Patient Prioritisation for Pharmaceutical Care: Development of an Adult Complexity Tool for Pharmaceutical Care (ACTPC)

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Contents

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List of Abbreviations

ACTPC	Adult Complexity Tool for Pharmaceutical Care
ADE	Adverse Drug Event
ADR	Adverse Drug Reaction
AIME	Adverse Inpatient Medication Event model
AMU	Adult Acute Medical Unit
ART	Assessment of Risk Tool
ASHP	American Society of Hospital Pharmacists
ERG	Expert Reference Group
CPOE	Computerised Pharmacist/Physician Order Entry
CPS	Clinical Pharmacy Service
DRP	Drug-related problem
EPMA	Electronic Prescribing and Medicines Administration
GPHC	General Pharmaceutical Council
HCRW	Health and Care Research Wales
EHR	Electronic Health Record
HRA	Health Research Authority
HRM	High-Risk Medicine
LoS	Length of Stay
ME	Medication Error
MOAT	Medicines Optimisation Assessment Tool
MPharm	Master of Pharmacy
MR	Medication Review
MRP	Medication Related Problem

NGT	Nasogastric Tube
NHS	National Health Service
NIHR	National Institute for Health Research
PAL	Patient Acuity Level
PARR	Patients at Risk of Rehospitalisation
PAST	Pharmaceutical Assessment Screening tool
PCNE	Pharmaceutical Care Network Europe
PE	Prescribing Error
PHC	Pharmaceutical Care
PPI	Patient Public Involvement
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
REC	Research Ethics Committee
TCM	Time Critical Medicine
TDM	Therapeutic Drug Monitoring
TPN	Total Parenteral Nutrition
UK	United Kingdom
USA	United States of America
WHO	World Health Organisation

Abstract

Background: Clinical pharmacy services play a key role in optimising medicines and improving patient safety. They aim for each patient to be reviewed daily by clinical pharmacists. However, current financial pressures within the NHS mean that there may not be resources for daily review of patients. Therefore, the ability to accurately screen and identify those patients with more urgent and/ or complex needs would be of great benefit, enabling appropriate allocation of costly staff resources. There have been attempts within some United Kingdom (UK) hospitals to implement locally developed pharmaceutical care screening tools, but these have not been methodically formulated for routine use and there is a lack of agreement as to what such tools should comprise. Thus, the overall aim of this study is to develop a screening tool that can be used by the hospital pharmacy team to triage new patient admissions according to the complexity of their pharmaceutical needs. It will mean that the right pharmacists see the right patients at the right time to deliver high quality and efficient pharmaceutical care to improve patient safety.

Methods: This thesis contains three studies, each applying different methods. The first was a systematic review of the literature to provide a structured overview and description of existing assessment tools used by hospital pharmacy services to assess patient priority and/or complexity. Study Two obtained expert consensus on the design of a pharmaceutical care complexity screening tool for use on admission to hospital. Two Delphi studies were conducted to obtain consensus on the necessary components of a pharmaceutical care complexity screening tool and the appropriate frequency and competency of clinical pharmacist input for each complexity level. Identified and refined tool components from Study One and from our previous UK survey and interview study of prioritisation tools were included in the first two-round Delphi study. The Delphi One survey was distributed to international medication safety experts including hospital pharmacists, academics and physicians. The expert panel was asked to rank each component on importance, using a nine-point Likert-scale. In Delphi study Two, a framework analysis of the previous interview data led to the formation of statements relating to practical aspects of the tool. Clinical pharmacists with a management role identified from Delphi One and via professional networks were invited to complete the Delphi Two survey. The same rating process and consensus approach was used as in Delphi One. Decisions made by the Delphi panels were incorporated into the final version of the Adult Complexity Tool for Pharmaceutical Care (ACTPC). Study Three was a feasibility study conducted on the Acute Medical Unit (AMU) of three UK hospitals. It aimed to assess the practicality and feasibility of the ACTPC tool and identify the most efficient and effective ways to measure the impact of the tool on patient outcomes and pharmacist workload patterns.

Results: The systemic review revealed that there has been growing interest in the development of pharmacy prioritisation tools in recent years. Seventeen published papers including eight UK based tools and nine international tools have described screening tools designed and used in clinical

pharmacy services for the assessment of patients to identify high risk patients and guide pharmaceutical care. Over 300 components were extracted from the interview data and systematic review and then refined for inclusion in the first Delphi study. Thirty-three experts completed Delphi one and consensus was reached on 92 components. Components were then grouped and shortened to 33 items (e.g. all individual high-risk medicines were grouped into a high-risk medicine category). The final items were included in the first draft of the Adult Complexity Tool for Pharmaceutical Care (ACTPC), which stratified patients into three levels - highly, moderately or least complex. The second Delphi study was completed by 40 expert panel members and consensus reached on clinical appropriateness and feasibility of review frequency and experience of pharmacy practitioner to care for patients at each level. These decisions were incorporated into the final version of the ACTPC. The feasibility study tested multiple outcomes for evaluating tool effectiveness and validity. Despite being a feasibility study, our results showed a statistically significant reduction in the number of patients receiving doses of erroneous medications and the number of patients who had serious and minor prescribing errors. The data demonstrated tool validity as patients with high and moderate complexity levels had higher numbers of serious and significant prescribing errors, including missing doses of time critical medicines, therefore identifying those patients at greater risk of drug related problems.

Conclusion: This work systematically developed a comprehensive pharmaceutical care complexity screening tool based on robustly collected data with input from national and international experts. ACTPC was found practical and feasible across three hospital sites. The feasibility study recommends that the ACTPC is tested in a larger study for its effectiveness in reducing actual patient harm and improving the delivery of patient centred pharmaceutical care. Further research is warranted to explore the use of the tool beyond AMU, the use of technology to deliver ACTPC and how the technician workforce can be utilised to prioritise patients.

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The Author

Meshal A. Alshakrah (MA) is a Saudi pharmacist. He achieved his pharmacy degree (BSc) from King Saud University, College of Pharmacy, Saudi Arabia in 2002. After completing this degree, he worked as a pharmacist in the King Abdul-Aziz medical city in Riyadh-Saudi Arabia. It is a tertiary care hospital, one of the biggest hospitals in Riyadh, serving more than 1600 beds with different specialties of care. He worked in various specialities including paediatric care, cardiac care, liver transplant care and intensive care. He completed his MSc in Advancing Clinical Pharmacy Practice from the University of Hertfordshire, College of Pharmacy, United Kingdom in 2015. The focus of his MSc degree was developing advanced knowledge, skills and attributes in the professional practice of Pharmacy and ensure safe, effective and rational use of medicines. His MSc thesis aimed to generate recommendations to reduce harm from anticoagulant medications. In 2016, he enrolled on a course in pharmacoepidemiology and pharmacovigilance at the London School of Hygiene & Tropical Medicine, and was awarded the professional certificate in pharmacoepidemiology & pharmacovigilance.

In April 2017, he was granted a scholarship from the Saudi Ministry of Higher Education to undertake a full-time PhD in pharmacy practice, Division of Pharmacy and Optometry, University of Manchester. It is hoped that the tool developed (ACTPC) through this PhD could improve patient safety and assist in workforce planning and resource utilisation by ensuring that the right pharmacists see the right patients at the right time.

Mr Alshakrah has gained many awards and certificates that demonstrate his commitment to work and enthusiasm for continuing professional and academic development (CPD). Some of these include certificates of appreciation, employee of the month awards and 1st place award at an international conference.

Acknowledgment

I am grateful to ALLAH, for giving me the strength, and patience to complete my PhD, and for surrounding me with wonderful people during my PhD journey.

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I would also like to thank all members, staff, and colleagues at University of Manchester – especially within the pharmacy department – for their support and friendship. I would also like to extend my thanks to all pharmacy staff at Manchester University Foundation Trust, King's College Hospital NHS Foundation Trust and Bolton NHS Foundation Trust for their significant contribution in the data collection and to all participants that took part in the study and enabled this research to be possible. Also, I would like to thank Dr Aseel Abuzour (AA) for contributing to the data collection on the time and motion study.

I would, also, like to express my deepest gratitude to all my family members. Words cannot express how grateful I am to my precious mother Norah, who encouraged me to pursue a PhD degree. Her motivation, endless prayers, and love have sustained me thus far. I would also like to thank my brothers, sister and daughters for always being there for me. Very special thanks are due to my lovely wife, Huda, for her unfailing love, continued support and whose understanding made completion possible. You motivated me at those times when I thought that it was impossible to continue.

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List of Publications and Presentations

Publications

Papers

1. Alshakrah MA, Steinke DT, Tully MP, Abuzour AS, Williams SD, Lewis PJ. Development of the adult complexity tool for pharmaceutical care (ACTPC) in hospital: A modified Delphi study. Res Soc Adm Pharm. February 2021. doi: 10.1016/j.sapharm.2021.02.009

2. Alshakrah MA, Steinke DT, Lewis PJ. Patient prioritization for pharmaceutical care in hospital: A systematic review of assessment tools. Res Soc Adm Pharm. September 2018. doi: 10.1016/j.sapharm.2018.09.009

Abstracts

1. Alshakrah M, Steinke D, Williams S, Tully M, Lewis P. Determining the necessary components of a pharmaceutical care complexity screening tool: An E-Delphi Study. Presented at the 24th European Association of Hospital Pharmacists Congress, Barcelona, Spain; 27-29 March 2019. Proceeding of 24th EAHP International Congress, A161. Available from: https://ejhp.bmj.com/content/26/Suppl_1/A161.2.abstract*

2. Alshakrah M, Steinke D, Lewis P. Patient prioritisation for pharmaceutical care: a systematic review of assessment tools. Presented at 78th FIP Word Congress of Pharmacy and Pharmaceutical Sciences, Glasgow, United Kingdom; 2-6 September 2018. 2018 International Pharmaceutical Federation (FIP) Congress in Glasgow proceeding. Available From: https://www.fip.org/abstracts?page=abstracts&action=generatePdf&item=20482

Presentations
External

1. Alshakrah M, Steinke D, Williams S, Tully M, Lewis P. Determining the necessary components of a pharmaceutical care complexity screening tool: An E-Delphi Study. Presented at the 24th European Association of Hospital Pharmacists Congress, Barcelona, Spain; 27-29 March 2019 (poster and oral presentation) *

2. Alshakrah M, Steinke D, Lewis P. Patient prioritisation for pharmaceutical care: a systematic review of assessment tools. Presented at 78th FIP Word Congress of Pharmacy and Pharmaceutical Sciences, Glasgow, United Kingdom; 2-6 September 2018 (poster)

Internal

1. Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital: Preliminary results of the feasibility study. Expert Reference Group (ERG) meeting; 25 February 2020 (oral presentation)

2. Determining the necessary components and the use of the adult complexity tool for pharmaceutical care (ACTPC): an e-Delphi study. Division of Pharmacy and Optometry (DPO) Showcase; 23-24 January 2020 (poster)

3. Developing of pharmaceutical care complexity screening tool to assess patient acuity and complexity at hospital admission: Preliminary results of the Delphi One and Two studies. Expert Reference Group (ERG) meeting; 21 January 2019 (oral presentation)

4. Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital: Preliminary results of the Delphi One and Two studies. Patient and Public Involvement (PPI) meeting; 3 December 2018 (oral presentation)

5. Patient prioritisation for pharmaceutical care: a systematic review of assessment tools. Division of Pharmacy and Optometry (DPO) Showcase; 20-21 September 2018 (poster)

6. Developing of pharmaceutical care complexity screening tool to assess patient acuity and complexity at hospital admission: Preliminary results of the Delphi One study. Expert Reference Group (ERG) meeting; 18 June 2018 (oral presentation)

7. Patient prioritisation for pharmaceutical care: understanding the workforce implications. Division of Pharmacy and Optometry (DPO) Showcase; 21-22 September 2017 (oral presentation)

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*Note. The abstract was accepted as an award nominee oral presentation, subsequently winning 1st prize for the best poster and abstract.

1. Chapter One: Introduction

The purpose of this chapter is to introduce the topic of this programme of research, state the contributors, and provide an outline of this thesis.

1.1 Introduction to the Research

Medication is the most common therapeutic intervention used in healthcare systems worldwide. Hospital pharmacists play an essential role in patient care, ensuring medicines are used safely and effectively.[1–4] In the UK, the professional responsibilities of pharmacists have grown over the last twenty years with the emergence of the paradigm of pharmaceutical care.[5,6] Pharmacy services currently attempt to provide a service in which clinical pharmacists review patients daily, Monday to Friday. However, current financial pressures within the NHS means that departments are under pressure to do "more for less". Thus, not all patients will be reviewed daily by a pharmacist. This gap in pharmaceutical care provision may not be a problem for some patients but for others it could have deleterious consequences. The ability to accurately screen and identify those patients who need the greatest pharmacy input and those who do not would be of great benefit to patients and hospital pharmacy teams enabling appropriate allocation of costly staff resources. Some hospitals have implemented locally developed screening tools to prioritise patients for pharmaceutical care.[7] These have not been methodically developed for routine use and there is a lack of agreement as to what such a tool should comprise.[7–9]

Other healthcare professions, notably nursing, have invested in developing tools that classify the severity of a patient's condition and the intensity of care patients will need. This assessment allows safe nursing levels to be calculated and patients are seen by the right staff with the right skills in the right place.[7,10,11] Currently, there is no formal mechanism to match

pharmacists' experience to patient need, leading to risk of harm and inefficiencies in the system.[7]

The aim of this thesis is therefore to develop a screening tool rigorously and systematically, which can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs. The care of those patients at greatest risk of preventable harm due to medication would then be provided quickly by an appropriately experienced clinical pharmacist, targeting the deployment of resource limited clinical pharmacy services.

1.2 Contributors

The main author, Mr Alshakrah, took the major role in the production of all research and resultant papers included in this thesis. He conceptualised and designed all the studies, collected the data, carried out the analysis, drafted and revised the manuscripts, and wrote the thesis. The co-authors of the studies, their qualifications and their contributions are presented below:

Penny J. Lewis, MPharm, PhD, FHEA, PGCertHE

Dr Lewis is Mr Alshakrah's main supervisor. She conceptualised all studies with Mr Alshakrah, and critically reviewed all manuscripts.

Douglas T. Steinke, BSC (Pharm), MSc, PhD

Dr Steinke is Mr Alshakrah's second supervisor. He conceptualised all studies with Mr Alshakrah, and critically reviewed all manuscripts.

1.3 Thesis Structure

This section consists of the rationale for submitting the thesis in a journal-based format and outlines the structure of this thesis.

1.3.1 Rationale for submitting in journal format

Students in the early stages of their PhD programme can choose either a standard thesis format or a journal-based format for their research. The introduction, background, methodology and discussion chapters are similar in both formats. However, the journal-based format allows for the organisation of the research in such a way that the different stages of the research can be presented as independent papers. The University of Manchester encourages students to opt for the journal-based format as it not only serves the purpose of a wider dissemination of the knowledge gained, but also trains students in publication issues earlier on. In other words, students are able to learn about the publication process as well as develop the skills required for publications by following the journal-based format for their research. A PhD student is therefore prepared as a future researcher to produce independent publications of a high quality due to the training received from the supervisory team and experts in the process. Moreover, given the fact that this thesis was based on sequential, related studies with different research designs, the journal-based format was seen to be a more appropriate choice as findings from these different studies helped determine the designs of subsequent studies. Therefore, the researcher and the supervisory team agreed upon the journal-based format for this thesis for the aforementioned reasons. The construction of this programme of research, led to the production of three individual papers one of which has been published and one has been accepted for publication.

1.3.2 Outline of the thesis

Before discussing the outline of this thesis, it must be pointed out and noted that the work contained in this thesis forms part of a National Institute for Health Research (NIHR) Research for Patient Benefit (RfPB) study. The overall aim of the funded project was to develop a screening tool rigorously and systematically, which can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs. This research project included multiple stages, as shown in Figure 1. All of these stages are included in this thesis with the exception of the survey of NHS acute hospital trusts and the qualitative component of the feasibility study, which are highlighted in grey.

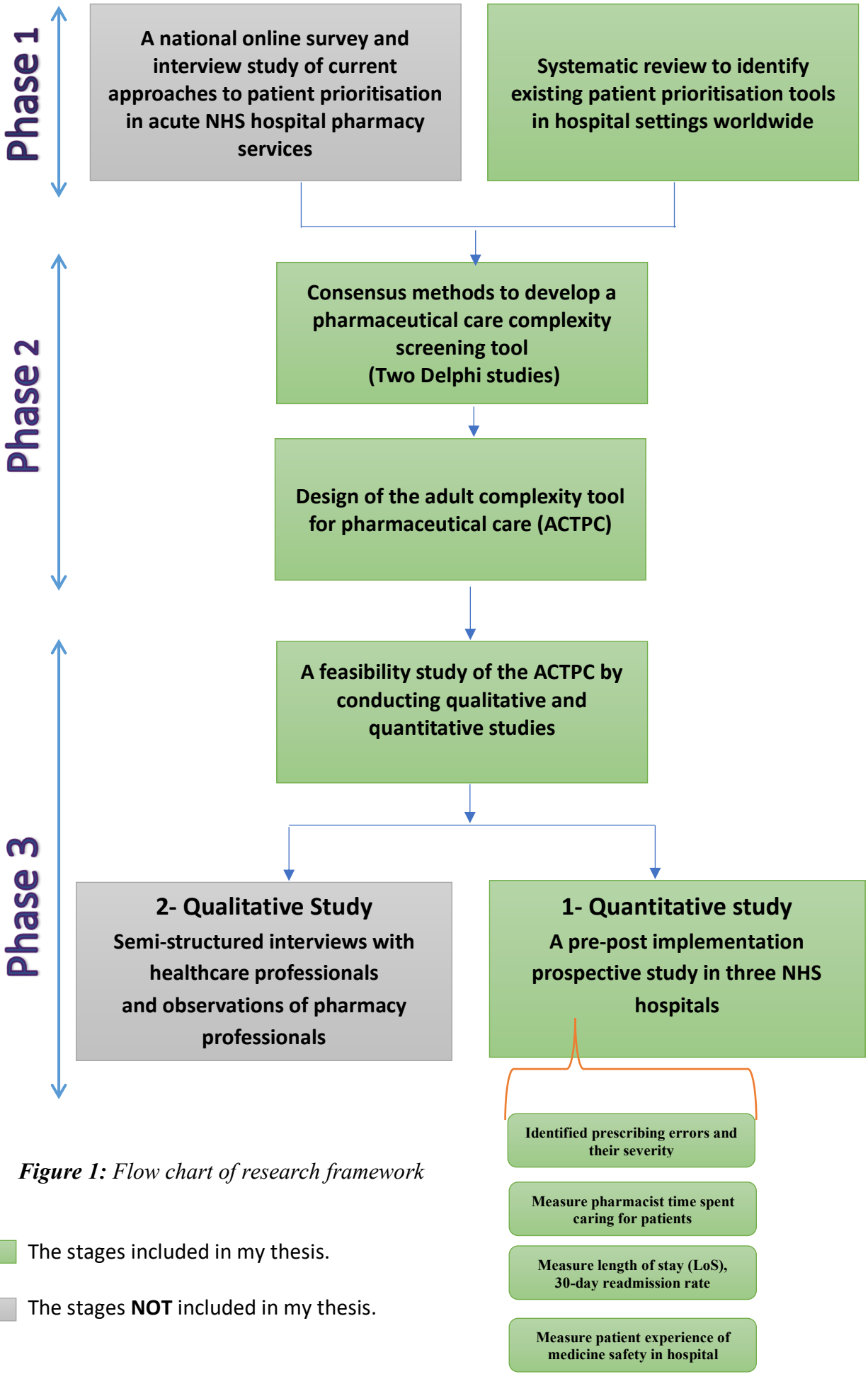

Figure 1: *Flow chart of research framework*

This thesis aimed to develop and test the feasibility of a screening tool that can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs. The research process for this thesis was sequential in nature that addressed one element of the thesis then moved to address the next one. The structure of the thesis is as follows (Figure 2):

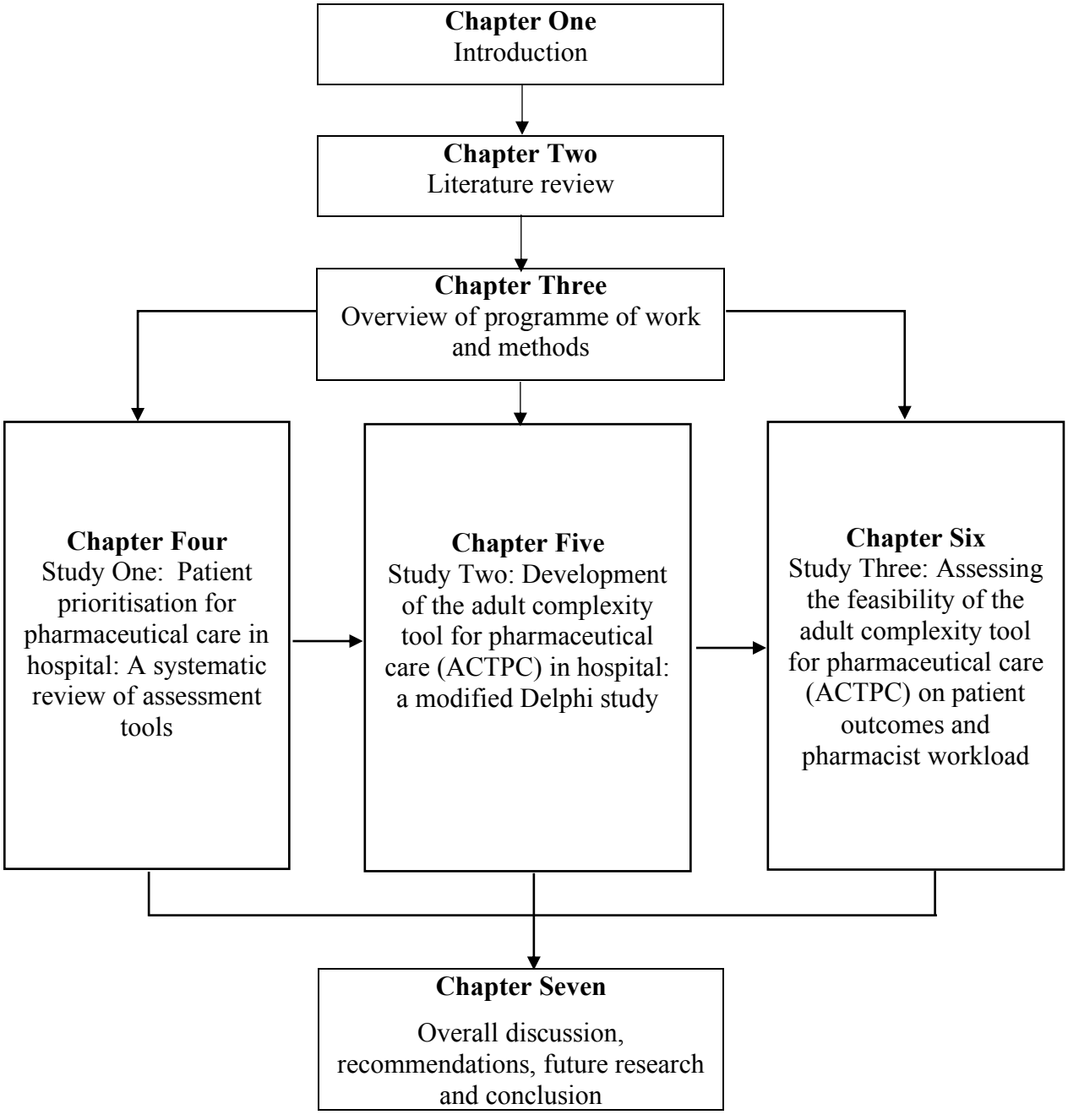

Figure 2: *Flow chart outlining the organisation of the thesis*

The **first chapter** introduces the programme of research. The **second chapter** provides an overview of pharmaceutical care including the role of hospital pharmacists, the structure of pharmacy education in the UK, drug related problems and associated risk assessment criteria, pharmaceutical assessment screening tools in hospital settings, and acuity tools used by other healthcare professionals.

The **third chapter** provides an overview of this programme of work and methods applied and provides the rationales for conducting each study, followed by an overview of the methods employed in each study including the data analysis undertaken and key ethical issues that arose when conducting each study.

The **fourth chapter** consists of the first study of this thesis, a systematic review of published tools used by hospital pharmacists to assess patient priority and/or complexity. The paper was published in the Journal of Research in Social and Administrative Pharmacy in 2018 and presented at the International Pharmaceutical Federation (FIP) World Congress of Pharmacy and Pharmaceutical Sciences, Glasgow in 2018.

The **fifth chapter** consists of the second study of this thesis, which sought to obtain expert consensus on the design of a pharmaceutical care complexity screening tool for use on admission to hospital. The paper was presented at the European Association of Hospital Pharmacists Congress, Barcelona in 2019. The abstract was accepted as an award nominee oral presentation, subsequently winning first place. This study was also submitted for publication in the Journal of Research in Social and Administrative Pharmacy in 2020 and has been accepted for publication.

The **sixth chapter** consists of the third study of this thesis. This study was conducted to assess the feasibility and impact of the Adult Complexity Tool for Pharmaceutical Care (ACTPC) on patient outcomes and pharmacist workload. The study manuscript is prepared for submission for publication.

The **seventh chapter** summarises the key findings from each study in this programme of research. It also reflects on the implications of the findings in relation to the current body of literature. Strengths and limitations of the research are discussed, as well as the directions for future research. The end of this chapter is an overall conclusion of the thesis.

2. Chapter Two: Literature Review

This chapter provides an overview of pharmaceutical care including the role of hospital pharmacists, the structure of pharmacy education in the UK, the risk assessment criteria of drug related problems (DRPs), pharmaceutical assessment screening tools in hospital settings, and acuity tools used by other healthcare professionals.

2.1 Pharmaceutical Care

Pharmaceutical care (PhC) was conceptualised to streamline and improve the role of the pharmacist in improving medication safety.[1] PhC is a quality philosophy that guides pharmacists in the provision of drug therapy to achieve the best possible therapeutic outcomes. The objective of PhC is to minimise inappropriate medication use through promoting health literacy, encouraging patient involvement in their medicines and advancing equality in healthcare.[12] Through these objectives, PhC improves the health and well-being of the patient and promotes cost efficient utilisation of health resources and reduction of health inequalities.[12]

Medication is the most frequent therapeutic intervention in healthcare systems globally. However, with this high frequency comes a high incidence rate of medication errors.[12] The launch of the third Global Patient Safety Challenge: *Medication Without Harm* by the World Health Organization (WHO) in 2017 focussed on the issue of medication safety. By drawing on experience gathered during the previous Challenges, the third Challenge sought to drive a change process directed towards minimising patient harm created by medication errors and unsafe medication practices.[13]

The concept of PhC is to enhance the role of the pharmacist in managing medication safety, optimising medicines and improving patient outcomes as well as improving the cost

efficiency of healthcare delivery.[14] The most important player in ensuring cost and operational efficiency of PhC is the pharmacist.

2.1.1 The role of hospital pharmacists in the UK

In the UK, the role of hospital pharmacists is both technical and clinical.[5] The technical role includes storing, dispensing and supplying of all medicines and medicinal products in the hospital. Over recent years many of these technical roles have been assigned to pharmacy technicians allowing pharmacists more time to dedicate to patient-facing/clinical roles.[15] The clinical role of pharmacists focuses on achieving the optimal benefit for patients from the use of medicines.[5] Hospital pharmacists liaise directly with members of multidisciplinary hospital teams to advise on medicine selection, dosage and appropriate routes of administration. They also educate patients and other hospital staff on potential side effects of medicines, ensure treatment is compatible with existing medicines and monitor the effects of medicines to ensure therapeutic safety and effectiveness.[5] Hospital pharmacists also participate in ward rounds with other healthcare professionals providing their expertise into therapeutic decision-making for each patient.[16] Furthermore, they are able to prescribe medicines.[17] It was stated that the risk of an error reaching the patient is reduced by involving pharmacists in the prescribing pathway.[18]

Medicines optimisation is a key role of hospital pharmacists, it refers to patient-centred activities ensuring appropriateness, effectiveness, safety, adherence and access to medication.[19] The aim is to ensure the patient receives the right medicine, at the right time, and the right dose.[19] pharmacists also carry out medication reconciliation, a formal process of ensuring patients' prescribed medication matches with what they are actually taking[20] preventing harm from omission of required medicines and improving patient outcomes. It is important to note that medicines reconciliation may need to be carried out on more than

one occasion during a hospital stay, for instance, when the patient is admitted to hospital, transferred between wards or discharged from hospital.[21] Medication discrepancies occur most frequently at the point of hospital admission and discharge.[22,23] Between 11% and 59% of medication discrepancies are potentially harmful.[24] It was reported that implementing medication reconciliation at admission, transfer, and discharge is an effective strategy for preventing adverse drug events.[25,26]

There is a growing body of literature demonstrating the benefits of clinical pharmacy services (CPS) and the role clinical pharmacists play in the identification, rectification and prevention of drug-related problems.[4,27–30] Furthermore, various reviews conclude that addition of CPS to the care of hospital inpatients improves the safety and quality of patient care.[4,31,32]

The identification of hospitalised patients who are at most risk of DRPs allows clinical pharmacists to provide prompt care for those patients. DRPs have been defined as "*An event or circumstance involving drug therapy that actually or potentially interferes with desired health outcomes*".[33] In order to identify patients at risk, an understanding of the risk factors for DRPs is required. A number of characteristics combine to increase the risk of DRPs. These include: polypharmacy, older age patients, patients with impaired renal or hepatic function and patients who take a medicine that requires therapeutic monitoring, or is a high-risk medicine.[34–36] Chapter four will provide more detail on the well-known risk factors for the development of DRPs.

