the pharmacist’s recommendations implemented was significantly lower than the physician’s due to the method of communication used. Only one third of the pharmacist’s
recommendations were communicated verbally, whereas all the physician’s recommendations were communicated in this manner. This theory was supported by interviewees in Chapter 6, who affirmed that not only did face-to-face communication enhance the rate of implementation, but it was also the preferred method of communication by both pharmacists and physicians as it facilitated synchronous bidirectional discussion [111, 355, 362-364]. Face-to-face communication is usually deemed the most effective method to facilitate implementation of these recommendations [360, 365].

Whilst the method of communication used appears to be important, it is also paramount that provision of prescribing recommendations is integrated into prescriber routine workflow. In Chapter 6, interviewees emphasised that better integration of pharmacists’ recommendations into prescribers’ workflow may require the organisation of scheduled discussions between pharmacists and physicians (e.g. as part of multidisciplinary team meetings) or pharmacist involvement in physicians’ ward rounds. Research has shown that pharmacist participation in consultant physician-led ward rounds can significantly add to the implementation rates of pharmacist recommendations [366]. Furthermore, the findings in Chapter 3 emphasised the importance of the timing of the recommendations – those provided to prescribers at a time when they are not reviewing the patient are much less likely to be implemented [333]. Thus, computer-generated pharmacotherapy recommendations within an EHR should ideally be provided at the point of prescribing or at the time of patient review to facilitate implementation [367].
7.3.3 The hospital environment

Environmental barriers within the hospital setting can prevent the review and implementation of recommendations to optimise medication appropriateness. As previously mentioned, face-to-face communication usually achieves the highest implementation rates, but this is not always possible in busy acute hospital wards [368]. Pharmacists and physicians may not be physically present on the ward at the same time to discuss recommendations face to face. Furthermore, there can be difficulties in contacting prescribers via telephone, and written recommendations in the patients’ clinical notes may be overlooked [369].

The implementation of pharmacist recommendations can be influenced by the type of pharmaceutical care model that exists in individual hospital settings. In Chapter 6, it was clear that both pharmacists and physicians felt that pharmaceutical care models with pharmacists and physicians working together on the same clinical care team were likely to have higher implementation rates of pharmacist recommendations compared to those without pharmacists integrated into the team. Previous research has shown that this team-based pharmacist approach not only increases the implementation rate significantly, but it can also result in earlier implementation of recommendations [204]; swifter implementation may be vital in the prevention of particular ADRs.

Participants in Chapters 3 and 6 questioned whether the hospital environment was the right place to optimise the appropriateness of prescribing for older adults, as the acute setting does not always facilitate the review of patients’ chronic medications [76]. Certain types of recommendations may be less likely to be
implemented in hospital; for example, recommendations to discontinue or taper benzodiazepines may be more appropriate for a setting where the patient is clinically stable, e.g. in primary care. In the qualitative studies, patient preference did not appear as one of the key factors affecting implementation. However, in a non-acute environment, such as the general practice setting, patient preference and involvement are likely to be much more influential [370, 371].

From this doctoral research, it is evident that prescribers do not always view recommendations addressing medication appropriateness as a priority in the acute hospital setting. Hospital prescribers’ busy workload, which is often characterised by severe time constraints, may prevent a thorough medication review being performed for every patient [111]. In addition, many indicated that there is a culture within hospital settings for prescribers to primarily focus on the patients’ acute illness and/or issues related to their own particular specialty [372, 373]. In Chapter 6, participants indicated that senior prescribers’ compliance with such prescribing norms has a substantial influence on junior prescribers’ behaviour [374]. Junior prescribers are less likely to implement recommendations that contravene the prescribing norms within their specialty team or within their hospital setting [375]. This lack of a holistic approach to older patients’ care in hospital settings is a fundamental barrier to implementing these recommendations and optimising pharmacotherapy.

**7.3.4 Prescriber identity**

In this thesis, it was clear that that the roles of individual prescribers and their professional identity have a significant effect on the implementation of medication
appropriateness recommendations. Interview participants in Chapters 3 and 6 asserted that prescriber specialty is an important determinant of implementation; specialists who do not have specific expertise in geriatric pharmacotherapy may be hesitant to make changes to medications that are outside their specialist field of knowledge. Similar to previous research, participants stated that some prescribers believe that they are responsible for managing medications solely within their specialty, and that dealing with other prescribing issues is not within their remit [376]. Furthermore, interviewees described specialists’ reluctance to interfere with medications that had been prescribed by a colleague or other specialist [377, 378].

It was clearly evident that prescriber experience is an important factor affecting the implementation rate of recommendations aimed at optimising medication in older adults, which concurs with previous research [379]. However, conflicting views were expressed by interviewees regarding this issue. Some participants suggested that higher implementation rates may be seen amongst junior prescribers as they are more likely to trust the source of the recommendations to be reliable – a lack of clinical knowledge may prevent them from distinguishing between clearly correct and incorrect recommendations [375]. Contrastingly, another common belief was that junior prescribers were less likely to implement recommendations. Irrespective of their knowledge or skills, it was indicated that junior prescribers may be more hesitant to change pharmacotherapy independently – either because they do not accept the role as the ‘decision-maker’, or because of fear of negative patient consequences or criticism from their senior colleagues, often resulting in no action being taken in response to particular recommendations [273].
This sense of clinical inertia was also indicated in the systematic review (Chapter 2), whereby the most common reason for non-implementation of computer-generated recommendations was that the patient was already tolerating the PIM [251]. Previous qualitative research has conveyed this ‘don’t rock the boat’ approach when it comes to making changes to older patients’ pharmacotherapy [380, 381]. Furthermore, in accordance with existing research, my findings accentuate the importance of providing medication recommendations to a ‘decision-maker’ [271], i.e. usually a senior member of the prescribing team. However, this ‘decision-maker’ status is not simply a function of experience and hierarchy [375]; it is also a reflection of prescriber knowledge, training, and self-efficacy [273].

7.3.5 Source of the recommendation

It was evident from this thesis that the source of medication appropriateness recommendations has a substantial impact on the implementation rate. This was distinctly conveyed by the marked contrast in implementation rates of physician-provided recommendations and pharmacist-provided recommendations demonstrated in Chapter 5. A previous study by Axon et al. has indicated that junior physicians are more likely to follow senior physicians’ prescribing recommendations rather than those from pharmacists [333]; as highlighted in Chapter 6, this is likely influenced by the medical hierarchy within hospital settings [375].

Prescribers having trust in the recommendation source is of paramount importance. A major theme from Chapter 6 was that knowing and trusting the pharmacist was a key facilitator to prescribers implementing the recommendations, which is commonly reported in the literature [326, 360, 361]. Trust is vital to
collaborative pharmacist-physician relationships [355, 382], as with any professional relationship [383]. Building trust can take time [384, 385], and some pharmacists in the interviews felt that they had to prove their competence to some physicians before they were trusted and their recommendations implemented. The need for trust has previously been explained by physicians’ lack of awareness of the pharmacists’ knowledge, skill set, and role within the healthcare team [323, 324]. Building and maintaining interprofessional trust can be achieved by the provision of valued recommendations consistently over time [355]. However, the findings in Chapter 6 are in line with previous published research in suggesting that high staff turnover may affect collaboration, and thus impact negatively on maintaining these trusting relationships between pharmacists and physicians over time [336, 341].

Similarly, trust in computerised interventions emerged as a subtheme in Chapter 3, whereby interviewees stressed that whilst they regarded computer-generated recommendations to be a potential aid to better quality prescribing, they would not trust them unquestionably. Previous research has shown that prescribers with higher levels of trust in CDSSs are significantly more likely to implement computer-generated recommendations [386]. However, as shown in Chapter 4, some CDSS-generated recommendations may be of potential adverse significance if implemented. Therefore, it is important that prescribers do not implicitly trust all computer-generated recommendations without using their clinical judgment [302].
7.4 Strengths and limitations

The specific strengths and limitations of each study have already been described in the individual research chapters (Chapters 2 – 6). However, the main overall strengths and limitations of this work will be discussed below.

One particular strength of this thesis was the complementary use of quantitative and qualitative research, whereby the results of one study either helped explain findings from previous studies or contributed to the development of research questions in subsequent investigations. For example, the quantitative results from Chapter 4 provided data to substantiate the qualitative findings from Chapter 3, supporting the argument that the clinical relevance of computer-generated recommendations was a significant factor affecting their implementation.

Using the TDF as a robust framework in the directed content analysis phase of both qualitative interview studies allowed me to make comparisons between the findings in Chapters 3 and 6, and subsequently to ascertain the key factors affecting prescriber implementation common to both studies [217, 261]. In addition, the interview transcripts in both qualitative studies also underwent conventional content analysis [261]. Using these methods in tandem was more time-consuming compared to standard approaches of qualitative analysis. However, this allowed me to convey the themes openly without the constraints of specifically reporting according to the TDF, whilst still identifying the predominant TDF domains which can be mapped to suitable intervention functions [226].
Where possible, the studies in this thesis were reported in accordance with best-practice guidelines. The PRISMA Statement was used to report the conduct of the systematic review and meta-analysis described in Chapter 2 [236]. Furthermore, the COREQ checklist guided reporting of the semi-structured interview studies in Chapters 3 and 6 [258]. It is important to emphasise that all five research chapters in this thesis are novel and have either been published in peer-reviewed journals, are currently under review, or are in preparation for submission for publication. Finally, the findings within this thesis have been presented at conferences locally, nationally, and internationally – indicating substantial interest in this body of work and the quality of the research conducted. Further endeavours shall be made to disseminate these findings and to use them to develop interventions which can sustainably minimise PIP in hospitalised older adults.

There are also a number of limitations within this thesis that must be acknowledged. Although the qualitative study in Chapter 3 included participants from six countries, it is acknowledged that the interviews were based around one single computerised intervention (i.e. the CDSS intervention in the SENATOR RCT) [202]. Therefore, some of the findings specific to this intervention may not be as transferable to other hospital settings with different software systems. Additionally, whilst the qualitative study described in Chapter 6 did assess the views of pharmacists and physician prescribers from two hospital sites, it is likely that some findings may not be generalisable across all hospital settings in the Republic of Ireland or in other countries. However, I contend that the context of the study sites
has been described in sufficient detail to allow readers to decide if the findings are transferable to their own setting.

Lastly, this thesis did not involve the development of a novel intervention. However, design and testing of a theoretically-informed intervention was beyond the scope of this body of work. It was deemed more important to firstly gain a greater understanding of the underlying factors that prevent medication optimisation for older adults in the hospital setting. Nonetheless, the findings in this thesis will inform the design of interventions targeting prescriber behaviour aimed at reduction of PIP in hospitalised older adults in future.

7.5 Implications of findings

The findings in this thesis have provided evidence to inform changes to practice that facilitate the implementation of recommendations to improve medication appropriateness in hospitalised older adults. Furthermore, the research described in this thesis has created a foundation to build on the evidence provided as well as yielding directions for new research.

7.5.1 Implications for practice

These findings suggest that a change to the specialty culture in hospitals is required. With the growing proportion of older adults in secondary care, many specialists will have responsibility for increasing numbers of these patients more frequently [387]. Specialists taking a more holistic approach to optimising medications for older adults must become the norm in hospital practice [388]. If PIP is identified and a
recommendation is made, the onus is on these specialists to ensure that PIP is reviewed promptly and implemented if deemed appropriate, rather than clinical inertia which perpetuates PIP, thereby potentially increasing the risk of patient harm [272].

The findings from this thesis concur with previous research in demonstrating that prescribers perceive their knowledge to be suboptimal with regard to prescribing in older adults [111], emphasising that further education and training in geriatric pharmacotherapy is required at both undergraduate and postgraduate level [389, 390]. These educational interventions have been shown to be acceptable to implement and effective in improving prescriber knowledge [143], and may therefore be one solution to overcome prescribing inertia and low self-efficacy with optimising geriatric pharmacotherapy when PIP issues are identified [391].

A key component for interventions to improve medication appropriateness is how the recommendations are provided, who receives them, and at what time during the hospitalisation of an older person. In line with several previous research studies, the research described in this thesis indicates that pharmacists should strive to deliver their recommendations face to face, where possible, in order to facilitate higher implementation rates. It is important to reiterate this point as suboptimal communication methods continue to prevail, which can contribute to adverse patient outcomes [339]. Furthermore, rather than relying on impromptu discussions with prescribers, hospital pharmacists should be afforded opportunities for regular structured face-to-face communication with attending physician prescribers when the patient’s case is being reviewed, e.g. such as on ward rounds.
or at multidisciplinary team meetings. In addition, when pharmacists are confident that their recommendations can reduce PIP, they can show appropriate assertiveness with regard to proposed medication changes [392]. Previous studies have shown that a lack of pharmacist assertiveness results in medication errors going uncorrected [363].

It was evident from the interviews in Chapter 6 that physicians’ awareness of pharmacists’ training was an issue [323]. Increased interprofessional education between pharmacists and physicians is warranted to facilitate greater understanding of each profession’s knowledge and skills, as well as to promote collaboration [393, 394]. As with previous research, the findings in this thesis advocate greater use of pharmacist-physician collaborative practice models to facilitate implementation of pharmacists’ medication recommendations [187, 204, 353]. Team-based pharmacist models may not be feasible in all institutions [204], but it is advisable that pharmacists have good engagement with other multidisciplinary team members, and, where possible, integrate with the attending physician’s team.

Pharmacist-physician team-based collaborations should begin with defined introductions – either formal or informal – to open the channels of communication and clarify roles [316, 395]. Given the high turnover of junior medical staff in hospitals, it would seem prudent for future collaborative models to have strong trust-based relationships between pharmacists and senior physician prescribers, particularly consultants. Having senior prescribers collaborating with pharmacists to
optimise pharmacotherapy in multimorbid older adults should serve as role models to junior prescribers and improve their prescribing habits [396].

With the advancement of technology, it is likely that computerised interventions will become much more widely used for prescribing optimisation in the coming decades [88]. Concerns have been expressed about their integration into hospital settings, including being costly to design and integrate into hospital settings, and the possibility of new types of clinical error [249]. However, most computerised systems designed to reduce medication errors are both clinically effective and cost-effective [250, 397, 398]. The systematic review in this thesis established that computerised interventions can significantly reduce PIP in hospitalised older adults. As systematic reviews are widely viewed as the ‘gold standard’ in evidence synthesis to inform practice [399], this systematic review adds justification for their use in hospitals, where possible, to reduce PIP and improve patient outcomes. In Chapter 3, it was highlighted that the timing and location of the computer-generated SENATOR recommendations was a key barrier to implementation. Provision of these recommendations in future must be seamlessly integrated into prescriber workflow, ideally in EHRs or EPRs.

Lastly, my findings indicate that the hospital environment may not always be conducive to making changes to long-term medications in acutely unwell older adults [76], and that it may be preferable to do this in primary care post-hospitalisation. However, for this to be achieved, better information exchange is required between primary and secondary healthcare settings in order to facilitate comprehensive medication reviews by GPs and pharmacists [400, 401]. As
described by the interview participants in Chapter 3, prescriber implementation of recommendations may be hindered by patient resistance to deprescribing certain medications, which is commonly reported in the literature for medications such as hypnotics and PPIs [402-404]. Therefore, better patient education is necessary to explain the harms of PIP; previous RCTs with patient education interventions have been proven to significantly reduce PIP in older adults [275, 276].

7.5.2 Implications for future research

Future research into this area should consider the measurement of ‘prescriber implementation’ rather than the commonly used term ‘prescriber acceptance’, as prescribers may agree with the recommendation at face value but not necessarily act on the recommendation. Nonetheless, prescriber implementation is merely a process measure (i.e. it assesses what prescribers do). To be valid in a clinical setting, process measures must correlate with important patient outcomes [331]. In Chapter 5, the physician-driven intervention was associated with a higher implementation rate for STOPP/START recommendations and a greater absolute risk reduction in ADRs in comparison to the pharmacist’s intervention. This prompts two further research questions. Firstly, future studies should examine if improved prescriber implementation of STOPP/START recommendations, as a process measure, correlates with improved patient outcomes (e.g. reduced ADRs). This may have ultimately proved to be a key shortcoming of the SENATOR intervention, whereby low implementation of the recommendations resulted in no difference in the proportion of patients with ADRs between the intervention and control groups [281]. Secondly, future research should aim to test in a multi-centre RCT setting if
there are statistically significant differences in prescriber implementation between physicians’ recommendations and pharmacists’ recommendations with a larger sample size of pharmacists and physicians to help account for interindividual differences.

This thesis underlines the importance of using qualitative research alongside RCTs in future – not only to explain the quantitative results associated with the trial, but also to help inform the research and development of future interventions [256, 257]. The qualitative findings in Chapter 3 and quantitative findings in Chapter 4 have together confirmed that the clinical relevance of the computer-generated recommendations in the SENATOR RCT significantly affected their implementation. Therefore, this body of work has reaffirmed that future researchers should consider mixed-methods approaches to answer complex research questions.

This thesis shows that meticulous software refinement is required for future computerised interventions to minimise inappropriate or irrelevant recommendations [304, 405], thus increasing the proportion of clinically relevant recommendations. In addition, it was suggested by interviewees that it is fundamentally important to provide the most clinically relevant recommendations first to reduce prescriber fatigue with these types of interventions [194]. Therefore, it is imperative for future researchers to consider developing an in-built ranking system within the software algorithms to prioritise prescribing recommendations with the highest clinical relevance. Furthermore, given the low inter-rater reliability with the scale used in Chapter 4, it would be worthwhile for future researchers to
consider developing a new validated scale to assess the clinical relevance of computer-generated pharmacotherapy recommendations.

As highlighted throughout this thesis, there is an urgent need to develop theoretically-informed interventions with enhanced prescriber implementation of recommendations to optimise medication appropriateness in older adults. Of the fourteen possible TDF domains, five appeared predominant in both qualitative studies in this thesis. As demonstrated in Chapters 3 and 6, mapping these predominant TDF domains to the BCW helped identify what intervention types may be successful in enhancing prescriber implementation rates. However, even though all nine intervention functions described in the BCW may be suitable in theory, all options may not be feasible in routine clinical practice. When designing future intervention strategies, it may be warranted to employ the APEASE criteria (Acceptability, Practicability, Effectiveness/cost-effectiveness, Affordability, Safety/side effects, Equity) [227]. This set of criteria can be used to help decide on the intervention content and delivery in a particular context, but should be applied in a systematic manner in combination with expert judgment. Even though the research in this thesis has been focused on secondary care, there is a clear need for further research to determine the best way to integrate these types of interventions into clinical workflows not only in hospitals but also in other settings, such as general practice, ambulatory care clinics, long-term care facilities, as well as in community pharmacies.
7.6 Conclusion

Optimising pharmacotherapy for multimorbid older adults is a complex process. The research described in this thesis was conducted in the context of a continuing high prevalence of PIP in hospitalised older adults. Prescriber implementation rates of recommendations to reduce PIP vary widely between interventions. Non-implementation increases the risk of medication-related harm, but the reasons for non-implementation in individual studies are often not clear or not reported.

This thesis has made a substantial contribution to the literature by achieving its aim of providing a comprehensive and detailed body of research exploring the key factors affecting prescriber implementation of recommendations to improve medication appropriateness in hospitalised older adults.

This work has provided evidence that prescriber implementation is primarily influenced by the clinical relevance of the recommendations, the method of communication, the identity of the prescriber, the source of the recommendation, and the acute hospital environment. Therefore, prescriber implementation of these recommendations is not attributable to one easily identifiable cause, and it is likely that a multi-faceted approach will be required in future interventions. The studies described in this thesis have laid the groundwork for the development of theoretically-informed interventions that could result in enhanced prescriber implementation of these recommendations, ultimately assisting with the aim of significantly reducing PIP and improving health outcomes for older adults.
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Appendices
Appendix 1: STOPP/START criteria version 2

Screening Tool of Older People’s Prescriptions (STOPP) version 2.

The following prescriptions are potentially inappropriate to use in patients aged 65 years and older.

Section A: Indication of medication

1. Any drug prescribed without an evidence-based clinical indication.
2. Any drug prescribed beyond the recommended duration, where treatment duration is well defined.
3. Any duplicate drug class prescription e.g. two concurrent NSAIDs, SSRIs, loop diuretics, ACE inhibitors, anticoagulants (optimisation of monotherapy within a single drug class should be observed prior to considering a new agent).

Section B: Cardiovascular System

1. Digoxin for heart failure with normal systolic ventricular function (no clear evidence of benefit).
2. Verapamil or diltiazem with NYHA Class III or IV heart failure (may worsen heart failure).
3. β-blocker in combination with verapamil or diltiazem (risk of heart block).
4. β-blocker with bradycardia (< 50/min), type II heart block or complete heart block (risk of complete heart block, asystole).
5. Amiodarone as first-line antiarrhythmic therapy in supraventricular tachyarrhythmias (higher risk of side effects than β-blockers, digoxin, verapamil or diltiazem).
6. Loop diuretic as first-line treatment for hypertension (safer, more effective alternatives available).
7. Loop diuretic for dependent ankle oedema without clinical, biochemical evidence or radiological evidence of heart failure, liver failure, nephrotic syndrome or renal failure (leg elevation and/or compression hosiery usually more appropriate).
8. Thiazide diuretic with current significant hypokalaemia (i.e. serum K+ < 3.0 mmol/l), hyponatraemia (i.e. serum Na+ < 130 mmol/l) hypercalcaemia (i.e. corrected serum calcium > 2.65 mmol/l) or with a history of gout (hypokalaemia, hyponatraemia, hypercalcaemia and gout can be precipitated by thiazide diuretic).
9. Loop diuretic for treatment of hypertension with concurrent urinary incontinence (may exacerbate incontinence).
10. Centrally-acting antihypertensives (e.g. methyldopa, clonidine, moxonidine, rilmenidine, guanfacine), unless clear intolerance of, or lack of efficacy with, other classes of antihypertensives (centrally-active antihypertensives are generally less well tolerated by older people than younger people).
11. ACE inhibitors or Angiotensin Receptor Blockers (ARBs) in patients with hyperkalaemia.
12. Aldosterone antagonists (e.g. spironolactone, eplerenone) with concurrent potassium-conserving drugs (e.g. ACE inhibitors, ARBs, amiloride, triamterene) without monitoring of serum potassium (risk of dangerous hyperkalaemia i.e. > 6.0 mmol/l – serum K⁺ should be monitored regularly, i.e. at least every 6 months).
13. Phosphodiesterase type-5 inhibitors (e.g. sildenafil, tadalafil, vardenafil) in severe heart failure characterised by hypotension i.e. systolic blood pressure < 90 mmHg, or concurrent nitrate therapy for angina (risk of cardiovascular collapse).

Section C: Antiplatelet/Anticoagulant Drugs

1. Long-term aspirin at doses greater than 160mg per day (increased risk of bleeding, no evidence for increased efficacy).
2. Aspirin with a past history of peptic ulcer disease without concomitant PPI (risk of recurrent peptic ulcer).
3. Aspirin, clopidogrel, dipyridamole, vitamin K antagonists, direct thrombin inhibitors, or factor Xa inhibitors with concurrent significant bleeding risk, i.e. uncontrolled severe hypertension, bleeding diathesis, recent non-trivial spontaneous bleeding) (high risk of bleeding).
4. Aspirin plus clopidogrel as secondary stroke prevention, unless the patient has a coronary stent(s) inserted in the previous 12 months or concurrent acute coronary syndrome or has a high grade symptomatic carotid arterial stenosis (no evidence of added benefit over clopidogrel monotherapy).
5. Aspirin in combination with vitamin K antagonist, direct thrombin inhibitor, or factor Xa inhibitors in patients with chronic atrial fibrillation (no added benefit from aspirin).
6. Antiplatelet agents with vitamin K antagonist, direct thrombin inhibitor, or factor Xa inhibitors in patients with stable coronary, cerebrovascular, or peripheral arterial disease (No added benefit from dual therapy).
7. Ticlopidine in any circumstances (clopidogrel and prasugrel have similar efficacy, stronger evidence and fewer side effects).
8. Vitamin K antagonist, direct thrombin inhibitor, or factor Xa inhibitors for first deep venous thrombosis without continuing provoking risk factors (e.g. thrombophilia) for > 6 months, (no proven added benefit).
9. Vitamin K antagonist, direct thrombin inhibitor, or factor Xa inhibitors for first pulmonary embolus without continuing provoking risk factors (e.g. thrombophilia) for > 12 months (no proven added benefit).
10. NSAID and vitamin K antagonist, direct thrombin inhibitor, or factor Xa inhibitors in combination (risk of major gastrointestinal bleeding).
11. NSAID with concurrent antiplatelet agent(s) without PPI prophylaxis (increased risk of peptic ulcer disease).

Section D: Central Nervous System and Psychotropic Drugs

1. Tricyclic antidepressants (TCAs) with dementia, narrow angle glaucoma, cardiac conduction abnormalities, prostatism, or prior history of urinary retention (risk of worsening these conditions).
2. Initiation of TCAs as first-line antidepressant treatment (higher risk of adverse drug reactions with TCAs than with SSRIs or SNRIs).
3. Neuroleptics with moderate-marked antimuscarinic/anticholinergic effects (chlorpromazine, clozapine, flupenthixol, fluphenazine, pipothiazine, promazine, zuclopenthixol) with a history of prostatism or previous urinary retention (high risk of urinary retention).
4. Selective serotonin re-uptake inhibitors (SSRIs) with current or recent significant hyponatraemia i.e. serum Na\(^+\) < 130 mmol/l (risk of exacerbating or precipitating hyponatraemia).
5. Benzodiazepines for ≥ 4 weeks (no indication for longer treatment; risk of prolonged sedation, confusion, impaired balance, falls, road traffic accidents; all benzodiazepines should be withdrawn gradually if taken for more than 4 weeks as there is a risk of causing a benzodiazepine withdrawal syndrome if stopped abruptly).
6. Antipsychotics (i.e. other than quetiapine or clozapine) in those with parkinsonism or Lewy Body Disease (risk of severe extra-pyramidal symptoms).
7. Anticholinergics/antimuscarinics to treat extra-pyramidal side effects of neuroleptic medications (risk of anticholinergic toxicity).
8. Anticholinergics/antimuscarinics in patients with delirium or dementia (risk of exacerbation of cognitive impairment).
9. Neuroleptic antipsychotic in patients with behavioural and psychological symptoms of dementia (BPSD) unless symptoms are severe and other non-pharmacological treatments have failed (increased risk of stroke).
10. Neuroleptics as hypnotics, unless sleep disorder is due to psychosis or dementia (risk of confusion, hypotension, extra-pyramidal side effects, falls).

11. Acetylcholinesterase inhibitors with a known history of persistent bradycardia (< 60 beats/minute), heart block or recurrent unexplained syncope or concurrent treatment with drugs that reduce heart rate such as β-blockers, digoxin, diltiazem, verapamil (risk of cardiac conduction failure, syncope and injury).

12. Phenothiazines as first-line treatment, since safer and more efficacious alternatives exist (phenothiazines are sedative, have significant antimuscarinic toxicity in older people, with the exception of prochlorperazine for nausea/vomiting/vertigo, chlorpromazine for relief of persistent hiccoughs and levomepromazine as an anti-emetic in palliative care).

13. Levodopa or dopamine agonists for benign essential tremor (no evidence of efficacy).

14. First-generation antihistamines (safer, less toxic antihistamines now widely available).

Section E: Renal System. The following drugs are potentially inappropriate in older people with acute or chronic kidney disease with renal function below particular levels of eGFR (refer to summary of product characteristics datasheets and local formulary guidelines)

1. Digoxin at a long-term dose greater than 125µg/day if eGFR < 30 ml/min/1.73m² (risk of digoxin toxicity if plasma levels not measured).

2. Direct thrombin inhibitors (e.g. dabigatran) if eGFR < 30 ml/min/1.73m² (risk of bleeding).

3. Factor Xa inhibitors (e.g. rivaroxaban, apixaban) if eGFR < 15 ml/min/1.73m² (risk of bleeding).

4. NSAIDs if eGFR < 50 ml/min/1.73m² (risk of deterioration in renal function).

5. Colchicine if eGFR < 10 ml/min/1.73m² (risk of colchicine toxicity).

6. Metformin if eGFR < 30 ml/min/1.73m² (risk of lactic acidosis).

Section F: Gastrointestinal System

1. Prochlorperazine or metoclopramide with parkinsonism (risk of exacerbating parkinsonian symptoms).

2. PPI for uncomplicated peptic ulcer disease or erosive peptic oesophagitis at full therapeutic dosage for > 8 weeks (dose reduction or earlier discontinuation indicated).
3. Drugs likely to cause constipation (e.g. antimuscarinic/anticholinergic drugs, oral iron, opioids, verapamil, aluminium antacids) in patients with chronic constipation where non-constipating alternatives are available (risk of exacerbation of constipation).

4. Oral elemental iron doses greater than 200 mg daily (e.g. ferrous fumarate > 600 mg/day, ferrous sulphate > 600 mg/day, ferrous gluconate > 1800 mg/day; no evidence of enhanced iron absorption above these doses).

Section G: Respiratory System

1. Theophylline as monotherapy for COPD (safer, more effective alternative; risk of adverse effects due to narrow therapeutic index).

2. Systemic corticosteroids instead of inhaled corticosteroids for maintenance therapy in moderate-severe COPD (unnecessary exposure to long-term side effects of systemic corticosteroids and effective inhaled therapies are available).

3. Antimuscarinic bronchodilators (e.g. ipratropium, tiotropium) with a history of narrow angle glaucoma (may exacerbate glaucoma) or bladder outflow obstruction (may cause urinary retention).

4. Non-selective β-blocker (whether oral or topical for glaucoma) with a history of asthma requiring treatment (risk of increased bronchospasm).

5. Benzodiazepines with acute or chronic respiratory failure i.e. pO₂ < 8.0 kPa ± pCO₂ > 6.5 kPa (risk of exacerbation of respiratory failure).

Section H: Musculoskeletal System

1. Non-steroidal anti-inflammatory drug (NSAID) other than COX-2 selective agents with history of peptic ulcer disease or gastrointestinal bleeding, unless with concurrent PPI or H₂ antagonist (risk of peptic ulcer relapse).

2. NSAID with severe hypertension (risk of exacerbation of hypertension) or severe heart failure (risk of exacerbation of heart failure).

3. Long-term use of NSAID (> 3 months) for symptom relief of osteoarthritis pain where paracetamol has not been tried (simple analgesics preferable and usually as effective for pain relief).

4. Long-term corticosteroids (> 3 months) as monotherapy for rheumatoid arthritis (risk of systemic corticosteroid side effects).

5. Corticosteroids (other than periodic intra-articular injections for mono-articular pain) for osteoarthritis (risk of systemic corticosteroid side effects).
6. Long-term NSAID or colchicine (> 3 months) for chronic treatment of gout where there is no contraindication to a xanthine-oxidase inhibitor (e.g. allopurinol, febuxostat) (xanthine-oxidase inhibitors are first choice prophylactic drugs in gout).

7. COX-2 selective NSAIDs with concurrent cardiovascular disease (increased risk of myocardial infarction and stroke).

8. NSAID with concurrent corticosteroids without PPI prophylaxis (increased risk of peptic ulcer disease).

9. Oral bisphosphonates in patients with a current or recent history of upper gastrointestinal disease i.e. dysphagia, oesophagitis, gastritis, duodenitis, or peptic ulcer disease, or upper gastrointestinal bleeding (risk of relapse/exacerbation of oesophagitis, oesophageal ulcer, oesophageal stricture).

Section I: Urogenital System

1. Antimuscarinic drugs with dementia, or chronic cognitive impairment (risk of increased confusion, agitation) or narrow-angle glaucoma (risk of acute exacerbation of glaucoma), or chronic prostatism (risk of urinary retention).

2. Selective alpha-1 selective alpha blockers in those with symptomatic orthostatic hypotension or micturition syncope (risk of precipitating recurrent syncope).

Section J. Endocrine System

1. Sulphonylureas with a long duration of action (e.g. glibenclamide, chlorpropamide, glimepiride) with type 2 diabetes mellitus (risk of prolonged hypoglycaemia).

2. Thiazolidinediones (e.g. rosiglitazone, pioglitazone) in patients with heart failure (risk of exacerbation of heart failure).

3. β-blockers in diabetes mellitus with frequent hypoglycaemic episodes (risk of suppressing hypoglycaemic symptoms).

4. Oestrogens with a history of breast cancer or venous thromboembolism (increased risk of recurrence).


6. Androgens (male sex hormones) in the absence of primary or secondary hypogonadism (risk of androgen toxicity; no proven benefit outside of the hypogonadism indication).
Section K: Drugs that predictably increase the risk of falls in older people

1. Benzodiazepines (sedative, may cause reduced sensorium, impair balance).
2. Neuroleptic drugs (may cause gait dyspraxia, parkinsonism).
3. Vasodilator drugs (e.g. alpha-1 receptor blockers, calcium channel blockers, long-acting nitrates, ACE inhibitors, ARBs) with persistent postural hypotension i.e. recurrent drop in systolic blood pressure ≥ 20mmHg (risk of syncope, falls).
4. Hypnotic Z-drugs e.g. zopiclone, zolpidem, zaleplon (may cause protracted daytime sedation, ataxia).

Section L: Analgesic Drugs

1. Use of oral or transdermal strong opioids (morphine, oxycodone, fentanyl, buprenorphine, diamorphine, methadone, tramadol, pethidine, pentazocine) as first-line therapy for mild pain (WHO analgesic ladder not observed).
2. Use of regular (as distinct from prn) opioids without concomitant laxative (risk of severe constipation).

Section N: Antimuscarinic/Anticholinergic Drug Burden

Concomitant use of two or more drugs with antimuscarinic/anticholinergic properties (e.g. bladder antispasmodics, intestinal antispasmodics, TCAs, first-generation antihistamines) (risk of increased antimuscarinic/anticholinergic toxicity).
Screening Tool to Alert to Right Treatment (START) version 2.

Unless an elderly patient’s clinical status is end-of-life and therefore requiring a more palliative focus of pharmacotherapy, the following drug therapies should be considered where omitted for no valid clinical reason(s). It is assumed that the prescriber observes all the specific contraindications to these drug therapies prior to recommending them to older patients.

Section A: Cardiovascular System

1. Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors in the presence of chronic atrial fibrillation.
2. Aspirin (75 mg – 160 mg once daily) in the presence of chronic atrial fibrillation, where Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors are contraindicated.
3. Antiplatelet therapy (aspirin or clopidogrel or prasugrel or ticagrelor) with a documented history of coronary, cerebral, or peripheral vascular disease.
4. Antihypertensive therapy where systolic blood pressure consistently > 160 mmHg and/or diastolic blood pressure consistently > 90 mmHg; if systolic blood pressure > 140 mmHg and/or diastolic blood pressure > 90 mmHg, if diabetic.
5. Statin therapy with a documented history of coronary, cerebral, or peripheral vascular disease, unless the patient’s status is end-of-life or age is > 85 years.
6. ACE inhibitor with systolic heart failure and/or documented coronary artery disease.
7. β-blocker with ischaemic heart disease.
8. Appropriate β-blocker (bisoprolol, nebivolol, metoprolol or carvedilol) with stable systolic heart failure.

Section B: Respiratory System

1. Regular inhaled β2 agonist or antimuscarinic bronchodilator (e.g. ipratropium, tiotropium) for mild to moderate asthma or COPD.
2. Regular inhaled corticosteroid for moderate-severe asthma or COPD, where FEV1 < 50% of predicted value and repeated exacerbations requiring treatment with oral corticosteroids.
3. Home continuous oxygen with documented chronic hypoxaemia (i.e. pO\textsubscript{2} < 8.0 kPa or 60 mmHg or SaO\textsubscript{2} < 89%).
Section C: Central Nervous System & Eyes

1. Levodopa or a dopamine agonist in idiopathic Parkinson’s disease with functional impairment and resultant disability.
2. Non-TCA antidepressant drug in the presence of persistent major depressive symptoms.
3. Acetylcholinesterase inhibitor (e.g. donepezil, rivastigmine, galantamine) for mild-moderate Alzheimer’s dementia or Lewy Body dementia (rivastigmine).
4. Topical prostaglandin, prostanamide, or β-blocker for primary open-angle glaucoma.
5. SSRI (or SNRI or pregabalin if SSRI contraindicated) for persistent severe anxiety that interferes with independent functioning.
6. Dopamine agonist (ropinirole or pramipexole or rotigotine) for Restless Legs Syndrome, once iron deficiency and severe renal failure have been excluded.

Section D: Gastrointestinal System

1. PPI with severe gastro-oesophageal reflux disease or peptic stricture requiring dilatation.
2. Fibre supplements (e.g. bran, ispaghula, methylcellulose, sterculia) for diverticulosis with a history of constipation.

Section E: Musculoskeletal System

1. Disease-modifying anti-rheumatic drug (DMARD) with active, disabling rheumatoid disease.
2. Bisphosphonates and vitamin D and calcium in patients taking long-term systemic corticosteroid therapy.
3. Vitamin D and calcium supplement in patients with known osteoporosis and/or previous fragility fracture(s) and/or (Bone Mineral Density T-scores more than -2.5 in multiple sites).
4. Bone anti-resorptive or anabolic therapy (e.g. bisphosphonate, strontium ranelate, teriparatide, denosumab) in patients with documented osteoporosis, where no pharmacological or clinical status contraindication exists (Bone Mineral Density T-scores more than -2.5 in multiple sites) and/or previous history of fragility fracture(s).
5. Vitamin D supplement in older people who are housebound or experiencing falls or with osteopenia (Bone Mineral Density T-score is > -1.0 but < -2.5 in multiple sites).
6. Xanthine-oxidase inhibitors (e.g. allopurinol, febuxostat) with a history of recurrent episodes of gout.
7. Folic acid supplement in patients taking methotrexate.

Section F: Endocrine System

1. ACE inhibitor or ARB (if intolerant of ACE inhibitor) in diabetes with evidence of renal disease i.e. dipstick proteinuria or microalbuminuria (> 30mg/24 hours) with or without serum biochemical renal impairment.

Section G: Urogenital System

1. Alpha-1 receptor blocker with symptomatic prostatism, where prostatectomy is not considered necessary.
2. 5-alpha reductase inhibitor with symptomatic prostatism, where prostatectomy is not considered necessary.
3. Topical vaginal oestrogen or vaginal oestrogen pessary for symptomatic atrophic vaginitis.

Section H: Analgesics

1. High-potency opioids in moderate-severe pain, where paracetamol, NSAIDs or low-potency opioids are not appropriate to the pain severity or have been ineffective.
2. Laxatives in patients receiving opioids regularly.

Section I: Vaccines

1. Seasonal trivalent influenza vaccine annually.
2. Pneumococcal vaccine at least once after age 65 according to national guidelines.

Reference: O'Mahony D, O'Sullivan D, Byrne S, O'Connor MN, Ryan C, Gallagher P.