It has been suggested that several factors lead to increased demand for pharmacists' expertise and the need to prioritise CPS. Such factors are: patient acuity or complexity, increasing number of prescriptions, increasing complexity of medication therapy and having

a history of drug allergy.[37–40] Before continuing it is useful to provide a definition of patient acuity.

2.1.2 What is patient acuity?

Several terms have been widely used in healthcare to describe the patients' need for healthcare services. The terms of patient acuity and complexity of care have been commonly used interchangeably. Patient acuity is defined by Finkler and his colleagues as "the measurement of patient severity of illness related to the amount of nursing care resources required to care for patient".[41] It is also defined as the ability to predict patient requirements for nursing care.[42] Although the term patient acuity is clearly defined from a nursing perspective, there is no accepted definition within pharmacy. In addition, the term patient complexity is also important, however, no such definition has been widely established.[43,44] Therefore, the measurements of complexity are commonly based on the number of medications that are taken by a patient (polypharmacy), number of chronic conditions (multimorbidity), and previous medical history.[44,45] The terms acuity and complexity are used interchangeably in this thesis.

We argue that, patient acuity or complexity related to pharmaceutical care is not necessarily concurrent with illness severity. We suggest that the aim of clinical pharmacy services is to provide timely care to those patients likely to benefit from the interventions of clinical pharmacists and the wider pharmacy team.

2.1.3 Prioritising clinical pharmacy services

Various areas of research have been prioritised to enhance medication safety. Sheikh and his colleagues managed to prioritise key research areas based on research ideas provided by 131 experts.[46] According to the authors, medication safety can be improved by delving into six key research areas including employing and upgrading existing technology, developing

guiding principles and regular functional procedures for high-risk medications, patients, and contexts, adopting score-based strategies in predicting high-risk situations and patients, approaches to raise patient's awareness of medication, offering focused training courses for health professionals, and universally applicable pictograms to prevent adverse outcomes associated with medications.[46] Although enhancing patient involvement and education is a common priority area in different healthcare settings, high-resource settings prioritise optimising current systems through technology improvement whilst low- and middle-resource settings focus on documenting and addressing systemic issues that lead to high-risk situations.[46] Medication related harm can be mitigated by a pharmacist's review.[47] However, in busy hospitals with high patient throughput and limited resources, it can be challenging to deliver the same level of CPS to all hospitalisation patients.[48] Consequently, there is a need for developing an effective CPS model that pharmacists can use to prioritise patients at high risk of adverse medication-related outcomes.

The objective of prioritising CPS is to maximise patient health outcomes where the resources of CPS are limited.[49] Ideally, hospital pharmacists would have resources to provide a comprehensive service (as described in section 2.1.1 above) to every patient based on their needs.[50] Owing to financial challenges, staffing issues, combined with an increasing number of elderly admissions with multimorbidity and polypharmacy and the current drive to provide seven day clinical services (since a limited service is often provided to wards at weekends) may mean that comprehensive CPS cannot be provided to all patients.[40,48–52] It is often not feasible for pharmacy professionals to perform medication review for all admitted patients at the point of admission and discharge.[53] Therefore, pharmacists are forced to target their clinical services to those patients who are most likely to benefit from them- that is, to assess and prioritise who are most likely at risk of DRPs.

2.1.4 Pharmacy workforce

The pharmacy workforce is made up of pharmacists, pharmacy technicians and pharmacy support staff.[38] With the increasing complexity of disease and rapidly growing ageing population seeking care in various healthcare settings, there is a need for the future pharmacy workforce to be adapted to provide optimum CPS.[49]

Working conditions, numbers of staff and workload have a significant impact on CPS.[38,54] Research has identified that an increase in number of clinical pharmacists can lead to a decrease in medication errors (MEs), adverse drug reactions (ADRs), hospital mortality rates and length of stay (LoS).[3,55–57] However, an increased pharmacist workload may impair their ability to detect errors.[58] Furthermore, other factors, such as knowledge and experience, should be considered. It has been argued that pharmacists must have adequate knowledge and experience to effectively and efficiently provide CPS.[50] There is a strong possibility that hospitalised patients with different complexities might benefit from daily review by a pharmacist with the appropriate skills and experience.[10,59]

Having considered the knowledge and experience required, the following section will explore in more detail the structure of UK pharmacy training and the way that hospital pharmacy roles are classified based on duration of work experience and skills.

2.1.5 Training and classification of UK pharmacists

In the past two decades, the number of students undertaking a pharmacy degree have more than doubled.[60] A pharmacist's qualification in the UK requires at least four years of university education undertaking the Master of Pharmacy (MPharm) degree from a General Pharmaceutical Council (GPhC) accredited university.[60]

The National Health Service (NHS) job evaluation handbook third edition defines national profiles for hospital pharmacists.[61,62] The handbook provides generic categories of pharmacists based on band and corresponding job title, qualifications and responsibilities to patients and to the organisation.[61,62] Table 1 provides a summary of generic profiles of pharmacists based on title, band, qualification and duties/responsibility to patient care.

Table 1: *NHS Generic Profiles of Pharmacists Based on Job Evaluation Handbook Third Edition*

Title	Band	Qualifications	Duties/Responsibilities to Patient Care
Pre-registration Pharmacist (Entry Level)	5	• *MPharm; • Training in professional registration including clinical placement.	• Reviews prescriptions, dispenses & supplies drugs to patients; • Checks drug history/ reconciliation; • Refers to Band 6 or to a more senior pharmacist; • Offers counselling services to patient.
Pharmacist Just after Pre-registration	6	• MPharm (4 years) • After pre-registration training & experience (1 year).	• Supervises less experienced pharmacist, technicians; • Clinical checking and monitoring; • Checks discharge prescription; • Counsels at discharge; • Refers to a more senior pharmacist; • Ensures formulary adherence and cost-effectiveness of therapy.
Pharmacist Specialist	7	• MPharm (4 years); • Pre-registration training & experience (1 year). • Starting Diploma	**<u>Band 7&8</u>** • Discuses patient management with clinicians; • Provides support to junior pharmacist on complex problems; • Develops and monitors policy for medicine management; • Ensures cost effective use of medicine products (stock review and management, questions inappropriate use of drugs, and training on medicine management).
Pharmacist Advanced	8a-b	• MPharm (4 years); • Pre-registration training (1 year); • Diploma level training and experience.	
Pharmacist Team Manager	8b/c	• MPharm (4 years); • Pre-registration training and experience (1 year); • Diploma level training and experience in the area of practice (Specialist area).	
Pharmacist Consultant	8b-d	• MPharm (4 years); • Pre-registration training and experience (1 year); • Diploma level or equivalent training and experience in the area of practice (Specialist area); • Post graduate degree e.g. *MPhil, MSc, PhD.	
Professional Manager Pharmaceutical Service	8c-9	• MPharm (4 years); • Pre-registration training and experience (1 year); • Diploma level or equivalent training and experience in the area of practice (Specialist area); • Specialist/management knowledge in the field of practice. • Post graduate degree in Management e.g. *MBA.	

**MPharm: Master's Degree in Pharmacy, MPhil: Master of Philosophy, MSc: Master of Science, MBA: Master of Business Administration, PhD: Doctor of Philosophy.*

2.1.6 Introduction to Drug Related Problems

Drug related problems (DRPs) have different terminologies such as medication related problems (MRPs), medication therapy problems (MTPs), drug therapy problems (DTPs) but this thesis adopts the term DRPs. DRPs is an umbrella term that includes ADEs, ADRs, and MEs (described below in Section 2.1.7). The relationship between each of these terms is shown in Figure 3 (produced by Otero et al[63]), which shows that not all DRPs cause medication related harm. MEs involve all preventable events, and may or may not result in medication related harm. MEs that lead to patient injury should be considered preventable adverse drug events. ADRs are actually a subset of ADEs, representing non-preventable harm. ADE includes harm from medication errors as well as from ADRs.

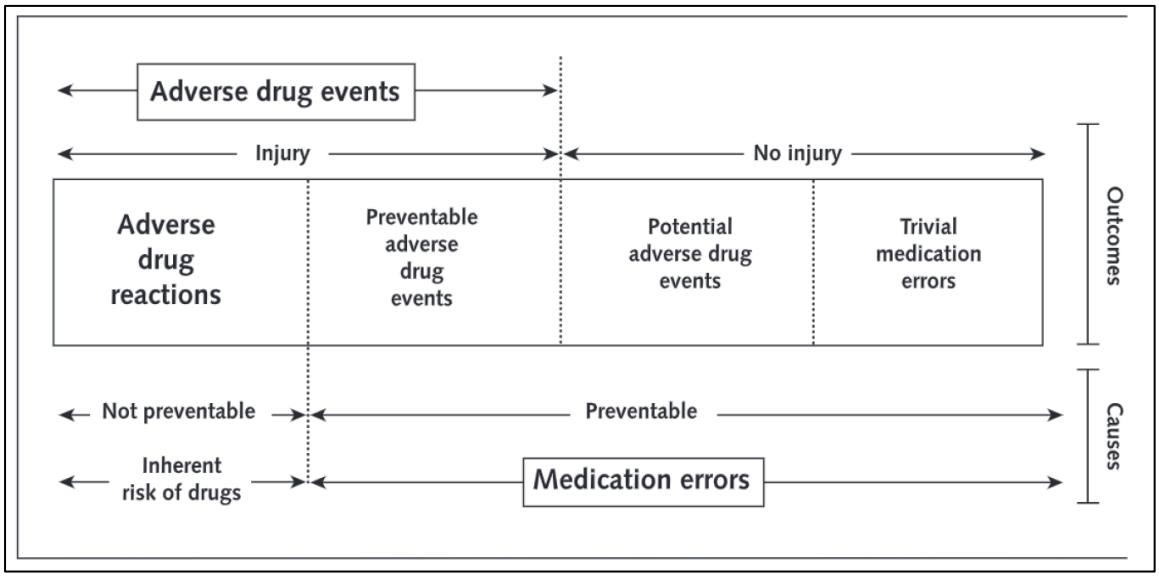

***Figure 3**: Relationships between adverse drug events, adverse drug reactions and medication errors*

DRPs are a major concern for policy makers and practitioners in healthcare systems globally. They place a substantial health and economic burden on both the patient and healthcare system.[34,64] DRPs contribute to increased morbidity, mortality and require additional medical attention increasing the cost of care.[36,65] Moreover, they account for

about 28% of patient visits to the emergency department.[66] Particular groups of medicines, such as antimicrobials and those prescribed in epilepsy, are reported to be independently associated with the occurrence of at least one preventable medication related problem.[67] Key risk factors for DRPs are identified as polypharmacy, medications with a narrow therapeutic range, medications that are renally excreted and the use of diuretics or anticoagulants.[31]

Interventions to identify and minimise DRPs have important clinical significance in instituting prompt and effective therapeutic interventions.[36] First, to gain an understanding of DRPs, it is necessary to provide a definition of DRPs.

2.1.7 Definitions of Drug Related Problems (DRPs), Adverse Drug Events (ADEs), Adverse Drug Reactions (ADRs), and Medication Errors (MEs)

Table 2 provides a summary of various commonly used definitions of DRPs, ADEs, ADRs and MEs quoted from the existing literature on DRPs.

Table 2: *Definitions of DRPs, ADEs, ADRs and MEs*

Term	Definition(s)
DRP	"*An event or circumstance involving drug therapy that actually or potentially interferes with desired health outcomes*".[33] The definition encompasses ADEs, ADRs and MEs.
ADE	*"Any untoward occurrence that may present during treatment with a pharmaceutical product but that does not necessarily have a causal relation to the treatment"*.[63]
ADR	*"A response to a drug that is noxious and unintended and occurs at doses normally used in man for the prophylaxis, diagnosis, or therapy of disease or for modification of physiological function*".[68]
ME	"*Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use*".[69]

The above definitions are different in that they have different causes: they can arise from a patients' reaction with the medication provided, from errors with the prescribing, dispensing, administering and monitoring of the medication, as well as patient adherence when taking the medication.

2.1.8 Risk assessment criteria for DRPs

The need for early detection and prompt management of patients at risk of DRPs in clinical settings led to the development of a variety of risk assessment criteria.[66] These criteria share similar goals and methodology of deployment. They are used by physicians, pharmacists, nurses (points of prescribing, dispensing and administering) and use available risk factors from manual or electronic medical records. However, these criteria vary because they address different sources of DRPs: ADEs,[66,70–76] ADRs[35,77] or MEs.[78] In addition, the way DRPs are defined varies across different studies.[35,66,70,76,79,80] They also vary because they target different patient populations such as geriatric patients (≥65yrs) or paediatric patients (<18yrs) who have different risk factors for developing DRPs and severity of DRPs.[35,76,80,81] Furthermore, there is variation because some criteria focus on specific therapeutic interventions associated with potentially higher risk of DRPs, such as opioid pain management in post-gastrointestinal surgery.[74]

2.1.9 Comparison of DRP risk assessment criteria

Current risk assessment criteria for DRPs may fall into two broad categories: (a) those that target specific types of DRPs; (b) those that target particular patient populations. In each of these categories, the included risk factors and severity of DRPs detected varies considerably.[80]

Tools that target particular types of DRPs (ADEs, ADRs or MEs) form the majority. They primarily focus on hospitalised patients and assess the risk of DRPs using two main approaches. The first approach uses available clinical characteristics such as patient history of DRPs and patient characteristics such as previous drug allergy found in medical records or a hospital database to compute the risk of DRPs.[70,73] The second approach uses trigger tools to determine and quantify type of DRPs and the degree of harm experienced by the patient.[71,72,75,76,80]

On the other hand, risk assessment criteria for DRPs based on particular patient populations focus mainly on associated risk factors affecting such patients. Mostly, these criteria differentiate patient populations based on age: geriatric vs. pediatrics.[35,80] Criteria for geriatric patients identify polypharmacy, medication that requires monitoring such as anticoagulation, history of ADEs/ADRs and co-morbidities as significant risk factors.[35,76] Criteria for paediatric populations, on the other hand, focus on the identification of DRP factors related to patient care, laboratory results, surgery, medication and the admitted ward.[80,81]

Despite the different categories of DRP risk tools, the majority of these tools are integrated into Electronic Health Records (EHR) or Computerised Pharmacist/Physician Order Entry (CPOE) for automation and real time generation of alerts, warnings or reminders at points of prescribing, dispensing and drug administration.[66,73] They aim at early identification and management of DRPs. The ultimate goal is to improve medication safety, achieve optimal effect of medication and reduce the overall costs of the healthcare system.[36,66]

2.1.10 Limitations and benefits of DRP risk assessment criteria

The different categories of tools for identifying and preventing DRPs are important for improving medication safety, patient outcomes, optimising hospital resources and the cost efficient delivery of care in clinical settings.[34,82] However, each category has limitations and benefits to patient care.

Tools targeting types of DRPs place emphasis on identifying and managing individual sources of DRPs such as ADEs, ADRs and MEs. The tools are thought to be clinically important as risk factors are often validated by expert and Delphi panel review.[72,73,76,77,80] Their main benefit is the identification of common causes of ADEs and using them for real time identification of at-risk patients prior to the event.[82] It is therefore beneficial to identify and focus resources to prevent potential DRPs.[76] The main limitation is that tools are heterogeneous and differ in structure, content, and intended setting preventing their universal application.

Tools targeting patient populations are clinically important since they re-focus resources to a cohort of patients at the greatest risk of DRPs reducing their overall burden.[35,76,80] However, patient-related DRP risk tools only focus on certain patient cohorts and their application to other types of patients is not possible.

The previously discussed criteria exist to identify the risk of DRPs. However, these criteria are broad and varied because they address different sources of DRPs and target different patient populations. The following sections will review the importance of patient prioritisation for pharmaceutical care and the tools currently available within the hospital pharmacy setting to identify patients most in need of pharmacists' input.

2.2 The Importance of Patient Prioritisation for Pharmaceutical Care

Ideally, each hospital pharmacy would have the resources to provide comprehensive CPS to every patient based on their needs.[50] Notably, UK hospitals are witnessing an increasing trend in elderly admissions with multimorbidity and polypharmacy and face demands for a seven day CPS.[32,51,83] Most UK hospital pharmacy departments already deliver a seven day medicine supply service. However, currently there are gaps in terms of the availability of CPS across weekends.[84]

A special emphasis should be made to cope with both the increasing numbers of patients and more complex medication therapy regimens.[10,36,37,50,85] However, the National Health Service (NHS) face challenges with obtaining sufficient funding and pharmacy departments are forced to be more innovative and improve their productivity to achieve their objectives.[50–52,83] Therefore, there are pressures for pharmacy departments to prioritise which patients need direct pharmaceutical care on a daily basis.[48] This would not only benefit the patient but also the pharmacy department enabling the appropriate allocation of costly staff resources.[10] Clinical pharmacy service prioritisation has been identified as one of the solutions for achieving cost effectiveness and increased productivity.[50,83]

2.3 Pharmaceutical Assessment Screening Tools

The development of clinical prioritisation tools is not an easy task and the process of identifying the factors predicting which patients are at increased risk of adverse medication-related harm has to be balanced against the need to review all patients.[28,47,86] Key requirements for a prioritisation tool are practicality and ease of use.[87] In this section, the literature regarding specific pharmacy led prioritisation tools will be presented, along with an analysis of the respective tools.

Studies have been published examining pharmaceutical assessment screening tools developed in Brazil, Denmark, the USA, New Zealand, the UK, France and Australia. However, the majority of studies have been conducted in the UK.

In Brazil, a risk scoring instrument to assess drug-related risk factors according to the patients' profile has been developed by Martinbiancho and colleagues.[37] The tool facilitates appropriate resource allocation of pharmaceutical care. The risk score assessment used several criteria based on the existing literature: patients with polypharmacy, patients over 65 years, patients on intravenous and high alert medicines, patients with comorbidities (renal/hepatic/cardiac and pulmonary issues), immunocompromised patients, and patients using total parenteral nutrition (TPN). The instrument indicates the priority level for monitoring of patients' drug therapy including drug interactions, incompatibilities and adverse reactions. The scores range from zero to four and the sum is then categorised into three levels of risk: high-risk (≥ 9), moderate risk (5-8), and low risk (≤ 4). High-risk patients are monitored as a priority, moderate risk patients require non-emergency monitoring and low risk patients are only observed. This assessment score allows pharmacists' attention to be focused on the patients at higher risk of ADEs. However, the score assessment does not include serum laboratory values, which can be a good indicator for patients who have complex health conditions, such as infections, renal and liver failure and consequently experience DRPs.

In Denmark, a group of researchers from the Aarhus University's Department of Clinical Pharmacology, developed and validated a simple risk scoring algorithm, Medicine Risk Score (MERIS), to help identify acutely admitted patients at high or low risk of medication errors.[88] The algorithm was developed through a literature search and consensus methods. The MERIS algorithm is a simple score developed via existing patient information derived

from electronic medical records, and thus the tool can be integrated into a Computerized Physician Order Entry (CPOE) system. The key strength of the MERIS algorithm derives from its calibration which, unlike other tools, has a relatively high sensitivity and specificity in detecting ME risk among patients (0.64 and 0.75, respectively). In other words, the MERIS has the ability to identify patients admitted at acute admissions unit who are at risk of MEs, and categorise them into low and high risk groups. However, in the MERIS algorithm scores, all variables were categorised, and the categorisation process was not described. Furthermore, bias may have been introduced by the use of relatively small samples (four groups were used, ranging from 50 to 146 patients per group) and a correspondingly small number of outcome events (9–33 per group). There were also variances in the characteristics of the groups, for instance two groups were limited to adults over the age of 65, while two groups included adults of all ages.

In the USA, The American Society of Health-System Pharmacists (ASHP) awarded a $0.5 million grant to Winterstein and colleagues to design and validate a tool for scoring pharmaceutical complexity.[89] In a similar manner, this tool aims to improve patient safety and prevent adverse drug events by identifying patients that would benefit from hospital pharmacist care. The team developed risk models for 16 preventable ADEs, by conducting literature searches, clinical expert interviews and using data from electronic health records of patients admitted to two large hospitals, which were then integrated into one complex score (c-score).[90] The tool had a high predictive performance especially for patients with the highest decile of C-score. However, aggregating several prediction models (16 of them) into one score led to a reduced predictive power for a significant number of ADEs, especially for patients ranked in lower percentiles (below 90%). Furthermore, the complex score uses electronic real-time health records and could therefore only be used in hospitals

with a fully integrated electronic prescribing and administration system with electronic pathology records.

In New Zealand, the Assessment of Risk Tool (ART) was developed by a team from the clinical pharmacy department of a New Zealand hospital.[85] The ART is a predictive risk-profiling tool designed as an application integrated into a hospital's patient information system. It is similar to the C- score tool and is based on real-time software. A literature review was used to identify risk factors, incorporated with expert opinion to allocate scores for risk groups. Thirty-eight electronic 'flags' were used to provide an assessment of risk score, indicating low, medium or high-risk patients for MEs and ADEs. The 38 'flags' were developed by conducting a literature review and consensus process. The 38 'flags' were made up from five broad groupings, such as patient profile (age, ethnicity), patient encounter type (frequency and type of hospital visits), clinical profile (known chronic disease states), high-risk medication (number and type) and laboratory values. This tool enabled pharmacists to conduct medicines reconciliation and clinical review faster and in a more focused way to high-risk patients. To achieve face validity, the collection of data took place three times daily and was updated at certain intervals during the day. By facilitating the identification and monitoring of patients at high risk for MEs and ADEs, the ART has improved the workflow of clinical pharmacists and improved medication safety. However, a limitation is that the ART may not be easily applied in other hospitals since it was developed by staff from within the base hospital and the expert group comprised of pharmacists only. The results may therefore not reflect those of a multidisciplinary group.

In a later study aimed at validating the ART, Falconer and her colleagues conducted a study at Middlemore Hospital, Auckland New Zealand where the ART was initially developed.[91] The authors used a prospective observational study of 247 admissions to the hospital's

cardiology ward and an additional general medical ward. Patients categorised as high-risk were associated with a significantly high number of unintended medication discrepancies compared to patients with the low or medium-risk profile. The study demonstrated that ART was effective in prioritising patients for medication reconciliation. However, the use of unintentional medication discrepancies and prescribing errors as a substitution for ADEs, which was the outcome of ART in study development was a major limitation of the study. Another limitation was that the study only used 25 selected predictors from the 38 that were developed.

In the UK, several pharmaceutical assessment screening tools have been developed and used. These tools aim to identify patients at risk of medication errors and adverse drug events. In Manchester for instance, two years after the description of ART by Falconer et al. (2014), Hickson and colleagues, conducted a service evaluation project that led to the development of a Pharmaceutical Assessment Screening Tool (PAST).[48] The study, which took place in a 900-bed capacity hospital, developed PAST to assign a patient acuity level (PAL) to all hospitalised patients for the purposes of prioritising the frequency and seniority of pharmacists conducting patient reviews. The tool was based on similar tools that existed in the literature but included PALs which were adapted from the UK Intensive Care Society's levels of critical care for adult patients[92] and the Shelford Group's Safer Nursing Care Tool.[93] PALs are a numerical score and measured, with Level 1 being the lowest and Level 3 being the highest. Factors such as polypharmacy, medication that requires close monitoring such as anticoagulants, laboratory values, history of ADEs/ADRs and co-morbidities, which are one or more organ dysfunctions, high cost medicines were considered significant risk factors. For instance, PALs were different for patients with a high-risk medication or who has one organ dysfunction compared to patients with both a

high-risk medication and an organ dysfunction, multiple organ dysfunction or any other factor. Only patients with a higher PAL were considered to be at a high risk of adverse drug events. It is likely that pharmacists with the most experience would be required to care for the patients with the highest PALs, that is, the most pharmaceutically complex patients at the greatest risk of adverse drug events.

A quasi-experimental service evaluation study was conducted six months after implementation of the tool to quantify agreement between PALs documented by pharmacists and expected PALs from pharmacy department PAST guidance. Patients were selected via random clusters from wards. Data were collected for 35 patients from seven different wards. For each patient, a PAL was determined by the research team according to the departmental PAST guidance and compared with the pharmacist documented PAL. Twenty patients (57%) had a pharmacist-documented PAL that agreed with the expected departmental PAST guidance suggesting that not all pharmacists adhere to the PAST guidance. The author suggested that further investigation to identify reasons for disagreement between pharmacist-documented and expected PALs based on the PAST guidance.

By assigning patients to three PAL levels, PAST proved to be an effective prioritisation tool after major improvements. However, at the time of its evaluation, the tool was not validated and thus one could not conclude with certainty whether the tool was effective or not in identifying patients in most need of pharmaceutical care.

In the same year, a study was conducted to determine the thoughts of pharmacists using PAST to assign PALs to patients.[94] Participants included 32 pharmacists from the same hospital where the tool was developed. Contrary to Hickson et al. who reported varying adherence to PAST guidelines, Saxby et al. found that most pharmacists (93%) felt confident in using PAST when assigning PAL to patients.[94] However, appropriate training

of pharmacists was recommended to ensure successful use of such tools. Nevertheless, relying on professional judgment when allocating PALs could result in overestimation or underestimation of PALs implying a lack of true agreement with PAST.

Another UK hospital pharmacy department developed a pharmaceutical care priority screening tool. It was developed by a team of clinical pharmacists following a serious medication error on a hospital ward where no clinical pharmacy service was available. The tool was designed to give risk scores to patients using an electronic prescribing and medicines administration (EPMA) system.[95] The risk scores were based on factors such as polypharmacy (over 10 medications), the prescribing of anticoagulants, unlicensed medicines, high risk/narrow therapeutic window medicines, extended duration antibiotic prescribing, medicines related to specific diseases, period of hospitalisation and status of medicines reconciliation. However, there are some limitations to this tool as it does not yet capture comorbidities, deranged blood results and other factors.

Another UK hospital designed a similar system using an EPMA system, namely a web-enabled 'portal', which displayed various patient characteristics across all wards.[96] The patient characteristics used were: the time since patient admission, existing pharmaceutical problems, which included drug-drug interactions and pharmaceutical–biochemistry alerts such as heparin-induced thrombocytopenia. In a survey with pharmacists, the tool was scored highly for usability and it was considered highly effective in their clinical practice in terms of helping them to prioritise high-risk patients. The benefit of this tool is seen in providing a timely pharmaceutical service to high-risk patients, which aims to improve patient outcomes. However, this particular tool also does not account for comorbidities or serum laboratory values.

Another UK hospital developed a toolkit which assesses patient and medication factors such as renal/hepatic function, polypharmacy, adverse drug reactions, therapeutic drug monitoring (TDM), drug administration and medication specific issues.[97] It can also indicate patients that need to be assessed by an experienced pharmacist. Pharmacists' perceived that this toolkit was easy and quick to use, however, certain pharmacological issues were not included in the toolkit, e.g. abuse of drugs and overdoses.

In the UK, Covvey and her colleagues conducted a retrospective case review of women discharged following birth admissions at a hospital.[39] The aim of the study was two-fold; conducting a practice audit based on demographic data of obstetric patients and appraising a triage tool created for prioritisation of pharmacy services. After collecting patients' admission and demographic data, as well as pharmacist interventions and missed opportunities in patient care on post-natal wards, the researchers developed a triage tool that was applied to all cases retrospectively. The triage tool assisted pharmacists in the identification of a risk category likely to initiate and direct pharmacist review. The evaluation of the triage tool for obstetric services depicted it as an effective approach for prioritising patients likely to require pharmacist review. While the national birth statistics reveal the external validity of the patient cohort, the study's sample size, coupled with the use of retrospective data to collect pharmacist interventions, which did not allow recording of verbal recommendations, is a major drawback of the study.

In the UK, a new tool has been recently developed by Geeson and her colleagues.[98] With most of the existing patient prioritisation tools identifying patients' risk for MEs, ADEs, and ADRs, Geeson and her colleagues study was motivated by the need to develop a

predictive tool for medicines optimisation.[98] They used a prospective cohort study whose participants were adults hospitalised at two hospitals to develop a prediction tool (the Medicines Optimisation Assessment Tool (MOAT). Pharmacists working in the respective hospitals collected data on medication related problems (MRPs) and potential risk factors. The relationship between the study outcome (MRPs) and risk factors was established through multivariate logistic regression modelling. After internal validation of the model, it was integrated into a simplified electronic scoring system, making MOAT an advanced tool that integrated research-based findings and technology. MOAT had fair predictive performance with a sensitivity of 90% for a 'medium-risk' category (specificity 30%), and 66% for a 'high-risk' category (specificity 61%).[98] Decision curve analysis suggests that the MOAT has the potential to be clinically useful across a wide range of predicted risk probabilities.[98] MOAT is categorised as a robust methodology with the potential for improved reliability and generalisability. The major limitation of this study is the possible underestimation of MRP prevalence due to missing MRPs or failure of pharmacists to document all MRPs and thus the need for external validation of MOAT.