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## Appendix 2: Theoretical Domains Framework (version 2)

<table>
<thead>
<tr>
<th>Domain (definition)</th>
<th>Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Knowledge</strong></td>
<td>Knowledge (including knowledge of condition / scientific rationale)</td>
</tr>
<tr>
<td>(An awareness of the existence of something)</td>
<td>Procedural knowledge</td>
</tr>
<tr>
<td></td>
<td>Knowledge of task environment</td>
</tr>
<tr>
<td><strong>2. Skills</strong></td>
<td>Skills</td>
</tr>
<tr>
<td>(An ability or proficiency acquired through practice)</td>
<td>Skills development</td>
</tr>
<tr>
<td></td>
<td>Competence</td>
</tr>
<tr>
<td></td>
<td>Ability</td>
</tr>
<tr>
<td></td>
<td>Interpersonal skills</td>
</tr>
<tr>
<td></td>
<td>Practice</td>
</tr>
<tr>
<td></td>
<td>Skill assessment</td>
</tr>
<tr>
<td><strong>3. Social/Professional Role and Identity</strong></td>
<td>Professional identity</td>
</tr>
<tr>
<td>(A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting)</td>
<td>Professional role</td>
</tr>
<tr>
<td></td>
<td>Social identity</td>
</tr>
<tr>
<td></td>
<td>Identity</td>
</tr>
<tr>
<td></td>
<td>Professional boundaries</td>
</tr>
<tr>
<td></td>
<td>Professional confidence</td>
</tr>
<tr>
<td></td>
<td>Group identity</td>
</tr>
<tr>
<td></td>
<td>Leadership</td>
</tr>
<tr>
<td></td>
<td>Organisational commitment</td>
</tr>
<tr>
<td><strong>4. Beliefs about Capabilities</strong></td>
<td>Self-confidence</td>
</tr>
<tr>
<td>(Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use)</td>
<td>Perceived competence</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
</tr>
<tr>
<td></td>
<td>Perceived behavioural control</td>
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<tr>
<td></td>
<td>Beliefs</td>
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<tr>
<td></td>
<td>Self-esteem</td>
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<tr>
<td></td>
<td>Empowerment</td>
</tr>
<tr>
<td></td>
<td>Professional confidence</td>
</tr>
<tr>
<td><strong>5. Optimism</strong></td>
<td>Optimism</td>
</tr>
<tr>
<td></td>
<td>Pessimism</td>
</tr>
<tr>
<td></td>
<td>Unrealistic optimism</td>
</tr>
<tr>
<td></td>
<td>Identity</td>
</tr>
<tr>
<td><strong>6. Beliefs about Consequences</strong></td>
<td>Beliefs</td>
</tr>
<tr>
<td></td>
<td>Outcome expectancies</td>
</tr>
<tr>
<td></td>
<td>Characteristics of outcome expectancies</td>
</tr>
<tr>
<td></td>
<td>Anticipated regret</td>
</tr>
<tr>
<td></td>
<td>Consequents</td>
</tr>
<tr>
<td><strong>7. Reinforcement</strong></td>
<td>Rewards (proximal / distal, valued / not valued, probable / improbable)</td>
</tr>
<tr>
<td>(Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus)</td>
<td>Incentives</td>
</tr>
<tr>
<td></td>
<td>Punishment</td>
</tr>
<tr>
<td></td>
<td>Consequents</td>
</tr>
<tr>
<td></td>
<td>Reinforcement</td>
</tr>
<tr>
<td></td>
<td>Contingencies</td>
</tr>
<tr>
<td></td>
<td>Sanctions</td>
</tr>
<tr>
<td>Domain (definition)</td>
<td>Constructs</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>8. Intentions</strong></td>
<td>Stability of intentions</td>
</tr>
<tr>
<td>(A conscious decision to perform a behaviour or a resolve to act in a certain way)</td>
<td>Stages of change model</td>
</tr>
<tr>
<td></td>
<td>Transtheoretical model and stages of change</td>
</tr>
<tr>
<td><strong>9. Goals</strong></td>
<td>Goals (distal / proximal)</td>
</tr>
<tr>
<td>(Mental representations of outcomes or end states that an individual wants to achieve)</td>
<td>Goal priority</td>
</tr>
<tr>
<td></td>
<td>Goal / target setting</td>
</tr>
<tr>
<td></td>
<td>Goals (autonomous /controlled)</td>
</tr>
<tr>
<td></td>
<td>Action planning</td>
</tr>
<tr>
<td></td>
<td>Implementation intention</td>
</tr>
<tr>
<td><strong>10. Memory, Attention and Decision Processes</strong></td>
<td>Memory</td>
</tr>
<tr>
<td>(The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives)</td>
<td>Attention</td>
</tr>
<tr>
<td></td>
<td>Attention control</td>
</tr>
<tr>
<td></td>
<td>Decision making</td>
</tr>
<tr>
<td></td>
<td>Cognitive overload / tiredness</td>
</tr>
<tr>
<td><strong>11. Environmental Context and Resources</strong></td>
<td>Environmental stressors</td>
</tr>
<tr>
<td>(Any circumstance of a person’s situation or environment that discourages, or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour)</td>
<td>Resources / material resources</td>
</tr>
<tr>
<td></td>
<td>Organisational culture / climate</td>
</tr>
<tr>
<td></td>
<td>Salient events / critical incidents</td>
</tr>
<tr>
<td></td>
<td>Person x environment interaction</td>
</tr>
<tr>
<td></td>
<td>Barriers and facilitators</td>
</tr>
<tr>
<td><strong>12. Social Influences</strong></td>
<td>Social pressure</td>
</tr>
<tr>
<td>(Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours)</td>
<td>Social norms</td>
</tr>
<tr>
<td></td>
<td>Group conformity</td>
</tr>
<tr>
<td></td>
<td>Social comparisons</td>
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<tr>
<td></td>
<td>Group norms</td>
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<td></td>
<td>Social support</td>
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<td></td>
<td>Power</td>
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<tr>
<td></td>
<td>Intergroup conflict</td>
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<tr>
<td></td>
<td>Alienation</td>
</tr>
<tr>
<td></td>
<td>Group Identity</td>
</tr>
<tr>
<td></td>
<td>Modelling</td>
</tr>
<tr>
<td><strong>13. Emotion</strong></td>
<td>Fear</td>
</tr>
<tr>
<td>(A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event)</td>
<td>Anxiety</td>
</tr>
<tr>
<td></td>
<td>Affect</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
</tr>
<tr>
<td></td>
<td>Depression</td>
</tr>
<tr>
<td></td>
<td>Positive / negative affect</td>
</tr>
<tr>
<td></td>
<td>Burn-out</td>
</tr>
<tr>
<td><strong>14. Behavioural Regulation</strong></td>
<td>Self-monitoring</td>
</tr>
<tr>
<td>(Anything aimed at managing or changing objectively observed or measured actions)</td>
<td>Breaking habit</td>
</tr>
<tr>
<td></td>
<td>Action planning</td>
</tr>
</tbody>
</table>


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Appendix 3: Behaviour Change Wheel

The domains of the TDF are presented in yellow here. Depending on which domains are identified, they can be mapped to intervention functions, shown here in red, which may be suitable components in the design of future interventions.


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Appendix 4: PRISMA checklist for systematic review

<table>
<thead>
<tr>
<th>Section/topic</th>
<th>#</th>
<th>Checklist item</th>
<th>Reported on page #</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>1</td>
<td>Identify the report as a systematic review, meta-analysis, or both.</td>
<td>48</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structured summary</td>
<td>2</td>
<td>Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.</td>
<td>49/50; Registration Number: 52</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rationale</td>
<td>3</td>
<td>Describe the rationale for the review in the context of what is already known.</td>
<td>51</td>
</tr>
<tr>
<td>Objectives</td>
<td>4</td>
<td>Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).</td>
<td>51/52</td>
</tr>
<tr>
<td>METHODS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol and registration</td>
<td>5</td>
<td>Indicate if a review protocol exists, if and where it can be accessed (e.g. web address), and, if available, provide registration information including registration number.</td>
<td>52</td>
</tr>
<tr>
<td>Eligibility criteria</td>
<td>6</td>
<td>Specify study characteristics (e.g. PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.</td>
<td>53</td>
</tr>
<tr>
<td>Information sources</td>
<td>7</td>
<td>Describe all information sources (e.g. databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.</td>
<td>52/53</td>
</tr>
<tr>
<td>Search</td>
<td>8</td>
<td>Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.</td>
<td>Appendix 5</td>
</tr>
<tr>
<td>Section/topic</td>
<td>#</td>
<td>Checklist item</td>
<td>Reported on page #</td>
</tr>
<tr>
<td>-----------------------------------</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Study selection</td>
<td>9</td>
<td>State the process for selecting studies (i.e. screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).</td>
<td>53</td>
</tr>
<tr>
<td>Data collection process</td>
<td>10</td>
<td>Describe method of data extraction from reports (e.g. piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.</td>
<td>53</td>
</tr>
<tr>
<td>Data items</td>
<td>11</td>
<td>List and define all variables for which data were sought (e.g. PICOS, funding sources) and any assumptions and simplifications made.</td>
<td>53</td>
</tr>
<tr>
<td>Risk of bias in individual studies</td>
<td>12</td>
<td>Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.</td>
<td>54</td>
</tr>
<tr>
<td>Summary measures</td>
<td>13</td>
<td>State the principal summary measures (e.g., risk ratio, difference in means).</td>
<td>54</td>
</tr>
<tr>
<td>Synthesis of results</td>
<td>14</td>
<td>Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g. I²) for each meta-analysis.</td>
<td>54</td>
</tr>
<tr>
<td>Risk of bias across studies</td>
<td>15</td>
<td>Specify any assessment of risk of bias that may affect the cumulative evidence (e.g. publication bias, selective reporting within studies).</td>
<td>54</td>
</tr>
<tr>
<td>Additional analyses</td>
<td>16</td>
<td>Describe methods of additional analyses (e.g. sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**RESULTS**

<table>
<thead>
<tr>
<th>Section/topic</th>
<th>#</th>
<th>Checklist item</th>
<th>Reported on page #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study selection</td>
<td>17</td>
<td>Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.</td>
<td>54/55</td>
</tr>
<tr>
<td>Study characteristics</td>
<td>18</td>
<td>For each study, present characteristics for which data were extracted (e.g. study size, PICOS, follow-up period) and provide the citations.</td>
<td>57-59 Appendix 6</td>
</tr>
<tr>
<td>Risk of bias within studies</td>
<td>19</td>
<td>Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).</td>
<td>60/61</td>
</tr>
<tr>
<td>Section/topic</td>
<td>#</td>
<td>Checklist item</td>
<td>Reported on page #</td>
</tr>
<tr>
<td>----------------------------</td>
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<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Results of individual studies</td>
<td>20</td>
<td>For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.</td>
<td>57-59, 62-63</td>
</tr>
<tr>
<td>Synthesis of results</td>
<td>21</td>
<td>Present results of each meta-analysis done, including confidence intervals and measures of consistency.</td>
<td>62</td>
</tr>
<tr>
<td>Risk of bias across studies</td>
<td>22</td>
<td>Present results of any assessment of risk of bias across studies (see Item 15).</td>
<td>60-61</td>
</tr>
<tr>
<td>Additional analysis</td>
<td>23</td>
<td>Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).</td>
<td>N/A</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summary of evidence</td>
<td>24</td>
<td>Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g. healthcare providers, users, and policy makers).</td>
<td>67-70</td>
</tr>
<tr>
<td>Limitations</td>
<td>25</td>
<td>Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g. incomplete retrieval of identified research, reporting bias).</td>
<td>68-69</td>
</tr>
<tr>
<td>Conclusions</td>
<td>26</td>
<td>Provide a general interpretation of the results in the context of other evidence, and implications for future research.</td>
<td>70</td>
</tr>
<tr>
<td>FUNDING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>27</td>
<td>Describe sources of funding for the systematic review and other support (e.g. supply of data); role of funders for the systematic review.</td>
<td>Published review [251]</td>
</tr>
</tbody>
</table>
Appendix 5: Search strategy for systematic review

Inappropriate prescribing OR potentially inappropriate prescribing OR inappropriate prescription* OR overprescribing OR underprescribing OR inappropriate polypharmacy OR inappropriate medicine* OR inappropriate medication* OR inappropriate drug* OR optimize prescribing OR improve appropriateness of prescribing

AND

aged OR elder* OR geriatric OR older person* OR older patient* OR older adult*

AND

Computer* OR software OR software intervention OR clinical decision support OR CDSS OR CDS

Note: This search strategy was developed in the PubMed database. For each of the remaining databases, the search strategy was modified to suit their specific search capabilities if necessary.
## Appendix 6: Supplementary details about the included studies in the systematic review

<table>
<thead>
<tr>
<th>Author et al.</th>
<th>Study design</th>
<th>Duration of study</th>
<th>Number of patients</th>
<th>Target medications</th>
<th>Intervention aimed at</th>
<th>Prescriber involved with intervention</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agostini et al. 2007 (USA) [211]</td>
<td>Before-after study</td>
<td>Pre- and post-intervention periods were both 12 months.</td>
<td>C: 12,356 I: 12,153 Total: 24,509</td>
<td>The sedative hypnotics diazepam and diphenhydramine.</td>
<td>Patients aged ≥ 65 years admitted to the adult inpatient service.</td>
<td>Physician</td>
<td>Computerised reminder in a CPOE system aiming to minimise use of diphenhydramine and diazepam, and directing physicians to either a non-pharmacological sleep protocol or to an alternative medication, such as trazodone or lorazepam.</td>
</tr>
<tr>
<td>Boustani et al. 2012 (USA) [240]</td>
<td>RCT</td>
<td>Twenty-one months.</td>
<td>C: 225 I: 199 Total: 424</td>
<td>Eighteen medications with moderate to severe centrally-acting anticholinergic properties, selected by an interdisciplinary team (which included a geriatrician, a geriatric nurse practitioner, a pharmacist, a social worker, a physical therapist, an occupational therapist, and an administrative assistant).</td>
<td>English-speaking patients ≥ 65 years hospitalised on a medical ward, with cognitive impairment at the time of hospital admission. Patients excluded if they had previously been enrolled in the study, were aphasic, or unresponsive at the time of screening.</td>
<td>Physician</td>
<td>If a physician ordered any one of 18 inappropriate anticholinergic medications in a CPOE system, a CDSS interruptive alert recommended to discontinue the medicine, dose modification, or suggested an alternative.</td>
</tr>
<tr>
<td>Ghibelli et al. 2013 (Italy) [238]</td>
<td>Before-after study</td>
<td>Two months for both phases.</td>
<td>C: 74 I: 60 Total: 134</td>
<td>PIMs according to the 2003 Beers criteria, as these were the explicit criteria in INTERcheck®.</td>
<td>Inpatients ≥ 65 years – only exclusion criteria were severe malignancy (life expectancy less than 6 months) or terminal illness.</td>
<td>Physician</td>
<td>The physician utilised a computerised prescription support system (INTERcheck®) to identify PIMs and potential drug-drug interactions, as well as aiming to reduce anticholinergic load and adjust doses in patients with renal impairment.</td>
</tr>
<tr>
<td>Author Year (Country)</td>
<td>Study design</td>
<td>Duration of study</td>
<td>Number of patients</td>
<td>Target medications</td>
<td>Intervention aimed at</td>
<td>Prescriber involved with intervention</td>
<td>Intervention</td>
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<tr>
<td>Griffey et al. 2011 (USA) [201]</td>
<td>Interrupted time series</td>
<td>Alternated OFF, ON, OFF, ON. First two blocks were 6 weeks long and last two blocks were 7 weeks long.</td>
<td>C: 668 I: 739 Total 1,407</td>
<td>Benzodiazepines, NSAIDs, opiates, sedative-hypnotics. These were selected by an expert panel including a geriatrician, a general psychiatrist, a pharmacist, two general internists, and an anaesthesiologist specialising in pain management, as had previously been done in Peterson et al. [200].</td>
<td>All persons aged ≥ 65 years who had an order for a medication in one of the targeted drug classes during the study period. The study excluded patient orders in which qualifying medication orders were subsequently cancelled and any orders with missing data.</td>
<td>Physician</td>
<td>When one of the study medications was ordered in a CPOE system for patients ≥ 65 years, a clinical decision support tool modified one or more of the following parameters: medication selection, default dosage, or default frequency. The physician could then choose to accept or override the recommendation. The tool was alternated ‘OFF’ and ‘ON’ in consecutive blocks during the study period.</td>
</tr>
<tr>
<td>Lester et al. 2015 (USA) [241]</td>
<td>Before-after study</td>
<td>Four years: 2010 to 2013. Results are from the second quarters of each year.</td>
<td>C: 3,259 I: 9,591 Total: 12,850</td>
<td>Diphenhydramine, metoclopramide, and all antipsychotics.</td>
<td>Patients aged ≥ 65 years.</td>
<td>Prescribers – doesn’t specify.</td>
<td>Informational alerts popped up when a PIM was ordered in the CPOE system. The physician was required to acknowledge the alert, before deciding on whether to cancel their order or continue prescribing the medication.</td>
</tr>
<tr>
<td>Mattison et al. 2010 (USA) [242]</td>
<td>Before-after study</td>
<td>Pre-alert: 6 months. Post-alert: 37 months.</td>
<td>Number of patients is not stated</td>
<td>A list of Beers 2003 criteria medications selected by a geriatrician and pharmacist, and then revised by the hospital’s Pharmacy and Therapeutics Committee.</td>
<td>All hospitalised inpatients aged ≥ 65 years.</td>
<td>Physicians</td>
<td>The CPOE system alerted prescribers when a PIM was ordered by providing a medication-specific warning that advised alternative medication or dose reduction.</td>
</tr>
<tr>
<td>Author Year (Country)</td>
<td>Study design</td>
<td>Duration of study</td>
<td>Number of patients</td>
<td>Target medications</td>
<td>Intervention aimed at</td>
<td>Prescriber involved with intervention</td>
<td>Intervention</td>
</tr>
<tr>
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</tr>
<tr>
<td>Peterson et al. 2005 (USA) [200]</td>
<td>Interrupted time series</td>
<td>Four consecutive 6-week study periods. 1st and 3rd were control periods (usual CPOE). 2nd and 4th periods were intervention periods.</td>
<td>C: 2,515 patient visits I: 2,647 patient visits Total: 5,162</td>
<td>Seventy-two psychotropic medications decided on by a panel of experts, including a geriatrician, a geriatric psychiatrist, a pharmacist, 2 internists, and an anaesthesiologist specialising in pain management.</td>
<td>All patients ≥ 65 years prescribed one of the targeted medications and admitted to any of the medical, surgical, neurology, and gynaecology services were evaluated. General ward and intensive care patients were eligible for analysis. Only those patients whose admission was entirely contained within 1 of the 6-week study periods were included.</td>
<td>Physicians</td>
<td>A decision support tool altered the default dose and frequency for psychotropic medications for patients ≥ 65 years, and suggested an alternative medication when prescribers ordered one of 12 psychotropic medications known to be poorly tolerated in older patients. The support tool was activated for 2 of 4 six-week study periods in an off-on-off-on pattern.</td>
</tr>
<tr>
<td>Terrell et al. 2009 (USA) [210]</td>
<td>RCT</td>
<td>Thirty months.</td>
<td>C: 1,925 I: 1,793 Total: 3,718</td>
<td>Nine high-use and high impact PIMs, selected by an expert panel consisting of two doctors of pharmacy, two physician information technology experts, three geriatricians, and three emergency physicians.</td>
<td>The intervention was aimed at emergency department physicians. C: 31 physicians I: 32 physicians</td>
<td>Physicians</td>
<td>Physicians in the intervention group were provided decision support when they attempted to prescribe a PIM for patients ≥ 65 years who were being discharged from the emergency department. The computerised reminder provided recommendations for alternatives which the physician could accept or reject.</td>
</tr>
</tbody>
</table>

USA: United States of America; C: Control group; I: Intervention group; CPOE: Computerised physician order entry; RCT: Randomised controlled trial; CDSS: Clinical decision support system; PIM: Potentially inappropriate medication; NSAID: Non-steroidal anti-inflammatory drug.
Appendix 7: Ethical approval for Chapter 3

6th September 2017

Professor Stephen Byrne
School of Pharmacy
University College Cork
Room UG06
Cavanagh Building
College Road
Cork

Re: Acceptability and delivery of computer-generated recommendations regarding medication optimization in a multi-centre randomized controlled trial.

Dear Professor Byrne

Approval is granted to carry out the above study at University College Cork and Cork University Hospital.

The following documents have been approved:

- Cover Letter dated 9th August 2017
- Application Form signed 9th August 2017
- Participant Information Letter
- Consent Form Version 1.0 dated August 2017
- Study Protocol
- Topic Guide
- Evidence of Insurance.

We note that the co-investigators involved in this study will be:

- Professor Denis O’Mahony, Consultant in Geriatric Medicine, Shane Cullinan, Lecturer in Pharmacy Practice and Kieran Dalton, PhD Researcher.

The date of this letter is the date of authorization of the study.

Please keep a copy of this signed approval letter in your study master file for audit purposes.

You should note that ethical approval will lapse if you do not adhere to the following conditions:

1. Submission of an Annual Progress Report/Annual Renewal Survey (due annually from the date of this approval letter)
2. Report unexpected adverse events, serious adverse events or any event that may affect ethical acceptability of the study
3. Submit any change to study documentation (minor or major) to CREC for review and approval. Amendments must be submitted on an amendment application form and revised study documents must clearly highlight the changes and contain a new version number and date. Amendments cannot be implemented without written approval from CREC.