Most of the tools are limited by human resources due to their dependence on medication review and the perception of pharmacists. In response, a group of researchers from France sought to develop a multivariate model-based strategy targeting high-risk patients.[99] Using data from 1,408 patients from a hospital in France, the authors conducted a prospective cohort study to identify MEs similar to the MOAT study.[98] The identified MEs were clinically evaluated and their occurrence predicted by fitting and internal validation of a multivariate logistic model. Eleven variables were selected and included in the development of a predictive model. The study demonstrated fair performance as evidenced by a higher concordance statistic (C-statistic of 0.72) compared to Geeson et al.'s study (C-statistic;

0.66).[98,99] Preliminary results demonstrated that the predictive model developed by Nguyen et al. could be used reliably in targeting interventions to high-risk patients when implemented in clinical practice.[99] Unlike Winterstein et al.'s study[90] that restricted their predictive models to actual ADEs, Nguyen et al.'s study was more inclusive and involved both actual and potential ADEs.[99] However, the model did not put into consideration diagnostic categories, biological markers or comorbidities which is a key limitation for this study. While there may be valid reasons for excluding these variables, it could make users question whether the model effectively measures all sources of risk.

In Australia, the Adverse Inpatient Medication Event model (AIME) to predict medication harm has been recently developed by Falconer and her colleagues for use in an Australian adult inpatient setting.[8] It included key criteria routinely used to prioritise patients at high-risk of medication harm. These criteria were identified through a systematic review of the literature and by conducting hospital pharmacist focus groups and a national survey of Australian clinical pharmacists. The AIME model demonstrated reasonable discrimination (AuROC = 0.70), superior to the MOAT model.[8,98] The authors stated that the (AIME) model has potential clinical utility and could assist with identifying high-risk inpatients for early pharmacist review. However, this tool has limitations in terms of universal application or generalisability. This is because the study is limited in its sample size and the method of retrospective data collection, which may not allow detection of possible medication-harm events. Furthermore, an external validation of the model in a multi-site study is required to test the model's performance on new patient cohorts.

The section above has discussed the development of prioritisation tools targeted to adult patients. A limited number of studies focused on the development of prioritisation tools that

targeted paediatric patients. Two groups of researchers from the UK and one research group from Australia developed three triage tools specifically for paediatric and neonatal patients.

In the UK, a group of researchers developed a tool that aimed to optimise pharmaceutical care by directing high-risk patients to the most knowledgeable and experienced pharmacist.[100] The study stated that all paediatric patients would be assigned to the appropriate pharmacist following the Early Warning Score (EWS), reason for being admitted and DRPs identified in the medicine reconciliation process. Patients' levels of acuity were measured with Level 1 being the lowest and Level 3 being the highest. This was then followed by the specially prepared pharmaceutical care plan where patients were matched to the appropriate pharmacist, with Band 8 pharmacist being assigned to Level 3 patients, and the less experienced Band 6/7 dealing with Level 1 patients (See table 1 for more details of pharmacists' bands). The benefit of this tool is that it can match the most skilled pharmacist to those with complex clinical profiles. However, a limitation is the tool may not be easily applied in other hospitals since it was developed and validated only in one paediatric hospital.

The second triage tool to aid pharmaceutical prioritisation in paediatric and neonatal patients has been developed in Scotland.[101] A literature review and Delphi technique were used to identify pharmaceutical care issues, known as criteria, to aid in the prioritisation and targeting of pharmacists' time to deliver pharmaceutical care to paediatric and neonatal patients. This is the only study in the UK to use the Delphi approach to develop a pharmaceutical prioritisation tool. However, it gave limited details on the method of expert involvement, number of experts and the panelists comprised only of pharmacists. Therefore,

the findings do not reflect those of a multidisciplinary group and are not generalisable to other hospitals.

The third paediatric tool was recently developed in Australia. Spencer and colleagues conducted a study in a Tertiary Paediatric Hospital in Australia.[102] In a similar method used by Covvey et al,[39] this study developed, tested, and validated a patient prioritisation tool for use amongst paediatric patients.[102] The patient prioritisation tool was developed based on a two-phased observational audit of interventions used by pharmacists. The tool proved to be effective for use at the start of the day and has a 98% specificity in identifying paediatric patients in need of pharmacist intervention. The study was based on only one tertiary paediatric facility, thereby limiting its generalisability to other healthcare settings.

The section above has discussed the tools used by hospital pharmacists. However, most of the techniques and tools that can be used by pharmacists to identify patients at increased risk of adverse medication related outcomes have insufficient development and validation processes and rely on electronic health records.[7,9] Furthermore, the existing tools need to be reviewed to ensure the pharmacy workforce uses them appropriately. Other healthcare professionals have used similar assessment tools successfully to ensure that safe nursing levels could be planned so that patients are seen by the right staff with the right skills in the right place.[103] The implications of this could be applied to the pharmacy workforce.[10] The next section will examine acuity tools used by nurses in hospital settings.

2.4 The Use of Acuity Tools in Nursing

Acuity scoring tools enable nurses to predict and allocate appropriate resources which, in turn, enables them to better manage their workload.[104,105] Most acute care departments experience continual challenges of overcrowding, prolonged length of stay and patient access affecting quality of care and patient outcomes. To address these challenges, varieties of patient acuity scoring tools – Canadian Triage Acuity Scale (CTAS), the Emergency Severity Index (ESI), the Manchester Triage System (MTS) and Safer Nursing Care Tool (SNCT), Obstetrical Triage Acuity Scale (OTAS) – have been developed.[106,107] These acuity scoring tools provide evidence-based methods to inform patient management and workforce planning.[103,108]

Trauma triage systems are acuity programs for assessing and prioritising patients' needs for treatment or transport based on the severity of their injuries.[109] They are important to reduce mortality and morbidity since a majority of trauma deaths occur in pre-hospital settings or in the first four hours of the trauma event.[109] Triage systems such as fast track, multi-professional team triage, and point-of-care testing are developed to manage patient flow and reduce length of stay in hospital.[104,105106,107]

NHS hospital staff use the Safer Nursing Care Tool (SNCT) to measure patient acuity and dependency across a range or wards and specialties.[103] The SNCT consists of acuity and dependency tool, which categorises patients into five ascending levels (0, 1a, 1b, 2 and 3) and nursing multipliers to determine their need for care.[106] When used concurrently with nurse sensitive indicators (NSI), the SNCT informs evidence-based staffing and nursing outcomes.[103]

The National Obstetric Triage Working Group in Canada developed the Obstetrical Triage Acuity Scale (OTAS) for determining healthcare needs for pregnant women on admission.

OTAS uses a five-point scoring scale to compute acuity – 1 (resuscitative), 2 (emergent), 3 (urgent), 4 (less urgent) and 5 (non-urgent).[107]

For the nursing profession, patient acuity scoring tools have improved responsiveness and accountability to patients, aligned nurse skills to patient needs, fostered professional growth, and improved openness and transparency in nurse staffing.[103] Consequently, it has also contributed to higher levels of job satisfaction and productivity.[110] Workload is one of the key factors influencing job satisfaction of nurses and an important determinant of their ability to assess and promote desired patient outcomes.[111] Thus, patient acuity scoring tools improve job satisfaction by dispelling feelings of inadequacy and frustrations associated with unfair workload distribution. They provide a mechanism for equitable nurse-patient allocation based on skill, ability and workload rather than on number of patients or working hours.[108,111] Patient acuity scoring tools also improves nurse productivity by matching nursing skills to patient needs.[108] For the healthcare system, patient acuity scoring tools have improved the ability of healthcare organisations to manage changing demands for nursing resources. It has provided valuable information on nurse staffing trends for the preparation of annual nursing resource budgets and the prediction or justification for the need for additional staff or staff positions.[110]

2.4.1 Impact on patient outcomes

Using evidence-based acuity scoring tools to predict patients' requirements for care has important implications for patient outcomes. It facilitates timely delivery of care especially in emergency (trauma) cases where the rate of preventable long-term morbidity or mortality is high within the first four hours.[109] It was established that patient acuity-based staffing improves the triaging process in trauma centres by speeding patient placement based on severity of injury.[109] In another study of 1,331 triage charts in Japan, a structured triage

system that ranks patient need for care as emergent, urgent, less urgent or non-urgent significantly reduced patient wait times compared to a non-structured triage system.[112] Data abstracted from electronic health records (EHR) in an obstetric triage unit in Canada also demonstrates that using OTAS, an acuity-scoring tool for obstetricians, reduced the median length of stay of patients from 105 to 101 minutes.[107]

In an acute care setting with fluctuating demand for care, acuity scoring tools integrated with electronic health records enables rapid and judicious nurse-patient allocation to prevent harm to the patient.[108] It was found that in a 504-bed non-teaching metropolitan acute care community hospital, the use of a Global Trigger Tool (GTT) for measuring adverse events to compute the risk of harm to patients (low, moderate or high) achieves better prediction than bedside nurse's perceptions of harm.[113] GTT improved prediction of patients at risk of harm and informed the choice of appropriate therapeutic care.[113] Overall, prioritising patients' need for care based on acuity-scoring tools promotes optimal patient outcomes by tracing patients' needs from admission to discharge, facilitating fair nurse staffing based on workload, monitoring and assessment of quality assurance and improvement, as well as promoting inter-disciplinary effectiveness and professional practice expectations.[104]

2.4.2 Specialist nurses' knowledge and experience of dealing with patient acuity

Effective and high quality care especially in acute care centres is associated with nurses' possession of the relevant specialist knowledge and skills.[108] The expectation of ranking and prioritising patient needs for care is to find the right nurse, with the right skills and the right place and time to improve management of high-acuity patients.[103] Thus, nurse knowledge and experience is considered for the level of patient acuity allocated.[110]

Acuity-scoring tools assist decision-makers on nurse staffing to assess available nurse skills and make appropriate decisions on patient allocation both for the individual nurse and for a

team of nurses.[105,108] Senior nurses or those with more experience and training are usually assigned to high-acuity patients whereas junior nurses or those with less experience and training are assigned to low-acuity patients.[103] Matching nurse skills to patients' needs enables the provision of consistent high quality of care. It is associated with decreased mortality rates, adverse outcomes and length of stay in the hospital.[105]

2.5 Conclusion

In conclusion, the development of patient prioritisation tools is a complicated process. While several prioritisation tools have been developed to help pharmacists to identify patients at increased risk of adverse medication related outcomes, most of them are ineffective in prioritising patients due to limitations such as lack of calibration, validation, and poor quality development processes.[7,9] In addition, pharmacists' prioritisation of high-risk patients is compounded by the challenge of recognising the ideal blend of criteria to be used as a prioritisation decision support tool by pharmacists.[47]

Currently, both nurses and pharmacists have the tools to identify and prioritise high-risk patients. However, nurses have a system in place to incorporate this information into the way that they practice; for instance, nurse resources and expertise are matched to patient need. No such system is currently in place for pharmacists.[7] Therefore, the rigorous and systematic development of a new prioritisation tool, which can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs is a priority. The care of those patients at greatest risk of preventable harm due to medication would then be provided quickly by an appropriately experienced clinical pharmacist, targeting the deployment of resource limited clinical pharmacy services. Although there are previous studies describing the use and development of

pharmaceutical screening tools, there had been no systematic review describing these tools or the impact that these tools have on patient safety or the pharmacy workforce. Therefore, a systematic review was conducted to provide a structured overview and description of existing pharmaceutical screening tools (details given in Chapter 4).

3. Chapter Three: Overview of Programme of Work and Methods

Research is a rigorous and systematic process which explores a subject area of interest by studying the various materials and resources available with an aim to contribute to the existing body of scientific knowledge.[114] This includes undertaking a detailed observation by employing the five senses. It also involves the measurement and experimentation of the various dynamics of the environment within which the research takes place, as well as the outcome of these measurements.[115] These combined efforts formulate the research program process that not only leads to the creation of new knowledge, but also a testing of the existing knowledge.

This chapter constitutes an overview of the research undertaken in this thesis, including the aims, objectives, methods and ethical approval process for each study.

3.1 Overview of Programme of Work

3.1.1 Research aim and objectives

The overall aim of this programme of work is to develop, rigorously and systematically, a screening tool, which can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs and assess its feasibility in a clinical setting. The care of those patients at greatest risk of preventable harm due to medication would then be provided quickly by an appropriately experienced clinical pharmacist, targeting the deployment of resource limited clinical pharmacy services. In order to achieve the aim of this research, various research objectives were designed with complementing methodologies to achieve them.

The objectives of this PhD thesis are to:

1. Provide a structured overview and description of existing pharmaceutical screening tools;
2. Develop a classification scheme for assigning pharmaceutical complexity levels to patients on admission;
3. Determine the appropriate frequency and competency of clinical pharmacist input for each complexity level;
4. Develop and design the Adult Complexity Tool for Pharmaceutical Care (ACTPC);
5. Identify the most efficient and effective ways to measure the impact of the ACTPC on patient outcomes and workload patterns;
6. Validate the ability of the ACTPC to distinguish between different patient's complexity levels;
7. Assess the feasibility of running a future definitive study to test the impact of implementing the ACTPC on patient outcomes and hospital pharmacist's workflow;
8. Generate recommendations for future research.

These objectives were achieved by conducting three major studies. The first objective was achieved in study one, objectives 2,3 and 4 in study two and objectives 5,6,7 and 8 in study three.

3.1.2 Programme of work structure

This PhD thesis commenced with the first study (found in Chapter Four), a systematic review that provides a structured overview and description of existing assessment tools with a focus on tool validity, risk factors, and high-risk drug classes. This review follows Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Guidelines for reporting systematic reviews.[116] The key databases in the medical field such as Medline, Embase, and Web of Science were used in the search.

The second study in the programme (Chapter Five) obtained expert consensus on the design of a pharmaceutical care complexity screening tool for use on admission to hospital. We conducted two Delphi studies to achieve consensus on the necessary components of a pharmaceutical care complexity screening tool and the appropriate frequency of clinical pharmacist input for each complexity level, as well as the competency level of pharmacy staff assigned. Identified and refined tool components from a previous UK survey and interview study of prioritisation tools[117] and a systematic review[7] were included in the first two-round Delphi study. The Delphi One survey was distributed to invited worldwide experts in medication safety including pharmacists, academics and physicians. The expert panel were asked to rank each component on importance, using a nine-point Likert-scale.

Once consensus was achieved on the tool components and the first draft of the ACTPC was developed, a second Delphi study was conducted with chief pharmacists and clinical service pharmacy managers in the UK to seek agreement on the clinical appropriateness and practicality of the draft tool, including the appropriate frequency and competency of clinical pharmacist input for each level of complexity incorporated in the tool. The second Delphi study was completed by 40 expert panel members and consensus reached on clinical appropriateness, feasibility of review frequency and appropriate experience of pharmacy practitioner to care for patients at each level. These decisions were then incorporated into the final version of the ACTPC.

After both Delphi studies were completed, the ACTPC tool was designed. In light of panellists' comments, it was decided two forms were necessary. ACTPC-Form 1, contains only red criteria descriptors (pharmaceutically highly complex descriptors) allowing swift identification of highly complex patients on admission. ACTPC-Form 2, contains all three criteria: 'red' (high), 'amber' (moderate) and 'green' (low) and is for use during or after medication reconciliation.

The first and second study of the programme of work, briefly described above, comprised the steps necessary to develop a pharmaceutical care complexity screening tool for use on admission to hospital. A major limitation identified was the need to apply the ACTPC in practice in order to assess its feasibility, including determining how best to measure the effectiveness of such a tool. The third study of the programme (Chapter Six) lists the steps undertaken to establish this feasibility. A pre-post ACTPC implementation prospective study was conducted at three NHS acute hospital trusts. A 3-week pre-implementation phase, a 1-week implementation period, and a 3-week post-implementation phase was undertaken in each site sequentially. Data collection was planned for the following outcomes:

- The number and types of prescribing errors detected by pharmacists and interventions made for three days before and after ACTPC implementation.
- The amount of time that pharmacists spend on tasks before and after ACTPC implementation.
- Length of patient stay in hospital and 30-day readmission rate before and after ACTPC implementation.

This thesis ends with a discussion of the overall findings of the programme of research (Chapter 7). The findings were pulled together to highlight that this is the first study to develop a comprehensive screening tool based on current knowledge and understanding of national and international tools combined with expert consensus. Furthermore, the data collected in the feasibility study tested multiple outcomes that could be used when evaluating the tool effectiveness and validity in a larger trial. The strengths and limitations of this thesis are then discussed followed by some implications for practice and future research. This chapter ends with the overall conclusion for the thesis.

3.2 Study One: Rationale and Methods

3.2.1 Study One: rationale

Study One aimed to identify and describe tools currently used in clinical pharmacy services to assess patient acuity and/or complexity. In order to achieve this aim, a literature review was undertaken to provide a structured overview and description of existing assessment tools used by hospital pharmacy services that assess patient priority and/or complexity. During this process, studies were identified that developed or described assessment tools that seek to prioritise patients for pharmacy services. Three types of literature reviews are commonly undertaken: the narrative literature review, the systematic literature review, and the meta-analysis literature review.[118]

A narrative literature review is a type of review that describes and discusses a specific topic or theme from a theoretical and contextual point of view. It does not explore the methodological approaches of the reviewed studies or the databases used and does not explicitly state the inclusion and exclusion criteria. For this reason, it is also called a non-systematic literature review.[118] Conversely, a systematic review seeks to answer specific research questions through a systematic approach that identifies, selects and evaluates the results of research studies on the topic under review on the basis of particular inclusion and exclusion criteria.[119] In order to establish the strength of the evidence and its credibility, a systematic review includes data available in all published and unpublished studies.[118–120] To this end, the key features of a systematic literature review include a well-defined set of objectives with an equally well-defined eligibility criteria for inclusion and exclusion of research studies, a methodology that can be reproduced if required, a systematic approach to the identification of included studies, and an assessment of the risk of bias in these studies.[120,121]

A meta-analysis literature review involves statistical techniques that summarise a significant number of quantitative studies to assess the effects of any particular variable. Meta-analysis is also a method that is sometimes added to a systematic review in order to assess the effects of an intervention in the best and most holistic manner.[115,118,120] Since the objective of this review is not to estimate the effects of clinical pharmacists' interventions using an assessment tool, the meta-analysis has been deemed unsuitable and therefore disregarded.

For the purposes of study One in this PhD thesis, a systematic review was undertaken instead of a narrative review. This was to address the first research objective in a more systematic manner. Furthermore, systematic reviews are considered the gold standard of evidence in medical literature.[119–121]

3.2.2 Study One: method

The research question was developed, "What tools are currently used in clinical pharmacy services to assess patient acuity and/or complexity?" A search strategy was developed by breaking down the research question into four categories, each with its own keyword groups. These keyword groups and categories were used as search terms in search engines. The categories of keywords included priority, tool, hospital and pharmaceutical care. Along with these keyword categories, synonyms as well as alternative spellings and plural forms of these words were also searched (a list is provided in Chapter 4, Section 4.2.1). OvidSP was used as a search engine as it includes several pharmacy and medical databases including Ovid MEDLINE® and Ovid MEDLINE® In Process & Other Non-Indexed Citations and Ovid MEDLINE® Daily Update, Embase (updated daily), Evidence Based Medicine Reviews, Cochrane Database of Systematic Reviews and International Pharmaceutical Abstracts. The search date was set from the year 1990 as this was the year that a definition

of pharmaceutical care was first published.[122] While the initial search was conducted until September 30th 2017, an updated search was then performed that spanned to November 30th 2017. A study selection process was then undertaken consisting of three different parts; title screening, abstract review, and full article assessment. The inclusion and exclusion criteria were used for the selection of articles and the results were discussed in review meetings. Articles that met the criteria through consensus decisions were then taken for each phase of the selection process, and were included in the review. For details on Study One inclusion and exclusion criteria, and full search and extraction strategy, see Chapter 4, Section 4.2.

Various phases were employed for study selection. Each of these began with removing the duplicates of studies using the Mendeley reference management software (Elsevier, 2017), following which, the remaining studies were evaluated on the basis of their titles through manual searching for duplicates. The studies filtered through this stage were then chosen for abstract review. The abstracts that appeared to fit the inclusion criteria were passed on to the full article review stage. The full article reviews were discussed in review meetings with the supervisory team, and a study was only included for data extraction if all team members agreed. Moreover, the discussions also considered whether further information from the corresponding author was required. A form was developed to extract the relevant data from the included studies. Moreover, the Cochrane checklist for Systematic Reviews of Interventions[123], and the PRISMA Guidelines for reporting systematic reviews were also used.[116] A number of revisions were undertaken on the extraction form before its final acceptance. The extraction form was designed to extract the relevant data in a systematic manner (Appendix 1).

3.2.3 Study One: ethical approval

Ethics approval was not required as the study purpose was to review the existing literature.

3.3 Study Two: Rationale, Methods and Data Analysis

Study Two consisted of two Delphi studies. Delphi One aimed to develop a classification scheme for assigning pharmaceutical complexity levels to individual patients on admission to hospital (Chapter 5, Section 5.2.1). Delphi Two's aim was to determine the appropriate frequency of clinical pharmacist input for each complexity level and the appropriate competency level of pharmacy staff to assign to each level (Chapter 5, Section 5.2.2). Details of each Delphi study method is described in this section of this thesis.

3.3.1 Study Two: rationale for using the Delphi technique

Study Two aimed to obtain expert consensus on the design of a pharmaceutical care complexity screening tool for use on patient admission to hospital by using a consensus method. Consensus techniques work by synthesising and clarifying expert opinions so that consensus amongst a group of experts can be reached. Quantitative estimates are usually derived in consensus techniques through a combination of quantitative and qualitative research approaches.[115,124] These techniques include, the RAND appropriateness method, the Delphi technique and the nominal group technique (NGT). The RAND appropriateness method combines the opinion of selected experts with the current scientific evidence available. The selected experts rate, meet for discussion and then re-rate issues of concern.[125] The Delphi technique consists of multiple survey rounds with feedback to the group of experts. It does not require a meeting between the group of experts. Furthermore, the Delphi technique commonly uses literature review as a basis of evidence.[126–128] The NGT is used for generating ideas but usually has no initial review of the current scientific literature.[129,130]

For Study Two, the Delphi method was seen to be suitable to achieving the objectives of this research which were to obtain consensus on the components of a pharmaceutical care

complexity screening tool as well as the appropriate frequency and competency of clinical pharmacist input for each complexity level. There are a number of reasons for this. Since the hospital pharmacists, academics and physicians with expert knowledge and experience of medication safety may be geographically dispersed, this method allowed for input from suitably qualified individuals without requiring travel or commitment of a significant amount of time to the research. Furthermore, research participants, such as healthcare staff, would be very likely to be able to communicate their ideas in the written form, and would be more committed to share their thoughts on the research topic. For these reasons, the Delphi technique is frequently used as a methodology of choice for healthcare studies.[124,126,131]

3.3.1.1 Delphi Technique

The Delphi technique is a multi-stage methodology commonly used in healthcare research in areas with insufficient existing information to build consensus.[131,132] The Delphi technique uses structured facilitation techniques to obtain reliable consensus from a group of experts. It is considered to be a rigorous consensus method.[125,133] The experts involved communicate their ideas without face-to-face meetings, and a multi-stage survey with controlled feedback is involved.[127,131,132] The RAND Corporation developed this technique in 1953 to generate expert opinion on future events.[132,134] The Delphi method proposes to achieve a reliable response to research questions from experts, and this is secured through a series of questionnaires involving repetitive questions with group feedback from previous rounds included.[132,135]

3.3.1.1.1 Strengths of the Delphi technique

The Delphi technique offers several advantages. The judgment of a group of experts may be closer to reality than that of any singular individual.[131,132] For this reason, the judgment

of these expert panels is considered to be part of the evidence used for research after a meta-analysis of randomised controlled trials, non-randomised trials, and cohort studies.[125] Moreover, the Delphi technique is less likely to have the disadvantages that are usually inherent in group meetings that employ other consensus reaching methods, such as the NGT and RAND appropriateness methods.[130,136] Within the Delphi technique, there is a higher likelihood that the experts would express their independent and logical opinions given the fact that they are not in a face-to-face discussion, and they do not have to consider the opinions of other individuals. Conversely, one or more individual's opinions are likely to be influenced in group discussions by those who are more experienced or more dominant. Nevertheless, the advantages inherent in group discussions are missing from this technique.[125,130]

One of the main advantages of using the Delphi technique is that it ensures anonymity as the participants do not interact with each other, and group results are fed back through means, medians and standard deviations. After the group feedback, the participants have the chance to reconsider their responses in subsequent rounds.[131,135] Furthermore, the Delphi technique offers greater organisation and flexibility in panel size, number of rounds, and participant recruitment with little consideration of geographical limitations and boundaries.[130,135] When online and email facilities are used as methods of communication, this increases the practicality of the Delphi technique.[130,135]

3.3.1.1.2 Limitations of the Delphi technique

Careful consideration should be given before using this technique as no universal guidelines exist.[132,135] It has some methodological disadvantages, such as the panel may not represent all the targeted experts and requiring the experts to have good written communication skills. Another potential issue is the response rate, which can vary.[130,132] The Delphi technique

may also be more time consuming than other methods, as the minimum time required for a two round Delphi process to be completed is between 30 and 45 days.[130] This time frame could also increase if the number of rounds exceeds two. Moreover, the completion of these rounds within this period is also dependent on how strictly the participants comply with the deadlines in each round. However, the use of online questionnaires minimises the effect of this disadvantage.[130,135] The Delphi technique has also been criticised for other reasons, including the issue of poor accountability for the views expressed , and a lack of scientific respectability of the method.[127,137]

Another limitation is the lack of standard acceptable definitions and criteria to select the panel of experts, although this is a problem that could arise in the formation of any group.[132,135] Recruiting these experts is also a limitation because the participant response cannot be controlled. This could mean that more knowledgeable experts are left out simply because they did not respond to the invitation letter.[132] This poor response rate is another potential limitation of the technique as is common with all studies that invite people through questionnaires.[127] The Delphi technique also requires that panel experts have a sufficient amount of time and motivation to complete multiple questionnaires. Again, these are issues that may arise in many other research methods. A possible solution to this is to send repeated reminders to the participants to improve the response rate.

3.3.1.2 Panel experts

Panel experts are identified through a sampling process which refers to the selection of a particular segment of the population for a research study. This population may include people, case studies, or events that are specific to the research topic under consideration.[138] Quantitative studies employ a representative sample so that generalisations from research findings can be drawn. For this reason, probability sampling is employed which means that a randomly selected sample from each unit of the population has a known chance of being

selected. Further methods of probability sampling include simple random sampling, systematic random sampling, stratified random sampling, cluster sampling and multi-stage cluster sampling.[115,118,138] Conversely, qualitative studies seek to understand complex phenomena rather than seeking statistical representativeness, and therefore nonprobability or non-random sampling methods are more suitable to qualitative research and their sample populations.[115,139,140] Some types of non-probability sampling include convenience sample, purposive sample, quota sample, snowball sample and theoretical sample.[115,118,138]

For the purpose of this study, purposive and snowball sampling techniques have been employed as the non-probability sampling methods were seen to be more suitable for this research question as explained in further detail below.

3.3.1.2.1 Purposive sampling

Purposive sampling is a deliberate method of non-random sampling of individuals or settings that share a particular characteristic that coincides with the aims and objectives of a research study. The researcher purposively selects individuals that are likely to make effective contributions to the study objectives. The target population can include people who have a specific experience, or who have been involved in specific incidents or any events that are relevant to the research study.[138]

3.3.1.2.2 Snowball sampling

Snowball sampling involves a researcher contacting a small group of people, who are considered to be experts in their fields and who are relevant to the research study. These small group of people are then used to generate more references, akin to word of mouth marketing. These people help to establish contact with a larger sample population. These identified contacts are then asked if they would be interested to participate in the research study and if they do express interest, they are then asked to refer more people who might be

interested in doing the same. While there is an element of bias in this method, as in people are likely to refer other people who have similar views to them, it was still considered to be a suitable method since a sampling frame (a list of all units in the population from which the sample can be selected) could not be accessed.[115,138]

3.3.2 Study Two: methods

3.3.2.1 Methods used to identify the tool components

The tool components were identified by conducting a systematic review of prioritisation tools,[7] and through a survey and interview study of NHS acute hospital trusts of current screening tools used for prioritisation of pharmacy services.[117] This is described in detail below.

The systematic review conducted in Study One identified a limited number of UK studies reporting on tools that hospitals use to assess patient complexity or to prioritise pharmaceutical care and such studies often lacked detailed information regarding tool use.[7] Therefore a national online survey was administered to chief pharmacists across 220 NHS hospital trusts to determine if the prioritisation of acute patients was facilitated with the use of any screening tools.[117] The respondents who had experience of using such tools were then invited for a telephone interview and to share their existing tool. Interviews were conducted with 36 pharmacy managers to understand more about tool component, design, implementation and perceived effectiveness of existing tools. Documentary analysis was performed on existing tools that were shared by the participating hospitals and qualitative data analysed using a thematic approach.[117] Tool components identified from this analysis and from our previously published systematic review[7] were reviewed and refined by the research team. The inclusion and exclusion criteria for the tool components were

specifically determined (see Chapter 5, Section 5.2 for detailed inclusion and exclusion criteria). When there was disagreement regarding inclusion of particular tool components, these were reviewed and discussed in independent face-to-face sessions between the research team and an expert reference group (ERG), consisting of chief pharmacists, academics and members of a Patient Public Involvement (PPI) group, to reach an agreement. The identified components were categorised into clinical related and medication related components and then combined for use in two Delphi studies. Details of each Delphi study method is described below.

3.3.2.2 Delphi One method

A modified Delphi technique was used with the final list of tool components compiled into a first two-round study questionnaire. A modified Delphi consensus helps reach an agreement through a series of questionnaires given to a group of experts.[131,132] The structure of the Delphi studies is presented below:

- Consensus defined;
- Identification of experts;
- Preparation of invitation letter and information sheet;
- Invitation of selected expert panel members;
- Selection of online survey program;
- Design of Delphi scales;
- Piloting of online questionnaire and subsequent modification;
- First round of Delphi questionnaire sent;
- Analysis of first round questionnaire;
- Preparation of feedback and design of second round questionnaire;
- Piloting of second round questionnaire and subsequent modification;
- Analysis of second round questionnaire.

3.3.2.2.1 Consensus definitions

Consensus was defined according to the RAND operational definition.[134] The importance of the tool components was classified into three levels of appropriateness:

I. Important: panel median score of 7-9, without disagreement.

II. Uncertain: panel median score of 4-6 or any median score with disagreement.

III. Unimportant: panel median score of 1-3, without disagreement.

Disagreement was defined as at least one third of the participants rating in the other lower region (i.e. 1-3) or in the upper region (i.e. 7-9).[134]

3.3.2.2.2 Selection of experts

In the interest of the accuracy of research findings, it is essential to clearly identify the potential experts for a study.[135,136,138,141,142] Definitions of experts include a group of knowledgeable individuals with specialist knowledge in a particular subject in their field.[127,135,142] Given this definition, knowledge was used as the main criteria to recruit experts, alongside a willingness to discuss the issue and their willingness to represent their own professions. The expert panel members in this study include worldwide experts in medication safety and UK hospital pharmacists with a management role e.g. chief pharmacist or lead clinical pharmacist. Experts were also selected on the basis of their potential use of the prioritisation tool developed as a result of this work.

3.3.2.2.3 Delphi One panel and recruitment

The Delphi One panel members included pharmacists, academics (without a clinical load) and physicians who are leading experts in medication safety. They were identified during the first phase of the research i.e. from the survey and interview study of NHS acute

hospitals[117] and from publications included in the systematic review.[7] These experts had the necessary experience to provide varied opinions on the subject. Forty-nine invitations were sent to potential experts across the UK and overseas. This large number of invitations is common practice in Delphi studies[126], and sought to ensure that at least 40 panel members would participate in Delphi One. The details for the experts who responded to these invitations were then anonymised. The surveys were distributed via email, a common method of corresponding with research participants.[131]

3.3.2.2.4 Rating scale of Delphi One

Round One

For round one, an email was sent to panellists in December 2017, which included a web link (SelectSurvey.NET) to the online questionnaire. The tool components in the questionnaire were organised on a 9-point Likert scale. Additionally, the online questionnaire also requested the professional role and country of residence of each participant. The Likert Scale was divided into three sections; a score between 1-3 was deemed unimportant, 4-6 as uncertain and 7-9 as important. Panellists were asked to rank each tool component for its importance in their daily hospital practice in terms of allowing them to identify patient complexity (Appendix 2). The participants also had the opportunity to explain their score under each component in a dedicated space provided for such purpose. Furthermore, a space was provided at the end of the questionnaire for participants to offer suggestions for any other tool components that should be included in the tool. Participants were provided with an overview of the study on the first page of the questionnaire and, in order to support the rating process, instructions for completing the rating scales was provided at the top of each page of the questionnaire.

Round Two

Once the first round of the questionnaire was completed, a median was calculated and the comments pertaining to the tool components collated. The second-round questionnaire was sent to the same panellists in May 2018, with the same tool components as the first questionnaire. This questionnaire also included the overall median score for each component, panellists' own previous scores and a summary of the comments provided by panellists to demonstrate the different justifications that were given (Appendix 3). The panellists were given the opportunity to modify their scores in light of this information, or to retain their original score if they disagreed with the group's opinion. After the second round, the Delphi One study was stopped given the fact that consensus was reached, therefore the number of rounds for the first Delphi was limited to two. Six weeks were given to panellists to respond to each round and up to four reminders were sent by email. For further details on the Delphi One method, see Chapter 5, Section 5.2.1.

3.3.2.3 Delphi Two method

Delphi Two aimed to identify the frequency of pharmacy visits and the level of pharmacist competence required for each complexity level. For Delphi Two, the initial list of statements was developed through a secondary analysis of the previous interviews conducted as part of this project.[117] Thirty-six transcripts were screened by the researcher to ensure that the data was relevant to the purpose of Delphi Two, i.e. to determine the frequency of clinical pharmacist input for each complexity level and the appropriate competency level of pharmacy staff to assign to each level. Statements focused on different aspects of tool use, such as the appropriate time to use the complexity tool, i.e. before, during or after medicine reconciliation and appropriate frequency and experience of clinical pharmacists. Data analysis was carried out using the Framework approach, which is a common data analysis approach in healthcare research.[143] Data was analysed through NVivo-12. The list of

statements was developed by the researcher and then reviewed by the research team for their appropriateness and clarity. The decision to keep or delete a particular statement from this draft was taken collectively by the research team. The commonly agreed statements were then combined into an online questionnaire for Delphi Two.

3.3.2.3.1 Delphi Two panel and recruitment

For this Delphi, clinical pharmacists with a management role in a UK hospital pharmacy, i.e. clinical pharmacy service managers or chief pharmacists, were sought as panel members. The research team used several approaches to recruit panellists for this study, including their professional networks and those of colleagues. The panellists who were unable to participate were requested to nominate other suitable individuals from their professional circle (snowball sampling method).[115,138] Participants recruited for the Delphi One study and who met the criteria for Delphi Two were also invited to participate. This process continued until at least 40 panel members were recruited. Each potential panel member was provided with study information including the aim of the Delphi and the extent and timing of their expected involvement.

3.3.2.3.2 Rating scale of Delphi Two

Round One

In October 2018, Delphi Two commenced with each panellist being sent an email with a link to the online questionnaire. The panellists were provided with a summary of the study on the first page of the questionnaire as well as the rating instructions. On the second page of the questionnaire, questions relating to demographic information, such as the professional role of each panellist, were included. Again, the information about the importance scale was placed on top of each page of the questionnaire as a reminder. Additionally, a draft of the

Adult Complexity Tool for Pharmaceutical Care (ACTPC) which included the agreed tool components as confirmed by Delphi One was attached on every page. A 9-point Likert scale was again used for the panellists to rate their degree of agreement or disagreement on the clinical appropriateness and practicality of the statements; 1-3 was identified as low, 4-6 was viewed as uncertain and 7-9 as high. A comments box was added under each statement to allow panellists to expand on their answer. Also, additional space was provided at the end of the questionnaire for panellists to include their suggestions or recommendations with regards to tool design and its applicability and practicality for use on admission to hospital (Appendix 4). A six-week deadline was set for completion of each Delphi survey and panellists were sent a reminder email on up to four occasions.

Round Two

The second round was conducted in December 2018. The questionnaire was sent to the same panellists with the same statements as in the first round. Additionally, a summary of panellists' comments from the first round were also included to show the variety of opinions, the overall median score, as well as their own previous scores. No statements were added to or removed from the first-round (Appendix 5). The same six-week deadline for completion, reminders and approach to analysis was applied as in round one. For details on the Delphi Two method, see Chapter 5, Section 5.2.2.

After both Delphi studies, the ACTPC tool was designed. In conjunction with the expert reference group (ERG) discussion and panellists' comments, it was decided two forms were necessary. ACTPC-1 aims to screen adult patients on admission to hospital to identify those who are high-risk/ highly complex (Appendix 6) while the ACTPC-2 aims to classify adult patients into different complexity levels (red, amber, green) requiring different degrees of pharmaceutical care (Appendix 7).

3.3.2.4 Tool description

The tool consists of three criteria: red, amber and green. Both forms contain the same red criteria descriptors. Form 1 contains the 'red' criteria only. Form 2 contains all three criteria: 'red' (high-risk), 'amber' (moderate-risk) and 'green' (low-risk).

ACTPC-1 is designed to capture high-risk patients as it contains the 'red' criteria only. This form helps the pharmacist to identify a newly admitted high-risk patient in the Adult Acute Medical Unit (AMU). Patients who meet one or more red criteria are rated as 'RED'. This means that this is a highly complex patient and where possible the patient should receive a medicines reconciliation and clinical review within the first 6-12 hours of admission (but no later than 24 hours) by an experienced clinical pharmacist. Following this, the patient should be seen daily by this grade of staff. Patients who do not meet any of the criteria in Form 1 will be classified as 'Non-RED'. This means that this is a moderately complex patient OR least complex patient. The ACTPC (Form 2) can then be used during or after medicines reconciliation. Also, patients who fit into any red criteria descriptors can be downgraded to 'amber' and 'green' criteria depending on their clinical condition and/or medication changes.

ACTPC-2 includes different risk factors and these risk factors would be more easily identified during or after medicines reconciliation. The patient will then be classified as highly, moderately or least complex based on the presence or absence of those factors. Patients who meet one or more red criteria are rated as 'RED' and are classified as highly complex and should be reviewed daily by an experienced clinical pharmacist. Furthermore, patients who meet one or more amber criteria are rated as 'AMBER' and are classified as moderately complex and should be seen by a clinical pharmacist in the first 24 hours of admission, then every one- or two-days dependent on resources. However, if the patient is

stable with no acute issues and does not have any red or amber criteria they are rated as 'GREEN' and are classified as least complex and should be seen by a clinical pharmacist in the first 24 hours of admission, then twice weekly. The ACTPC-2 should be used on a daily basis during the patient's stay in the AMU. Figure 4 summarises the guidelines for the ACTPC.

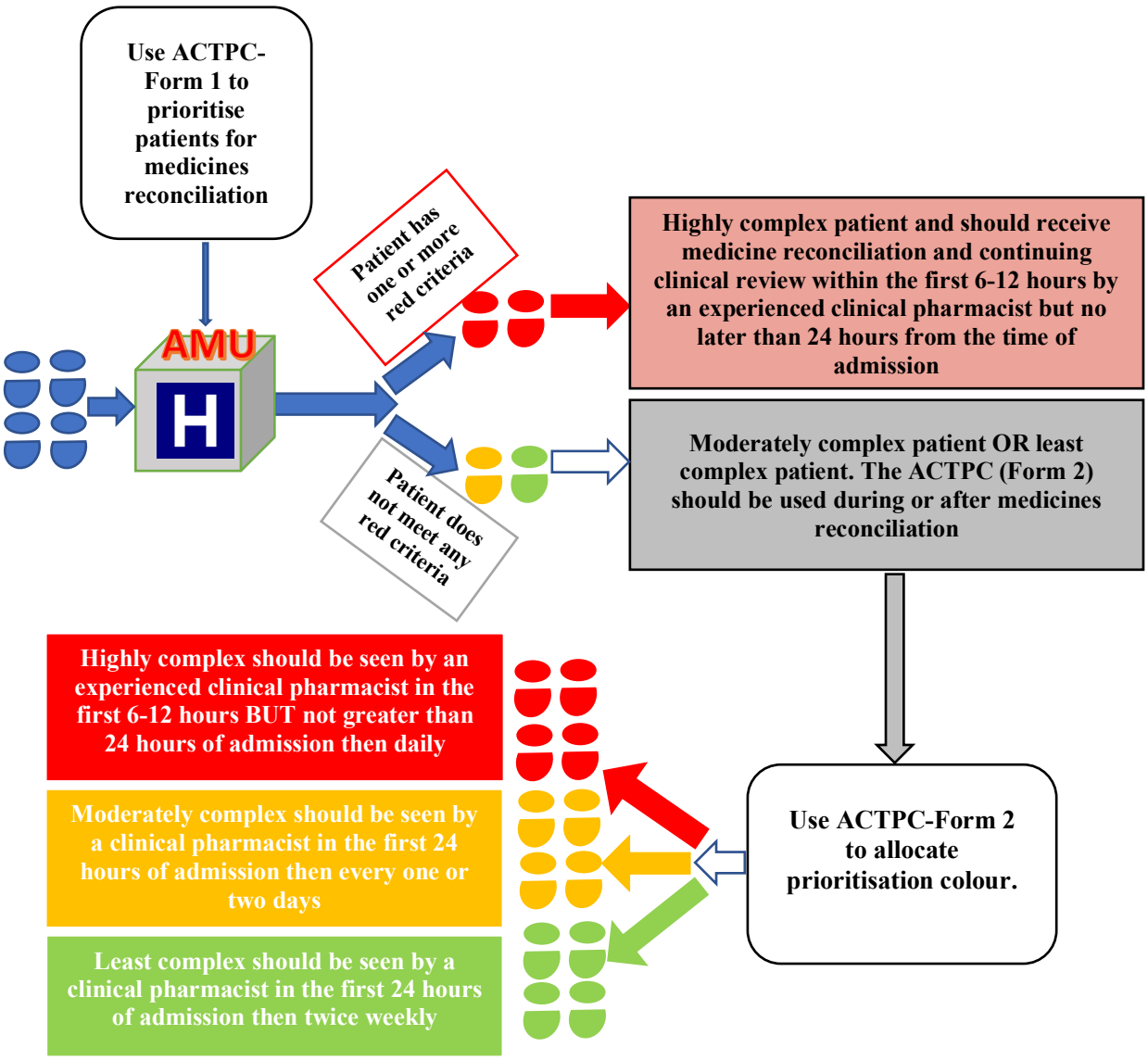

***Figure 4**: The guideline of the ACTPC*

3.3.3 Study Two: data analysis

The data generated from the answers to the online questionnaire were analysed qualitatively and quantitatively. The quantitative data was statistically analysed to identify whether or not consensus had been obtained for each tool component in Delphi One or for each statement in Delphi Two. Data were analysed using IBM SPSS version 23 to calculate the frequency distribution of the group scores on a scale of 1–9, the median score and the panel inter-quartile range (IQR).

The written responses of the panellists in both Delphi studies were analysed qualitatively by transcribing and summarising the comments of the first-round survey and presenting them in a comment box, together with the second- round questionnaire. This was done to help panellists understand the opinions of others on the proposed tool components or statements. Furthermore, panellists could reconsider their views. Providing panellists' comments or feedback to the group in a simple format can increase their understanding of the groups' assessment.[144]

A number of approaches have been employed in qualitative data analysis.[118,143,145,146] These include content analysis, grounded theory, narrative analysis, thematic analysis, and Framework analysis. However, for the purpose of the Delphi Two study, framework analysis was chosen for qualitative data analysis, facilitated by the use of NVivo-12, which involves a matrix-based method for arranging data in an orderly and synthesised manner.[143] This involves the construction of a central theme as well as sub themes, which are then represented in the matrix. This framework is then applied to the data which is organised into core themes and helps in the identification of sub themes within the matrix for each case.[118]

3.3.4 Study Two: ethical approval

Ethical approval for this study was not required as the Delphi study sought involvement of individuals in their capacity as subject experts and not as research participants. Furthermore, data are reported at group level and individual responses cannot be identified from the results.

3.4 Study Three: Rationale, Methods and Data Analysis

3.4.1 Study Three: rationale

The previous two studies of this programme of work describe the steps taken to design the ACTPC. The next stage in the development of the ACTPC was to test its feasibility in the practice setting.

Most of the literature uses the terms of 'feasibility studies' and 'pilot studies' interchangeably. The National Institute for Health Research (NIHR) offers useful distinctive definitions for these two entities. Feasibility studies are defined as a piece of research that is undertaken before the main study in order to establish if the study can be done.[147] A feasibility study determines the major parameters that go into designing the main study.[147] It also focuses on developing an understanding of any uncertainties that may arise during the course of a main study, in order to prepare for them and to address them before launching the full-scale study.[148]

Conversely, a pilot study is described as a smaller version of the main study, and differs from the feasibility study in that it mirrors the main study in terms of its research methodology, including the selected primary outcome measures.[147] A pilot study therefore focuses on the processes of the main study, including the recruitment, randomization, treatment and follow-up to ensure that these processes are run efficiently.[148] A pilot study

is often the first phase of the main study, and the data collected as part of the pilot study can even be used to contribute to the final analysis of the main study. A pilot study does not question the issue of whether the main study can be conducted or not, which a feasibility study does.[147]

On the other hand, the Medical Research Council (MRC) guidance for developing and evaluating interventions does not distinguish between feasibility and pilot studies, suggesting that the feasibility and piloting stage of a study includes the need to test procedures for their acceptability, recruitment and sample size calculation.[149] However, the MRC guidance does state the need for a pilot and/or feasibility study in order to assert and address the uncertainties of any main study.

3.4.1.1 Importance of feasibility studies

An essential part of any feasibility study is to determine its possibility to deliver a successful study, as well as establishing its workability.[150] A feasibility study is also used as an opportunity to justify the financial and non-financial resources needed to undertake the main study.[151] The MRC's new guidelines for the development and evaluation of complex interventions suggest that the use of feasibility or piloting studies can be pivotal in determining the potential problems of acceptability, compliance, and delivery of the interventions.[149] Given the fact that these problems can be anticipated during the feasibility or piloting stage, they can be addressed prior to a large-scale outcome evaluation, such as a randomised controlled trial (RCT).

These guidelines also highlight the importance of modelling and refining an intervention as well as determining its feasibility before it can be applied to large scale study.[149] If a particular intervention works on a smaller sample size during a feasibility study, it increases its applicability in full scale research, in a wider range of situations, and larger sample populations as well.[138,150] Furthermore, the MRC's new guidelines for the development and

evaluation of complex interventions also proposes the use of feasibility and piloting stages for research studies so that preparatory work is undertaken. This includes the testing of study procedures for their acceptability, establishing the likely recruitment and retention rates of the sample population, as well as the calculation of sample sizes.[149]

Feasibility studies are able to utilise a number of methods, including qualitative, quantitative, and mixed methods.[152] The new MRC guidelines also advocate the use of a mixture of methods, as this is more likely to have a greater effectiveness in assessing the feasibility of running a definitive RCT of a complex intervention.[149] It is proposed that there are some recommendations that can enhance good practice in terms of the pilot/feasibility study design.[153] These recommendations are based on seven evidence-based key objectives, which are likely to contribute towards improved scientific rigour of a pilot/feasibility study, and also enhance the interpretation of its results. These objectives include the following:

- Testing the integrity of the study protocol for future trial;
- Securing initial estimates for sample size calculation in the future;
- Testing data collection forms and questionnaires;
- Testing the randomisation procedure;
- Estimating recruitment and consent rates;
- Determining the acceptability of the intervention;
- Selecting the most appropriate outcome measure.

Furthermore, it is important to state the criteria for success of a feasibility study.[153] The criteria should be based on the primary feasibility objectives. In general, the outcome of feasibility studies should conclude with one of the following four recommendations[153]:

- Stop; as a main study is not feasible.
- Continue but with modified protocol; as the study is feasible with modifications.

- Continue without modifications but close monitoring is needed; as a study is feasible with close monitoring
- Continue without modifications; as the study is feasible.

3.4.2 Study Three: methods

This current feasibility study is the foundation for a definitive study to assess the effectiveness of the ACTPC in the hospital setting. A prospective before-and-after study method was selected to identify the most efficient and effective ways to measure the impact of the tool on patient outcomes and workload patterns. A before-and-after study design measures an outcome before and after a particular intervention is implemented.[153] This was the most appropriate design for the feasibility study, as this approach would reflect the experience of participants at an individual hospital level (i.e. the cluster) in a subsequent cluster randomised control trial.[149] Furthermore, this research method is suitable as it identifies if an outcome is impacted by the intervention, or not.[153]

A pre-post study design has many advantages, including simplicity, convenience, circumvention of ethical issues, low-resource requirements, and associated costs.[154] In addition, it has the strength of temporality to be able to suggest that the outcome is impacted by the intervention.[155] However, it cannot tell the researcher for certain that the intervention deployed was the cause of improvements.[155] Another limitation of this design is that it cannot control for other factors that may have occurred simultaneously to the intervention and that may have contributed to the change in outcome.[154] Therefore, bias can sometimes be introduced in this design.[154]

A pre-post prospective feasibility study was conducted between July 2019 and January 2020 at three NHS acute hospital trusts. The third study aimed to measure the number and severity of prescribing errors, the number and types of interventions made by the ward-based clinical pharmacists in the AMU, length of stay in hospital, 30-day readmission rate, patient's experience and views of medication safety and the amount of time that pharmacists spend on tasks.

All these outcomes are of interest to the research team as they have impact on patient care.[156–160] The length of stay in hospital has been recommended as a useful outcome measure that could be used as a potential target for quality improvement activities in hospital settings.[157,159] In addition, readmission rates in hospitals are constantly being used for both quality improvement and cost control.[156] In terms of prescribing errors (PEs), it is estimated that they are responsible for a substantial proportion of all medication errors and are an important cause of harm to patients[158] making them a priority area for patient safety initiatives.[160] Therefore, these outcomes measures are considered important measures that the use of the ACTPC could have impact upon.

The feasibility study was divided into a 3-week pre-implementation of the ACTPC phase, a 1-week implementation period, and a 3-week post-implementation phase (the ACTPC still used during this phase) in each site sequentially (Table 3). The inclusion of three sites allowed us to explore the feasibility of implementing the ACTPC across settings with different resources, systems and processes. We designed the tool to be transferable across all settings.

Table 3: *Study periods for each hospital pre and post implementation*

Hospitals contributing in the feasibility study	Before implementation of the ACTPC- over a three-week period	Implementation of the ACTPC- over a one-week period	After implementation of the ACTPC- over a three-week period
Hospital A	**14 October 2019 - 01 November 2019**	**04 November 2019 - 08 November 2019**	**11 November 2019 - 29 November 2019**
Hospital B	**28 October 2019 -15 November 2019**	**18 November 2019 - 22 November 2019**	**25 November 2019 - 13 December 2019**
Hospital C	**25 November 2019 - 13 December 2019**	**16 December 2019 - 20 December 2019**	**23 December 2019 – 08 January 2020**

3.4.2.1 Implementation description

The implementation refers to the use of the ACTPC by pharmacy professionals (Appendix 6&7). Tool completion involves the identification of specific risk factors in patients at their point of admission to an adult acute medical unit. Appendix 8 provides the guidance given to ACTPC users.

It is possible that, if someone is categorised as 'low risk', they may not be seen frequently enough if they deteriorate, medication is changed or if the complexity level is wrongly allocated by the pharmacist. However, there is already a system in place which involves the AMU's medical or nursing staff communicating with pharmacy staff on a daily basis to tell them about any deterioration in a patient's condition. In other words, if the patient needs to be seen by pharmacists, the nurses or clinicians will contact the pharmacy staff to inform them of this, as they currently do as part of usual practice

.

3.4.2.2 Study Three: rationale for using qualitative and quantitative study

The objective of this feasibility study was to assess the ACTPC in terms of its practicality, and inform the design of a future cluster randomised control trial. It was estimated that the

use of both qualitative and quantitative methods would lead to more complete and enhanced assessment of the feasibility of using ACTPC. The planned qualitative component of this study was also thought to be helpful in achieving this by developing an understanding of participant experiences of using the ACTPC. Therefore, a mixed-methods approach was used to achieve the research objectives and to generate a comprehensive assessment of the feasibility and acceptability of the ACTPC. Using a mixed methods approach is more beneficial than when using either quantitative or qualitative approaches individually, and thus adopted.[114,161] The quantitative approach enabled the researcher to test how best collect data on outcomes and to calculate the sample size for a future cluster randomised control trial while the qualitative approach provided data on individual experiences and perspectives. The mixed-method approach has been previously used in healthcare research and provides valuable direction and actions for future trials.[138] The quantitative approach prospectively measured the length of stay (LoS), 30-day readmission rate, prescribing error (PE) rate, medicines optimisation interventions and the amount of time that pharmacists spend on tasks. Furthermore, the qualitative approach, using interviews and observations, explored the acceptability, feasibility and transferability of the tool on the acute medical units.

As mentioned in the first chapter of this thesis, this feasibility study contains multiple studies. However, the qualitative study was excluded from this thesis as it was undertaken by other researchers due to the time constraints of a PhD. However, all documentation for the qualitative and quantitative study were prepared and completed by the researcher (MA) as part of the overall study approval process and included the following:

- Patient Participant Information Sheet (Appendix 9)
- Pharmacist Participant Information Sheet (Appendix 10)
- Pharmacist Consent Form (Appendix 11)

- Semi-Structured Interview Schedule for Healthcare Professionals and Stakeholders (Appendix 12)
- Healthcare Professional Participant Information Sheet (Appendix 13)
- Healthcare Professional Participant Consent Form (Appendix 14)

A research associate was recruited after ethical approval was granted to conduct interviews and observations and assist with the write up of the qualitative study data. Therefore, the quantitative study only will be explained in greater detail in the sections below.

3.4.2.3 Aim and objectives of the quantitative study

The aim of the quantitative study is to determine the most appropriate measures of patient and pharmacy outcomes and to a calculate sample size for the future study.

The objectives of the quantitative study were to:

1. Identify and quantify the most efficient and effective ways to measure the impact of the tool on patient outcomes and pharmacy staff workload and patterns;
2. Calculate required sample sizes for the future stepped wedge cluster randomised control trial.

3.4.2.4 Study setting

The study was carried out on the AMU of three NHS hospital trusts in the UK. Site A contains 54 beds with approximately 1100 admissions per month and 7 pharmacy staff. Admissions pharmacists provide cover 7am-8pm and 9am-5.15pm at weekends. Site B has 49 beds with approximately 800 admissions per month and two pharmacists. An admissions pharmacist is available 9am-5pm and 9am-1pm at weekends. Site C contains 56 beds with approximately 622 admissions per month and 6 pharmacy staff. Admissions pharmacists provide cover 8am-5.30pm and 9am-5pm at weekends.

3.4.2.5 Study sample size

As the quantitative study aims to measure several outcomes, (including but not limited to prescribing error rate, length of stay in hospital, 30-day readmission rate, the number and types of interventions made by pharmacists, patient experience and views of medication safety and pharmacist time spent on tasks) the sample size was different for each outcome as follows:

3.4.2.5.1 Prescribing errors and interventions

Sample sizes between 24 and 50 have been recommended for a feasibility study.[153,162] However, in order to conduct a rigorous data collection process, the sample size calculation was completed based on a previous rate of prescription errors on an acute medical unit in the UK as 45%; power 80%; level of significance of 0.05 and assuming that the ACTPC has a 10% reduction on prescribing errors. Below summarises the sample size calculation based on Dawson and Trapp calculations.[163]

The sample size for the research was calculated using the following formula.

n= (p1 (100-p1) +p2 (100-p2)/ (p2 - p1)^2 ×f (α,β)

Description:

n = desired sample size

p1 = estimated prevalence of the characteristic of interest in the project area = (45%)

p2 = % success in the two groups (10% of reduction= 35%)

α – level of significance

1-β – statistical power of study

F (α, β) – value given (7.9)

Sample size= (45(100-45) +35(100-35) / (35 - 45) ^2 ×7.9

Sample size= 375

3.4.2.5.2 Patient experience

Patient's experience and views of medication safety was collected using a validated Medication-Related Patient Measure of Organisation Safety (MR-PMOS) questionnaire

(Appendix 15). The eligibility criteria for patients taking part in this part of the study include all those admitted to the AMU for more than 24hrs, which can be identified by the AMU clinical pharmacist who can check the patient's medical record for the time of admission; those patients who are able to read, understand and speak English and aged 18 years and over. The AMU pharmacists will be aware of the clinical status of the patient, and have access to their medical records, as part of their usual role. Data was collected over one day before implementation of the tool and one day after the implementation. We aimed to distribute approximately 75 questionnaires for completion before the implementation and 75 questionnaires after implementation of ACTPC.

3.4.2.5.3 The amount of time pharmacists spends on tasks (Time and Motion Study)

All pharmacists working on AMU were eligible for inclusion. Up to 15 pharmacists before and after the implementation of the tool were invited to participate in the Time and Motion Study. Data were collected at the three hospital sites on weekdays (Monday to Friday) on three individual days on the AMU before the implementation of the ACTPC and three individual days after implementation.

3.4.2.6 Training of data collectors

Before commencement of the pre-implementation phase, hospital pharmacists working in the AMU were trained on how to use the ACTPC and the data collection forms. The training session was undertaken on NHS hospital premises (following an arrangement with each NHS trust coordinator regarding appropriate dates and locations for the training to take place). The training session was conducted in a convenient and appropriate room, which accommodated up to 10 persons. The room contained the necessary equipment for visual materials, such as a projector and screen. Refreshments were provided for pharmacists during the session.

Pharmacist data collectors received a face-to-face training session by the lead study investigator MA supported by PL. The training session provided a general overview of the study's aims, a definition and a discussion of prescribing errors, the electronic data collection form (using example of Form^{2}™) and step-by-step instructions explaining how to collect data (Appendix 16&17). The pharmacists were also provided with the ACTPC tool and an explanation of how it works. In addition, three theoretical case studies were provided to the pharmacists in order to establish and clarify their understanding of the tool use following the training session (Appendix 18).