Oíthcilt na hÉireann, Corcaigh - National University of Ireland, Cork
4. Notify CREC of discontinuation of the study

5. Submit an End of Trial Declaration Form and Final Study Report/Study Synopsis when the study has been completed

Yours sincerely

[Signature]
Professor Michael G Molloy
Chairman
Clinical Research Ethics Committee
of the Cork Teaching Hospital

The Clinical Research Ethics Committee of the Cork Teaching Hospitals, UCC, is a recognised Ethics Committee under Regulation 7 of the European Communities (Clinical Trials on Medicinal Products for Human Use) Regulations 2004, and is authorised by the Department of Health and Children to carry out the ethical review of clinical trials of investigational medicinal products. The Committee is fully compliant with the Regulations as they relate to Ethics Committees and the conditions and principles of Good Clinical Practice.
**Appendix 8: COREQ checklist for qualitative interview study from Chapter 3**

**Domain 1: Research Team and Reflexivity**

### Personal characteristics

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Interviewer/facilitator</td>
<td>Which author/s conducted the interview or focus group?</td>
</tr>
<tr>
<td>2.</td>
<td>Credentials</td>
<td>What were the researcher’s credentials (e.g. PhD, MD)?</td>
</tr>
<tr>
<td>3.</td>
<td>Occupation</td>
<td>What was their occupation at the time of the study?</td>
</tr>
<tr>
<td>4.</td>
<td>Sex</td>
<td>Was the researcher male or female?</td>
</tr>
<tr>
<td>5.</td>
<td>Experience and training</td>
<td>What experience or training did the researcher have?</td>
</tr>
</tbody>
</table>

### Relationship with participants

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>6.</td>
<td>Relationship established</td>
<td>Was a relationship established prior to study commencement?</td>
</tr>
<tr>
<td>7.</td>
<td>Participant knowledge of the interviewer</td>
<td>What did the participants know about the researcher (e.g. personal goals, reasons for doing the research)?</td>
</tr>
<tr>
<td>8.</td>
<td>Interviewer characteristics</td>
<td>What characteristics were reported about the interviewer/facilitator? (e.g. bias, assumptions, reasons and interests in the research topic)</td>
</tr>
</tbody>
</table>
Domain 2: Study Design

Theoretical framework

9. Methodological orientation and Theory

What methodological orientation was stated to underpin the study (e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis)?

Content analysis was used in this study to analyse the data from the interview transcripts. Conventional content analysis was used to identify the conventional themes, which were attributed as factors that influenced implementation of the SENATOR recommendations. The Theoretical Domains Framework (TDF) was used to structure the interview topic guides, and directed content analysis was used to identify the relevant TDF domains.

Participant selection

10. Sampling

How were participants selected (e.g. purposive, convenience, consecutive, snowball)?

Primary researchers involved with the SENATOR trial were recruited using purposive sampling as there were limited numbers of primary researchers at each site. Snowball sampling was used to recruit prescribers, whereby the SENATOR primary researchers and their colleagues referred the interviewer to prescribers in their site who would participate in the study. Participants were contacted via email, and were provided with an information sheet and consent form in their native language in advance of the interview.

11. Method of approach

How were participants approached (e.g. face-to-face, telephone, mail, email)?

24.

12. Sample size

How many participants were in the study?

None.

13. Nonparticipation

How many people refused to participate or dropped out? Reasons?

Setting

14. Setting of data collection

Where was the data collected (e.g. home, clinic, workplace)?

All interviews took place in the participant’s workplace, or in their workplace when previously working as part of the SENATOR trial.

15. Presence of nonparticipants

Was anyone else present besides the participants and researchers?

No.

16. Description of sample

What are the important characteristics of the sample (e.g. demographic data, date)?

Table 3.1 provides details of where the participants were sampled from, whilst Table 3.2 provides demographic details of the participants. The interviews took place between November 2017 and May 2018.
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Data collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>17. Interview guide</strong></td>
<td>Were questions, prompts, guides provided by the authors?</td>
<td>Two separate topic guides comprising a similar line of questioning (with prompts where appropriate) were formulated for both prescribers and primary researchers, and these were based on a review of the literature, the TDF, and my own and my supervisors’ knowledge of the research area of the randomised controlled trial and research area. Careful consideration was given to the language used, knowing that English would not be the first language for all participants. Interviewees were provided with a sample of a SENATOR report in their native language during the interview as a reminder of the report design and the types of recommendations provided. The topic guide for interviewing prescribers was piloted with a prescriber who had received SENATOR recommendations in the lead trial site, and this interview was included in the data analysis. The topic guide for interviewing primary researchers was piloted with a primary researcher working with a similar randomised controlled trial (OPERAM study), who was very familiar with the SENATOR trial procedures. The topic guides were iteratively refined during the study to ensure that emerging themes were explored in subsequent interviews.</td>
</tr>
<tr>
<td></td>
<td>Was it pilot tested?</td>
<td></td>
</tr>
<tr>
<td><strong>18. Repeat interviews</strong></td>
<td>Were repeat interviews carried out? If yes, how many?</td>
<td>No.</td>
</tr>
<tr>
<td><strong>19. Audio/visual recording</strong></td>
<td>Did the research use audio or visual recording to collect the data?</td>
<td>All interviews were audio-recorded.</td>
</tr>
<tr>
<td><strong>20. Field notes</strong></td>
<td>Were field notes made during and/or after the interview or focus group?</td>
<td>Field notes were recorded after each interview, and were used to refine topic guides and inform data analysis.</td>
</tr>
<tr>
<td><strong>21. Duration</strong></td>
<td>What was the duration of the interviews or focus group?</td>
<td>The average interview length was 24 minutes (range 18 – 64 minutes).</td>
</tr>
<tr>
<td><strong>22. Data saturation</strong></td>
<td>Was data saturation discussed?</td>
<td>Data analysis coincided with data collection, and sampling continued until no new themes emerged. As per the Francis <em>et al.</em> method, an additional three interviews were conducted without any new themes appearing to confirm that data saturation had been reached. No.</td>
</tr>
<tr>
<td><strong>23. Transcripts returned</strong></td>
<td>Were transcripts returned to participants for comment and/or correction?</td>
<td></td>
</tr>
</tbody>
</table>

255
## Domain 3: Analysis and Findings

### Data analysis

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.</td>
<td>Number of data coders</td>
<td>How many data coders coded the data?</td>
<td>Two (KD and SC).</td>
</tr>
<tr>
<td>25.</td>
<td>Description of the coding tree</td>
<td>Did authors provide a description of the coding tree?</td>
<td>A description of the process is provided, whereby initial, non-hierarchical codes were categorised, and subsequently developed to generate themes and subthemes as part of conventional content analysis. The TDF was the chosen framework for directed content analysis, and was used as the basis for a coding tree here. Conventional content analysis comprised open coding to inductively create initial, non-hierarchical codes. These initial codes were subsequently categorised to generate the evolving themes and subthemes. Directed content analysis was then employed whereby the transcripts were deductively coded using the TDF to identify the domains present.</td>
</tr>
<tr>
<td>26.</td>
<td>Derivation of themes</td>
<td>Were themes identified in advance or derived from the data?</td>
<td>Conventional content analysis comprised open coding to inductively create initial, non-hierarchical codes. These initial codes were subsequently categorised to generate the evolving themes and subthemes. Directed content analysis was then employed whereby the transcripts were deductively coded using the TDF to identify the domains present.</td>
</tr>
</tbody>
</table>

### Reporting

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.</td>
<td>Quotations presented</td>
<td>Were participant quotations presented to illustrate the themes/findings?</td>
<td>Yes.</td>
</tr>
<tr>
<td>30.</td>
<td>Data and findings consistent</td>
<td>Were there consistency between the data presented and the findings?</td>
<td>Quotations are presented in a manner consistent with findings.</td>
</tr>
<tr>
<td>31.</td>
<td>Clarity of major themes</td>
<td>Were major themes clearly presented in the findings?</td>
<td>Major themes are clearly presented in the results section.</td>
</tr>
<tr>
<td>32.</td>
<td>Clarity of minor themes</td>
<td>Is there a description of diverse cases or discussion of minor themes?</td>
<td>Subthemes are presented under each of the major themes.</td>
</tr>
</tbody>
</table>

SENATOR: Software ENgine for the Assessment & optimization of drug and non-drug Therapy in Older peRsons

OPERAM: Optimising Therapy to prevent avoidable hospital admissions in the Multi-morbid elderly
Appendix 9: Final version of topic guides for Chapter 3

Topic guide for SENATOR primary researchers

1. As we know, the SENATOR engine analysed patients’ information and made recommendations to optimise patients’ medications. Here is an example of a report that was generated. What are your thoughts on the design of the report?
   - Structure, layout, colours, font size, information provided
   - Location of report

2. When a prescriber was looking at a SENATOR report for the first time, what do you think they would have thought of it?
   - Do you think that they knew what the report was asking them to do?

3. What are your thoughts on the quality of the recommendations?
   - Thoughts on the relevance of the recommendations?
   - Would you change anything about the recommendations/report?

4. What are your thoughts on the timing of the intervention?
   - Would it have been better to have the report at the original point of prescribing/admission?

5. What are your thoughts on conducting this intervention in the hospital setting?
   - Do you think there is a more appropriate setting this could take place?

6. Whose role is it to make recommendations to optimise older patients’ medications in your hospital?
   - How would these recommendations be communicated (do you know?)
7. How do you communicate the presence of the report and the recommendations?
   – Were there any barriers to this communication?

8. What are your thoughts on the methods of communication of the report’s recommendations in this hospital?
   – What method of communication did you find most successful when providing the recommendations to the prescribing team, e.g. face-to-face or via telephone?

9. Given your professional background, how do you feel your role may affect the number of recommendations implemented?
   – The role/status of the primary researcher

10. How do you feel when discussing the report with the prescribing team?

11. Did you have any particular rewarding or negative experiences in your role in carrying out the intervention?

12. What was the reaction of prescribers in your hospital to the SENATOR report/recommendations?
   – Was there a positive or negative reaction?
   – Do you think that prescribers saw it as a priority to review the SENATOR report recommendations?

13. In your opinion, whose role should it be to review computer-generated recommendations like this in the hospital setting?
   – Do you think there should be someone to screen the recommendations before reaching the prescriber?
14. The prescriber implementation rates for the SENATOR recommendations were lower than expected – why do you think that may be?

15. How do you think that we could achieve higher implementation rates of the recommendations?

16. Do you foresee any problems for implementing an intervention like this routinely in future?
   - Resources (money, electronic prescribing)
   - Having a defined role for someone to lead/deliver the intervention

17. Do you think there is anything more you could have done to enhance the acceptance rates of the recommendations?
   - Anything more that your Principal Investigator could have done?
   - Anything more that the lead site (Cork) could have done?

18. How could SENATOR (or a similar intervention) be done better in future?
   - What resources would be required?
   - What information would you want to be provided by the computer?
   - How should the information to be provided?

That brings us to the end of the interview. Do you have any additional comments that you would like to make, or any points you would like to expand on?
**Topic guide for prescribers**

The SENATOR trial involves a computer programme analysing older patients’ medications, medical conditions, and other information with the aim of optimising prescribing. The programme then generates a report for the prescribing team to review with recommendations to address potentially inappropriate medications or potential prescribing omissions.

1. Firstly, what are your thoughts on the SENATOR intervention overall?

2. Do you think that automated programmes can help reduce potential inappropriately prescribing in hospitalised older adults?
   - Why? / Why not?

3. What is your role in reviewing the appropriateness of medications an older patient is prescribed during their hospital stay?
   - Is this a priority of yours on a daily basis?

4. How confident do you feel in prescribing for this patient group?
   - Do you think that your prescribing decisions would benefit from regular automated support/feedback/advice?
   - How do you feel about trusting recommendations from an automated programme?

As I said, the SENATOR intervention produced a report highlighting potentially inappropriate medications or potential prescribing omissions. Here is an example of a report generated.
5. How did you receive the report or how were you made aware of the recommendations?
   - What are your thoughts on the method of communication for this intervention?
   - What about the timing of the intervention?

6. When you looked at the SENATOR report for the first time, what did you think of it?
   - Did you understand what the report was aiming to do or what it asked of you?
   - What do you think of the design of the report? (e.g. layout, font size, length, colours, data / information contained within the report etc.)

7. When looking at the report, how easy or difficult was it for you to identify which of the recommendations were relevant for each patient?
   - Do you think all of the recommendations that you have reviewed have been relevant for your patients’ needs?
   - If you saw irrelevant recommendations, would it make you question the validity / relevance of the other recommendations?

8. What influence, if any, did the SENATOR report have on your decision-making?

9. Is there anything that may have prevented you from acting upon the SENATOR recommendations?
   - Patient’s acute medical presentation / Lack of information to hand / Work environment / Resources / Time / Your role / Role of others
10. In your opinion, whose role should it be to review these computer-generated recommendations in the hospital setting?
   – Do you think someone should screen the recommendations before reaching the prescriber (e.g. doctor, pharmacist, nurse)?

11. The prescriber implementation rates for the recommendations were lower than anticipated – what do you think are the reasons for this?
   – How do you think that we could achieve higher implementation rates of the computer-generated recommendations?

12. What problems, if any, do you foresee in implementing this intervention into routine clinical practice?
   – Resources (e.g. money to cover the cost, electronic prescribing, having a person to review the recommendations)

13. Do you have any suggestions for how we could enhance the implementation of this type of intervention in future?
   – What resources would be required? Electronic prescribing?
   – What information would you want to be provided by the computer?
   – How would you like this information to be provided? Information box/report/alert?

That brings us to the end of the interview. Do you have any additional comments that you would like to make, or any points you would like to expand on?
Appendix 10: Sample SENATOR report

SENATOR Trial Id: [Redacted]

Gender: Female
Date of Birth: [Redacted]
Age: 73

The recommendations below are based on medications prescribed at the time of assessment and do NOT include those on hold.

SENATOR provides generic recommendations but cannot account for all the individual characteristics for any given patient; this remains the sole responsibility of the prescribing clinician in deciding to use or not use the recommendations below.

Routine Daily Drugs prior to Senator Assessment as of 02/11/2022
(Please consider stopping the drugs in orange, see explanation in STOPP recommendations that follow)

<table>
<thead>
<tr>
<th>#</th>
<th>Generic Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pantoprazole</td>
</tr>
<tr>
<td>2</td>
<td>furosemide</td>
</tr>
<tr>
<td>3</td>
<td>levetiracetam hydrochloride</td>
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<tr>
<td>4</td>
<td>oxycodone hydrochloride</td>
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<tr>
<td>5</td>
<td>metoclopride</td>
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<td>6</td>
<td>metronidazole</td>
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PRN Drugs:

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<tr>
<td>1</td>
<td>ondansetron</td>
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<tr>
<td>2</td>
<td>oxycodone hydrochloride</td>
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STOPP Recommendations
(The following prescription is potentially inappropriate for the following reason)

Please check that all prescribed drugs are clearly indicated. Please also check for any inappropriate duplicate drug class prescription (e.g., two ACE inhibitors, two selective serotonin reuptake inhibitors).

- **furosemide**: Loop diuretic for dependent anice oedema without clinical, biochemical evidence or radiological evidence of heart failure, liver failure, nephrotic syndrome or renal failure (leg elevation and/or compression hosiery usually more appropriate).

- **oxycodone hydrochloride**: Use of oral or transdermal strong opioids (morphine, oxycodone, fentanyl, buprenorphine, diamorphine, methadone, tramadol, pethidine, pentazocine) as first line therapy for mild pain (WHO analgesic ladder not observed).

- **pantoprazole**: Any drug prescribed beyond the recommended duration, where treatment duration is well defined.
START Recommendations
(Unless an older patient's clinical status is end-of-life and therefore requiring a more palliative focus of pharmacotherapy, the following drug therapies should be considered where omitted for no valid clinical reasons. It is assumed that the prescriber observes all the specific contraindications to these drug therapies prior to recommending them to older patients. The following prescription is appropriate for the following reasons):

- Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors in the presence of chronic atrial fibrillation.
- OR
- Aspirin (75 mg – 160 mg once daily) in the presence of chronic atrial fibrillation, where Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors are contraindicated.
- Laxatives in patients receiving opioids regularly.
- Seasonal trivalent influenza vaccine annually.
- Pneumococcal vaccine at least once after age 65 according to national guidelines.

Potentially Adverse Medication Interactions

Potentially Important Drug-Disease Interactions

Non pharmaceutical therapies that may help your patient

SURGICAL PATIENTS: In patients aged 65 years hospitalized with acute surgical illness, there is a significant risk of developing delirium. The following interventions are evidence-based and have been shown to prevent delirium in this at-risk population when implemented together, as a multi-component intervention.

- Ambulate early
  a) Get the patient out of bed on postoperative day 1 and for several hours each day
  b) Administer physical therapy daily; administer occupational therapy, as needed

- Hydrate and feed
  a) Restore serum sodium, potassium and glucose to normal levels (glucose < 16.67 mmol/L (300 mg/d) for diabetics)
  b) Treat dehydration or fluid overload
  c) Ask the patient to use dentures and positionrim/her properly for meals
  d) If the patient is unable to eat, consider other means of feeding

- Oxygenate
  a) Supplement oxygen to maintain blood oxygen saturation >90%, preferably >95% (with caution in patients with COPD)
  b) Correct systolic blood pressure to a level of >2/3 of baseline or >90 mmHg

- Control pain
  a) Follow national, local or hospital guidelines for the treatment of pain
  b) Address the underlying causes of the pain

- Regulate bladder and bowel function
  a) Check for bowel movement by postoperative day 2 and every 48 hours afterwards
  b) Actively prevent and treat constipation
  c) Remove urinary catheter by postoperative day 2 and screen for retention or incontinence afterwards
d) Employ a skin care program for patients with established incontinence

Prevent, detect early, and treat major postoperative complications
a) For suspected myocardial infarction/ischemia, perform an electrocardiogram and analyze cardiac enzymes
b) For supraventricular arrhythmias/atrial fibrillation, ensure appropriate ventricular rate control, balanced electrolytes, and administer anticoagulants in cases of persistent atrial fibrillation.
c) Prevent pulmonary emboli with appropriate doses of prophylactic anticoagulants
d) For pneumonia/chronic obstructive pulmonary disease, screen and treat as needed
e) Screen for and treat urinary tract infection
f) Transfuse blood if hemoglobin levels are <8 g/dl.

Contraindications
There are no established contraindications to the use of non-pharmacological interventions for the prevention of delirium

Disclaimer: Whilst every effort has been made to ensure that the information provided by SENATOR is accurate, up-to-date and complete, no warranty is made to that effect. In addition, the drug information contained herein may be time-sensitive and should not be utilized as a reference resource beyond the date hereof. SENATOR’s drug information is a reference resource designed as a supplement to, and is not a substitute for, the expertise, skill, knowledge, and judgement of healthcare practitioners in patients care. The absence of a warning for a given drug or drug combination in no way should be construed to indicate that the drug or drug combination is safe, effective, or appropriate for any given patient. The information contained herein is not intended to cover all possible uses, directions, precautions, warnings, drug interactions, allergic reactions, or adverse treatment effects. Cipla Limited does not assume any responsibility for any aspect of healthcare administered with the aid of information contained herein. Whereas the prescription advice generated by SENATOR software is evidence-based and correct as far as can be determined, it is emphasized that this advice should not supplant careful clinical judgement in individual cases. It is further emphasized that the final decision to accept or reject SENATOR-generated treatment advice rests primarily with the patient’s attending medical staff.

(Reproduced with the permission of Prof. Denis O’Mahony, Principal Investigator of SENATOR trial, in August 2019)
# Appendix 11: Supplementary quotations for Chapter 3

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<tr>
<th>Theme</th>
<th>Descriptor</th>
<th>Illustrative Quotations</th>
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<tr>
<td>1. Computerised Output</td>
<td>Aid to prescribing, but cannot be trusted blindly</td>
<td>“...essentially what they’re doing is giving us guidance and as clinicians it’s up to us to decide what we do about it”. <strong>Surgical Prescriber 1</strong>&lt;br&gt;“I think they can be very helpful. They can’t do it automatically but I think they can give very good hints, so I think in general they’re helpful as assisting”. <strong>Medical Prescriber 3</strong>&lt;br&gt;“I think it’s a useful resource. Also, I think that we make mistakes when we’re prescribing because there’s too much information we have to attend to and sometimes we just can’t handle everything, and so I think it’s a very good thing that we can have a computer or someone who can supervise what we are doing. So it’s like, it helps us to do our job better”. <strong>Medical Prescriber 10</strong>&lt;br&gt;“I don’t think you can look at the advice alone. Em...like I said sometimes there are a bit of errors, which I think is normal. Em...you have to think about it yourself and not just read like the advice and put it into eh...put it into practice but really think about it as well”. <strong>Medical Prescriber 2</strong>&lt;br&gt;“I think...the human intelligence, at least as it is today, computers haven’t taken that over...that we use them as assisting us but not relying on it completely so if there comes, you know if there’s something that we think sounds funny we can always take over and correct that”. <strong>Medical Prescriber 12</strong>&lt;br&gt;“If it comes out with something that is completely opposed to my views then I would also then be looking into that to find out then, okay, I wouldn’t have perceived that as an interaction. Is there other stuff to back it up? I don’t think I would be blindly led by a computer”. <strong>Medical Prescriber 6</strong>&lt;br&gt;“I wouldn’t implicitly trust automated recommendations I suppose is what I’m trying to get at”. <strong>Medical Prescriber 8</strong>&lt;br&gt;“...you cannot trust the programme blindly, i.e. you have to still think about the medication”. <strong>Medical Prescriber 4</strong>&lt;br&gt;“I mean I wouldn’t ever rely solely on a computer, but I think it’s kind of helpful to have that, that initial maybe...em...notification from a computer programme, and you can work with that then”. <strong>Medical Prescriber 1</strong>&lt;br&gt;“...it’s not specific to the particular patient because it does...it did not take into account the complexity of that particular patient”. <strong>Primary Researcher 9</strong>&lt;br&gt;“...the decision support software says that for a thousand people, that’s the right thing to do. It may not be the right thing to do for that person”. <strong>Surgical Prescriber 2</strong>&lt;br&gt;“...the computer cannot take into context the human aspect of the patient and therefore they cannot they cannot advise on the individual, they can advise on the, on the actual drugs”. <strong>Medical Prescriber 9</strong></td>
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<td>Lack of specificity</td>
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<td>Theme</td>
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| 1. Computerised Output (continued) | Recommendations of low relevance contributing to prescriber fatigue | “I think absolutely for sure, em, the fact that a lot of the recommendations were simply not relevant or appropriate, I think that’s very very very very important. Em, and...obviously explains part...at least partly explains the low uptake”. Primary Researcher 7  
“I had recommendations that were irrelevant and even, even dangerous.” Medical Prescriber 4  
“So I think there’s potential for benefit, but you need to make sure it’s not information overload and people aren’t just getting dismissive of it”. Medical Prescriber 6  
“...if we could filter out the irrelevant or inappropriate recommendations, I think that the whole value of the report would go upwards very significantly. Because undoubtedly there is a fatigue as well when you get lots and lots of recommendations”. Primary Researcher 7  
“...it seems that if there’s been a negative one then they’re not so receptive the next time”. Primary Researcher 4  
“Well if you have some not very specific recommendations, you can see that they are...the second time you go they are...or the third time they are less interested in the study. So I already had physicians who start laughing when I go there again. So it’s definitely a barrier to the adherence”. Primary Researcher 1  
“...some consultants were really interested and over time when I repeatedly met the same consultant, they kind of lost interest because some of the recommendations were too broad, too generic. They were not tailored to that particular patient”. Primary Researcher 9 |
| Provision of the recommendations: Report Layout and Length | “...well this is rather clear. Stop these. Start these. So em I don’t know if you can get any more clearer than that”. Medical Prescriber 12  
“There’s a lot of text in it so if people are very busy, they might think it’s too big, too big a file. But having this in colour – STOPP and START – this is very good, very clear yeah”. Primary Researcher 8  
“I’d try and keep it a little bit shorter, so make sure the report (you know) only has recommendations that really are relevant to the setting”. Primary Researcher 2  
“...if it could be a one-page document I think that would be better because I think we all have short attention spans...” Primary Researcher 7  
“...it’s probably a little bit too long and a bit too detailed (you know), and that maybe just focusing on the smaller number of maybe significant...significant STOPP or START recommendations might make more sense”. Medical Prescriber 1 |
| Provision of the recommendations by the primary researcher | “...if you’ve had a chance to speak to the researchers, you’ve get...you’ve got a better understanding”. Medical Prescriber 6  
“...their interest would be higher if I was a doctor who would give the report to them”. Primary Researcher 1 |
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<th>Theme</th>
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<td>2. Acute hospital environment</td>
<td>Right setting for the intervention</td>
<td>“It’s the right place to do it, absolutely. Here we have the possibility to monitor the response and the side effects”. <strong>Medical Prescriber 12</strong>&lt;br&gt;“…the inpatient services are very specialty-driven. And probably the only people who’ve really got a whole overview of the person, to me, is the general practitioners and they’re the ones who are having to, who are being asked to, continue prescriptions”. <strong>Medical Prescriber 6</strong>&lt;br&gt;“I mean they, these recommendations are relevant to the patient, but they’re not particularly relevant to a patient in hospital at that particular time”. <strong>Primary Researcher 2</strong>&lt;br&gt;“In the ward, I’m often just dealing with the acute issues. And I probably don’t see it so much as my role to start stopping what other people have done. I think when the SENATOR trial first came out I wondered why it wasn’t being targeted in general practice”. <strong>Medical Prescriber 6</strong></td>
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<td>Unfamiliar intervention in a busy environment</td>
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<td>“So unless they actually become part of the fabric of a health service, then you’re gonna have a situation where you’re gonna have a few enthusiastic early uptakers, and then you’re gonna have everyone else who kind of (you know) will uptake, take them up for a period of time and then will drift out of consciousness”. <strong>Surgical Prescriber 2</strong>&lt;br&gt;“I think just by repeating this I think people will get more eh...yeah familiar with this kind of program”. <strong>Medical Prescriber 4</strong>&lt;br&gt;“I think so yeah, and also (you know) this is something new. People are not used to this”. <strong>Medical Prescriber 12</strong>&lt;br&gt;“...any trial would probably suffer from similar...you know similar challenges in a really busy hospital where people just are kind of too busy to give an awful lot of time to a research project”. <strong>Primary Researcher 2</strong>&lt;br&gt;“...they were rushed, they were busy doing something else, and the recommendations that I would have highlighted to them would not have been seen as a priority, it would have been something that they would have come back to at a later stage”. <strong>Primary Researcher 7</strong>&lt;br&gt;“...it’s very busy busy mornings we have here but so it is easy to get lost. So in order for it to be used in the everyday rounds, it has to become more established so that (you know) it’s a part of that, that everyday work, not just something that (you know) you hear about once a week, or every other week, or something like that, then you forget about it”. <strong>Medical Prescriber 12</strong></td>
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| 268 |
### Theme

2. Acute hospital environment (continued)

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<th>Illustrative Quotations</th>
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<td>Timing of the intervention and location of the recommendations</td>
<td>“...if it was present right at the time where they’re dealing with the patient, where they’re focused on the patient, I think that could absolutely have improved uptake of the recommendations”. <strong>Primary Researcher 7</strong>&lt;br&gt;“The intervention of getting the information may not have been the best time. The patient isn’t on your mind - you’re not thinking about the patient, you’re not doing a chart review”. <strong>Medical Prescriber 8</strong>&lt;br&gt;“I’d say it was more the timing and...you know it was hit or miss if you got somebody who was in the middle of doing a hundred things and you’re interrupting them to tell them about this report you’ve placed, they’re not going to be very receptive to...to hearing about it”. <strong>Primary Researcher 2</strong>&lt;br&gt;“...certainly from me the big issue was just the timing of getting the report versus when I saw the patient, when I was probably most invested in (you know) their, their care pathway”. <strong>Medical Prescriber 1</strong>&lt;br&gt;“...it is a little bit of an interruption and especially you may be dealing with another patient’s case and so to to to sort of think back on...on a different patient and their prescription I think it’s hard to really grasp and take in the recommendations at that particular time”. <strong>Primary Researcher 7</strong>&lt;br&gt;“...it might just be around kind of timing actually more than anything else, and that maybe the route of the information just being a bit disconnected. You know a patient’s in one place, you get your information in a different place...” <strong>Medical Prescriber 8</strong>&lt;br&gt;“I think it’s location. I think simply if we saw it we’d have gone ‘oh yeah, that’s sensible’. So, putting it physically in where we’re writing our notes”. <strong>Medical Prescriber 11</strong>&lt;br&gt;“If instead having it inside the history, it was em...it appeared with the programme, with the prescription programme, because you have to use it - there’s no other way, and probably they would pay more attention”. <strong>Medical Prescriber 10</strong>&lt;br&gt;“I suppose one of the other things is that this came into me by email, and em...it, it, it maybe wasn’t immediate enough in terms of the patient interaction to take it on board, you know that you would...probably the best time to get this is actually the first time you see the patient on the ward round”. <strong>Medical Prescriber 1</strong>&lt;br&gt;“I find the eh, the email a bit better for me personally, because eh if it’s filed in the notes it can get lost amongst all the pages and I wouldn’t necessary know that the patient would have that type of recommendations”. <strong>Medical Prescriber 9</strong>&lt;br&gt;“Ill often the time when you’ll come, when you’ll actually open this email will be a couple of days later after you’ve gotten it and at that stage the patient is well gone home and that window is kinda missed you know”. <strong>Surgical Prescriber 2</strong></td>
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| 3. Prescriber role and identity            | Responsibility | “But I’m not the prescribing clinician. You know because a lot of the time, and you can say it well yes you are because they’ve come into hospital and you’ve, you or a member of your team have physically prescribed them, but really you’re not. You’re, you’re carrying on a prescription on a decision that’s been made by somebody else. You’re honouring their decision”. **Surgical Prescriber 2**  
“Well I think it’s my responsibility to do so as a doctor and I’m the one who has to decide which medicines I give to someone”. **Medical Prescriber 10**  
“They don’t feel it’s their place. They feel it’s a GP’s job so they don’t want to get involved or they’re not confident enough to get involved”. **Primary Researcher 4**  
“…really it needs to be targeted at the people who are making the decisions to initiate the medications in the first place rather than me, who is seeing them on a very casual basis. I might see somebody’s prescription chart once in their entire relationship with me (you know), whereas you’re talking about a general practitioner who is seeing them on a very regular basis”. **Surgical Prescriber 2** |
|                                            | Prescriber Inertia | “…if it’s related, if someone’s come in with a fall and then it’s related to the admission, I’d be much more likely to look at the SENATOR recommendations in detail. So if they’ve come in with something which I perceive to be something completely unrelated, and they’re on lots of complex cardiac medicines for heart failure which is stable, I’ll be much more reluctant to fiddle around with things, and I suppose in sort of the thought process is: well if it’s not broken, don’t…don’t try to fix it…” **Medical Prescriber 6**  
“…the doctors that don’t want to make a change, they’re not going to make a change…” **Primary Researcher 4**  
“I’m not gonna start interfering with somebody’s medications unless there’s a glaring danger in them or I see something that’s absolutely contraindicated…” **Surgical Prescriber 2** |
|                                            | Prescriber outlook towards research studies | “…so when the doctors are enthusiastic about the study, they will read it, and they will take it…they will see it more as a priority but if the doctor isn’t interested in the study, they will not see it as a priority”. **Primary Researcher 6**  
“I think it depends on the person itself if they are open-minded for studies. Sometimes physicians are not really…they can have the impression that not all the physicians are very open-minded to studies, and others are…eh…open-minded so I think it also depends on it”. **Primary Researcher 1**  
“So I guess while it’s part of a study, we’ll take on that responsibility”. **Medical Prescriber 6**  
“I appreciated the work they did so I was receptive to em…doing this and receiving the information because I think it’s important, and I think that before they did it I already thought that we needed something like this so I was very ready to have it and I wanted to see it and I don’t know if the rest of the people who participated had the same feeling”. **Medical Prescriber 10** |
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| 3. Prescriber role and identity (continued) | Prescriber specialty and fear of encroachment | “...we would kind of just, probably just intervene on the ones that are within our area of specialty. We leave the other ones generally alone”. Surgical Prescriber 2  
“One thing you’ll find I suppose with consultants is their kind of, their particular area is what they would focus on, so if they’re admitted under cardiology, they may look at cardiology meds, and you know if they’re on a high dose of a PPI it’s not something they’re really gonna review”. Primary Researcher 2  
“...a number of the recommendations would be out of my comfort zone of what I manage”. Surgical Prescriber 1  
“...it comes down to what I’m prescribing...em...and I suppose your confidence with prescribing certain medications wanes the longer you’re away from a certain specialty”. Medical Prescriber 8  
“They have conditions that are out of my range of knowledge, and their treatment often...their treatment of one condition might collide with another condition that I’m not an expert in”. Medical Prescriber 12  
“I clearly understand that there are certain specialist fields that I’m capable of dealing with, and that’s that acute surgical problem”. Surgical Prescriber 1  
“I probably don’t see it so much as my role to start stopping what other people have done”. Medical Prescriber 6  
“So medications started by one specialist doctor, the other specialist doctor is a bit reluctant to change em...or is not happy to deal with this medication. It looks like instead of holistic treatment of the patient, each consultant is treating their part”. Primary Researcher 9  
“...you may have a patient admitted under you or you see the patient but you’re not the only person involved in their care so you may be reluctant to stop a medication that somebody else started. You may not have all the information why the medication was started”. Medical Prescriber 1  
“I think especially if you’re meeting a patient for the first time and they’re on a number of different medications em...you will not want to interfere with medications that you didn’t start or certainly medications that are outside of your own specialty”. Primary Researcher 7  
“...you’re carrying on a prescription on a decision that’s been made by somebody else. You’re honouring their decision. So, in honouring their decision, you’re dishonouring their decision by changing that, and without due regard to them for doing it”. Surgical Prescriber 2 |
| Prescribers forgetting about the intervention | | “I think the team has to be given a...a real nudge – ‘read the STOPP medications!’ – not because they won’t, because I think we just forget”. Medical Prescriber 11  
“I think it was usually something that they would put on the long finger, that they would intend to come back to”. Primary Researcher 7  
“...it’s all about reminders. I think people are well-intentioned, I think they just forget”. Medical Prescriber 11 |
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| 3. Prescriber role and identity (continued) | Prescriber experience and the need for a ‘decision-maker’                  | “...if you’re just started as a doctor...em I think you’re also a bit hesitant to, to stop certain medications than if you’ve years of experience”. **Medical Prescriber 12**  
“...if you have a lot of years of work, it’s possible that you tend to consolidate your ideas so **SENATOR** could be less effective in changing your prescription”. **Medical Prescriber 7**  
“I mean it definitely has to be somebody with senior clinical decision-making power. Em...most interns won’t really have the kind of experience to go tinkering with people’s medications and they shouldn’t be”. **Medical Prescriber 8**  
“The junior doctors, like interns – they are maybe...do not have the eh...they’re not that independent or they (you know) don’t take many decisions without consulting their seniors”. **Medical Prescriber 12**  
“I think it’s probably more important that it’s targeted at the actual decision-maker”. **Surgical Prescriber 2**  |
| 4. The patient               | Acute status of the patient                                                 | “The primary reason is I think they are not (the physicians here) are not worried about the chronic medications, they focus on the acute conditions”. **Primary Researcher 5**  
“...when the patients are admitted in secondary care in hospital, the clinical team only deals with the acute problem. They are not interested in looking into the other medications...” **Primary Researcher 9**  
“I think the mindset on a busy clinical job is to sort out the acute issue and the long term medications oftentimes I would imagine physicians don’t feel that they’re the ones that should have to em...em...change or interfere or sort of adjust the long term medications”. **Primary Researcher 7**  
“...the priority to that patient may have been focused on, on more acute issues around that you know, you know do I need to operate or not? So that’s probably why there’s been a slight, a lower em acceptance of some of the recommendations”. **Surgical Prescriber 1**  
“...personally my focus would be on the acute pathology, which shall be the abdominal pain and...and it’s rare that we have in the past made any meaningful alterations to certain medication”. **Surgical Prescriber 1**  
“...from a surgery point of view, it’s a...(you know)...you’re very much focused on an interventional situation”. **Surgical Prescriber 2**  
“...we know when they’re surgical if it is a...like fracture, the focus is on the fracture, not all the other medication, so they are not willing to change many things”. **Primary Researcher 8**  
“...surgeons most of the time don’t care about these things, well some of them at least, because they are really focused on the surgery, and it’s like this is someone else’s job”. **Medical Prescriber 10**  
“The benzodiazepine one - again if the patient’s unwell and they’ve been on a long-term sleeping tablet, my impression would be let’s sort the acute issue. If they’re drowsy or something like that, then that’s a different issue”. **Primary Researcher 7**  |
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<td>4. The patient (continued)</td>
<td>Knowing the patient</td>
<td>“I’m not sure the grade is affected, it’s more who is in charge of the patient and who knows the patient best”. <strong>Primary Researcher 8</strong>&lt;br&gt;“I think doctors that meet the patient for the first time at the hospital admission, they don’t know...they don’t know him so much. Eh...and maybe they don’t investigate any more than what they need for the acute problem”. <strong>Primary Researcher 10</strong>&lt;br&gt;“...they didn’t have a complete picture of the patient when I discussed the recommendation. So, I’m thinking that also is one of the reasons why they don’t adapt the change”. <strong>Primary Researcher 9</strong>&lt;br&gt;“They don’t want to get involved...em...you know making big changes. They think that’s a job for the GP that knows the patient better and knows what they’ve been taking long-term and the reasons why”. <strong>Primary Researcher 4</strong></td>
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<td>Patient involvement</td>
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<td>“…give more information to the patient itself, like go to the patients and then say like “this medication we can stop, this medication we can stop”, like we inform the patients as well and then em...maybe it would work a bit better”. <strong>Medical Prescriber 2</strong>&lt;br&gt;“The patient in theory could affect the number of recommendations. I think that good communication between prescriber, pharmacist, and patient is the good way, is the good way to...because, because, because patients should be, should be the centre role, centre role. In my experience, patient have in part, a little part in influencing the recommendation”. <strong>Primary Researcher 3</strong></td>
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<td>Patient preference</td>
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<td>“So, eh...and then there’s of course patient preference factors. Some of them really prefer to have some drugs”. <strong>Medical Prescriber 3</strong>&lt;br&gt;“I think, again, if a patient is very positive and keen for changes to be made, and speaks to the doctor then that seems to help”. <strong>Primary Researcher 4</strong>&lt;br&gt;“A lot of the recommendations involved taking patients off sleeping tablets and benzos and things, which you’re gonna get resistance to”. <strong>Primary Researcher 2</strong>&lt;br&gt;“I wouldn’t stop some things, someone’s medications, without explaining to them why”. <strong>Medical Prescriber 6</strong></td>
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**STOPP**: Screening Tool of Older People’s Prescriptions  **START**: Screening Tool to Alert to Right Treatment  **SENATOR**: Software ENgine for the Assessment & optimization of drug and non-drug Therapy in Older peRsons  **GP**: General practitioner
Appendix 12: Reasons for criterion exclusion in evaluation of clinical relevance

As part of the intervention, recommendations START I1 and START I2 (suggesting to ensure patients received influenza and pneumococcal vaccinations) appeared on all SENATOR reports. These recommendations were excluded from the assessment of clinical relevance and implementation as it was not documented if all these patients had been vaccinated or not. STOPP A1 (a recommendation suggesting to stop “Any drug prescribed without an evidence-based clinical indication”) was also written on the report but this too could not be assessed for clinical relevance or implementation, as the indication was not clear for all medications. Therefore, of the 114 STOPP/START criteria (version 2), recommendations based on 3 criteria were excluded from the analysis.

However, it should also be noted that two slight software modifications were made a few weeks into patient recruitment:

i) START A2 ("Aspirin [75 mg – 160 mg once daily] in the presence of chronic atrial fibrillation, where Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors are contraindicated") was initially triggering as a stand-alone recommendation, but later appeared as a joint recommendation along with START A1 ("Vitamin K antagonists or direct thrombin inhibitors or factor Xa inhibitors in the presence of chronic atrial fibrillation"). Therefore, relevance and implementation data are only available for START A1 from that point on.
ii) STOPP A3 (a recommendation to stop “Any duplicate drug class prescription”) was initially appearing on reports. However, due to high numbers of STOPP A3 recommendations being produced that were not clinically relevant, this recommendation trigger was ceased by trial researchers.
Appendix 13: Inter-rater reliability assessment

A convenience sample of three pharmacists and three physicians (one consultant geriatrician, and two specialist registrars – i.e. senior residents – in geriatric medicine) were invited to participate. Raters were purposively selected on the basis of their involvement with the SENATOR project and/or the OPERAM project.

Twenty intervention cases were selected at random, representing approximately 10% of intervention patients recruited at Cork University Hospital. Details of this random selection can be found below. The study’s objectives were explained to each rater, and all raters were supplied with instructions on how to assess the clinical relevance of the recommendations, whereby the rater had to independently assign a code of 0 – 5 for each SENATOR-generated STOPP/START recommendation based on the clinical relevance categories. Three sample cases (all based on real intervention patients) were provided with the clinical relevance codes already assigned to the recommendations, and with a rationale given as to why each code was chosen by the pharmacist-physician pair for each patient. The twenty clinical cases were presented in a standardised format (Appendix 14) to include age, sex, comorbidities, medications prescribed at the time of randomisation, laboratory test results, and any other important information required to facilitate the raters in evaluating the clinical relevance of the STOPP/START recommendations.