The attendees had ample opportunity to explore and clarify their own understanding of the topics covered with the researcher and their peers. In addition, iPads were provided to the pharmacists during this session in order to establish and clarify their understanding of the data collection process prior to data collection.

All participating hospital sites received a study manual containing all the information covered in the training session including the guide on how to use the electronic data collection form (Appendix 17). All study materials (e.g. study manual, data collection forms and the training PowerPoint presentation) were available to data collectors in their trust via a pharmacy shared drive. Data collectors were invited to contact the research team at any time with any queries they had regarding the study. At the end of the training session, participants received an evaluation form to ensure whether the outcomes have been achieved (Appendix 19).

3.4.2.7 Data collection

Data collection was planned for different outcomes including, the number and types of prescribing errors detected by pharmacists and interventions made before and after ACTPC

implementation, length of patient stay in hospital, 30-day readmission rate, patient experience and the amount of time that pharmacists spend on tasks before and after ACTPC implementation (Time and Motion study). Data collection was conducted on three days over a three-week period during both the pre- and post- implementation phase. Despite this being a feasibility study, we managed to collect data over three days to reach our sample size calculation. The AMU capacity is between 49-56 beds. We assumed that AMU pharmacists could review 40 patients daily in each participating hospital. The total number of patients who would be reviewed daily in three hospitals is 120 patients. Therefore, three days of data collection of PEs would be enough to reach the sample size calculation (sample size=375patients). The data were collected by ten pharmacists.

The implementation phase was conducted for one week after the pre- implementation phase to ensure pharmacists were familiar with the tool. During this phase, the ACTPC was implemented and no data were collected. All outcomes measured by the quantitative study were collected during the pre- and post- implementation phase. The section below will explain how and when the data were collected.

3.4.2.7.1 Pre- implementation phase

During the pre-implementation phase, usual practice did not change and patient services did not alter. Various outcomes were collected during this phase in the three hospital sites as follows:

Prescribing errors and medicine optimisation interventions

We used an established definition of a prescribing error as ‘‘one which occurs when, as a result of a prescribing decision or prescription- writing process, there is an unintended, significant reduction in the probability of treatment being timely and effective, or increase in the risk of harm when compared with generally accepted practice’’.[164] Prescribing errors (PEs) did not include errors where patients had not been prescribed their regular medicines

on admission. Pharmacist interventions include identification and rectification of prescribing errors, optimisation (the enhancement of a patient's medication to improve efficacy of therapy) or a 'consult' (reactive provision of advice to a patient and/or a healthcare professional regarding a specific medication issue).[165]

Data related to the prescribing errors identified and medicines optimisation interventions made for patients admitted to the AMU before the implementation of the ACTPC tool were recorded by the clinical pharmacists employed by the participating NHS trust. They recorded information about prescribing errors and medicine optimisation interventions that they identified during their usual practice of screening and reviewing patient prescription charts. Recording information about these tasks was the only additional research activity for the pharmacists. The data were collected on one day per week over three weeks prior to the implementation of the ACTPC.

The data collection form was designed in an electronic format to be completed by the AMU clinical pharmacists. It did not include any identifiable data about the screened patients or the AMU pharmacists (data collectors). Data collection occurred on working days between 8:30 AM and 5:00 PM. It is normal practice in the UK for ward-based clinical pharmacists to check inpatient prescriptions at regular times and for medicines reconciliation to be undertaken. Inpatient charts are checked on a daily basis by the ward-based clinical pharmacists and discharge prescriptions are also reviewed and authorised before medication is provided. As far as electronic prescription orders are concerned, they can be checked on the hospital wards or in the pharmacy and can be amended or clarified based on a pharmacist's clinical judgement. The pharmacists may also discuss any recommendations or safety issues they identify with the clinical team. The collected data included patient age, number of prescribed medicines including pre- admission medicines and newly prescribed medicines, number and nature of any prescribing errors and number and type of

interventions made by the AMU pharmacists and number and type of omitted medicines including time critical medicines prior to medicine reconciliation. (see Chapter 6, Section 6.2.2.1 for detailed data collection on PE for Study Three)

Patient experience

Patient's experience and views of medication safety were collected using a validated Medication-Related Patient Measure of Organisation Safety (MR-PMOS) questionnaire (Appendix 15). The research associate distributed and collected the patient information sheet (Appendix 9) together with the anonymous questionnaire to the eligible patient (Appendix 15). The questionnaire does not contain any personal information or any identifiable patient data. Data was to be gathered over one day over a period of 3 weeks before the implementation of the tool.

The amount of time pharmacists spend on tasks (Time and Motion Study)

The time and motion study was part of the feasibility study in two hospitals only. The initial aim was to include all three hospitals. However, after initial approvals, hospital C had to be excluded from this part of study because of technical issues. These issues were related to hospital C's electronic prescribing system, which shut down for a while (approximately two weeks) and therefore pharmacists adopted a paper system as an interim measure. This was problematic for the study because their usual practice was disrupted. The research team therefore agreed that it was best to exclude hospital C from the time and motion study only. All pharmacists working on AMU in sites A and B were included in this study.

The time and motion study aimed to quantify how pharmacists distribute their time across various daily tasks and interactions both with patients and other healthcare professionals. The research associate approached pharmacists working at the AMU to establish if they would like to participate in the study. The participant information sheet (Appendix 10) and

a copy of the consent form (Appendix 11) were given to all AMU pharmacists. If they agreed to participate in the study, the pharmacists were asked to contact the research associate with a signed hard copy of a consent form and proposed a time convenient for the participant to be observed. The research associate observed the pharmacist and recorded the time spent per task on an electronic data collection form which has been made for this purpose. The form did not include any identifiable data of the screened patients. Data were recorded one day per week over a period of 3 weeks before the implementation of the tool. (see Chapter 6, Section 6.2.2.5 for detailed data collection on Time and Motion Study). Due to the delay in the process of recruiting a research associate to collect data for this study, conducting a pilot test of the data collection form in the hospital was difficult. Therefore, the research team considered that the first observation day in each participating hospital to be a pilot test for the data collection form. No major changes to the data collection form were required after this pilot. The data collected on the two days were not excluded from the total observation time.

The length of stay (LoS)

The researcher collected this information by contacting staff in each of the hospitals' business intelligence departments and asking them to provide the aggregated data of the LoS within a period of 3 weeks before the implementation of the tool. No patient identifiable data were sent to the researcher.

30-day readmission rate

The researcher contacted the business intelligence department in each participating hospital to obtain the aggregated number of patients admitted to the AMU and discharged from the AMU (denominator) during the pre-implementation period (3 weeks); then the aggregated number of those patients who were readmitted to all hospital wards within the 30-day period (numerator) to establish the rate of readmission. The readmission rate is the aggregated

number of readmission (numerator) divided by the aggregated number of discharge patients (denominator). No patient identifiable data were collected by the researcher.

3.4.2.7.2 Implementation phase

The implementation phase was conducted after the pre implementation phase over one week at each site. The implementation was described above (See section 3.4.2.1). During this phase, the ACTPC (Appendix 6&7) was implemented and no data were collected and no patient services altered.

3.4.2.7.3 Post implementation phase

The post implementation phase was conducted after the implementation phase over three weeks in each site. The ACTPC was still used during this phase. The same data were collected in the post implementation stage as in the pre implementation stage.

3.4.3 Study Three: data analysis

Data obtained from the feasibility study were analysed to determine the most appropriate outcome measures for the future cluster randomised control trial and to do a power calculation. Data were classified into the length of stay (LoS), 30-day readmission rates, prescribing errors (including the number, type and severity), medicines optimisation interventions and pharmacy staff time spent on tasks.

Subsequently, the base file was exported as an Excel spread sheet then coded, entered into SPSS 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp) and analysed. Once the data was cleaned, it was stratified by hospital and described in terms of mean (standard deviation (SD), median (inter-quartile range (IQR), counts and frequency as appropriate. Comparisons between the data for each

hospital before and after the implementation were made using ANOVA for parametric data, Kruskal-Wallis test for non-parametric data and chi-square test for categorical data.

Data types can be categorical or quantitative.[164] Categorical data can be ordinal or nominal, whereas quantitative data may be measured or counted[164]. It is essential to define if the data is parametric or non-parametric, and this can be done by testing for normality. For measured data, normally distributed data is parametric, and vice versa.

A t test for independent samples could have potentially been used to test for differences between pre and post in relation to number of doses missed, number of doses missed of time critical medications, number of doses received before identification of the prescribing errors and time of pharmacist activities, as the independent variable is categorical with two levels (pre and post) and the dependent variables are continuous. In order to decide which test could be used, it was necessary to examine whether the variables (outcome measures) were normally distributed or not for each hospital site in both the pre and post data. This showed that these variables were not normally distributed and so the independent samples t test was not considered an appropriate option, and the none parametric alternative (Mann Whitney) was used instead.

Comparisons between the data for each hospital before and after implementation of the ACTPC were made using Mann-Whitney tests for continuous data and Chi-square test for categorical data to examine whether there were statistically significant differences between each hospital site before and after implementation. Furthermore, Kruskal-Wallis Rank and Chi-square tests were also performed on the data to see whether the results can be combined. Kruskal-Wallis Rank was considered as appropriate because the independent variable (site) has three levels and the dependent variables are continuous. In all statistical tests, p values of less than 0.05 were considered statistically significant.

The measuring of prescribing errors per patient in this feasibility study is essential to demonstrate the tool's validity in its ability to accurately reflect differences across patients according to the Red, Amber and Green (RAG) rating. Furthermore, expressing the error rate per patient demonstrates the impact that the use of the tool has on the number of patients experiencing errors with their medicines, making patient experience the priority rather than the more process orientated outcome of errors per prescriptions. Therefore, the analysis of prescribing errors was measured per patient rather than per prescribed item.

Furthermore, every patient has an equal opportunity to have an error[166] and people with prescribing errors in this feasibility study are just by chance. Hence, we compared serious/significant and minor prescribing error rates as a proportion of total patients in the study phase, rather than the proportion of total patients with prescribing errors.

The analysis provided an understanding of the usefulness of the tool, for instance, any change in prescribing errors and any change in the number of medicine interventions made by the pharmacist and the time spent on each task before and after implementation of the ACTPC. To ensure the data quality and to avoid any missing data, the electronic form (Form^{2TM}) has been designed so no section can be omitted. Furthermore, all forms were submitted directly to the university server ensuring no form is missing.

3.4.4 Study Three: ethical approval

Ethics application for the Third Study was first made to the University of Manchester who issued a temporary protocol number (UoM Ref: NHS001570; appendix 20) with direction to apply for approval from Health Research Authority (HRA) and Research Ethics Committee (REC). An approval was given by HRA and Health and Care Research Wales (HCRW) (IRAS# 261401; Appendix 21). Furthermore, a favourable ethical opinion was obtained by REC Committee Yorkshire & The Humber - Sheffield Research Ethics

Committee (REC# 19/YH/0285; Appendix 22). Amendments to the original ethics application were made, including the collection of qualitative data from pharmacy technicians, extension of the study end date and a change in PI for one participating hospital. All amendments were approved (see Appendix 23 and Appendix 24 at the end of the thesis). Detail of ethical considerations for this study are described below.

3.4.5 Study Three: ethical considerations

A number of ethical issues were considered during the design and conduct of Study Three. This study will follow the ethical principles of the "UK policy framework for health and social care research", Good Clinical Practice (GCP) and within the laws and regulations of England in which the research is conducted.

1) Confidentiality and data security:

- The study had NHS Research Ethical Approval and HRA Approval.
- Data on prescribing errors and medicines optimisation interventions were collected by clinical pharmacists employed by the participating NHS trusts. It is usual practice for pharmacists, they prospectively examined the drug charts of patients admitted to adult medical units at the participating NHS trust sites in order to identify any prescribing errors and medicines optimisation interventions as part of their role as a ward pharmacist and as per routine practice. Recording information about the prescribing errors and interventions on the data collection form was the only additional research activity. No personal identifiable data were collected about the patients or the data collectors during the prescribing errors and medicines optimisation interventions study.

- The research associate in the time and motion study observed the pharmacists/pharmacy technicians, to investigate how they used the ACTPC tool and how much time was required to assign complexity levels to patients. No personal identifiable data was collected about the patients or colleagues that they interacted with during the observation

- Patients were asked if they are willing to complete the MR-PMOS questionnaire. The questionnaire was completed anonymously and did not contain any personal information or any identifiable patient data. Questionnaires were kept secure in a locked filing cabinet at the University of Manchester. All questionnaire data collected from patients for this study were stored securely in locked filing cabinets located in a locked office on the premises of the University of Manchester and will be kept for five years after publication of the research. The filing cabinets were locked and only the researcher and his supervisors will possess the keys.

- Confidentiality were guaranteed to all participants and maintained throughout the project. All quantitative data did not include any identifiable patient data. The quantitative data collected were entered into statistical software SPSS 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp) on a University-owned computer and stored on the secure University of Manchester Research Data Storage (RDS). The data collected were only used for this research study. All data will be retained for 5 years in accordance with the policy of the University of Manchester and at the end of this time period data will be disposed of securely.

2) Risk of prescribing errors or any signs of malpractice/negligence identified by local data collector:

If the pharmacist data collectors find any cases of malpractice/negligent practice or identify prescribing errors that carry risk to patient safety, they were reminded to investigate and report these events using the normal hospital procedures as per usual practice.

3) Risks involved in the use of ACTPC:

It was possible that, if someone was categorised as 'low risk', they might not be seen frequently enough if they deteriorate or if the complexity level was wrongly allocated by the pharmacist/pharmacy technician. There is already a system in place which involves the AMU's medical or nursing staff communicating with pharmacy staff on a daily basis to tell them about any deterioration in a patient's condition. In other words, if the patient needs to be seen by pharmacists, the nurses or clinicians will contact the pharmacy staff to inform them of this, as they currently do.

4) Emotional distress for data collectors or interviewees:

The data were collected for three days over three weeks, i.e. with a week between each day of data collection; thus it would not have much impact on the data collectors' workload and emotional state. It was not expected that there would be any emotional distress for data collectors who might find cases of prescribing errors afflicting patients, as this is their routine work. The only additional research activity was that they recorded these patient outcomes on the data collection sheet. However, they were reminded:

A- To report any distress cases to the NHS site coordinators, sponsor and principal investigator.

B- To stop collecting data and to go to quiet and comfortable space to disengage from the study if they have any instances of emotional distress. Data collectors were reminded to engage with their local well-being service (Occupational Health Service) at the hospital.

4. Chapter Four: Study One

Title	Patient prioritization for pharmaceutical care in hospital: A systematic review of assessment tools
Type	Review article
Authors	Meshal A. Alshakrah, Douglas T. Steinke, Penny J. Lewis
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Patient prioritization for pharmaceutical care in hospital: A systematic review of assessment tools

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Abstract

Background: Clinical pharmacy services improve patient safety, outcomes, and care quality; however, UK clinical pharmacy services face limited resources, insufficient capacity, and patients who present with increasingly complex medication regimes and morbidities. These indicate a need for the prioritization of pharmacy services. Several prioritization tools have been developed; however, there has been no comprehensive review of such tools to date.

Objective: A systematic review was conducted to provide a structured overview and description of existing assessment tools with a focus on study quality, themes, tool validity, risk factors, and high-risk drug classes.

Methods: Systematic searches for English-language publications (from 1990 to September 2017) were conducted in Embase, Medline, Scopus, International Pharmaceutical Abstracts, and Web of Science. Papers in the inpatient setting and in which the tool users were pharmacists or pharmacy technicians were included. Data on each study (e.g. aim and design) and the structure of tools (e.g. risk factors) from each included study were extracted by 2 independent reviewers. A descriptive analysis was conducted to summarize these tools along with a thematic analysis of study findings. The quality of each paper was assessed using the Hawker method.

Results: Nineteen studies involving 17 risk assessment tools were included. Most tools were developed in Europe (76.5%) and published in the last 5 years (82%). Most tools (88%) were designed to identify patients at greatest risk of adverse drug reactions, adverse drug events, or medication errors and to guide appropriate pharmaceutical care. Ten out of 17 tools (59%) were validated. None showed a measurable impact on prescription errors or adverse drug events. Keys themes identified from the studies were the positive impact of

risk assessment tools on both patient care and provision of pharmacy services as well as the limitations of risk assessment tools.

Conclusions: Current assessment tools are heterogeneous in their content, targeting diverse patient groups and clinical settings making generalization difficult. However, an underlying theme of all studies was that tools appear to achieve their aim in directing pharmaceutical care to where it is needed most which might provide reassurance and incentive for greater adoption and development of tools across clinical pharmacy services. However, further research is required to measure objectively the impact of tools on patient outcomes and on workforce efficiency so that comparisons can be made between tools.

Keywords: pharmacy prioritization, patient safety, care quality, risk assessment, patient priority, assessment tool

4.1 Introduction

Drug-related problems (DRPs) are a major concern for policymakers and practitioners in healthcare systems globally. They place a substantial health and economic burden on both the patient and healthcare system.[1–4] DRPs could account for about 28% of patient visits to the emergency department.[5] The rate of medication related hospitalization ranges from between 2 to 5.6%.[6,7] Despite this, many DRPs can be prevented, thus reducing the length of hospital stays, associated costs, as well as morbidity and mortality.[8,9] Interventions to identify and minimize DRPs have key clinical significance in instituting prompt and effective therapeutic interventions.[10]

Clinical pharmacy services can be defined as the pharmacist led services that contribute actively to patient care in order to optimize drug therapy outcomes, these might include but are not limited to patient education, adjustment or monitoring of medication and reviews of medication charts.[11,12] There is evidence to suggest that clinical pharmacy services improve patient safety[12,13]and that clinical pharmacists are major contributors to the identification, rectification, and prevention of DRPs[14] which can decrease the length of hospital stays.[12]

Ideally, each hospital pharmacy would have the resources to provide comprehensive clinical pharmacy services to every patient based on their needs.[15] However, pharmacy departments are faced with numerous challenges, such as reduced funding, staffing issues, which are combined with an increasing number of elderly admissions with multimorbidities and polypharmacy, and a demand for a 7-day clinical services.[15–22] This has led to more innovative approaches to service delivery, which means that comprehensive clinical pharmacy services are not provided to all patients.[15,17,21,23,24] Prioritization of clinical pharmacy services has been identified as one of the solutions for achieving cost effectiveness and increased productivity.[15,17,19,22–24] Therefore, there is a necessity to assess and prioritize patients who are in most need of input from the pharmacist. This approach

would improve the delivery of clinical pharmacy services within a resource-limited healthcare service with the aim of enhancing patient care.[21]

For the early detection and prompt management of high-risk patients in clinical settings, several risk assessment tools have been developed. Several such tools exist in pharmacies and help with the assessment of patient acuity, which is defined as the ability to predict patient requirements for care.[25] These tools differ from each other concerning the target patient group (e.g., pediatrics, adult), address diverse sources of DRPs, and the setting that they were developed for (e.g., primary or secondary care).

Despite the existence of multiple tools, a comprehensive review of these instruments has yet to be undertaken. Therefore, a systematic review was conducted to provide a structured overview and description of existing assessment tools used by hospital pharmacies that assess patient priority and/or complexity with a focus on study quality, themes, tool validity, risk factors, and high-risk drug classes. The findings of a review of current approaches to prioritization may be useful to both pharmacists and researchers who may want to compare the tools and findings or design a new tool for local needs in daily practice.

4.2 Methods

4.2.1 Literature search

This review follows PRISMA Guidelines for reporting systematic reviews.[26] Medline, Embase, International Pharmaceutical Abstracts, Scopus, and Web of Science electronic databases were used in the search from January 1990 to September 2017. The reference lists of all included studies were also searched manually. The search involved the use of synonyms, truncation symbols, such as an asterisk (*), as well as Boolean terms “OR” and “AND,” which made the search more general or more specific, respectively. Four keywords—priority, tool, hospital, and pharmaceutical care—were used to start the search

(Table 4). The keywords and their synonyms together with the Boolean operators "AND" and "OR" were used to obtain the articles. The search strategy is supplied in appendix 4.A. After the database search was complete, all duplicate citations were removed using Mendeley reference management software (Elsevier, 2017). Following this, the reviewer (MA) assessed publications for eligibility by title, abstract, or full text screening. Any article for which there was uncertainty regarding inclusion or exclusion was discussed between 3 authors (MA, DS, and PL) until agreement was reached.

***Table 4**: Search keywords*

Search Keywords		
1. Priority	OR	priorit*, triage*, acuity, complex*.
2. Tool	OR	tool*, scor*, screen*, criteria, scale, classif*, assess*, clinical assess* tool*, instrument*, measure*, stratif*, software.
3. Hospital	OR	hospital*, secondary care.
4. Pharmaceutical care	OR	pharmacy, pharmacist*, pharmaceutical, pharmac* service*, hospital pharmac*, clinical pharmac*, clinical pharmac* service*
5. 1 AND 2 AND 3 AND 4		

4.2.2 Inclusion criteria

Studies where the tool users were pharmacists or pharmacy technicians were included. All age groups of patients were included in the literature review; i.e., children, adults, or the elderly. Only studies of tools used in the inpatient setting were included as the acuity of patients and the clinical services offered by pharmacies differ substantially in other settings such as community pharmacies or hospital outpatients.

Studies using quantitative, qualitative, or mixed methodology; published reviews; as well

as conference abstracts with sufficient detail related to the tool description were included in the search. In general, as the definition of pharmaceutical care was first introduced in 1990, all the studies published since that date until the date of the search (updated on November 30, 2017) were included in the review.

4.2.3 Exclusion criteria

Papers written in languages other than English were excluded because analyzing and describing the tools required a complete understanding of the text.

4.2.4 Data extraction and quality assessment

To achieve consistency, reduce bias, and ensure the extracted data were valid, standardized data extraction forms were developed and used. The data extracted from the studies included the author, the country, study aim, design, duration, sample size, population group, tool type, tool benefits, tool limitations, study limitations, and tool validity. For each study, data were extracted by 2 of the authors independently (MA and PL), with any disagreements in extraction being resolved by discussion between all authors (MA, DS, and PL).

A thematic analysis was conducted with data collected from the included articles. Overarching themes were iteratively and inductively identified using the following steps: the articles were read to gain familiarization and understanding of their content.[27] Following this, a list of key ideas was generated and grouped; these were then coded in the articles using distinct colored highlighters to indicate potential patterns. Codes were grouped together into categories. The initial codes and categories were reviewed and agreed by the authors, after which they were applied in each included paper. Before the data were entered into the framework matrix using an Excel spreadsheet, the data had been summarized. Once all the data were coded, the codes were sorted into the overarching themes. Finally, the identified themes were collated and analyzed to interpret the underlying meanings, which

were labelled as subthemes. The thematic analysis was performed by two authors (MA and PL). During all stages there were repeated discussions between all authors (MA, DS, and PL) of the overall interpretation of the data.

The quality of included papers was assessed by MA using the quality assessment tool by Hawker and colleagues.[28] It is considered appropriate for use in this review because it appraises disparate publication papers, accounting for qualitative, quantitative, review articles, and conference abstracts. In addition, it is more consistent to use this checklist, as opposed to individual checklists for each type of study. Furthermore, the 9-item checklist allows the researcher to quantify and score results, thus enabling comparison of quality between publication papers to identify areas that are weak/strong.

Hawker's assessment tool includes 9 questions with 4 criteria: good, fair, poor, and very poor. Having applied the tool to the reviewed studies, a number was assigned to each section of the included studies as follows: 4 for good, 3 for fair, 2 for poor, and 1 for very poor. This produced a score for each study that ranged from 9 to 36. Hawker and colleagues do not suggest any limits for categorizing the sum quality rankings of the article.[28] However, previous studies[29,30] have divided categories into high quality, medium quality and low quality. This stratification of quality has been adapted to the current review and the descriptors for the overall quality were also provided with the ranges in the score: 9–23 points for low quality (C), 24–29 points for medium quality (B), and 30–36 points for high quality (A). The summary of the quality assessment is supplied in appendix 4.B.

4.3 Results

Overall, 14,937 articles were retrieved: Medline (n = 600), Embase (n = 6369), International Pharmaceutical Abstracts (n = 618), Scopus (n = 6,266), and Web of Science (n = 1,084). Of these, 5,683 were removed because of repetition and 9,239 were removed for irrelevance. After reviewing the titles, abstracts, and full texts, fifteen publications were identified as being relevant. A further manual search of the reference lists of retrieved articles led to the identification of 4 additional articles. Therefore, the reviewers agreed on a final selection of 19 publications for inclusion. A flow chart of this process is presented in Figure 5.

Nineteen studies (shown in Table 5) evaluated 17 scoring tools for assessing the risk of DRPs and prioritizing the need for pharmaceutical care for patients at the greatest risk of DRPs. All scoring tools were developed by pharmacists and relied on their knowledge and expertise. In other words, all tools were designed by those that would use them.