For the random selection of the twenty intervention cases, a list of all intervention patients in the study site was divided into four according to the date of recruitment to ensure patient cases were obtained from different times during the RCT.
An independent researcher (external to the study) rearranged the four lists of patient numbers into a random order. The first five patients with at least three STOPP/START recommendations in each list were chosen as the cases in the inter-rater reliability assessment. Thus, twenty intervention patient cases were selected at random.
Appendix 14: Standardised case format for inter-rater reliability assessment

Age: 80
Sex: Female
Date of recruitment: 11/2017

Presenting Condition: Patient presenting with urosepsis. Patient fell during the night before admission to hospital when on her way to the toilet with bruising to right arm and leg, but no fracture.

Medical History:

1. Hypertension
2. Hypercholesterolemia
3. Chronic ischaemic heart disease
4. Osteoarthritis
5. Osteoporosis

Medications:

1. Tinzaparin 3500 units od SC On since admission
2. Piperacillin/Tazobactam 4.5g tds IV On since admission
3. Aspirin 75mg od po
4. Ramipril 2.5mg od po
5. Atorvastatin 20mg od po
6. Zolpidem 10mg nocte po On for 6 – 12 months
7. Paracetamol 1g qds po/IV prn

Laboratory Parameters:

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Other relevant information:

- Blood Pressure: 124/79 mmHg.
- Heart Rate: 76 beats/minute.
- Patient does not have a history of recurrent falls.
- On at home but not charted: Calcium/Vitamin D₃ 500mg/400 units 1 tablet bd po and Risedronate sodium 35mg once weekly po.
**STOPP Recommendations:**

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<td>Bone anti-resorptive or anabolic therapy (e.g. bisphosphonate, strontium ranelate, teriparatide, denosumab) in patients with documented osteoporosis, where no pharmacological or clinical status contraindication exists (Bone Mineral Density T-scores more than -2.5 in multiple sites) and/or previous history of fragility fracture(s).</td>
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Appendix 15: Clinical relevance of individual STOPP and START recommendations

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PPI: Proton pump inhibitor       ACE: Angiotensin Converting Enzyme       ARB: Angiotensin Receptor Blocker
NSAID: Non-steroidal anti-inflammatory drug       DMARD: Disease-modifying anti-rheumatic drug
Appendix 17: STOPP/START criteria version 1

STOPP (Screening Tool of Older People’s potentially inappropriate Prescriptions).

The following prescriptions are potentially inappropriate in persons aged ≥ 65 years of age.

A. Cardiovascular System

1. Digoxin at a long-term dose > 125µg/day with impaired renal function* (increased risk of toxicity).
2. Loop diuretic for dependent ankle oedema only i.e. no clinical signs of heart failure (no evidence of efficacy, compression hosiery usually more appropriate).
3. Loop diuretic as first-line monotherapy for hypertension (safer, more effective alternatives available).
4. Thiazide diuretic with a history of gout (may exacerbate gout).
5. Non-cardioselective β-blocker with chronic obstructive pulmonary disease (COPD) (risk of bronchospasm).
6. β-blocker in combination with verapamil (risk of symptomatic heart block).
7. Use of diltiazem or verapamil with NYHA Class III or IV heart failure (may worsen heart failure).
8. Calcium channel blockers with chronic constipation (may exacerbate constipation).
9. Use of aspirin and warfarin in combination without histamine H₂ receptor antagonist (except cimetidine because of interaction with warfarin) or proton pump inhibitor (PPI) (high risk of gastrointestinal bleeding).
11. Aspirin with a past history of peptic ulcer disease without histamine H₂ receptor antagonist or PPI (risk of bleeding).
12. Aspirin at dose > 150mg day (increased bleeding risk, no evidence for increased efficacy).
13. Aspirin with no history of coronary, cerebral, or peripheral arterial symptoms or occlusive arterial event (not indicated).
14. Aspirin to treat dizziness not clearly attributable to cerebrovascular disease (not indicated).
15. Warfarin for first, uncomplicated deep venous thrombosis for longer than 6 months duration (no proven added benefit).
16. Warfarin for first uncomplicated pulmonary embolus for longer than 12 months duration (no proven benefit).
17. Aspirin, clopidogrel, dipyridamole, or warfarin with concurrent bleeding disorder (high risk of bleeding).
   * GFR < 50ml/min.

B. Central Nervous System and Psychotropic Drugs

1. Tricyclic antidepressants (TCAs) with dementia (risk of worsening cognitive impairment).
2. TCAs with glaucoma (likely to exacerbate glaucoma).
3. TCAs with cardiac conductive abnormalities (pro-arrhythmic effects).
4. TCAs with constipation (likely to worsen constipation).
5. TCAs with an opiate or calcium channel blocker (risk of severe constipation).
6. TCAs with prostatism or prior history of urinary retention (risk of urinary retention).
7. Long-term (i.e. > 1 month), long-acting benzodiazepines, e.g. chlordiazepoxide, flurazepam, nitrazepam, chlorazepate and benzodiazepines with long-acting metabolites e.g. diazepam (risk of prolonged sedation, confusion, impaired balance, falls).
8. Long-term (i.e. > 1 month) neuroleptics as long-term hypnotics (risk of confusion, hypotension, extra-pyramidal side effects, falls).
9. Long-term neuroleptics (> 1 month) in those with parkinsonism (likely to worsen extra-pyramidal symptoms).
10. Phenothiazines in patients with epilepsy (may lower seizure threshold).
11. Anticholinergics to treat extra-pyramidal side effects of neuroleptic medications (risk of anticholinergic toxicity).
12. Selective serotonin re-uptake inhibitors (SSRIs) with a history of clinically significant hyponatraemia (non-iatrogenic hyponatraemia < 130mmol/l within the previous 2 months).
13. Prolonged use (> 1 week) of first-generation antihistamines, i.e. diphenhydramine, chlorpheniramine, cyclizine, promethazine (risk of sedation and anti-cholinergic side effects).

C. Gastrointestinal System

1. Diphenoxylate, loperamide or codeine phosphate for treatment of diarrhoea of unknown cause (risk of delayed diagnosis, may exacerbate constipation with overflow diarrhoea, may precipitate toxic megacolon in inflammatory bowel disease, may delay recovery in unrecognised gastroenteritis).
2. Diphenoxylate, loperamide or codeine phosphate for treatment of severe infective gastroenteritis i.e. bloody diarrhoea, high fever or severe systemic toxicity (risk of exacerbation or protraction of infection).

3. Prochlorperazine or metoclopramide with parkinsonism (risk of exacerbating parkinsonism).

4. PPI for peptic ulcer disease at full therapeutic dosage for > 8 weeks (earlier discontinuation or dose reduction for maintenance/prophylactic treatment of peptic ulcer disease, oesophagitis or GORD indicated).

5. Anticholinergic antispasmodic drugs with chronic constipation (risk of exacerbation of constipation).

D. Respiratory System

1. Theophylline as monotherapy for COPD (safer, more effective alternative; risk of adverse effects due to narrow therapeutic index).

2. Systemic corticosteroids instead of inhaled corticosteroids for maintenance therapy in moderate-severe COPD (unnecessary exposure to long-term side effects of systemic steroids).

3. Nebulised ipratropium with glaucoma (may exacerbate glaucoma).

E. Musculoskeletal System

1. Non-steroidal anti-inflammatory drug (NSAID) with history of peptic ulcer disease or gastrointestinal bleeding, unless with concurrent histamine H₂ receptor antagonist, PPI, or misoprostol (risk of peptic ulcer relapse).

2. NSAID with moderate-severe hypertension (moderate: 160/100mmHg – 179/109mmHg; severe: ≥ 180/110mmHg) (risk of exacerbation of hypertension).

3. NSAID with heart failure (risk of exacerbation of heart failure).

4. Long-term use of NSAID (> 3 months) for relief of mild joint pain in osteoarthritis (simple analgesics preferable and usually as effective for pain relief).

5. Warfarin and NSAID together (risk of gastrointestinal bleeding).

6. NSAID with chronic renal failure* (risk of deterioration in renal function). * estimated GFR 20 – 50ml/min.

7. Long-term corticosteroids (> 3 months) as monotherapy for rheumatoid arthritis or osterarthritis (risk of major systemic corticosteroid side effects).

8. Long-term NSAID or colchicine for chronic treatment of gout where there is no contraindication to allopurinol (allopurinol first choice prophylactic drug in gout).
F. Urogenital System

1. Bladder antimuscarinic drugs with dementia (risk of increased confusion, agitation).
2. Bladder antimuscarinic drugs with chronic glaucoma (risk of acute exacerbation of glaucoma).
3. Bladder antimuscarinic drugs with chronic constipation (risk of exacerbation of constipation).
4. Bladder antimuscarinic drugs with chronic prostatism (risk of urinary retention).
5. Alpha-blockers in males with frequent incontinence i.e. one or more episodes of incontinence daily (risk of urinary frequency and worsening of incontinence).
6. Alpha-blockers with long-term urinary catheter in situ, i.e. more than 2 months (drug not indicated).

G. Endocrine System

1. Glibenclamide or chlorpropamide with type 2 diabetes mellitus (risk of prolonged hypoglycaemia).
2. β-blockers in those with diabetes mellitus and frequent hypoglycaemic episodes i.e. ≥ 1 episode per month (risk of masking hypoglycaemic symptoms).
3. Oestrogens with a history of breast cancer or venous thromboembolism (increased risk of recurrence).

H. Drugs that adversely affect those prone to falls (≥ 1 fall in past three months)

1. Benzodiazepines (sedative, may cause reduced sensorium, impair balance).
2. Neuroleptic drugs (may cause gait dyspraxia, parkinsonism).
3. First generation antihistamines (sedative, may impair sensorium).
4. Vasodilator drugs known to cause hypotension in those with persistent postural hypotension i.e. recurrent > 20mmHg drop in systolic blood pressure (risk of syncope, falls).
5. Long-term opiates in those with recurrent falls (risk of drowsiness, postural hypotension, vertigo).
I. Analgesic Drugs

1. Use of long-term powerful opiates e.g. morphine or fentanyl as first line therapy for mild-moderate pain *(WHO analgesic ladder not observed)*.

2. Regular opiates for more than 2 weeks in those with chronic constipation without concurrent use of laxatives *(risk of severe constipation)*.

3. Long-term opiates in those with dementia unless indicted for palliative care or management of moderate/severe chronic pain syndrome *(risk of exacerbation of cognitive impairment)*.

J. Duplicate Drug Classes

Any regular duplicate drug class prescription e.g. two concurrent opiates, NSAIDs, SSRIs, loop diuretics, Angiotensin Converting Enzyme (ACE) inhibitors *(optimisation of monotherapy within a single drug class should be observed prior to considering a new class of drug)*. This excludes duplicate prescribing of drugs that may be required on a prn basis e.g. inhaled β2 agonists (long and short acting) for asthma or COPD, and opiates for management of breakthrough pain.
START: Screening Tool to Alert doctors to Right i.e. appropriate, indicated Treatment.

These medications should be considered for people ≥ 65 years of age with the following conditions, where no contraindication to prescription exists.

A. Cardiovascular System

1. Warfarin in the presence of chronic atrial fibrillation.
2. Aspirin in the presence of chronic atrial fibrillation, where warfarin is contraindicated, but not aspirin.
3. Aspirin or clopidogrel with a documented history of atherosclerotic coronary, cerebral, or peripheral vascular disease in patients with sinus rhythm.
4. Antihypertensive therapy where systolic blood pressure consistently > 160 mmHg.
5. Statin therapy with a documented history of coronary, cerebral, or peripheral vascular disease, where the patient’s functional status remains independent for activities of daily living and life expectancy is > 5 years.
6. ACE inhibitor with chronic heart failure.
7. ACE inhibitor following acute myocardial infarction.
8. β-blocker with chronic stable angina.

B. Respiratory System

1. Regular inhaled β₂ agonist or anticholinergic agent for mild to moderate asthma or COPD.
2. Regular inhaled corticosteroid for moderate-severe asthma or COPD, where predicted FEV1 < 50%.
3. Home continuous oxygen with documented chronic type 1 respiratory failure (pO₂ < 8.0kPa, pCO₂ < 6.5kPa) or type 2 respiratory failure (pO₂ < 8.0kPa, pCO₂ > 6.5kPa).

C. Central Nervous System

1. Levodopa in idiopathic Parkinson’s disease with definite functional impairment and resultant disability.
2. Antidepressant drug in the presence of moderate-severe depressive symptoms lasting at least three months.
D. Gastrointestinal System

1. Proton Pump Inhibitor with severe gastro-oesophageal acid reflux disease or peptic stricture requiring dilatation.
2. Fibre supplement for chronic, symptomatic diverticular disease with constipation.

E. Musculoskeletal System

1. Disease-modifying anti-rheumatic drug (DMARD) with active moderate-severe rheumatoid disease lasting > 12 weeks.
2. Bisphosphonates in patients taking maintenance oral corticosteroid therapy.
3. Calcium and Vitamin D supplement in patients with known osteoporosis (radiological evidence or previous fragility fracture or acquired dorsal kyphosis).

F. Endocrine System

1. Metformin with type 2 diabetes +/- metabolic syndrome (in the absence of renal impairment*).
2. ACE inhibitor or Angiotensin Receptor Blocker in diabetes with nephropathy i.e. overt urinalysis proteinuria or microalbuminuria (> 30mg/24 hours) +/- serum biochemical renal impairment*.
3. Antiplatelet therapy in diabetes mellitus if one or more co-existing major cardiovascular risk factor present (hypertension, hypercholesterolaemia, smoking history).
4. Statin therapy in diabetes mellitus if one or more co-existing major cardiovascular risk factor present.
   * GFR < 50ml/min


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Appendix 18: Prescriber implementation rates for START recommendations (including START-based recommendations to prescribe “missing medications”)

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ACE: Angiotensin Converting Enzyme  
COPD: Chronic obstructive pulmonary disease  
FEV1: Forced expiratory volume in 1 second  
†p-value calculated using chi-squared test.  
* Statistically significant difference observed (p < 0.05).
Appendix 19: Ethical approval for Chapter 6

Date: 3rd July 2018

Professor Stephen Byrne
School of Pharmacy
Cavanagh Pharmacy Building
Room UG06
College Road
Cork

Study Title: To identify factors affecting prescriber implementation of hospital pharmacists’ medication recommendations.

Approval is granted to carry out the above study at:

Acute hospitals under the remit of the UCC Cork Teaching Hospitals.

The following documents have been approved:

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We note that the co-investigator(s) involved in this project will be:

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<tr>
<td>Professor Denis O’Mahony</td>
<td>Consultant Geriatrician</td>
</tr>
<tr>
<td>Aoife Fleming</td>
<td>Lecturer</td>
</tr>
<tr>
<td>Kieran Dalton</td>
<td>PhD Researcher</td>
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</tbody>
</table>

The date of this letter is the date of authorization of the study.

Please keep a copy of this signed approval letter in your study master file for audit purposes.

You should note that ethical approval will lapse if you do not adhere to the following conditions:

1. Submission of an Annual Progress Report/Annual Renewal Survey (due annually from the date of this approval letter)

2. Report unexpected adverse events, serious adverse events or any event that may affect ethical acceptability of the study

Ollscoil na hÉireann, Corcaigh - National University of Ireland, Cork,
3. Submit any change to study documentation (minor or major) to CREC for review and approval. Amendments must be submitted on an amendment application form and revised study documents must clearly highlight the changes and contain a new version number and date. Amendments cannot be implemented without written approval from CREC.

4. Notify CREC of discontinuation of the study

5. Submit an End of Trial Declaration Form and Final Study Report/Study Synopsis when the study has been completed.

Yours sincerely

[Signature]

Professor Michael G Molloy
Chairman
Clinical Research Ethics Committee of the Cork Teaching Hospitals

The Clinical Research Ethics Committee of the Cork Teaching Hospitals, UCC, is a recognised Ethics Committee under Regulation 7 of the European Communities (Clinical Trials on Medicinal Products for Human Use) Regulations 2004, and is authorised by the Department of Health and Children to carry out the ethical review of clinical trials of investigational medicinal products. The Committee is fully compliant with the Regulations as they relate to Ethics Committees and the conditions and principles of Good Clinical Practice.

Ollscoil na hÉireann, Corcaigh - National University of Ireland, Cork.
Appendix 20: COREQ checklist for qualitative interview study from Chapter 6

**Domain 1: Research Team and Reflexivity**

**Personal characteristics**

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<tbody>
<tr>
<td><strong>1.</strong> Interviewer/facilitator</td>
<td>Which author/s conducted the interview or focus group?</td>
<td>KD conducted the interviews.</td>
</tr>
<tr>
<td><strong>2.</strong> Credentials</td>
<td>What were the researcher’s credentials (e.g. PhD, MD)?</td>
<td>At the time of undertaking the interviews, KD’s credentials were BPharm, MPharm, MPSI.</td>
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<tr>
<td><strong>3.</strong> Occupation</td>
<td>What was their occupation at the time of the study?</td>
<td>KD is an Irish registered pharmacist, who was undertaking a PhD in Clinical Pharmacy research when this study was conducted.</td>
</tr>
<tr>
<td><strong>4.</strong> Sex</td>
<td>Was the researcher male or female?</td>
<td>Male.</td>
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<tr>
<td><strong>5.</strong> Experience and training</td>
<td>What experience or training did the researcher have?</td>
<td>KD completed training in utilisation of NVivo software, and received training in analysis of qualitative interviews at Oxford University, United Kingdom.</td>
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**Relationship with participants**

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<tr>
<td><strong>6.</strong> Relationship established</td>
<td>Was a relationship established prior to study commencement?</td>
<td>The interviewer had no previous relationship or established rapport with any of the interviewees prior to study commencement.</td>
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<tr>
<td><strong>7.</strong> Participant knowledge of the interviewer</td>
<td>What did the participants know about the researcher (e.g. personal goals, reasons for doing the research)?</td>
<td>KD had disclosed to all participants that he was a pharmacist undertaking this study as part of his PhD, prior to conducting the interviews.</td>
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<tr>
<td><strong>8.</strong> Interviewer characteristics</td>
<td>What characteristics were reported about the interviewer/facilitator? (e.g. bias, assumptions, reasons and interests in the research topic)</td>
<td>KD is a registered pharmacist who was conducting this study as part of his PhD exploring factors affecting physician prescriber implementation of medication appropriateness recommendations in hospitalised older adults. This information was disclosed to participants ahead of the interview.</td>
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</table>
Domain 2: Study Design

Theoretical framework

9. Methodological orientation and Theory

What methodological orientation was stated to underpin the study (e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis)?

Content analysis was used in this study to analyse the data from the interview transcripts. Conventional content analysis was used to identify the conventional themes, which were attributed as factors that influence physician prescriber implementation of hospital pharmacist recommendations. The Theoretical Domains Framework (TDF) was used to structure the interview topic guides, and directed content analysis was used to identify the relevant TDF domains from the interview transcripts.

Participant selection

10. Sampling

How were participants selected (e.g. purposive, convenience, consecutive, snowball)?

Participants were identified and recruited through a combination of convenience sampling and purposive sampling. Of the pharmacists, the pilot participant was recruited face to face by KD at their place of work, three were identified via a colleague of KD, and two were recruited via snowballing (i.e. identified from a pharmacist who had already participated in the study). Of the physicians, two were identified through a colleague of KD, three via snowballing, and three were identified via pharmacists who had not already participated in the study (note: these pharmacists were identified through a colleague of KD).

11. Method of approach

How were participants approached (e.g. face-to-face, telephone, mail, email)?

Nine participants were recruited via email, three participants were approached face to face by KD at their place of work, and two were contacted via text message.

12. Sample size

How many participants were in the study?

14.

13. Nonparticipation

How many people refused to participate or dropped out? Reasons?

None.

Setting

14. Setting of data collection

Where was the data collected (e.g. home, clinic, workplace)?

One interview was conducted in a private room at the interviewer’s workplace as this was the preference of the interviewee. However, all other interviews were conducted in a private room in the participant’s respective hospital site to minimise disruption to their work day.
15. Presence of nonparticipants
Was anyone else present besides the participants and researchers?
No.

16. Description of sample
What are the important characteristics of the sample (e.g. demographic data, date)?
Ten participants were female. With regard to hospital-based experience, half the participants had less than 5 years’ experience, four participants had ≥ 5 years’ experience but less than 10 years’ experience, and three participants had over 10 years’ experience. The interviews took place between August 2018 and August 2019.

Data collection

17. Interview guide
Were questions, prompts, guides provided by the authors? Was it pilot tested?
Two separate topic guides comprising a similar line of questioning (with prompts where appropriate) were formulated for the pharmacist and physician participants. The topic guides were based on a review of the literature, the TDF, and my own and my supervisors’ knowledge of the research area. Each topic guide was pilot tested with one participant each, and both of these interviews were included in the study. The topic guides were iteratively refined during the study where appropriate to ensure that emerging themes were explored in subsequent interviews.