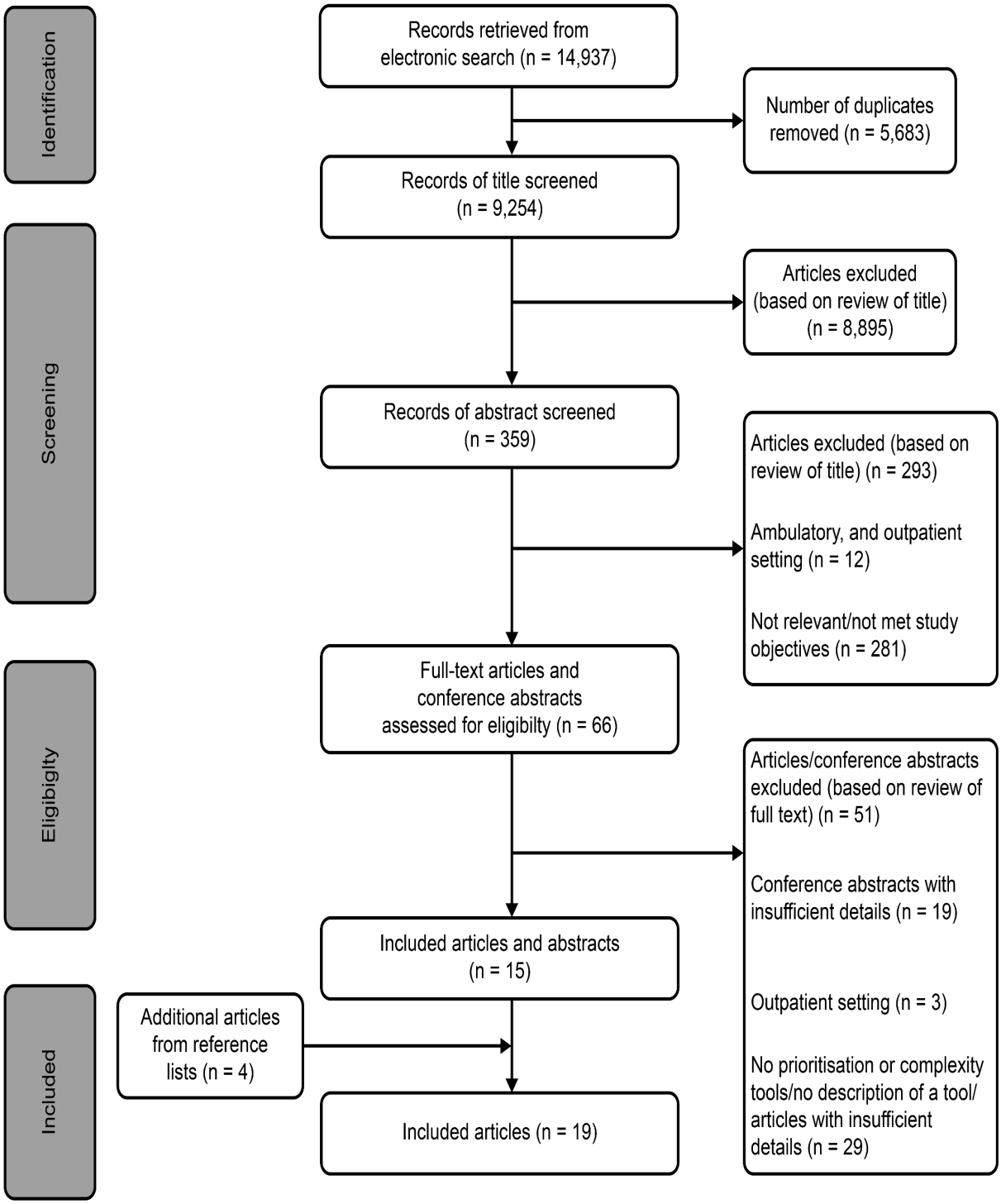

***Figure 5**: Flow diagram of articles included/excluded in the systematic literature review*

***Table 5**: A summary of the studies related to the pharmacy risk assessment tools*

Reference year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
Carlson and Phelps (2015)[31]	U.S.	To describe an electronic clinical scoring system to prioritize patient medication monitoring	Descriptive article	NR	NR	In-patients pediatric and adult patients	E	Ph	Enables the identification of patients who could benefit from detailed MedRec	Improves pharmacists' efficiency allowing them to focus their time on high acuity patients	NR	Review article	NR
Cottrell et al. (2013)[32]	U.K.	To develop a tool to identify patients at greatest risk of harm of medication incidents using real time prescribing information from HEPMA	Prospective cohort study	Apr–Oct 2009 Apr–Oct 2011 (12 M)	Fifteen patients, 5 from each risk category (low, medium, and high)	In-patients	E	Ph	Helps to provide safe, effective, and patient centered care.	It has a positive impact on the timely provision of pharmaceutical care to high-risk patients	Does not currently incorporate data from laboratory and other clinical systems; Does not capture co-morbidities and deranged blood results	Small sample size	Validated tool
Covvey et al. (2015)[33]	U.K.	To evaluate a triage tool to prioritize obstetric pharmacy services	Retrospective chart review	June 2014 (1 M)	175	Obstetric patients	P	Ph	Opportunities to improve MedRec, multidisciplinary team coordination and prevention of adverse events	Identifies and prioritizes high-risk obstetric patients for pharmacist review	Measures only obstetric patients. Additional research needed to expand to diverse populations	Small sample size. Capture of pharmacy intervention excluded verbal pharmacists' recommendations	Validated tool

***Table 5**: Continued*

Reference year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
El hajji et al. (2015)[34]	U.K.	To develop a predictive model to identify patients at high-risk of readmission and post-discharge mortality to prioritize CPS	Retrospective chart review	Oct 2003-Sep 2008	806	In-patients who had received the IMM service at the hospital	NR	Ph	Can be used to identify patients at high risk of readmission, mortality and longer hospital stay	Enables the prioritization of CPS to optimize patient outcomes	It is a complex risk assessment tool as it included score from other algorithms	Small sample size regarding epidemiology investigations	Validated tool
Falconer et al. (2014)[35]	New Zealand	To develop a tool to prioritize in-patients for ADE prevention	Prospective case review	Oct 2010-Sep 2011 (One-Year)	NR	In-patients Adults Patients actively or previously enrolled in CCM program	E	Ph	Facilitate the identification and monitoring of patients at high risk for MEs and ADEs	Enables pharmacists to conduct timely interventions such as MedRec and clinical review; Improves workflow efficiency for CPs and aids medication safety efforts	Laboratory data not linked to the electronic assessment risk tool	Formal validation of the tool to prioritize patients at high, medium, and low risk has not been completed	Non-validated tool
Falconer et al. (2017)[36]	New Zealand	To validate risk assessment tool and determine which of the 25 flags are associated with ADEs	Prospective observational	Sep 2012 to Feb 2013	247	In-patients Adults	Same tool that described in Falconer's paper (2014)					Exclusion of laboratory flags and exclusion of patients admitted during weekends	Validated tool

***Table 5**: Continued*

Reference year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
Fernandez-Llamazares et al. (2015)[37]	Spain	To design a pharmaceutical care plan for chronic pediatric patients using a risk stratification tool	Prospective study	Apr–Jun 2014	195	In-patients Pediatric patients with chronic conditions	NR	Ph	Stratifies pediatric patients with chronic conditions into distinct risk levels and patients who will benefit from pharmacist intervention	Helps pharmacist to prioritize patients who will benefit from pharmaceutical care intervention	NR	NR	Validated tool
Hickson et al. (2016)[16]	U.K.	To design a pharmaceutical assessment screening (PAST) tool to measure patient acuity and prioritize pharmaceutical care	Quasi-experimental service evaluation	Jan–July 2014	35	In – patients Adults	E	Ph	Ability to rank patient acuity into 3 levels to identify those at greatest risk for developing ADE	Prioritize pharmaceutical care	Scoring varies depending on clinical experience and judgment of individual pharmacist. Has unused sections such as heart, lung, and brain dysfunction	Small sample size	Non-validated tool
Jeon et al. (2017)[38]	U.S.	To develop EHR-based prediction model (C-score) for ranking hospitalized patients based on preventable ADEs	Systematic literature review and survey	Survey (12 days)	37391 ASHP members and 21 preventable ADEs	ASHP members	E	Ph	May improve patient safety by identifying preventable ADEs	Can prioritize patients for pharmacist medication therapy management services	NR	The evaluation of the tool was limited by very low response rate	NR

Table 5: ***Continued***

Reference Year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
Martinbiancho et al. (2011)[39]	Brazil	To develop a risk screening tool for ADR to guide the allocation of pharmaceutical care	Prospective observational	3 months	1442	In–patients, adults, pediatrics	P	Ph	Detects population at risk of ADR	Helps hospital pharmacists to guide appropriate pharmaceutical care	Uses the number of IV medications as a risk factor which can result in false high score to patients	The score is applied only once to each patient during the hospitalization period	Validated tool
Mondoloni et al. (2016)[40]	France	To develop a medication reconciliation activity for patients at the greatest risk of MEs	Prospective study	2 months	82	In-patients. All patients hospitalized through the emergency room	P	Ph	Helps to identify patients at the greatest risk of medication errors	Enables the pharmacist to act quickly to identify and correct the errors and reduce the pharmacist's workload	NR	Insufficient collection of risk factors by emergency prescribers	NR
Mott et al. (2016)[41]	U.K.	To identify patients at greater need for PhC and the level of pharmacist experience required	Prospective observational study	3 months	245	In-patients. Pediatric patients	P	Ph	Assists in identifying patients in need of a greater level of care	Optimizes pharmaceutical care by directing patients to the most appropriate pharmacist	Developed and validated in a single pediatric hospital limiting its applicability to other patients	NR	NR
Mullan and Jennings (2013)[42]	U.K.	To assess the use of individual features, prioritization, report generation and pharmacist views on the EP Web Portal	Survey questionnaire	Feb–Mar 2013	29	All pharmacists covering EP wards	E	Ph	Enables activities that improve patient safety such MedRec, drug interventions and biochemistry review	Improves the time utilization by pharmacist and decreases workload; Helps pharmacists to prioritize high-risk patients	The new report is underused, presenting potential problems such as missed doses, and thus requires follow-up studies to identify whether there are any underlying problems	NR	NR

***Table 5**: Continued*

Reference year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
Munday and Forrest (2016)[43]	U.K.	To describe a system prioritizing patients based on pharmaceutical care needs (clinical triage and referral system)	Descriptivestudy	NR	NR	In-patients All acute care inpatients	E	Ph	Improves patient prioritization and quality of service, equity of patient care and patient safety	Enables pharmacists to prioritize patients for PhC and improves workflow	The use of triage tool is used together with the professional judgement of the pharmacist may vary outcomes	Review article	Validated tool
Nguyen et al. (2017) [44]	France	To develop a predictive model to identify high-risk patients and the impact on clinical decisions (MEs)	Prospective cohort	March-April 2014	1408	In-patients Adults (≥17 yrs)	E	Ph	Predicts occurrence of MEs to guide intervention for high-risk patients	Improves pharmacist human resource allocation and subsequent patient safety	Tool excluded biological markers, diagnostic categories, and co-morbidities with a high potential for ADRs	Non-harmful MEs were not included	Validated tool
Roten et al. (2010)[10]	Switzerland	To develop and validate a screening tool for DRPs	Prospective, observational, comparative study	Aug–Nov 2007	610	In-patients Adults	E	Ph	Facilitates efficient and rapid screening of patients at risk of DRPs	Allows the clinical pharmacist to prioritize patient medication review and improve their work efficiency	Low specificity due to false positives. The tool does not identify some DRPs such as oral OAC but could be addressed during ward visits	No physician was involved in the classification of clinically relevant interventions	Validated tool

Table 5: ***Continued***

Reference year	Country	Study aim	Study design	Study duration	Sample size	Population group	Tool		Perceived tool benefits		Tool limitations	Study limitations	Tool validity
							Type	Used by	Patient care	Pharmacy services			
Saedder et al. (2016)[45]	Denmark	To develop a screening tool to detect admitted patients at risk of MEs.	Retrospective and Prospective observational study	April 2012 January 2013	302	In-patients Adults (≥18 yrs)	P	Ph	Detects population at risk of MEs	Simple risk-score tool easily automated which facilitate and rapid screening of patient records	The risk-score tool lacked a true reference standard for potential MEs, which is subjective and affected by individual pharmacists' point of view	Small sample size	Validated tool
Safadeh et al. (2012)[46]	U.K.	To design a generic tool for assessing and scoring pharmaceutical needs of in-patients	Prospective cohort	Dec 2010–Jan 2011	68	In-patients Adults	E	Ph	Ensures patients with complex pharmaceutical needs are seen quickly	Allows junior pharmacists to prioritize pharmaceutical needs of patients Pharmacist perceived that this toolkit is easy and quick to use	The tool does not include some pharmaceutical categories such as abuse of drugs and overdoses	Small sample size	Non-validated tool
Saxby et al. (2016)[47]	U.K.	To determine pharmacists' views on PAST to assess PAL and factors for assigning PAL level	Survey questionnaire	NR	32	Pharmacists	Same tool as described in Hickson's paper		Ability to rank patient acuity into 3 levels to identify those at greatest risk for developing ADE	Pharmacists are comfortable using PAST for assessing PAL and monitoring pharmaceutical care	Requires careful design and appropriate training for effective use	Professional level varies in the assignment of PAL	Non-validated tool

Notes: **NR:** Not reported; **E**: Electronic; **P**: Paper; **Ph:** Pharmacist; PhC: Pharmaceutical care; **HEPMA:** Hospital Electronic Prescribing and Medicines Administration; **MedRec:** Medicine reconciliation; **M:** Month, **CPS:** Clinical pharmacy service; **IMM:** Integrated medicines management; **CCM:** Chronic care management; **MEs:** Medication error; **ADR:** Adverse drug reaction; **CP**: Clinical pharmacist; **ART:** Assessment of risk tool; **PAST:** Pharmaceutical Assessment Screening Tool; **EHR:** Electronic health record; **C-score:** Complexity score; **ASHP:** The American Society of Health System Pharmacists; **EP:** Electronic prescribing; **DRP:** Drug-related problem; **OAC:** Oral anticoagulant; **CPOE**: Computerized physician order entry; **PAL:** Patient acuity level.

Regarding quality assessment, 10 studies were identified as high quality, 4 as medium quality and 5 as low quality. Despite some being of lower quality than others, all studies were relevant to the research and were therefore included in this review. None of the reviewed papers were of very poor quality. The number of scoring tools was lower than the number of studies because the pharmaceutical assessment screening tool (PAST)[16] and the assessment risk tool (ART)[35] were each applied in two different studies.[36,47] Where PAST, a tool for measuring patient acuity and prioritizing pharmaceutical care, was designed in an initial study,[16] a subsequent study[47] attempted to establish pharmacists' attitudes toward the tool. Similarly, an initial study[35] described the development of the ART for prioritizing in-patients for the prevention of ADEs, and a follow-up as followed by study[36] which validated the same tool. Most (14/17) of the tools were published in the last 5 years, revealing an increased interest in the development of risk assessment tools globally. The studies were conducted in diverse regions of the world. More studies regarding the development of priority tools were conducted in Europe (n = 14; 73%)[10,16,32–34,37,40–47] with the UK leading with 9 (47%) studies.[16,32–34,41–43,46,47] Table 5 shows the countries which have developed and published a tool.

The studies adopted various research designs. Most (n = 11; 58%) were prospective observational studies, either single center or multi-center.[10,32,35–37,39–41,44–46] The remaining studies were retrospective observational studies,[33,34] descriptive,[31,43] systematic review/ survey,[38] quasi-experimental study,[16] and survey.[42,47]

The studies varied because they addressed diverse aims. Most studies (79%) assessed distinct risk screening tools to assess their ability to identify patients at greatest risk of ADRs, ADEs, or MEs and to guide appropriate pharmaceutical care.[10,16,32–41,44–46] Two studies assessed their tools, and pharmacists' views of them.[42,47] Two other studies provided a description of an electronic clinical scoring system to prioritize patients based on pharmaceutical care needs.[31,43] One study[41] investigated a tool for assigning patients with a higher need of pharmaceutical care to the appropriate pharmacist.

The studies also varied in that they target diverse patient populations applicable to their settings including adult patients (≥ 18 years),[10,16,35,36,44–46] pediatric patients (< 18 years),[37,41] and obstetric patients.[33] Furthermore, some studies targeted pharmacists and measured their opinions of existing tools.[42,46,47] Ten tools were developed electronically,[10,16,31,32,35,38,42–44,46] 5 in paper form,[33,39–41,45] and 2 studies did not state the tool format.[34,37] Some of the electronic tools used electronic algorithms[10,44] and some were simply stored electronically.[16,31,32,35,38,42,43,46]

4.3.1 Thematic analysis

Three overarching themes were identified. The positive impact of the risk assessment tools on patient care, the positive impact of the risk assessment tools on the delivery of pharmacy services, and limitations of risk assessment tools. During the thematic analysis of the tool benefits, 2 subthemes for patient care and 4 subthemes for pharmaceutical care were identified (Figure 6).

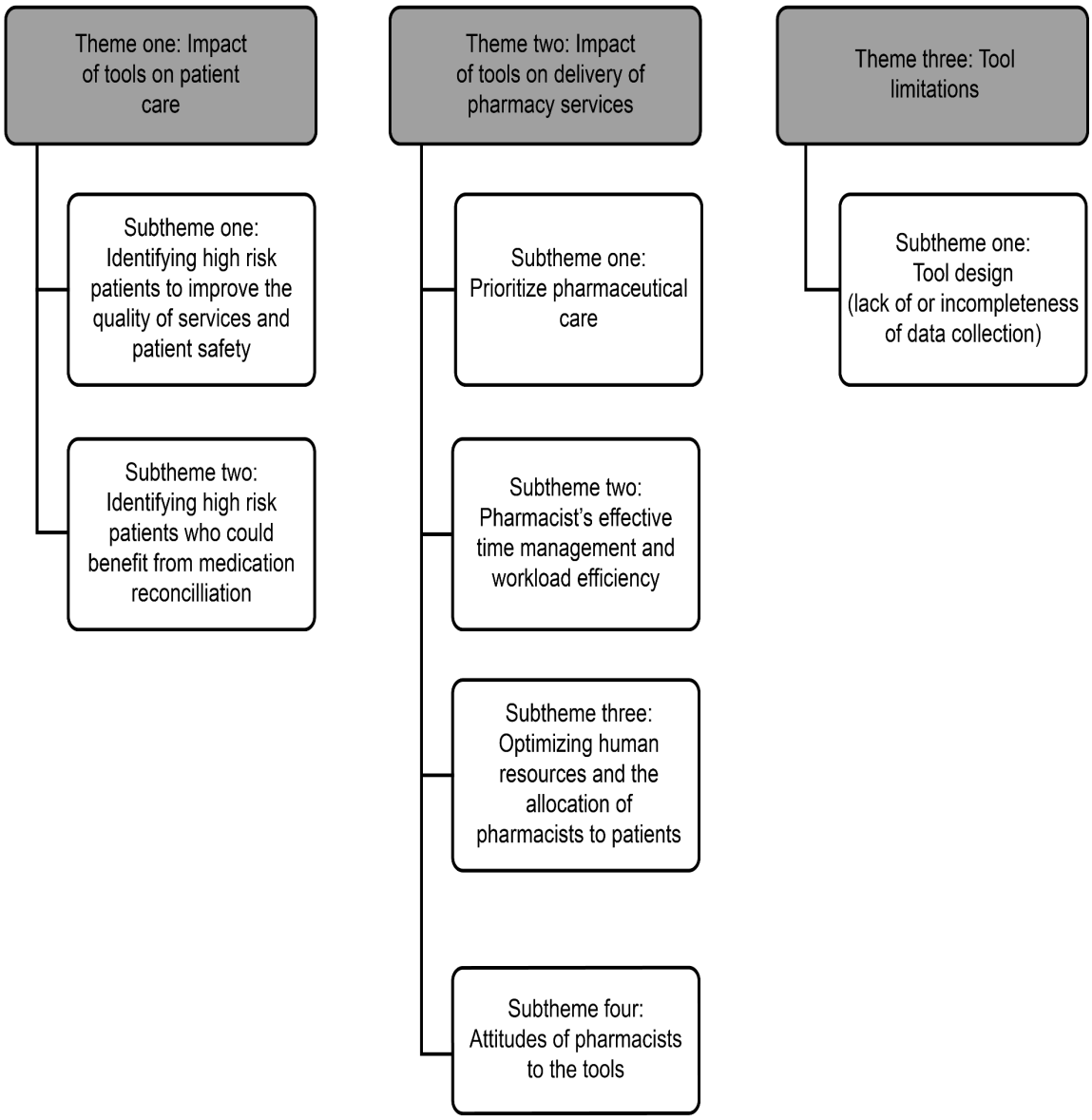

***Figure 6**: The themes and their subthemes of the tool benefits and limitations*

4.3.1.1 The positive impact of the risk assessment tools on patient care

The first overarching theme during the thematic analysis was identified as the positive impact of the risk assessment tools on patient care. There was a consensus among the studies that the various assessed risk-scoring tools are beneficial in identifying patients at higher risk of DRPs and consequently in guiding pharmaceutical care. They conveyed several benefits to patients and pharmacists. For patients, 2 subthemes were found across the 19 studies. The first subtheme was concerned with identifying high-risk patients to improve the quality of pharmacy services and improve patient safety. For instance, one tool was capable of ranking patient acuity into 3 levels according to the potential risk of developing ADEs.[16] Another study[45] showed that their tool could identify patients at risk of developing MEs. Two studies[37,41] were able to stratify pediatric patients into diverse risk levels, which could be used to prioritize those patients who would benefit more from pharmacists' interventions. One study[34] emphasized the ability of their tool to identify patients at high risk of readmission, longer hospital stay, and post discharge mortality.

The second subtheme was concerned with identifying high-risk patients who could benefit from medication reconciliation. Medication reconciliation is a formal process of ensuring patients' prescribed medication matches with what they are actually taking.[48] One study[33] examined opportunities to improve medication reconciliation, multidisciplinary team coordination, and the prevention of adverse events. Another study[31] described an electronic clinical scoring system that was able to identify patients who could benefit from detailed medication reconciliations.

4.3.1.2 The impact of the risk assessment tools on the delivery of pharmacy services

Regarding benefits of the tools for pharmacists and hospital managers, the impact on the provision of pharmacy services was identified as the second overarching theme during the thematic analysis. Four subthemes were identified. The first subtheme was the prioritization

of pharmaceutical care. Nine studies identified the tools as beneficial in prioritizing, guiding and monitoring pharmaceutical care to conduct interventions, such as medication review, medication reconciliation, clinical review, and medication therapy management services.[10,16,33,35–39,47]

The second subtheme related to pharmacists' effective time management and workload efficiency. Each study had a distinct approach with some focusing on the improvement of work flow or workload efficiency,[31,35,36,40,42,43] others focusing on the timely provision of pharmaceutical care,[31,32,40] and still others on the rapid screening of patient records.[45]

The third subtheme was related to optimizing human resources and the allocation of pharmacists to patients, which was based on patient complexity and the expertise of pharmacists. One study[44] concluded that patient-specific allocation of clinical pharmacy services could be more efficient at the time of patients' hospital admission. Another study[41] focused on optimizing pharmaceutical care by directing the care of pediatric patients to the most knowledgeable and experienced pharmacist.

The fourth subtheme dealt with the attitudes of pharmacists to the tools. The tool described in two studies[42,46] was perceived by pharmacists as easy and quick to use and pharmacists were comfortable using the PAST for assessing patient acuity level.[47] It also allowed junior pharmacists to focus on and prioritize the pharmaceutical needs of patients.[46] Notably, this was the only study referring to the perceptions of junior pharmacists regarding the tool.

4.3.1.3 Limitations of risk assessment tools

The limitations of risk-scoring tools were identified as the third overarching theme. This theme is related to the design of tools and included the lack of, or incompleteness of, data collection, which was described commonly as a tool limitation. In 2 studies that used the same tool, laboratory data were not linked to the risk assessment tool and excluded patients

who were admitted during weekends.[35,36] Other tools did not identify some DRPs,[10] or excluded drug overdose,[46] biological markers,[44] diagnostic categories,[44] comorbidity, deranged blood results,[32,44] and laboratory data.[32]

Some limitations were also associated with scoring differences. The authors of 3 studies described that the tools had variations in scoring, depending on clinical experience and judgment of individual pharmacists.[16,43,45] Two other studies required careful tool design and pharmacists to be trained to use the tool more effectively.[16,47]

4.3.2 Tool validity

Regarding validity, 10 out of 17 tools were validated with 2 studies explicitly stating the tools were not validated. However, 5 studies did not state if the tools were validated. Validity was measured by obtaining risk indicators from the literature, and assessing them for inter-observer agreement and agreement with other indicators.[39] One tool was validated by using an expert group of 3 clinical pharmacists delivering obstetric services, as well as formal input from several academic collaborators.[33]

In one study,[10] the use of the screening tool was compared across 4 clinical pharmacists. The tool was developed in a pre-existing population and validated in a pilot prospective study.[45] In another study,[37] a pre-test tool was developed and used in 195 patients from 7 hospitals. In the description of an electronic tool, one study[43] stated that the tool was piloted for triage and referral. In another study,[44] the data about MEs was fitted and internally validated using a multivariate logistic model to predict occurrence.

In the ART, 38 flags were used to in the determination of patient prioritisation.[35] A subsequent study of the tool,[36] identified that 25 flags of the original 38 to be significantly associated with the risk of unintentional MEs. To improve validity, another study[34] divided a sample of patients (n = 806) into a development sample (n = 605) and a validation sample

(n = 201) to create risk-predictive algorithms that would aid in developing a predictive model for identifying patients at high risk of readmission and post-discharge mortality. In another study, 5 patients were assigned to each risk group which were reviewed with the score being assigned based on group's validation of pharmaceutical risk.[32]

4.3.3 Risk factors included in the tools

The risk factors that each tool incorporated to determine acuity were placed into 2 categories: drug related (7 risk factors) and patient related (8 risk factors). Two additional categories included other risk factors, which did not fit into either category. The most common risk factors (see Table 6) identified were as follows in descending order of prevalence: high-risk medication (15/17 tools, 88%), drugs requiring monitoring (15/17 tools, 88%), polypharmacy (13/17 tools, 76.5%), use of total parenteral nutrition/nasogastric tube (3/17 tools, 17.6%), high-cost medication, and number of intravenous and unlicensed medication (1 tool each, 6%). Several definitions of polypharmacy exist, ranging from the prescription of 3 to 6 medications or in some cases more. Notably, some studies failed to include the criteria for defining high-risk medication.[31,32,37,41,42,46] Five tools included various other factors that were not frequently used across all tools, such as cytochrome P450 inducers and inhibitors, blood substitutes, drug induced hemorrhage, and acute kidney injury. They can be found in the "Other" column. The patient related category included other risk factors, which are listed in descending order of prevalence: age (13/17 tools, 76.5%), renal impairment (9/17 tools, 53%), comorbidity (9/17 tools, 53%), hepatic impairment (5/17 tools, 29%), reason/time/type of admission (5/17 tools, 29%), readmission (3/17 tools, 18%), allergies (3/17 tools, 18%), and length of stay (2/17 tools, 12%). Other studies mentioned other factors, such as human immunodeficiency virus, cystic fibrosis, Parkinson's disease, depression, and other factors (Table 6).

***Table 6**: A summary of the risk factors*

Reference/ year	Drug related								Patient related								
	Polypharmacy	Number of IV medicine	High-risk medications	High cost	Use of TPN/NGT	Need monitoring	Unlicensed	Other	Age	Renal	Liver	Co morbid	Allergy	Readmission	Reason, time, and type of admission	Length of stay	Other
Carlson and Phelps (2015)[31]	–	–	+	–	+	+	–	–	+	+	–	–	–	–	–	–	–
Cottrell et al. (2013)[32]	+	–	+	–	–	+	+	–	–	–	–	–	+	–	–	–	–
Covvey et al. (2015)[33]	+	–	+	–	–	+	–	–	+	+	+	+	+	–	–	–	DM, depression, schizophrenia, asthma, HTN, HIV, Crohn's disease
Elhajji et al (2014)[34]	+	–	+	–	–	+	–	–	+	–	–	+	–	+	–	+	–
Falconer et al. (2014)[35]	+	–	+	–	–	+	–	–	+	+	–	+	–	+	–	–	DM, COPD, CHF, CVD, Poor medication adherence
Falconer et al. (2017)[36]	Same tool that described in Falconer's paper (2014)																

Table 6: *Continued*

Reference/ year	Drug related								Patient related								
	Polypharmacy	Number of IV medicine	High-risk medications	High cost	Use of TPN/NGT	Need monitoring	Unlicensed	Other	Age	Renal	Liver	Co morbid	Allergy	Readmission	Reason, time, and type of admission	Length of stay	Other
Fernandez et al. (2015)[37]	+	–	+	–	–	–	–	–	+	–	–	+	–	–	+	–	Obesity, malnutrition, and cognitive/social problems
Hickson et al. (2016)[16]	–	–	+	+	–	+	–	–	–	+	+	+	–	–	–	–	HIV, CF, and Parkinson's Disease
Jeon et al. (2017)[38]	–	–	+	–	–	+	–	Drug-induced hemorrhage, acute kidney injury, severe electrolyte imbalances, hepatic failure, blood dyscrasia, seizures, and uncontrolled hospital acquired infection							NR		
Martinbiancho et al. (2011)[39]	+	+	+	–	+	+	–	–	+	+	+	+	–	–	-	-	Cardiac problems, pulmonary problems, and immunosuppression

Table 6: ***Continued***

Reference/ year	Drug related								Patient related								
	Polypharmacy	Number of IV medicine	High-risk medications	High cost	Use of TPN/NGT	Need monitoring	Unlicensed	Other	Age	Renal	Liver	Co morbid	Allergy	Readmission	Reason, time, and type of admission	Length of stay	Other
Mondoloni et al. (2016)[40]	+	_	+	_	_	+	_	_	+	_	_	+	_	_	_	_	HTN, HF, diabetes, cancer, and memory disorder
Mott et al. (2016)[41]	NR								+	_	_	+	+	_	+	_	Early warning score and medicines reconciliation
Mullan et al. (2013)[42]	+	_	+	_	_	+	_	Drug interaction. Pharmaceutical biochemistry alert such as heparin induced thrombocytopenia	_	_	_	_	_	_	+	+	_
Munday and Forrest (2016)[43]	+	_	+	_	_	+	_	Significant drug interaction. IV antibiotics	+	+	+	_	_	_	+	_	Patient has undergone surgery/procedure. Patient with swallowing difficulties/oral route not available.
Nguyen et al. (2017) [44]	+	_	+	_	+	+	_	Blood substitutes	+	_	_	_	_	+	+	_	_

***Table 6**: Continued*

Reference/ Year	Drug related								Patient related								
	Polypharmacy	**Number of IV medicine**	**High-risk medications**	**High cost**	**Use of TPN/NGT**	**Need monitoring**	**Unlicensed**	**Other**	**Age**	**Renal**	**Liver**	**Co morbid**	**Allergy**	**Readmission**	**Reason, time, and type of admission**	**Length of stay**	**Other**
Roten et al. (2010)[10]	+	_	+	_	_	+	_	Cytochrome P450 inducers and inhibitors, IV acetaminophen, anti- infectives > 3 days and patients on digoxin with low serum potassium	+	+	_	_	_	_	_	_	_
Saedder et al. (2016)[45]	+	_	+	_	_	+	_	_	+	+	_	+	_	_	_	_	_
Safadeh et al (2012)[46]	+	_	_	_	_	+	_	Drug interaction, drug specific issue, and administration issue	+	+	+	_	_	_	_	_	_
Saxby et al. (2016)[47]	Same tool that described in Hickson's paper (2016)																
Total of studies	13	1	15	1	3	15	1	_	13	9	5	9	3	3	5	2	_

+: Risk factors were included in the study; -: Risk factors were not included in the study; IV: Intravenous infusion; TPN: Total parenteral nutrition; NGT: Nasogastric tube; DM: Diabetes mellitus; HTN: Hypertension; HIV: Human immunodeficiency virus; COPD: Chronic obstructive pulmonary disease; CHF: Congestive heart failure; CVD: Cerebrovascular disease; CF: Cystic fibrosis; HF: Heart failure; NR: Not reported.

4.3.4 High-risk drug classes

Twelve drug classes were identified in the 19 studies. The summary of drug classes is supplied in appendix 4.C. Some classes of drugs were considered more important than others in the risk assessment tools and are listed in the order of frequency: anticoagulants (14/17 tools, 82%), cardiovascular medication (12/17 tools, 70.5%), antiepileptics (12/17 tools, 70.5%), antimicrobial medication (12/17 tools, 70.5%), chemotherapy (10/17 tools, 59%), aminoglycosides (a subgroup of antimicrobials; 10/17 tools, 59%), immunosuppressants (9/17 tools, 53%), hypoglycemic/insulin (9/17 tools, 53%), opiates (9/17 tools, 53%), antidepressants (7/17 tools, 41%), anti-inflammatories/NSAIDs (5/17 tools, 29%), and corticosteroids (3/17 tools, 18%). Other studies mentioned other medications, such as potassium chloride (IV), eye drops, theophylline, aminophylline, and anti-retrovirals.

4.4 Discussion

The present study is the first review to identify and describe the tools that have been designed and are currently used by clinical pharmacy services to assess patient acuity and complexity. The included studies provide a solid foundation for the reader to enhance their understanding of existing tools that may aid detection of high acuity patients for early and targeted pharmacist interventions. This study focuses exclusively on pharmacist tools and does not reflect on other healthcare professionals, which are outside of the scope of this study.

This review revealed a rising interest in the development of risk assessment tools for DRPs to categorize patients as high-risk and to prioritize pharmaceutical care. The UK seems to have placed a greater emphasis on the development of such tools with other countries following suit. It could be postulated that this interest stems from the unique nature of the UK's National Health Service, which is free at the point of use and funded solely via general Government taxation.[49] Rising numbers of patients and funding pressures within this service have heightened over recent years, and there is a drive to maximize efficiency across the NHS.[15,19,20,22] Thus, a possible explanation is that this situation increases the pressure on NHS pharmacy departments to prioritize which patients need direct pharmaceutical care.

Most tools reviewed in the present study were developed for adults aged older than 17 years. In 2 studies,[37,41] the emphasis was on pediatric patients. No tools have been found that focused on elderly patients within the hospital setting; however, such patients were included in the studies of the general adult population. This is interesting since elderly patients are more likely to have multiple morbidities and associated complex pharmacotherapy, which puts them at risk of adverse outcomes.[39]

This review highlighted the variation in the complexity and use of algorithms. It also demonstrated that most tools have been designed in an electronic format to ease the

screening process and to reduce the amount of time spent by pharmacists on retrieving patient records, as well as reducing the amount of paperwork.[31,42,46] However, most of the studies that were reviewed failed to explain how the tools operate.

The tools include many risk factors. The most prevalent risk factors are high-risk medications—medications requiring monitoring, age, and polypharmacy. Regarding high-risk medications, there was no consistent definition of "high risk" in the reviewed studies. High-risk medication has been defined as harmful to patients[15]; therefore, awareness of their harm to patients, can potentially decrease the hospitalization period, life-threatening conditions, and death by almost 50%.[50] The four most commonly named drug classes in all the reviewed studies were: anticoagulants, antimicrobials, cardiovascular, and antiepileptic drugs. This finding correlates with other studies that have reported similar drug classes to be associated with hospital setting problems.[50,51]

Furthermore, this review found polypharmacy is commonly considered a risk factor for requiring pharmaceutical care. This finding was supported by several studies that concluded that polypharmacy can lead to negative health outcomes and frequent hospitalization by influencing DRPs.[52–55] Polypharmacy is particularly prevalent among the elderly population who are more likely to have multiple conditions.[10]

Hospital length of stay is also considered a key indicator of resource usage in hospitals.[56] Length of stay and hospital costs are often correlated.[57] Only 2 reviewed tools included length of stay as a risk factor. The reason for this was not stated in the other studies. One of the reasons could be some tools were used at the beginning of hospital admission.

The tools were reported to have clear benefits regarding patient care and pharmacy services delivery. However, some of these benefits are the perceptions of those using and implementing the tools, and were not necessarily confirmed by robust data to verify these

perceptions. The tools on the whole aim to improve pharmacists' workload and help them work more efficiently. This goal seems to have been achieved in other healthcare settings. For instance, decision makers can already use the acuity-scoring tools to assist in assigning the appropriately experienced and knowledgeable nurse to the right patient.[58,59] This ensures a more consistent quality of care, decreases mortality rates, improves outcomes, and shortens hospital stays.[58] The tools have reportedly many benefits for both the pharmacy team and patients; inevitably, however, in addition to the tools, clinical experience still plays a critical role in pharmacists' decisions regarding outcomes and scoring of patients.

Overall, only one publication focused on an assessment tool for patients, which assisted in directing the right pharmacist to the right patient in the pediatric department; however, there was insufficient detail provided in this study.[41] Therefore, more research is needed to explore how tools are used to allocate the most appropriately experienced pharmacist to individual patients in the general inpatient population. Only 3 studies[42,46,47] explored pharmacists' views of the tools and further work is necessary to gain a more complete picture of the impact of tools on the individual pharmacist and their own acquisition of knowledge and skills.

The safety of patients has been significantly improved by providing clinical pharmacist services among diverse hospital services.[12] Clinical pharmacy services have a positive impact on patients' outcomes by decreasing MEs, ADEs, and ADRs.[12,51,60] Risk assessment tools could be of benefit to patients as such tools provide early indicators to detect MEs. Interestingly, the impact of tools on patients and on MEs and ADEs has not been demonstrated in any of the studies. Hence, there is a need for more research that investigates the impact of the tools on patient care quality and patient safety.

When we assessed the quality of the studies within the review, some were ranked as low quality but still included. These low ranking studies were abstracts to conferences

presenting the assessment tools developed within their hospitals. The papers connected to the abstracts had not been published as full academic papers at the time of the review. The process of academic publication is time-consuming and requires research skills which may form a barrier to the publication of studies undertaken by practising pharmacists who have competing pressures. A recent study of assessment tools used in UK hospital pharmacies indicated that there are a number of tools that have been developed but have not been presented at a congress or meeting.[61] This leads us to believe that the number of tools is likely to be much higher than those that are formally disseminated through conferences and academic publications.

The findings of this review have several implications for pharmacy practice. Those pharmacists who work in clinical practice and are considering adopting or developing their own prioritization tool can take some reassurance that current published tools appear to achieve their aim of successfully targeting clinical pharmacy services to where they are needed most. The tools presented in this review could be adapted or further developed to suit differing clinical and organizational contexts. Lessons that have been learned from exploring the limitations of existing tools include the need for thorough training in the application of tools and extensive consideration of the inclusion of relevant risk factors to ensure accuracy of detecting high acuity patients. Going forward tool implementation should be monitored, validated and where possible its impact measured to allow for comparison across tools.

4.4.1 Limitations

Only studies written in English were included in this review, which may mean that noteworthy studies published in other languages were overlooked. The literature search, abstract and full-text screening and quality assessment were performed by only one of the

authors (MA). It was difficult to gain fair results when applying Hawker's quality assessment tool, since some abstracts lack the sufficient detail to meet quality assessment criteria. Despite this, it was important to include abstracts if they provided sufficient information about a prioritization tool, due to the limited published literature in this area.

Limitations of the included studies are that the tools were not described in full detail; for example, there is a lack of description about what constitutes a high-risk medication. Overall, the published assessment tools are very heterogeneous and differ in aim, structure, content, targeted patient groups, and the extent of validation. As a result comparison across studies and generalizability of the review findings are limited.

4.5 Conclusion

This review is the first to provide a summary of currently published tools that will be of use to researchers and pharmacy managers interested in current approaches to identifying those patients are at the greatest risk from DRPs. It is clear that there has been growing interest in the development of risk assessment tools in recent years. Seventeen published papers have described screening tools designed and used in clinical pharmacy services for the assessment of patients to identify high acuity patients and guide pharmaceutical care. Overall, published assessment tools are heterogeneous, differing in structure, content, targeted patient group, setting, selected outcomes, and extent of validation.

Despite this authors were unanimous in that these tools are beneficial in identifying patients perceived to be at higher risk of DRPs and consequently in guiding the provision of pharmaceutical care.

Current published studies fail to provide a measurable impact of the tools on patients and their ability to prevent actual harm from medication use. Future studies should attempt to

measure patient outcomes and apply similar methods to facilitate comparison across different tools. There is clearly no "gold standard," in terms of pharmacy specific acuity tools and more work is needed to ensure a consistent, high-quality approach to prioritization of services.

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4.7 Study One Appendices

Appendix 4.A: Search strategy

Search strategy for Medline:

#	Searches	Results
1	priorit*.mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, and synonyms]	86838
2	triage*.mp.	17228
3	acuity.mp.	90954
4	complex*.mp.	1273626
5	1 or 2 or 3 or 4	1458036
6	tool*.mp.	486875
7	scor*.mp.	697844
8	screen*.mp.	617050
9	criteria.mp.	438374
10	scale.mp.	477813
11	classif*.mp.	469517
12	assess*.mp.	2477446
13	measure*.mp.	2663537
14	instrument*.mp.	235132
15	clinical assess* tool*.mp.	300
16	stratif*.mp.	124843
17	software.mp.	176740
18	6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17	6245139
19	hospital*.mp.	1275983
20	secondary care.mp.	4532
21	19 or 20	1278712
22	pharmaceutical care.mp.	1657
23	pharmacy.mp.	51434
24	pharmacist*.mp. protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	26710
25	pharmac* service*.mp.	26496
26	hospital pharmac*.mp.	3461
27	clinical pharmac*.mp.	13611
28	clinical pharmac* service*.mp.	650
29	pharmaceutical.mp.	179014
30	22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	233049
31	5 and 18 and 21 and 30	719
32	31	719
33	limit 32 to (English language and year = “1990–current”)	600

Search strategy for Embase:

#	Searches	Results
1	priorit*.mp. [mp = title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, and floating subheading word]	9168508
2	triage*.mp.	22471
3	acuity.mp.	130033
4	complex*.mp.	1693722
5	1 or 2 or 3 or 4	10273035
6	tool*.mp.	765972
7	scor*.mp.	1230975
8	screen*.mp.	1095141
9	criteria.mp.	739223
10	scale.mp.	891130
11	classif*.mp.	1002668
12	assess*.mp.	4118394
13	measure*.mp.	3693220
14	instrument*.mp.	576368
15	clinical assess* tool*.mp.	21453
16	stratif*.mp.	219590
17	software.mp.	236855
18	6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17	9850574
19	hospital*.mp.	2113138
20	secondary care.mp.	9034
21	19 or 20	2117652
22	pharmaceutical care.mp.	18711
23	pharmacy.mp.	114623
24	pharmacist*.mp.	85677
25	pharmac* service*.mp.	6732
26	hospital pharmac*.mp.	16937
27	clinical pharmac*.mp.	44609
28	clinical pharmac* service*.mp.	1296
29	pharmaceutical.mp.	181080
30	22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	346837
31	5 and 18 and 21 and 30	6735
32	31	6735
33	limit 32 to (English language and year = “1990–current”)	6369

Search strategy for International Pharmaceutical Abstracts:

#	Searches	Results
1	priorit*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	1885
2	triage*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	233
3	acuity.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	454
4	complex*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	25420
5	1 or 2 or 3 or 4	27826
6	tool*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	10336
7	scor*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	15498
8	screen*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	12510
9	criteria.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	12441
10	scale.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	10954
11	classif*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	9518
12	assess*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	63762
13	measure*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	54279
14	instrument*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	3625
15	clinical assess* tool*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	4
16	stratif*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	2473
17	software.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	3687
18	6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17	145434
19	hospital*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	54586
20	secondary care.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	166
21	19 or 20	54683
22	pharmaceutical care.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	6664
23	pharmacy.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	64385
24	pharmacist*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	51415
25	pharmac* service*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	19273
26	hospital pharmac*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	15956
27	clinical pharmac*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	11158
28	clinical pharmac* service*.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	2771
29	pharmaceutical.mp. [mp = title, subject heading word, registry word, abstract, and trade name/generic name]	50974
30	22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	114055
31	5 and 18 and 21 and 30	687
32	31	687
33	limit 32 to (English language and year = “1990–current”)	618

Search strategy for Scopus:

#	Searches	Results
1	TITLE-ABS-KEY (priorit* OR triage* OR acuity OR complex*)	12430249
2	TITLE-ABS-KEY (tool* OR scor* OR screen* OR criteria OR scale OR classif* OR assess* OR measure* OR instrument* OR {clinical assess* tool*} OR stratif* OR software)	18978666
3	TITLE-ABS-KEY (hospital* OR secondary care)	777177
4	TITLE-ABS-KEY ({pharmaceutical care} OR pharmacy OR {pharmac* service*} OR {hospital pharmac*} OR {clinical pharmac*} OR {clinical pharmac* service*} OR pharmacist* OR pharmaceutical)	37178
5	1 AND 2 AND 3 AND 4	6760
6	5 AND PUB YEAR > 1989 AND (LIMIT-TO (LANGUAGE, "English")	6266

Search strategy for Web of Science:

#	Searches	Results
1	priorit* OR triage* OR acuity OR complex*	3409659
2	tool* OR scor* OR screen* OR criteria OR scale OR classif* OR assess* OR measure* OR instrument* OR clinical assess* tool* OR stratif* OR software	12369905
3	hospital* OR secondary care)	8866054
4	pharmaceutical care OR pharmacy OR pharmac* service* OR hospital pharmac* OR clinical pharmac* OR clinical pharmac* service* OR pharmacist* OR pharmaceutical	333277
5	1 AND 2 AND 3 AND 4	1188
6	limit 5 to (English language and year = "1990–current")	1084

Appendix 4.B: Quality assessment of included studies

Reference year	Abstract and title				Introduction and aims				Method and data				Sampling				Data analysis				Ethics and bias				Findings/results				Generalizability				Implications/usefulness				Sum score	Overall quality
	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor		
Carlson and Phelps (2015)[27]				1		3				2						1		2				2				2				2			4				**19**	**C***
Cottrell et al. (2013)[28]			2			3				3				2				2				3				3				2			4				**24**	**B***
Covvey et al. (2015)[29]	4				4					3				2			4					3			4					2			4				**30**	**A***
Elhajji et al. (2014)[30]	4				4					3			3				4					3			4					3			4				**32**	**A***
Falconer et al. (2014)[31]	4				4					3				2				3				3			4					3			4				**30**	**A***
Falconer et al. (2017)[32]	4				4					3			3				4					3			4					3			4				**32**	**A***
Fernandez-Llamazares et al. (2015)[33]	4					2				2				2				2				1				2				2				3			**19**	**C***
Hickson et al. (2016)[14]	4				4					3				2			4					3			4					2			4				**30**	**A***
Jeon et al. (2017)[34]	4				4				4					3				3				3			4					3			4				**32**	**A***

Reference year	Abstract and title				Introduction and aims				Method and data				Sampling				Data analysis				Ethics and bias				Findings/results				Generalizability				Implications/usefulness				Sum score	Overall quality
	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor	Good	Fair	Poor	Very Poor		
Martinbiancho et al. (2011)[35]		3				3				3				3			4							1		3				3			4				**27**	**B***
Mondoloni et al. (2016)[36]		3					2			3					2				2				2				2				2			3			**21**	**C***
Mott et al. (2016)[37]	4						2				2				2				2				2				2				2			3			**21**	**C***
Mullan et al. (2013)[38]	4					3				3				3					2			3				3				2			4			**27**	**B***
Munday and Forrest (2016)[39]			2			3					2					1			2				2				2				2			3			**19**	**C***
Nguyen et al. (2017)[40]	4				4				4				4				4					3			4					3			4				**34**	**A***
Roten et al. (2010)[9]	4				4					3			4				4					3				3				3			4				**32**	**A***
Saedder et al. (2016)[41]	4				4				4					3			4						2			3				3			4				**31**	**A***
Safadeh et al. (2012)[42]	4					3				3					2				2				2			3					2			4			**25**	**B***
Saxby et al. (2016)[43]	4				4					3				3			4					3			4					3			4				**32**	**A***

*High quality (A), 30–36 points
*Medium quality (B), 24–29 points
*Low quality (C), 9–23 points.

Appendix 4.C: A summary of high-risk drug classes included in tools

Reference/ year	Classes of drugs												
	Anticoagulants	Antimicrobial	Cardiovascular	Chemotherapy	Opiates	Hypoglycemic/Insulin	Antiepileptics	Aminoglycosides	Corticosteroids	Anti-inflammatory NSAIDs	Immunosuppressants	Antidepressant	Other
Carlson and Phelps (2015)[31]	+	+	+	+	–	–	+	+	–	–	+	+	Lithium
Cottrell et al. (2013)[32]	+	+	–	+	–	–	+	–	–	–	+	–	–
Covvey et al. (2015)[33]	+	+	+	–	+	+	+	+	+	+	+	+	Lithium Anti-retrovirals
El hajji et al. (2014)[34]	+	–	+	+	+	–	+	–	+	+	–	+	–
Falconer et al. (2014)[35]	+	+	+	–	+	+	+	+	–	–	–	–	–
Falconer et al. (2017)[36]	Same tool that described in Falconer's paper (2014)												
Fernandez et al. (2015)[37]	NR												
Hickson et al. (2016) [16]	+	+	+	+	+	+	+	+	–	–	+	–	Theophylline Aminophylline Lithium Anti-retrovirals

Appendix 4.C: Continued

Reference/ year	Classes of drugs												
	Anticoagulants	Antimicrobial	Cardiovascular	Chemotherapy	Opiates	Hypoglycemic/Insulin	Antiepileptics	Aminoglycosides	Corticosteroids	Anti-inflammatory NSAIDs	Immunosuppressants	Antidepressant	Other
Jeon et al. (2017)[38]	+	+	+	_	+	+	_	+	_	_	+	_	_
Martinbiancho et al. (2011)[39]	+	+	+	+	+	+	+	+	+	_	+	_	Potassium chloride (IV)
Mondoloni et al. (2016)[40]	+	_	+	+	_	+	+	_	_	_	_	-	Eye drops
Mott et al. (2016)[41]	NR												
Mullan et al. (2013)[42]	+	+	+	_	+	+	+	+	_	_	_	_	_
Munday and Forrest (2016)[43]	+	+	_	+	_	_	+	+	_	+	+	+	_
Nguyen et al. (2017)[44]	+	+	+	+	+	+	_	+	_	+	_	+	Lithium
Roten et al. (2010)[10]	+	+	+	+	_	_	+	+	_	_	+	+	_
Saedder et al. (2016)[45]	+	+	+	+	+	+	+	_	_	+	+	+	Lithium
Safadeh et al. (2012)[46]	NR												
Saxby et al. (2016)[47]	Same tool that described in Hickson's paper (2014)												
Total of studies	14	12	12	10	9	9	12	10	3	5	9	7	_

+: Drug classes were included in the study; -: Drug classes were not included in the study; NR: Not reported.

5. Chapter Five: Study Two

Title	Development of the adult complexity tool for pharmaceutical care (ACTPC) in hospital: a modified Delphi study
Type	Original article
Authors	Meshal A. Alshakrah, Douglas T. Steinke, Mary P. Tully, Aseel S. Abuzour, Steven D. Williams, Penny J. Lewis
Status	It has been accepted for publication*
Journal	Research in Social & Administrative Pharmacy
Date of submission	October 2020

*Note. As this chapter has been accepted for publication, the formatting and layout are consistent with the journal's guidance. References from the paper are placed at the end of the chapter rather than at the end of the thesis.

Development of the adult complexity tool for pharmaceutical care (ACTPC) in hospital: a modified Delphi study

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Abstract

Background: Hospital pharmacists play an essential role in patient care; however, a lack of resources means pharmacists are unable to review all patients daily. Consequently, there is a demand for reliable screening tools to allocate care to patients with urgent and/or complex pharmaceutical needs. Several tools have been developed, but no broad consensus exists on the design of a screening tool to be used in the adult hospital setting.

Objective: To obtain expert consensus on the design of a pharmaceutical care complexity screening tool for use on admission to hospital.

Methods: Two Delphi studies were conducted: the first sought to gain consensus from experts including pharmacists, academics and physicians on the components of a pharmaceutical complexity tool, the second to achieve consensus from UK chief pharmacists and clinical service pharmacy managers on the clinical appropriateness and practicality of the tool. Tool components and Delphi statements were identified and refined from our previous systematic review, UK survey and interview study of prioritisation tools. A valid definition for consensus was used.

Results: Over 300 components were extracted from the interview data and systematic review and then refined for inclusion in the first Delphi study. Thirty-three experts completed Delphi One and consensus was reached on 92 components. Components were grouped into demographic, clinical and medication components and condensed to 33 items, which were included in the first draft of the Adult Complexity Tool for Pharmaceutical Care (ACTPC). The tool stratified patients into highly, moderately or least complex. Forty expert panellists completed Delphi Two and consensus was reached on review frequency and experience of pharmacy practitioner at each level. These decisions were incorporated into the final version of the ACTPC.

Conclusions: The ACTPC is the first systematically designed and internationally agreed tool for use on medical admission to hospital. It has potential to enable the delivery of targeted patient-centred pharmaceutical care.

Keywords: pharmacy prioritisation, assessment tool, hospital pharmacy, clinical pharmacy services, patient safety, Delphi technique.

5.1 Introduction

Medication is the most frequent therapeutic intervention in health care systems globally. However, medication errors and inappropriate prescribing are common problems associated with medication use. [1–5] Pharmacists are key to identifying and resolving such errors, optimising medicines and improving patient outcomes.[6]

In the UK, clinical pharmacy services traditionally involve a clinical pharmacist visiting an allocated hospital ward and reviewing each patient on a daily basis on weekdays.[7] However, reduced funding, staffing issues and an increasing number of elderly admissions with comorbidities and polypharmacy, has made daily delivery of clinical pharmacy services to each patient difficult.[8–12] Consequently, it is possible that patients who might gain from timely pharmaceutical care are overlooked. In the same vein, not all patients need a pharmacist to review them every day throughout their admission. It is evident that hospitalised patients have a range of pharmaceutical needs varying in complexity, due to factors such as illness severity, co-morbidities, high-risk medications and polypharmacy.[13] However, patient complexity and the severity of patient needs are not taken into consideration in the traditional model of clinical pharmacy service delivery. A different model of service delivery is required that makes better use of available resources[14] and prioritises clinical care to ensure the best patient outcomes.[8]

Clinical pharmacy hospital service resources could be better utilised by ensuring pharmacy staff have the appropriate level of expertise to review patients who are at a higher risk of harm as a result of medication, thus ensuring cost effectiveness.[15] This requires an understanding of which patients need to be examined by more experienced pharmacists.[16] Pharmacists with advanced knowledge and skills can prevent medication harm and ensure medicines are optimised in patients with complex pharmaceutical needs; those patients with moderate pharmaceutical needs can be allocated to moderately experienced pharmacists and

patients with simple pharmaceutical needs can be seen by highly trained technicians.[17] In other healthcare professions, notably nursing, investments have been made into the development of classification tools that aid in the identification of the severity of the conditions and the level of care the patient may need.[18] These tools allow nursing staff to identify the right level of nursing care and for the appropriate staff to be allocated.[19] However, there is no robustly developed tool to match pharmacists' experience to patients' needs leading to potential inefficiencies in pharmacy service delivery.[20]

Several studies have examined risk assessment tools that seek to prioritise patients for pharmacy services. Our systematic review of the literature [20] and a UK national survey[21] have demonstrated that several pharmaceutical complexity tools have been developed in UK hospitals, however, they are often locally developed with a lack of formal agreement on their components. Furthermore, a recent review of the literature on this subject described studies using consensus, however, there were limitations in terms of their methodology and validation.[22] To date, no broad agreement of experts exists on valid components of a pharmaceutical care complexity screening tool in the adult hospital setting. Therefore, this study aims to develop a pharmaceutical screening tool, rigorously and systematically, by using consensus methods. It is hoped that the resulting pharmaceutical screening tool can be used by clinical pharmacists to triage new patients according to the level of pharmaceutical care required, improving the delivery of limited pharmacy services and enhancing patient care.

Ethics approval

Ethical approval for this study was not required as the Delphi study sought involvement of individuals in their capacity as subject experts and not as research participants. Furthermore, data are reported at group level and individual responses cannot be identified from the results.

5.2 Methods

This study incorporated two separate and sequential Delphi studies. The Delphi technique, commonly used in healthcare, involves a series of questionnaires given to a group of experts [23] to establish consensus in an area where there is insufficient information.[23–25] The aim of Delphi One study was to develop a classification scheme for assigning pharmaceutical complexity levels to individual patients on admission to hospital. The aim of Delphi Two was to determine the appropriate frequency of clinical pharmacist input for each complexity level and the appropriate competency level of pharmacy staff to assign to each level. Figure 7 provides an overview of the different stages of the study and these are described below.

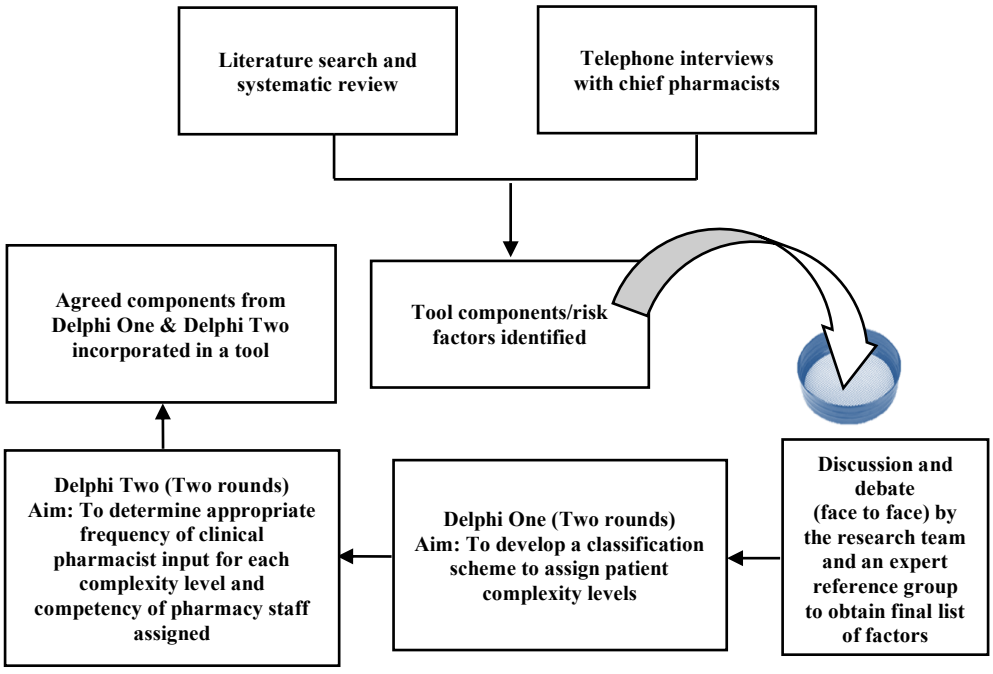

Figure 7: *Flow diagram of the development of components of a pharmaceutical care complexity screening tool*

5.2.1 Delphi One

There is little evidence as to how hospitals assess patient complexity and/or prioritise pharmaceutical care and therefore, prior to this Delphi study, a systematic review was conducted to identify existing patient prioritisation tools in hospital settings worldwide.[20] Limited published literature regarding existing tools prompted a national online survey of all 220 acute NHS hospital pharmacy services to establish existing screening tools used by clinical pharmacy services for the prioritisation of acute patients.[21] The respondents who used tools were invited to take part in a telephone interview and to share their existing tool, the details of which can be found elsewhere.[21]

Tool components that may help clinical pharmacists categorise and identify high risk patients for drug related problems (DRPs) who need the greatest pharmacy input, were extracted from the systematic review and telephone interviews (including tool documents) and entered into a spreadsheet. Components relating to any medical condition in adult inpatients were included. Duplicate components, those related to paediatric patients and or applicable to non-acute settings (i.e. outpatient or primary care) and non-clinical components (e.g. cost) were excluded. Any disagreement regarding the inclusion or exclusion of particular components were discussed face-to- face by the research team and an expert reference group until agreement was reached. The study reference group, consisted of hospital chief pharmacists, academics and, members of the study's Patient Public Involvement (PPI) group. Components meeting the inclusion criteria were then categorised into clinical or medication related components and incorporated into round one questionnaire of Delphi One study.

Prior to the expert Delphi panel receiving the questionnaire, the draft questionnaire was piloted with three clinical pharmacists to ensure the feasibility of the procedures and the clarity of the components.

A few minor modifications were made, such as amending the expected total time to complete the questionnaire.

5.2.1.1 Delphi One panel and recruitment

Delphi One panel members were pharmacists, academics and physicians with expert knowledge and experience of medication safety. They were identified from interviews conducted in our previous study[21] and from key publications.[20] In total, 49 international and national experts were invited to complete Delphi One to ensure a minimum of 40 panel members took part. Having an international perspective on the panel may increase the applicability of tool components to other contexts. The surveys were sent via email, the most common way of distributing Delphi questionnaires.[23]

5.2.1.2 Rating scale of Delphi One and definition of consensus

An email containing study details and a web link to an online questionnaire (using SelectSurvey.NET) was sent to panellists in December 2017. Instructions were provided on the first page of the questionnaire along with questions regarding panellist's professional role and country of residence. The main body of the questionnaire consisted of the tool components with a 9-point Likert scale. The Likert Scale was divided into three sections where a score of 1-3 was identified as unimportant, 4-6 was viewed as uncertain and 7-9 - as important. Panellists were asked to rank each tool component for its importance in their daily hospital practice in terms of allowing them to identify patient complexity. There was also a space under each component where the panel members could write free text to explain their choice. Additional space was provided at the end of the questionnaire for the panellists to suggest any other tool components not contained in the questionnaire that they considered important for inclusion.

After completion of the first-round questionnaire, the median score was calculated and comments related to the tool components collated. No components were added or removed. In May 2018, the second-round questionnaire, including panellists' own previous score, the group median score and a summary of the panellist's comments were sent out. The panellists were then given an opportunity to modify their score. After the second round, consensus was reached and no further rounds conducted. Panellists were given six weeks to respond to each round and up to four reminders were sent by email to those who did not respond. SPSS 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp) was used to calculate the frequency distribution of the group scores on a scale of 1–9, the median score and the panel inter-quartile range (IQR).