18. Repeat interviews
Were repeat interviews carried out? If yes, how many?
No.

19. Audio/visual recording
Did the research use audio or visual recording to collect the data?
All interviews were audio-recorded.

20. Field notes
Were field notes made during and/or after the interview or focus group?
Field notes were recorded after each interview, and were used to refine topic guides and inform data analysis.

21. Duration
What was the duration of the interviews or focus group?
The mean interview length was 33 minutes (range 18 – 47 minutes).

22. Data saturation
Was data saturation discussed?
Data analysis coincided with data collection. It was as planned in advance that if no new themes emerged in the additional three interviews after the eleventh interview (i.e. to complete the 14-participant sampling matrix), then this would confirm that data saturation had been reached.

23. Transcripts returned
Were transcripts returned to participants for comment and/or correction?
No.
## Domain 3: Analysis and Findings

### Data analysis

24. **Number of data coders**  
How many data coders coded the data?  
Two (KD and AF).

25. **Description of the coding tree**  
Did authors provide a description of the coding tree?  
A description of the process is provided, whereby initial, non-hierarchical codes were categorised, and subsequently developed to generate themes and subthemes as part of conventional content analysis. The TDF was the chosen framework for directed content analysis, and was used as the basis for a coding tree here.

26. **Derivation of themes**  
Were themes identified in advance or derived from the data?  
Conventional content analysis comprised open coding to inductively create initial, non-hierarchical codes. These initial codes were subsequently categorised to generate the evolving themes and subthemes. Directed content analysis was then employed whereby the transcripts were deductively coded using the TDF to identify the domains present.

### Reporting

27. **Software**  
What software, if applicable, was used to manage the data?  
QSR NVivo® Version 11.

28. **Participant checking**  
Did participants provide feedback on the findings?  
No.

29. **Quotations presented**  
Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number  
Yes.

30. **Data and findings consistent**  
Was there consistency between the data presented and the findings?  
Quotations are presented in a manner consistent with findings.

31. **Clarity of major themes**  
Were major themes clearly presented in the findings?  
Major themes are clearly presented in the results section.

32. **Clarity of minor themes**  
Is there a description of diverse cases or discussion of minor themes?  
Subthemes are presented under each of the major themes.
Appendix 21: Final version of topic guides for Chapter 6

Topic guide for pharmacists

1. What do you see as the main roles that pharmacists have in the multidisciplinary care of older adults in the hospital setting?

2. How aware do you think physicians are of the pharmacist’s role in the hospital setting?
   - What do you think doctors’ opinions are of hospital pharmacists’ roles?

3. How would you compare your knowledge and skill set with that of a physician when it comes to medication appropriateness in hospitalised older adults?
   - Are there any gaps in the knowledge or skill set of physicians that pharmacists can help with in particular?
   - Are there any gaps in the knowledge or skill set of pharmacists?

4. To what extent do pharmacists and physicians share the same goals in terms of reducing potentially inappropriate prescribing in older adults?

5. How would you describe your day-to-day interactions with physicians?

6. How do you inform physicians of medication appropriateness issues in older adults?
   - How do you decide what method of communication to use?
   - Do you use different communication methods for different types of recommendations?
   - Do you find any methods of communication more effective than others?
   - If the most effective method is not the most commonly used, ask why.
7. What factors might make it more likely for a physician to implement recommendations from a pharmacist?

8. What factors might make it less likely for a physician to implement recommendations from a pharmacist?

9. Are there any specific types of recommendations that you think are more likely or less likely going to be implemented by physicians?
   - e.g. recommendations regarding medication reconciliation, medication appropriateness, drug interactions, renal dose adjustment etc.

10. How does the experience of a pharmacist affect the number of recommendations implemented by physicians?

11. How do the characteristics of an individual pharmacist affect the implementation of recommendations?

12. How does the grade or experience of physician affect the number of recommendations implemented?

13. How does the specialty of physician affect the number of recommendations implemented?
   - Are some specialties more likely or less likely to implement the recommendations?
   - How do you feel about making a recommendation to a specialist concerning their area of expertise?

14. How do the characteristics of an individual physician affect the number of recommendations implemented?
15. How important do you think it is for the physician to know you or be familiar with you when it comes to implementing your recommendations?

16. On a scale of 1 to 10, how would you, as a pharmacist with (insert number) years of experience, rate your confidence in discussing medication appropriateness with physicians, 1 being not confident at all and 10 being very confident?

17. You identify that an older patient under the care of a hospital physician has been prescribed a potentially inappropriate medication long-term by another prescriber, and make a recommendation to stop this medication. How likely is it that this will be implemented?

18. What are the organisational barriers to pharmacists providing medication recommendations?

19. How does the hospital environment affect the implementation rate of pharmacist recommendations?
   – Is there enough time/opportunity to address these issues?

20. Does the patient have any impact on the number of pharmacist recommendations implemented?

21. Are pharmacist recommendations audited or reviewed by your department? Any quality improvement initiatives?

22. Do you think that the culture within this particular hospital has any impact on i) the relationship between pharmacists and physicians and/or ii) physicians’ implementation of pharmacist recommendations?
23. Do you have experience from another hospital that is relevant? Were the means of communicating with physicians different and what was the effect on the implementation of recommendations?

24. If you could change how pharmacists make recommendations or interventions for older adults in your hospital setting, what would you suggest?

25. In some jurisdictions, pharmacists prescribe as part of the hospital multidisciplinary team. How do you feel about pharmacists having some form of prescribing (or deprescribing) role in the care of older adults?

26. A study by our research group has suggested that physicians are more likely to implement recommendations from fellow physicians than from pharmacists when it comes to recommendations addressing older patients’ medications. What are your thoughts on this?

That brings us to the end of the interview. Do you have any additional comments that you would like to make, or any points you would like to expand on?
**Topic guide for physicians**

1. What do you see as your role in identifying and addressing issues of potentially inappropriate prescribing in hospitalised older adults?
   - How do you feel about making changes in older patients’ medications?

2. What do you see as the main roles that pharmacists have in the multidisciplinary care of older adults in the hospital setting?

3. How would you compare your knowledge and skill set with that of a pharmacist when it comes to medication appropriateness in hospitalised older adults?
   - Are there any gaps in your knowledge or skill set that pharmacists can help with?
   - Are there any gaps in the knowledge or skill set of pharmacists?

4. To what extent do pharmacists and physicians share the same goals in terms of reducing potentially inappropriate prescribing in older adults?

5. How would you describe your relationship or day-to-day interactions with pharmacists?

6. At present, how do you receive recommendations from pharmacists in hospital?
   - e.g. face to face, over the telephone, written, or a combination?
   - How do you most commonly receive these recommendations?
   - What method do you find most effective? Why?
   - If the most effective method is not the most commonly used method, why do you think that is the case?

7. What factors might make it more likely for you implement a recommendation from a pharmacist?
8. What factors might make it less likely for you to implement a recommendation from a pharmacist?

9. Are there any specific types of recommendations from hospital pharmacists that you find most beneficial?
   - e.g. recommendations regarding medication reconciliation, medication appropriateness, drug interactions, renal dose adjustment etc.

10. How does the experience of a pharmacist affect the number of their recommendations that you implement?

11. How do the characteristics of an individual pharmacist affect the implementation of pharmacist recommendations?

12. How does the grade or experience of physician affect the number of pharmacist recommendations implemented, do you think?

13. How does the specialty of physician affect the number of pharmacist recommendations implemented?
    - Are some specialties more likely or less likely to implement the recommendations?

14. How do the characteristics of an individual physician affect the implementation of pharmacist recommendations?

15. How important is it for you to know or be familiar with the pharmacist you are receiving recommendations from?
16. On a scale of 1 to 10, how would you, as a(n) (insert grade of doctor) rate your confidence in discussing medication appropriateness with a hospital pharmacist, 1 being not confident at all and 10 being very confident? Why?

17. Can you describe an instance where a pharmacist made a recommendation that you did not implement.

   - What are reasons you did not implement the recommendation?

18. How does the hospital environment affect the implementation rate of pharmacist recommendations?

   - Is there enough time/opportunity to address these issues?

19. Does the patient have any impact on the number of pharmacist recommendations implemented?

20. A pharmacist makes a recommendation to you to stop a potentially inappropriate medication that an older patient has been taking long-term under the care of another physician. What would you do?

21. If pharmacist recommendations are not implemented, what clinical impact (if any) does this have on older patients?

22. If you could change how pharmacists make recommendations or interventions for older adults in your hospital setting, what would you suggest?

23. In some jurisdictions, pharmacists prescribe as part of the hospital multidisciplinary team. How do you feel about pharmacists having some form of prescribing (or deprescribing) role in the care of older adults?
24. A study by our research group has suggested that physicians are more likely to implement recommendations from fellow physicians than from pharmacists when it comes to recommendations addressing older patients’ medications? What are your thoughts on this?

That brings us to the end of the interview. Do you have any additional comments that you would like to make, or any points you would like to expand on?
### Appendix 22: Supplementary Quotations for Chapter 6

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<tr>
<th>Theme</th>
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<th>Illustrative Quotations</th>
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| 1. Clinical relevance and complexity of the recommendation | Clinical relevance in the hospital setting | “I don’t think they’ll really do much about long-term medicines because – like here’s an acute setting, so they might only have them for a week. But like tapering a person off like long-term benzos is a long-term project, so I don’t think they have the time for it here to be honest”. Pharmacist 1  
“I think physicians are so busy, they…it’s not something that’s on their radar when a patient presents to an acute hospital setting, and I suppose if you stand back and look at it – is it the role of a hospital, an acute hospital, to optimise pharmacotherapy on a, on, on a…in older...is that the best time to do it? Is it not the best time for that to be done in primary care?” Pharmacist 6  
“...maybe if they press too hard on the what we would may consider the less important issues, you know that might kind of annoy you a little bit. You might feel like, you know, that’s a minor issue compared to what’s actually going with the patient. We need to focus on the bigger things”. Physician 5  
“...I suppose is it relevant to the patient’s clinical picture at the time of admission? So, for example, if it’s something to do with a sleeping tablet and it’s not relevant to the patient’s admission at the moment, they might feel that the GP might be a better person, you know, to review those type of medications”. Pharmacist 3  
“I suppose you would grade them in some sort of way, you would grade them on importance as well as to if something is very minor or very important. So like some absolute contra-indications or double-prescribing of anticoagulants like things that have potential serious side effects would be taken very seriously”. Physician 3  
“I find that interactions, even especially if they’re theoretical interactions and they’re not going to affect the patient too much, I don’t think they are really considered. They’re not really intervened on too much”. Pharmacist 2  
“I suppose it depends on what the recommendation is, like say if someone had A Fib [atrial fibrillation] and a high CHA₂DS₂-VASc score, then if the pharmacist has recommended anticoagulation and they weren’t anticoagulated, that obviously has a big impact. I think the higher impact things tend to be implemented...” Physician 2  
“I suppose if it’s more urgent. Like, if they saw a patient and the patient was on Calcichew® D3 at home and they’re on just Calcichew® now, they might not think of that as a problem. But if it was a risk, so if there were an interaction that puts the patient at risk, they’d definitely change it more readily”. Pharmacist 1 |
<p>| Priority | | “…maybe they’re in a very stressful day or they’re very busy and they’re not that interested in hearing about medication for a particular patient or they might feel they have more pressing issues to deal with”. Pharmacist 3 |</p>
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<th>Illustrative Quotations</th>
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| 1. Clinical relevance and complexity of the recommendation (continued) | Priority (continued) | “But if you’re on a completely different ward dealing with an emergency and like you’re going to say ‘Yeah, I’ll do it at some point’ and you might not actually do it. So, they’re kind of smaller errors that you wouldn’t pay that much attention to and I think it’s just how you prioritise the...like perceived problem with the prescription”. **Physician 3**  
“...things like benzos not being stopped in your older people. Like you know that does have an effect for sure but it’s not going to be a priority for a patient. You know it’s not going to be one of the priorities for an inpatient during their stay here...” **Pharmacist 6**  
“...it’s an acute setting here. So, there’s always someone more sick than the patient they’re at. So, maybe towards the end of a patient’s admission when you can actually have the time to sit down and review it, their medicines on discharge. There’s always another 10 patients that are sicker than them. So, it even might fall through the cracks then towards the end”. **Pharmacist 1** |
| Complexity of decision-making | | “...it’s the ease of doing it as well. So like if you take that example of a PPI: if someone tells you they’re on 15 and not 30 at home and give you the kardex and it’s in front of you, yeah that’s easy to do”. **Physician 3**  
“...someone comes in and they’re on glaucoma eye drops – yeah prescribe that. There’s no thinking about it – it’s black and white”. **Pharmacist 6**  
“I would always, unless it was something very benign, like I don’t know Chloromycetin® eye drops or something and their eye is fine, then I would be happy to cancel that, but I would usually always call and ask the registrar if it was appropriate to stop or not”. **Physician 7**  
“I think the experience part comes in when it’s more grey areas...” **Pharmacist 3**  
“They probably interact more with the intern and the SHO on the team in person, you know, with recommendations or with issues, who in turn may have to pass it up to me then if they’re not sure what to do”. **Physician 5**  
“I think the most junior of doctors I’d say, the interns or the SHOs, I think are more likely to ask for advice regarding more complex stuff”. **Physician 8**  
“So I think the more straightforward ones where the guidelines are very clear are acted on probably quicker and it’s easier for people to make a decision around that because there’s no ‘oh maybe I need to check with a senior member of the team’ or ‘that needs to be discussed maybe with the GP’...” **Pharmacist 3**  
“More evidence-based things, they’d be more quick to change”. **Pharmacist 1**  
“Well like if they tell us more information about why we should change it. Kind of like their back up info about why are they making that recommendation”. **Physician 1**  
“But I think if you can present your case and give them good evidence, they’ll do it. Like, don’t just say that there’s an interaction there. Tell them where you got the interaction and what kind of – like, what it could cause if you don’t change it. So, give them plenty of information”. **Pharmacist 1** |
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<tr>
<td>2. Interprofessional communication</td>
<td>Route of communication</td>
<td>“...I think face-to-face communication of the changes is the easiest way to actually get them implemented...” Physician 3&lt;br&gt;“I suppose to meet with the doctors is always easier, so if you can like face to face have a discussion when you have the information in front of you - so when you have the patient’s kardex or the patient’s notes, it’s always easier to explain something rather than doing it through a phone call”. Pharmacist 3&lt;br&gt;“I think face-to-face when you’re both there and you can look at the drug chart if necessary and you can pull the notes and you can say ‘look, this is the issue’, whereas I think if you’re relying on...the least effective probably is like our notes that we leave on the drug chart, because I don’t think that a lot of the time, you know, during a ward round, they don’t look at the drug chart...” Pharmacist 5&lt;br&gt;“...other methods of communication are not as effective as face-to-face and getting you to do it right in front of them...” Physician 1&lt;br&gt;“Sometimes it could be acted upon incorrectly if you’re not there to look at what, you know...so I think like definitely face-to-face communication on a ward is the most effective”. Pharmacist 5&lt;br&gt;“I think for serious things, face-to-face is great. You can kind of talk back and forth sometimes you know. Written things – you know, you may...people may not understand the reason something’s being prescribed or the reason for maybe going outside the license...” Physician 5&lt;br&gt;“Oh, face to face, they’ll do it, they kind of get your point. They’ll do it straight away, and leaving a note - it can just fall by the wayside...” Pharmacist 4&lt;br&gt;“...I guess one thing is the written recommendations on the front of the kardex, it’s usually on the green piece of paper. We would follow their recommendations but a lot of the times it can get missed. So, I guess that’s one factor that makes us less likely to implement it. If we just miss it”. Physician 1&lt;br&gt;“...if you talk to the person face to face, I think they’d do it. They’re more inclined to take up your recommendations than if you left a note”. Pharmacist 1&lt;br&gt;“I think if it’s not communicated well. Like definitely the best way of communicating it is by saying it, whereas sometimes you can look at what they have written especially if it is in the notes and say, as I said like, are they telling us just to use it with caution or are they telling us to absolutely stop it? So, I think verbal is better than written communication”. Physician 2&lt;br&gt;“...if I think it’s an urgent issue, I will bleep them and talk to them verbally, because they’ll just respond to it a lot quicker that way. If I leave a note, they might not see it till the next ward round or they might not be looked at at all”. Pharmacist 2&lt;br&gt;“...I suppose more pharmacy time would useful, because I think the sort of rather cold abstracts or the way we deal with a lot of it is, it’s written in the notes, it’s sort of vague almost anonymous green script...” Physician 8</td>
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<td>Theme</td>
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| 2. Interprofessional communication        | Route of communication                          | “If they just write a note in a book, in the notes, I’d say they’d be less likely to implement them. Possibly if they didn’t get (I suppose) the reasoning behind them…” Pharmacist 4  
“I find that a verbal communication is much more effective than a written communication regarding an intervention I want to make because you can explain it better verbally and I think they are more likely to take it on board. That’s kind of just what I found. So I would be inclined to bleep them and talk to them through the issue and I think they are more inclined to take it on board then”. Pharmacist 2  
“…I’ve worked in places where you get a phone call maybe after your ward round with the big list of recommendations verbally that you’d be trying to write down and like the serious potential for information to be lost there…” Physician 5  
“I don’t really see much difference in over the phone or face-to-face in terms of them getting, them following through on the intervention I think. Yeah I think they would follow through just as much if I talk to them over the phone than I did face to face yeah”. Pharmacist 2 |
| Combination of communication methods      |                                                | “...the most effective way of doing, getting stuff implemented is both by writing in the notes, and verbally contacting them. So, if you just write it in the notes, it may not happen. Em...you have to speak to somebody. It’s really important that you speak to somebody”. Pharmacist 6  
“...and then both verbal and written communication because sometimes we need reminders”. Physician 3  
“I could say well I also put it in writing on the intervention slip, just to kind of have a back-up there and just in case the SHO didn’t discuss it with the team, that somebody might see it then written as well”. Pharmacist 2  
“You know, coming to meet somebody is much more difficult. So, I think the note is probably the most important but, like if you were to maybe make a verbal kind of reference to the fact that ‘I have made a note on this person’ that might be helpful as well”. Physician 7 |
| Pharmacist manner, language, and assertiveness |                                                | “Definitely, I think if you’ve got a nice manner, and you approach in a less accusatory fashion, you’ll get things I think a little bit easier, or explain better rather than going up and saying ‘That’s wrong, that’s dangerous, don’t do that’. But then I’ve also seen (I suppose) a couple of pharmacists who might be quite reluctant to counteract anything that a doctor has done. Like ‘Oh, they may know. So, I’m not saying anything’, or ‘I don’t really write in the patients notes because the team might get offended’, that kind of way. So, I think there is kind of that still hierarchy system - can still be there sometimes and can affect people. But definitely, the way you approach it will definitely affect it”. Pharmacist 4  
“...we shouldn’t just go in and say ‘you are wrong. This is what you should be doing’. I would always say ‘maybe think about doing this instead’. So I suppose we shouldn’t be arrogant either”. Pharmacist 2 |
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| 2. Interprofessional communication (continued) | Pharmacist manner, language, and assertiveness (continued) | “I think experience...I think you...if you have a lot of experience, and you’re confident in what you’re saying to physicians, they’re gonna trust you then, and they’re gonna trust you. I think I can say confidently that the doctors trust me...” **Pharmacist 6**
“I guess just being friendly to be honest. Nothing much to it. As long as they are friendly and nice and smile and are nice to you about it and not condescending, like you’d do anything for anyone who is nice to you”. **Physician 1**
“But most of the time I’ll just say ‘this is the guidance. Consider changing x to y’ because the guidance states this. So, again, I’m not telling them what to do, but just what I know and what I have found and to maybe review it again”. **Pharmacist 2**
“I suppose if it’s more direct, like ‘please consider stopping’, as opposed to ‘the guidelines state...’ If it’s an actual like ‘I think you should consider stopping it’, as opposed to just this kind of abstract concept”. **Physician 2**
“They’re making these decisions, but I feel like sometimes they think ‘Oh you know, I’m writing this as a kind of an FYI’ but no one pushes it to say that you know you need to...can you have a look at my note or, what do you think about this? I feel like the individual pharmacist doesn’t approach it kind of even verbally...” **Physician 7**
“...you need to be assertive and confident, but not overly arrogant in what you are saying”. **Pharmacist 2**
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| 3. Prescriber role and identity | Experience/Grade | “I feel my knowledge at intern level of pharmacology and therapeutics is so much less than it should be, and that pharmacists have this really in-depth knowledge and understanding of a lot of different drugs...” **Physician 7**  
“I find if you go to interns, they won’t change things realistically, especially now. They’re only about four months in now. They won’t change – I won’t really go to interns too often because they’ll just bounce it back off their SHOs and registrars”. **Pharmacist 1**  
“Well I suppose I’m at an SHO level, I mightn’t always be sure whether this can be stopped...” **Physician 6**  
“I think usually their clinical experience plays a huge part in their decision to change [referring to senior physicians]”. **Physician 1**  
“I suppose it’s probably twofold: when they don’t have that much experience, they are probably more likely to take on the advice that you are giving them sometimes, so you know they mightn’t...like a lot of the time if I was making a recommendation on a patient’s medications, they would probably take on face value what I was saying as correct because they mightn’t have the experience behind them or they mightn’t be familiar with the medication”. **Pharmacist 3**  
“I think you may find that as you get older you are more likely to say, I know it all and continue on. So I think the grade is you may find the lower the grade the more likely they are to take on board pharmacists recommendations and more open to it I think. Like lots of things as we get older, we are maybe a bit more sure of ourselves and less likely to take on advice”. **Physician 8**  
“...if you take someone more experienced, while you might not always follow the recommendation, I think someone with experience would be more able to actually be making an informed decision and not following it for a reason...” **Physician 3**  
“...maybe the more old school consultants would’ve been more dismissive of pharmacist input...” **Pharmacist 5**  
“...senior doctors have kind of disregarded what the pharmacist’s opinion has been and from like, for no valid reason that I could see at that point in time”. **Physician 7**  
“I would kind of generalise and see that kind of the younger generation are a lot more accepting, a lot more encouraging of your involvement. I think personally that’s because they, a lot of them would have been trained with us. The older generation would have been completely separate...” **Pharmacist 4**  
“I think when you first start off as an intern you would be scared of making changes by yourself even if the pharmacist tells you that it is the correct dose or that there’s a kind of interaction - we would always go to our, let’s say registrar first before we make any changes. But as you get more experienced you become more comfortable making the changes on your own”. **Physician 1**  
“...it might be that the SHO or the registrar has charted that particular medication and, you know, a more junior member of the team mightn’t feel confident in discontinuing it on the advice of pharmacy or they might feel that again, it might need further discussion before they discontinue it or amend the prescription”. **Pharmacist 3** |
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| 3. Prescriber role and identity (continued) | Less experienced physicians implementing on the basis of blind trust in their seniors | “I suppose the lower…I suppose they would probably be more likely to accept their recommendations as kind of more gospel, whereas we might use our own experience to weigh up the pros and cons of taking the advice, and you know saying what are…and looking at the (kind of) goals, and make our own decision on whether we want to follow the advice…” Physician 5  
“…when they don’t have that much experience, they are probably more likely to take on the advice that you are giving them sometimes, so you know they mightn’t…like a lot of the time if I was making a recommendation on a patient’s medications, they would probably take on face value what I was saying as correct because they mightn’t have the experience behind them or they mightn’t be familiar with the medication”. Pharmacist 3  
“I think we probably take on board what anyone senior would say. So, if it’s a senior pharmacist you probably take it on board, whereas I don’t know maybe the more senior physicians would have their own opinions on whether it’s appropriate or not”. Physician 2  
“I think that interns and SHOs, well especially interns, or less experienced doctors would be more likely to just do what they were told or what they are asked to do without taking the clinical context into account. So, I think they would be less able to know the importance of doing or not doing something”. Physician 3 |
| Hierarchical influences |  | “…because medicine is quite hierarchical, you’re really…it’s followed by a rigid structure, so maybe they feel like going to the more junior person and letting them pass on the message if needed is the appropriate way to do it”. Physician 5  
“That may be around grade too often, a lot of this is consultant-driven. So, a registrar and SHO may not feel empowered to sort of follow a recommendation either”. Physician 8  
“…whereas if it’s something that like their registrar has told them to do this or the SHO did it, and they’re slower then to change the work that another member of their team has done, you know, without checking, without checking with them, or they just don’t know”. Pharmacist 5  
“…you’re always going to go through your consultant or the senior registrar to make a kind of a medication prescribing decision”. Physician 7  
“Maybe sometimes, they were just told ‘oh prescribe this’ or whatever, so they’re not really sure do they…who is correct? Is it their registrar or is it you?” Pharmacist 5  
“…maybe junior doctors don’t change immediately if someone else has told them to prescribe something, but they might question it with the rest of the team”. Physician 4  
“I might approach maybe the SHO rather than the registrar because I think the SHO would be more willing to listen to me and would be likely to discuss it with the rest of the team, and would be grateful for the interaction. Whereas in my experience talking to registrars, if I query something, it’s…the reply that I get is ‘well that’s what I want, so don’t question it’ basically. They might not say don’t question it, but that’s implied”. Pharmacist 2 |
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| 3. Prescriber role and identity (continued) | Hierarchical culture and the ‘trickle-down effect’ | “I feel like there is probably a bit of a ‘Well the doctor knows best’ kind of thing, you know”. **Physician 7**  
“…there can be moments of conflict and it probably is to do with a personality clash or that, maybe sometimes they perceive that they have got more important things to be dealing with than answering or talking about recommendations or answering a query from a pharmacist”. **Pharmacist 3**  
“I think any of the consultants I have worked with have been very open to pharmacist intervention and discussion with them as well. So, I would have no problem ever discussing anything with the pharmacist”. **Physician 2**  
“I kind of feel sometimes that the pharmacists make comments or write a note about potential you know, adverse effects or have you considered X, Y or Z but that the like senior doctors especially tend to just kind of fluff that off, and they say ‘Oh well, we’re the doctor making the prescribing decision, we have already kind of considered what the pharmacist is saying’…” **Physician 7**  
“I suppose there’s a power thing. So, do you know, like someone telling you something…and maybe held in a position of power, I’ve no doubt maybe has an effect, do you know. Because that’s quite sizeable really, and then that might be that kind of trickle-down effect too of ignoring…” **Physician 4** |
| Personality | | “Like obviously you’re gonna have surgeons or doctors who are way more abrupt and not as warm, or as friendly…but at the end of the day, it shouldn’t matter what their characteristics are, as long as the recommendation is sound from an experienced pharmacist, and is of benefit to the patient”. **Pharmacist 6**  
“I feel like some characters are probably more inclined to be kind of open-minded about most things”. **Physician 7**  
“…the personality of the person will obviously dictate how well they take that advice up or how they perceive that or how helpful they perceive that advice to be”. **Pharmacist 3**  
“…some would be more receptive to maybe perceived criticism or to a perceived challenge of their own prescribing”. **Physician 3**  
“There are some people that would, you know, think they are always right and they don’t want to take advice from other people”. **Physician 5**  
“…the reply that I got from the physician was ‘I’ve prescribed it like that because that’s how I want it done’. Rather than ‘okay thanks for your query. This is why I’m doing this way and this is the evidence behind it’. It was just ‘this is why I’m doing it because I want it this way’. So I suppose maybe arrogance might come into it a little bit”. **Pharmacist 2**  
“Probably more arrogant physicians are less likely to take up recommendations”. **Physician 1** |
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<td>3. Prescriber role and identity (continued)</td>
<td>Specialty</td>
<td>“I think the specialty is hugely influential on taking up recommendations”. <strong>Physician 7</strong>&lt;br&gt;“And then some would be, wouldn’t want to prescribe medicines that they aren’t familiar with. So I think knowledge of the drugs themselves would probably be the biggest factor as to what you do and you don’t, and I think that some doctors will be fairly set in their ways of using certain medications only and then not deviating from that”. <strong>Physician 3</strong>&lt;br&gt;“...if you take surgeons or like specialties that maybe aren’t very medical and would have a lot less pharmacology knowledge, would be more likely to just take up anything. I’m not saying this is good or bad but would be more likely to just follow any recommendation made by someone else because they have less knowledge about the subject”. <strong>Pharmacist 6</strong>&lt;br&gt;“...especially medicines that might be outside the far, day-to-day prescribing practice, we may not know as much...” <strong>Physician 5</strong>&lt;br&gt;“So, I feel like in the context of a specialty, that those physicians probably would be very protective of their specialty drugs whereas the other non-kind of specialty drugs, so non-cardiac drugs for example in cardiology patients, I feel like recommendations would be both helpful and pretty well respected in that context really”. <strong>Physician 7</strong>&lt;br&gt;“If you were making a recommendation...maybe a recommendation about the specialty...so, a cardiology drug, the cardiologist, they might not listen to you as fast. But if it was about another type of drug, they’d probably take it up faster”. <strong>Pharmacist 1</strong>&lt;br&gt;“...you’d be more likely to agree with recommendations outside your specialty, and in your specialty, you may have more knowledge or more of that soft knowledge...” <strong>Physician 5</strong>&lt;br&gt;“The pharmacist can kind of look at it as a whole, whereas you’ll see now you go into a cardiac ward, a cardiologist will never touch a mental health drug, ‘That’s not - I didn’t prescribe it’”. <strong>Pharmacist 4</strong>&lt;br&gt;“So, we would normally not, unless you get psychiatry input, we wouldn’t have the background of the appropriateness of antipsychotics in particular”. <strong>Physician 4</strong>&lt;br&gt;“You might find cardiologists might be reluctant to fiddle around with respiratory drugs or respiratory physicians might be slow enough to fiddle around with psychiatry drugs. So I think geriatricians are probably a group that are sort of happy to fiddle around with most medications”. <strong>Physician 8</strong>&lt;br&gt;“I think it depends on the team, you know. We’ll say your geriatricians probably would be quite welcoming of pharmacist involvement and quite aware of the roles that they play, say other teams, not as much...” <strong>Pharmacist 5</strong>&lt;br&gt;“I think as geriatricians we would be more likely to want to make our own decisions about medication management and sort of taking the patient’s own like context into account”. <strong>Physician 3</strong>&lt;br&gt;“I think the geriatric teams are probably very supportive of pharmacists and there does seem to be... You do you get the feeling that there is a shared care there between geriatricians and pharmacists. Em...and I think geriatricians are trained to be very aware of the patient as a whole and kind of a holistic view”. <strong>Pharmacist 2</strong></td>
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| 3. Prescriber role and identity (continued) | Professional boundaries / Encroachment | “…he was involved with the patient initially, he saw me as coming in and almost interfering, and just being overly cautious”.  
**Pharmacist 4**  
“…if they’re confident in their own ability, they feel maybe that they don’t need the advice of a pharmacist and that they’ve made their decision and that it’s not our place to question their decision retrospectively”.  
**Pharmacist 3**  
“…if it’s something that’s very specialty-based - do you know like certain like, I don’t know, rheumatological drugs or cardiac drugs that I don’t use that frequently that they’re under someone else’s specialist care for, I would be a lot less likely to stop it”.  
**Physician 3**  
“…some people would be I suppose less keen to stop medications that they felt if they haven’t started it, sometimes they’d be less keen to stop it. Whereas I think geriatricians would kind of take ownership for just stopping it”.  
**Physician 2**  
“Again, it comes down to: does a doctor who might be only seeing the patient, you know, on this presentation stop the medication that was started by another colleague”.  
**Pharmacist 3**  
“…what importance they do place on the role of the pharmacist because a lot of the role of the pharmacist would overlap with what they might have considered that they’ve done anyway…”  
**Pharmacist 5** |
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| 4. Knowing each other and developing trusting relationships | Knowing each other | “I think definitely in terms of uptake of recommendations, if you have a very good relationship with the team, you’re more likely...it’s more likely because they know you”. Pharmacist 3  
“I suppose like if you were just a random person coming up...because I think that’s what happens a lot. They don’t know...if you can’t put a face to the name, they don’t know you really”. Pharmacist 1  
“...if you don’t know the team or you don’t know the doctor you’re kind of going ‘Oh God, I have to walk up there now and approach this’, but yeah, I’d say I wouldn’t be meek about it anyway”. Pharmacist 4  
“But I suppose if you’re just leaving a note to a team that you don’t know, how do they even know who you are?” Pharmacist 1  
“I think it would be extremely beneficial if we knew them at a kind of a deeper level”. Physician 7  
“So I think it’s not essential. But I think like any bit when you are working as part of a team if you know somebody it probably makes interactions a little bit better”. Physician 8  
“...if they see an intervention from you, you know, because they know you, they are more likely to act on that intervention, which I suppose is natural”. Pharmacist 3  

Outsider | “So you’re kind of back in the mist”. Pharmacist 5  
“Outside the loop sometime yeah. Certainly...that probably is one of the main sources of miscommunication, or not picking up recommendations in that they may not be....yeah inside the exact loop with the train of thought or the goal of care...” Physician 5  

Relationship-building | “…when you have an interpersonal relationship with someone, you’re more likely to take on board their opinion, and subsequently maybe implement their recommendations”. Physician 5  
“I suppose you build up a sort of relationship with some pharmacists too where you know that you have worked with them before and you know that their advice is very good and solid. So sometimes when maybe newer people or younger people are in the ward, you may be less sure as to what their sort of experience is...” Physician 8  
“I think I’d have a good relationship with the SHOs and registrars because the interns change every three months and the SHOs kind of change as well, but you kind of have more exposure to them because they’d actually be kind of the main people you see on the team, so they might get used to you more as well...a lot better relationship with them”. Pharmacist 1  
“I think if they were like again like a cardiology pharmacist that if they mentioned something on the ward round, I think they would have built up a rapport with the consultants who were there obviously more long-term than we are, and it probably would be implemented easier, if they had already built up that rapport”. Physician 2 |
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| 4. Knowing each other and developing trusting relationships (continued) | Relationship-building (continued)              | “Good rapport always helps. If you know the same pharmacist and you are working with them all the time, I think that benefits, like that definitely helps. If the pharmacist was to change every single day, I don't think that should be a reason to not implement their recommendations anyway”. **Physician 1**  
“I think, as you’re there and you get to know people more that they come to you with questions and things like that. You do need to put in a bit of time and effort, I suppose, into building up those kinds of relationships”. **Pharmacist 5**                                                                                     |
|                                                                    | Trusting pharmacists’ recommendations          | “…if you build up a relationship, a working relationship, then it helps massively and there’s much more trust and you even get to know why one person is doing one thing and one person is doing another”. **Physician 5**  
“…like any relationship, like if you build up, if you make a few recommendations that were good, they kind of trust you more, so I think it’s very important…” **Pharmacist 1**  
“Because you know the pharmacist, and you have a personal relationship with them, and you trust their opinion…” **Physician 3**  
“…when you’re working in a particular area, you get to know the different doctors that work in that particular area and they’re more familiar with you, even just seeing your face kind of repeatedly then, I think you have more I suppose credence in their eyes or credibility in their eyes, because you know they’ve seen you at work and they’ve seen you, you know review patients’ medications and review patients’ charts”. **Pharmacist 3**  
“I suppose they’re less experienced [referring to more junior physicians] and they have more trust in other healthcare professionals that might have more experience than them. So I suppose the less experienced they are…the more trust they would have that other people will guide them”. **Pharmacist 2** |
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| 5, Hospital environment   | Opportunity for intervention     | “...I think meeting as opposed to kind of opportunistically trying to find the team on the ward...” Physician 2  
“I suppose when I’m on the wards, it’s probably more ad hoc interactions...” Pharmacist 3  
“...if you miss the team when they are around on a ward round, you are relying on, you know, if it’s extremely urgent, you’re bleeping and waiting for them to ring you back”. Pharmacist 5  
“You know it was just easier when the pharmacist was there on the ward round to flag things with the consultant and then you’d get an answer straight away”. Physician 2  
“...the pharmacist went on a round once a week and that was very good and it helped the...again, the knowledge passing and for new doctors...” Physician 4 |
| Busy                      |                                  | “At the same time, they could be very busy, so they might not think that doing them is important as well [referring to pharmacist recommendations]”. Pharmacist 1  
“I think when you’re on a busy service you mightn’t necessarily do it straight away [the pharmacist recommendation]. So, I think that’s probably one of the biggest factors is if you have a long patient list and if it’s not something say particularly pressing, then you might not do it straight away”. Physician 2  
“...it is all a bit chaotic, and that doesn’t lend to safe prescribing really and the overall hospital environment and workload could all impact on it certainly, and that will also then impact on following the guidance”. Physician 5  
“I think time is a huge thing. I think all of the teams are very time-poor. They don’t really have the time to look at the drug chart, they don’t have the time to look up what it is the issue is or why it should be changed...” Pharmacist 5 |
| Timing                    |                                  | “I suppose one of the issues is that when you do bleep an intern or bleep an SHO about a medication issue, you know, they could be having a really busy incident on another ward or they could be, I suppose dealing with something pressing on another ward and you are trying to explain to them about a patient on your particular ward”. Pharmacist 3  
“...get a bleep, find a phone, ring the number back... You know, maybe that’s engaged and, you know, you can play what they call phone tag for all that - so that can be an issue”. Physician 5  
“...at the moment we either leave a note or we bleep the team and we are always kind of going ‘why have you done this?’ and ‘can you review it?’”, rather than at the time of prescribing we could have discussed it and you’d already have your answers and you wouldn’t have to go querying it because you’d know why it has been done”. Pharmacist 2  
“Ideally, at the point of prescribing or at the bedside or when the doctors have the kardex and the medication notes, that would be the time to raise any issues...” Pharmacist 3 |
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<td>5. Hospital environment</td>
<td>Documentation in the medical notes</td>
<td>“...the written notes can sometimes be a disaster, because even like the binding holes rip and the pages either are in the wrong position or they fall out or they’re shoved into the back of the chart”. <strong>Physician 7</strong>&lt;br&gt;“So if you are not on a ward round, I suppose some things can be omitted from the notes sometimes and so I suppose when I'm reviewing medication, I don’t assume that I have all the information to hand”. <strong>Pharmacist 2</strong>&lt;br&gt;“...I suppose you have to take into consideration that there’s other factors that mightn’t be, you know, maybe particularly clear in the notes, so you know, from a pharmacist’s point of view, I think it’s always very prudent to, you know, to discuss any issue you have rather than just kind of dictating what you think the dose might be”. <strong>Pharmacist 3</strong></td>
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<td>Working as a team</td>
<td>“...I think being on their team would make it [would make implementation more likely]. You are their team, you’re kind of in their specialty, they know you - I think that’s much better rather than random pharmacists kind of approaching them on the ward...” <strong>Pharmacist 4</strong>&lt;br&gt;“...well if you’re part of the team then I feel like people know you at a kind of deeper, like behind the professional level you know, and you get to know people...” <strong>Physician 7</strong>&lt;br&gt;“I think you’ve a better relationship with the doctors if you have a team-based approach and I think if you’re familiar with the team and you have maybe more easier methods of communication where you are seeing each other more frequently or you’re catching up with each other at certain points of the day, then I think that makes the likelihood that interventions can be acted on much more likely...” <strong>Pharmacist 3</strong></td>
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<td>Staffing levels</td>
<td>“I think staffing levels is a big thing here, like we don’t have enough pharmacists here to cover every ward, so like I said, if you have screened a drug in the dispensary and you have to go up to the ward that you’re not familiar with - the team isn’t familiar with you. So, if we had more staff levels I think that, and that they actually see your face, they’d be more inclined to implement it...” <strong>Physician 1</strong>&lt;br&gt;“I think it may be as simple as sort of more face time, more pharmacists, more clearly a role and understood role among doctors...” <strong>Physician 8</strong>&lt;br&gt;“I think we don’t have sufficient staff to expand our roles and really develop relationships. It’s all about developing relationships with the physicians, particularly the consultants and I don’t think we’re able to do that with what we have at the moment to develop relationships with the consultants”. <strong>Physician 6</strong>&lt;br&gt;“It’s really really variable depending on what hospital you’re in. I really don’t see a lot of them here [referring to day-to-day interactions with pharmacists]”. <strong>Physician 3</strong>&lt;br&gt;“...I suppose there is that thing there’s so few of us, many of them [physicians] won’t even know that we’re around...” <strong>Pharmacist 4</strong></td>
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GP: General practitioner  CHA₂DS₂-VASc: a scoring system to calculate stroke risk in non-valvular atrial fibrillation patients based on Congestive heart failure, Hypertension, Age ≥75, Diabetes mellitus, history of Stroke or transient ischemic attack, Vascular disease, Age 65-74, and Sex category.  PPI: Proton pump inhibitor  SHO: Senior house officer  FYI: For your information