Consensus was defined according to the RAND appropriateness operational definition.[26] A tool component was considered important if consensus was achieved in the second round with a panel median score of 7–9, without disagreement. It was considered unimportant if the panel median score was 1–3, without disagreement. The component was considered uncertain if the panel median score was 4–6 or any median score with disagreement. Disagreement was defined as at least one-third of the panel members rating the component in the opposite region to the other two-thirds[26] (e.g. 34% of the panel members rating the component as 1–3 and a median score of 7–9).[27]

5.2.2 Delphi Two

The Delphi Two study sought to determine the appropriate frequency of clinical pharmacist input for each complexity level and the appropriate competency level of pharmacy staff to assign to each level. In Delphi Two, an initial list of statements was developed from the analysis of previously conducted telephone interviews.[21] Thirty-six interview transcripts were screened for data relevant to the aim of this Delphi, i.e. to determine the frequency of

clinical pharmacist input for each complexity level and the appropriate competency level of pharmacy staff to assign to each level. Framework Analysis was used to analyse the data[28] facilitated by the use of NVivo-12. A draft list of statements was reviewed by the research team for appropriateness and clarity. The statements focused on different aspects of tool use, such as the appropriate time to use the complexity tool, i.e. before, during or after medicines reconciliation and appropriate frequency and experience of clinical pharmacists. The final agreed statements (n=23) were combined into an online questionnaire, Delphi Two. As with the previous Delphi, the questionnaire was piloted with three clinical pharmacists and no modifications were made.

5.2.2.1 Delphi Two panel and recruitment

The Delphi Two study only included UK experts as the topic of the Delphi (pharmacy experience and frequency of review) are heavily influenced by contextual factors (e.g. resources, education, policy) unique to the UK Panellists were invited to take part if they were NHS clinical pharmacists with a management role e.g. chief pharmacist or lead clinical pharmacist. Panellists meeting the criteria were invited from Delphi One, via professional networks and through snowballing.[29] This process continued until at least 40 panel members were recruited.

5.2.2.2 Rating scale of Delphi Two and definition of consensus

In October 2018, each panel member was sent an email with a link to the online questionnaire, study summary and rating instructions. As with Delphi One, the professional role of each panel member was added. A draft of the Adult Complexity Tool for Pharmaceutical Care (ACTPC) which included the agreed tool components as confirmed by Delphi One was attached. A nine-point Likert scale was used for participants to rate their level of agreement or disagreement with each statement, i.e. if you were using the ACTPC

to prioritise patients to receive pharmacy services, how practical or clinically appropriate would it be to include the statement in the ACTPC. The Likert scale was divided into three sections where the score between 1-3 was identified as low practicality or clinically appropriateness, 4-6 was viewed as not sure (uncertain) and 7-9 as high practicality or clinical appropriateness. A comment box was added under each statement to allow respondents to explain their answer. Additional space was provided at the end of the questionnaire for panellists' feedback on the tool in terms of its design, applicability and practicality. Questionnaire data were exported to Microsoft Excel® for descriptive analysis to identify whether or not consensus had been obtained for each statement. The same consensus approach was used as in Delphi One. SPSS 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp) was used to calculate the frequency distribution of the group scores on a scale of 1–9, the median score and the panel inter-quartile range (IQR). All comments provided by the panellists were summarised.

The second-round questionnaire was sent to the same panellists in December 2018 and no statements were added to or removed from the first-round. A summary of panellist's comments was included to demonstrate various opinions, overall median score and panellist's previous score. Panellists had six-weeks to complete each survey and up to four reminders were sent.

5.3 Results

5.3.1 Delphi One

A preliminary list of 300 tool components were gathered from the systematic review, telephone interviews and documentary analysis. One hundred and ninety-one tool components were excluded according to our criteria resulting in 109 tool components in the

Delphi questionnaire. These were divided into two classes; medicine related (n=65, Table 7) and clinical condition related components (n=44, Table 8).

Out of 49 experts invited to participate, 41 (84%) completed the first round Delphi, of whom 33 (80.5%) completed the second round. The expert panel members consisted of 32 pharmacists and 9 medical doctors from seven different countries, UK (34), France (2), Spain (1), Norway (1), Uganda (1), Denmark (1) and New Zealand (1). Their experience ranged from 5-30 years. The Delphi One process is illustrated in Figure 8.

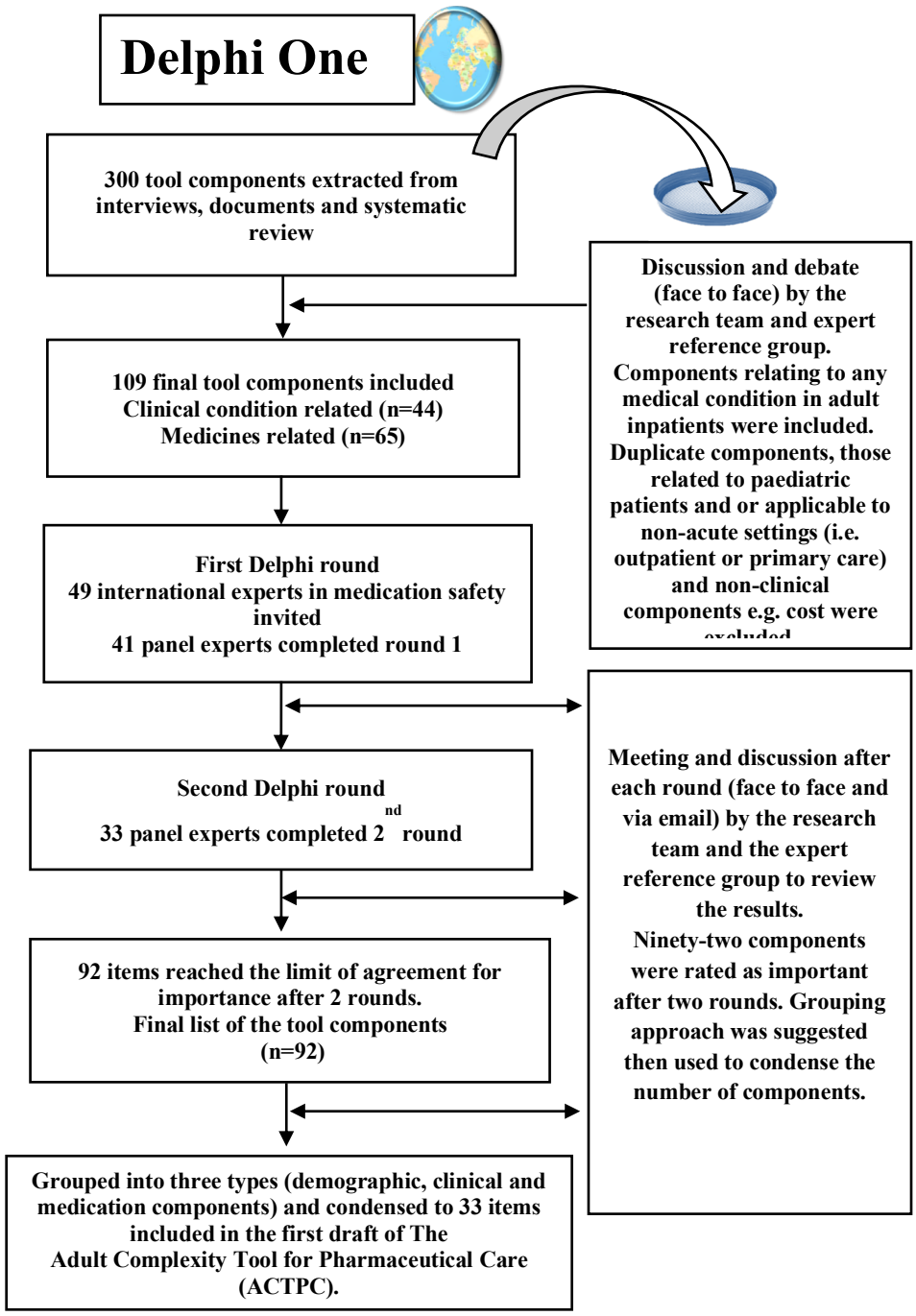

***Figure 8**: Overview of Delphi One: gaining consensus on tool components.*

The results of the Delphi One study are shown in Table 7 and 8, which is arranged by the median score, Interquartile Range (IQR), number of panellists who rate the risk factor as 'unimportant', 'uncertain' or 'important' and the agreement on the importance of the risk factor or tool component in both Delphi rounds. In the second round of Delphi One, 92 components were rated as 'important' (Likert scale: 7-9) with regard to their contribution to the occurrence of drug related problems (DRPs), 16 components were rated as 'uncertain' (Likert scale: 4-6), only 1 component was rated as 'unimportant' (Likert scale: 1-3). The sum of the IQRs changed from 205 in the first round to 99 in the second round, representing a stronger consensus between the panellists.

Table 7: *Medication related components included in Delphi One (both rounds).*

No.	Medication Related Risk Factors		Delphi One - Round 1 (N=41)						Delphi One - Round 2 (N=33)					
			Median	IQR	Number of panellists who rated the risk factors for their importance for inclusion into a pharmaceutical complexity screening tool			Agreement on the importance of the risk factor	Median	IQR	Number of panellists who rated the risk factors for their importance for inclusion into a pharmaceutical complexity screening tool			Agreement on the importance of the risk factor
					1 to 3	4 to 6	7 to 9				1 to 3	4 to 6	7 to 9	
1	Medicines that when omitted or delayed can lead to harm	Insulin	8	(8-9)	2	1	38	93%	8	(8-9)	0	0	33	100%
2		Corticosteroids	8	(7-8)	1	8	32	78%	8	(7-8)	0	3	30	91%
3		Desmopressin	7	(6-8)	1	10	30	73%	7	(7-7)	0	5	28	85%
4		Clozapine	9	(7-9)	0	3	38	93%	9	(8-9)	0	0	33	100%
5		Parkinson's disease medication	8	(8-9)	0	2	39	95%	8	(8-9)	0	0	33	100%
6		Anti-epileptic medicines	8	(8-9)	0	1	40	98%	8	(8-9)	0	0	33	100%
7		Tacrolimus	9	(7-9)	0	1	40	98%	9	(8-9)	0	0	33	100%
8		Immunosuppressants	8	(8-9)	0	2	39	95%	8	(8-9)	0	0	33	100%
9		Biologics	7	(7-9)	2	6	33	80%	7	(7-8)	0	4	29	88%
10	Medicines that are likely to result in moderate to significant drug interactions	Disulfiram	6	(4-7)	9	21	11	27%	5	(5-6)	5	25	3	9%
11		Selective serotonin reuptake inhibitors	5	(4-7)	8	22	11	27%	5	(4-5)	6	24	3	9%
12		Monoamine oxidase inhibitors	7	(7-8)	1	8	32	78%	7	(7-7)	1	5	27	82%
13		Tricyclic antidepressants	6	(4-7)	6	19	16	39%	6	(5-6)	1	24	8	24%
14		Other antidepressants	5	(4-7)	10	19	12	29%	5	(4-5)	3	27	3	9%
15		Cimetidine	6	(5-7)	8	15	18	44%	6	(5-6)	6	22	5	15%
16		Clarithromycin	7	(5-8)	5	10	26	63%	7	(6-7)	2	7	24	73%
17		Erythromycin	7	(5-8)	5	10	26	63%	7	(6-7)	2	7	24	73%
18		Triazole antifungals	7	(6-8)	4	7	30	73%	7	(7-7)	1	6	26	79%
19		Rifampicin	8	(7-8)	0	5	36	88%	8	(8-8)	0	1	32	97%
20		Rifabutin	8	(7-8)	0	7	34	83%	8	(7-8)	0	0	33	100%
21		Antiretrovirals drugs	8	(7-8)	0	2	39	95%	8	(8-8)	0	0	33	100%
22		Antipsychotics	7	(6-8)	2	9	30	73%	7	(7-7)	0	6	27	82%
23		Antiepileptics	8	(7-8)	0	3	38	93%	8	(8-8)	0	2	31	94%
24		Parkinson's medication	8	(7-8)	0	5	36	88%	8	(8-8)	0	1	32	97%
25	Medicines that require monitoring or therapeutic drug monitoring by a pharmacist	Digoxin	7	(5-8)	4	15	22	54%	7	(6-7)	2	13	18	55%
26		Phenytoin	8	(6-8)	3	9	29	71%	7	(7-8)	1	4	28	85%
27		Clozapine	8	(7-9)	1	4	36	88%	8	(8-8)	0	1	32	97%
28		Theophylline	7	(6-8)	2	10	29	71%	7	(7-7)	1	7	25	76%
29		Aminophylline	7	(6-8)	1	10	30	73%	7	(7-7)	0	6	27	82%
30		Vancomycin	8	(7-8)	0	6	35	85%	8	(8-8)	0	1	32	97%
31		Methotrexate	8	(7-8)	2	8	31	76%	8	(7-8)	1	2	30	91%
32		Gentamicin	8	(8-9)	0	4	37	90%	8	(8-9)	0	1	32	97%

33		Amikacin	8	(8-9)	0	5	36	88%	8	(8-8)	0	2	31	94%
34		Tobramycin	8	(7-9)	0	5	36	88%	8	(8-9)	0	1	32	97%
35		Lithium	8	(7-9)	1	4	36	88%	8	(8-8)	0	2	31	94%
36		Triazole antifungals (high dose or extended course duration	7	(6-8)	1	11	29	71%	7	(7-8)	0	5	28	85%
37		Amphotericin	8	(7-9)	0	8	33	80%	8	(7-8)	0	2	31	94%
38		Antiretrovirals	8	(6-8)	1	14	26	63%	8	(7-8)	0	5	28	85%
39		Total parenteral nutrition	8	(6-8)	2	10	29	71%	8	(7-8)	0	7	26	79%
40	Medicines that require additional reviewing and/or monitoring by a pharmacist	Iloprost	7	(6-8)	0	12	29	71%	7	(7-7)	0	7	26	79%
41		Immunoglobulins	7	(7-8)	2	6	33	80%	7	(7-8)	1	3	29	88%
42		Milrinone	7	(5-7)	0	18	23	56%	7	(6-7)	0	13	20	61%
43		Antipsychotic depot injection	6	(5-7)	7	15	19	46%	6	(5-7)	3	20	10	30%
44		Intravenous beta-blocker	7	(6-8)	0	19	22	54%	7	(6-7)	0	10	23	70%
45		Hospital restricted antibiotics e.g. carbapenems	8	(7-9)	0	6	35	85%	8	(7-8)	0	5	28	85%
46	One or more medications that cause an increased risk of falls	For example (but not limited to) ACE inhibitors, beta-blockers, benzodiazepines, zopiclone, etc.	7	(7-8)	2	6	33	80%	7	(7-7)	1	7	25	76%
47	One or more medications that cause QT prolongation and Torsade's de Pointes	For example (but not limited to) amiodarone, erythromycin, quetiapine, citalopram, etc.	7	(7-8)	1	6	34	83%	7	(7-8)	0	4	29	88%
48	One or more medications to treat overdose or severe adverse drug events	For example (but not limited to), antidotes/reversal drugs such as naloxone, acetylcysteine, adrenaline, etc.	7	(6-8)	1	12	28	68%	7	(6-8)	1	9	23	70%
49	Regular strong opiates	For example (but not limited to) oxycodone, morphine equivalent doses > or equal to 30mg daily, etc.	7	(6-8)	3	11	27	66%	7	(6-7)	1	9	23	70%
50	Medicines that are adjunct in the treatment of opioid dependence	For example (but not limited to) methadone, buprenorphine, etc.	8	(7-8)	1	5	35	85%	8	(7-8)	1	1	31	94%
51	Coumarin oral anticoagulants	For example (but not limited to) warfarin, sinthrome, etc.	8	(7-9)	1	3	37	90%	8	(8-9)	0	3	30	91%
52	Novel oral anticoagulant medication	(otherwise known as direct oral anticoagulant medication)	7	(6-8)	1	11	29	71%	7	(7-8)	0	5	28	85%

		For example (but not limited to), Rivaroxaban, Dabigatran, etc												
53	Low molecular weight heparin at treatment dose	Heparin at treatment dose	7	(6-8)	2	10	29	71%	7	(7-7)	0	7	26	79%
54	Anticoagulant infusions Or intravenous anticoagulants		8	(7-9)	1	3	37	90%	8	(8-9)	1	1	31	94%
55	Dual anti-platelet therapy (DAPT)		7	(6-8)	2	14	25	61%	7	(6-7)	0	10	23	70%
56	Cytotoxic medication		8	(7-9)	1	4	36	88%	8	(8-9)	0	3	30	91%
57	Intravenous antibiotics		7	(6-8)	2	14	25	61%	7	(6-7)	2	10	21	64%
58	One or more continuous intravenous infusions (excluding fluids and antibiotics)		7	(6-8)	1	15	25	61%	7	(6-7)	1	13	19	58%
59	Potassium infusion > 40 mmole/1 Litre		8	(7-9)	1	5	35	85%	8	(7-8)	1	1	31	94%
60	Sodium chloride for injection, greater than 0.9% concentration		7	(6-8)	0	16	25	61%	7	(7-8)	0	6	27	82%
61	Intravenous calcium		7	(6-8)	2	13	26	63%	7	(6-7)	1	9	23	70%
62	Intravenous magnesium		6	(6-7)	2	21	18	44%	6	(6-7)	1	19	13	39%
63	Intravenous phosphate		7	(6-7)	2	18	21	51%	7	(6-7)	1	13	19	58%
64	Intravenous glucose> 20%		7	(6-8)	1	16	24	59%	7	(7-7)	1	6	26	79%
65	Subcutaneous syringe drivers		7	(6-8)	1	12	28	68%	7	(7-7)	1	7	25	76%

Notes: **IQR:** The interquartile range.

Table 8: *Clinical related components included in Delphi One (both rounds).*

No.	Clinical Related Risk Factors	Delphi One - Round 1 (N=41)						Delphi One - Round 2 (N=33)					
		Median	IQR	Number of panellists who rated the risk factors for their importance for inclusion into a pharmaceutical complexity screening tool			Agreement on the importance of the risk factor	Median	IQR	Number of panellists who rated the risk factors for their importance for inclusion into a pharmaceutical complexity screening tool			Agreement on the importance of the risk factor
				1 to 3	4 to 6	7 to 9				1 to 3	4 to 6	7 to 9	
1	The patient is between 16-18 years of age	3	(2-4)	27	8	6	15%	3	(2-3)	28	5	0	0%
2	The patient is between 60-65 years of age	5	(3-7)	12	13	16	39%	6	(4-6)	8	17	8	24%
3	The patient is between 66-70 years of age	7	(5-8)	7	13	21	51%	6	(5-7)	5	13	15	45%
4	The patient is over 70 years of age	8	(7-9)	4	5	32	78%	8	(6-8)	1	10	22	67%
5	Pregnant or breast-feeding	8	(7-9)	0	6	35	85%	8	(8-9)	0	2	31	94%
6	Extreme weight (frail/obese)	7	(7-8)	2	6	33	80%	7	(7-8)	1	4	28	85%
7	Prescribed 5 or more regular medicines	7	(6-8)	2	12	27	66%	7	(6-7)	2	7	24	73%
8	Prescribed 10 or more regular medicines	8	(7-9)	0	6	35	85%	8	(8-8)	0	1	32	97%
9	Prescribed 15 or more regular medicines	9	(8-9)	0	1	40	98%	9	(9-9)	0	0	33	100%
10	Nil by mouth or have swallowing difficulties	8	(7-9)	2	1	38	93%	8	(8-8)	0	1	32	97%
11	With an ileostomy or colostomy	6	(5-8)	4	18	19	46%	6	(5-7)	2	19	12	36%
12	Taking medicines as part of a clinical trial	7	(6-8)	3	13	25	61%	7	(6-8)	1	9	23	70%
13	An organ transplant patient	9	(8-9)	0	3	38	93%	9	(8-9)	0	1	32	97%
14	Predicted to undergo surgery/procedure	6	(5-7)	1	26	14	34%	6	(5-6)	0	26	7	21%
15	A palliative care patient	7	(6-8)	3	13	25	61%	7	(6-7)	2	10	21	64%
16	History of severe allergic reaction	7	(6-8)	2	11	28	68%	7	(7-8)	1	7	25	76%
17	Acute kidney injury - stage 1: a rise in creatinine from 1.5 to 1.9 times the baseline value	7	(6-8)	4	9	28	68%	7	(7-7)	1	6	26	79%
18	Acute kidney injury - stage 2: a rise in creatinine from 2-2.9 times the baseline value	8	(7-8)	0	6	35	85%	8	(7-8)	0	3	30	91%
19	Acute kidney injury - stage 3: a rise in creatinine ≥ 3 times the baseline value	9	(8-9)	0	1	40	98%	9	(9-9)	0	0	33	100%
20	Chronic kidney disease - normal to high: GFR ≥ 90 ml/minute	4	(2-7)	19	11	11	27%	4	(2-5)	14	18	1	3%
21	Chronic kidney disease - mildly decreased: GFR 60-89 ml/minute	6	(3-7)	11	17	13	32%	6	(4-6)	7	23	3	9%
22	Chronic kidney disease - mildly to moderately decreased: GFR 45-59 ml/minute	7	(5-8)	4	13	24	59%	7	(5-7)	1	13	19	58%
23	Chronic kidney disease - moderately to severely decreased: GFR 30-44 ml/minute	8	(6-8)	2	9	30	73%	8	(7-8)	0	6	27	82%

24	**Chronic kidney disease - severely decreased: GFR 15-29 ml/minute**	**9**	**(8-9)**	**1**	**0**	**40**	**98%**	**9**	**(8-9)**	**0**	**0**	**33**	**100%**
25	**Chronic kidney disease - kidney failure: GFR < 15 ml/minute**	**9**	**(8-9)**	**1**	**0**	**40**	**98%**	**9**	**(9-9)**	**0**	**0**	**33**	**100%**
26	**Liver function tests deranged but greater than or equal to 3 times the upper limit of normal**	**8**	**(7-9)**	**1**	**4**	**36**	**88%**	**8**	**(8-9)**	**1**	**1**	**31**	**94%**
27	**Liver function tests deranged but less than 3 times the upper limit of normal**	**6**	**(5-7)**	**4**	**21**	**16**	**39%**	**6**	**(5-7)**	**3**	**20**	**10**	**30%**
28	**Sepsis**	**8**	**(8-9)**	**1**	**4**	**36**	**88%**	**8**	**(7-9)**	**2**	**0**	**31**	**94%**
29	**Decompensated heart failure**	**8**	**(7-8)**	**3**	**5**	**33**	**80%**	**8**	**(7-8)**	**3**	**0**	**30**	**91%**
30	**Uncontrolled pain**	**7**	**(7-8)**	**2**	**3**	**36**	**88%**	**7**	**(7-8)**	**2**	**2**	**29**	**88%**
31	**Admitted due to a NSTEMI/STEMI**	**7**	**(6-8)**	**3**	**13**	**25**	**61%**	**7**	**(7-7)**	**3**	**5**	**25**	**76%**
32	**Admitted due to a malignancy**	**6**	**(5-7)**	**6**	**24**	**11**	**27%**	**6**	**(5-6)**	**4**	**23**	**6**	**18%**
33	**Endocarditis**	**7**	**(6-8)**	**4**	**10**	**27**	**66%**	**7**	**(7-8)**	**2**	**5**	**26**	**79%**
34	**Meningitis**	**8**	**(6-9)**	**4**	**9**	**28**	**68%**	**8**	**(7-8)**	**2**	**3**	**28**	**85%**
35	**Gastric absorption problems**	**7**	**(7-8)**	**2**	**8**	**31**	**76%**	**7**	**(6-8)**	**2**	**7**	**24**	**73%**
36	**Hyperthyroid crisis**	**7**	**(5-7)**	**4**	**15**	**22**	**54%**	**7**	**(6-7)**	**2**	**10**	**21**	**64%**
37	**Myasthenia gravis**	**7**	**(6-8)**	**3**	**9**	**29**	**71%**	**7**	**(6-8)**	**2**	**7**	**24**	**73%**
38	**Porphyria**	**7**	**(6-8)**	**3**	**9**	**29**	**71%**	**7**	**(7-8)**	**2**	**6**	**25**	**76%**
39	**G6PD deficiency**	**7**	**(6-8)**	**1**	**10**	**30**	**73%**	**7**	**(7-8)**	**1**	**6**	**26**	**79%**
40	**Abnormal laboratory results (excluding renal and hepatic)**	**7**	**(6-7)**	**2**	**14**	**25**	**61%**	**7**	**(7-7)**	**1**	**5**	**27**	**82%**
41	**An Early Warning Score that is equal to or > 3**	**6**	**(5-7)**	**5**	**23**	**13**	**32%**	**6**	**(5-6)**	**3**	**24**	**6**	**18%**
42	**An Early Warning Score that is equal to or > 5**	**7**	**(6-8)**	**1**	**12**	**28**	**68%**	**7**	**(6-7)**	**0**	**12**	**21**	**64%**
43	**Patients admitted due to an adverse drug event**	**8**	**(7-9)**	**0**	**5**	**36**	**88%**	**8**	**(7-9)**	**0**	**2**	**31**	**94%**
44	**Patients discharged from hospital in the last 30 days**	**7**	**(5-8)**	**5**	**13**	**23**	**56%**	**7**	**(6-8)**	**4**	**9**	**20**	**61%**

Notes: **IQR:** The interquartile range; **GFR:** Glomerular filtration rate; **G6PD:** Glucose-6-phosphate dehydrogenase; **STEMI:** ST-segment elevation myocardial infarction; **NSTEMI:** Non-ST segment elevation myocardial infarction.

Table 9 shows the median score given to the risk factors or the tool components on the importance scale for both rounds. After the second round, 92 components had a median score of 7 or more on the 9-point Likert scale were therefore classified as important. The panellists rated seven out of 109 components at the highest median score (9). These components were: (a) acute kidney injury (AKI) - stage 3: a rise in creatinine ≥ 3 times the baseline value, (b) chronic kidney disease - severely decreased: GFR 15-29 ml/minute, (c) chronic kidney disease - kidney failure: GFR < 15 ml/minute, (d) an organ transplant patient, (e) prescribed 15 or more regular medicines, (f) clozapine and (g) tacrolimus. Agreement on the importance of these risk factors reached 100% for six of these factors with tacrolimus reaching 97%.

Thirty-seven out of 109 components had a median score of 8, and 48 components had a median score of 7. Sixteen components had a median score of 4, 5 or 6 and were therefore considered equivocal. Only one component (patient is between 16-18 years of age) had a median score of 3. Agreement on the unimportance of this risk factor reached 85%. None of the rated components in Delphi One had a score of 1 or 2. There was no disagreement within the components that had a median score of 7 or more. Table 9 shows all the components that had a different median score of 3-9. Ninety-two components were rated as important for inclusion into a pharmaceutical complexity screening tool. However, the incorporation of 92 criteria into a useable tool is clearly unfeasible; therefore, a grouping approach was used to condense the number of components. For instance, several high-risk medicines were grouped together into one high-risk medicine category and diseases, such as meningitis, human immunodeficiency virus (HIV), tuberculosis (TB) and others were grouped into one infectious diseases category. They were grouped into three types (demographic, clinical and medication components) and shortened to 33 items which were included in the first draft of the Adult Complexity Tool for Pharmaceutical Care (ACTPC).

***Table 9**: Median scores and number of components scored in each point in the RAND importance scale*

RAND importance scale	Round 1 (N=109)	Round 2 (N=109)
Number of components with a median score 7-9 (important)	93	92
Number of components achieving median score 9 (important)	7	7
Number of components achieving median score 8 (important)	38	37
Number of components achieving median score 7 (important)	48	48
Number of components with a median score 4-6 (equivocal)	15	16
Number of components achieving median score 6 (equivocal)	11	12
Number of components achieving median score 5 (equivocal)	3	3
Number of components achieving median score 4 (equivocal)	1	1
Number of components achieving median score 1-3 (unimportant)	1	1
Number of components achieving median score 3 (unimportant)	1	1
Number of components achieving median score 2 (unimportant)	0	0
Number of components achieving median score 1 (unimportant)	0	0

5.3.2 Delphi Two

In total, 23 statements relating to the use of the ACTPC, including the frequency with which a patient should be seen and the level of experience of the pharmacist practitioner, were developed from the previous telephone interviews[21] and incorporated in the Delphi Two questionnaire (Table 10).

Fifty-six expert panel members from different NHS acute trusts across the UK (clinical pharmacists with a management role e.g. chief pharmacists and lead clinical pharmacists) were contacted to take part and 43 (77%) accepted and completed the first online questionnaire and 40 (93%) of them completed the second one. The Delphi Two process is demonstrated in Figure 9. After two Delphi rounds, a total of 18 (87%) statements reached the consensus limit of agreement. Out of these statements, 16 reached the consensus limit of agreement for practicality and 11 statements reached the consensus limit of agreement for clinical appropriateness (Table 11). Interestingly, the median score in both rounds was the same. Since consensus was achieved in both rounds for the same statements, the research team decided not to conduct further rounds. The sum of the IQRs changed from 104 in the first round to 69 in the second round, representing a stronger consensus between panellists. The research team reviewed the statements that reached agreement then grouped them into 3 types (highly, moderately and least complex) and shortened them to 3 statements which were then included in the latest version of the ACTPC.

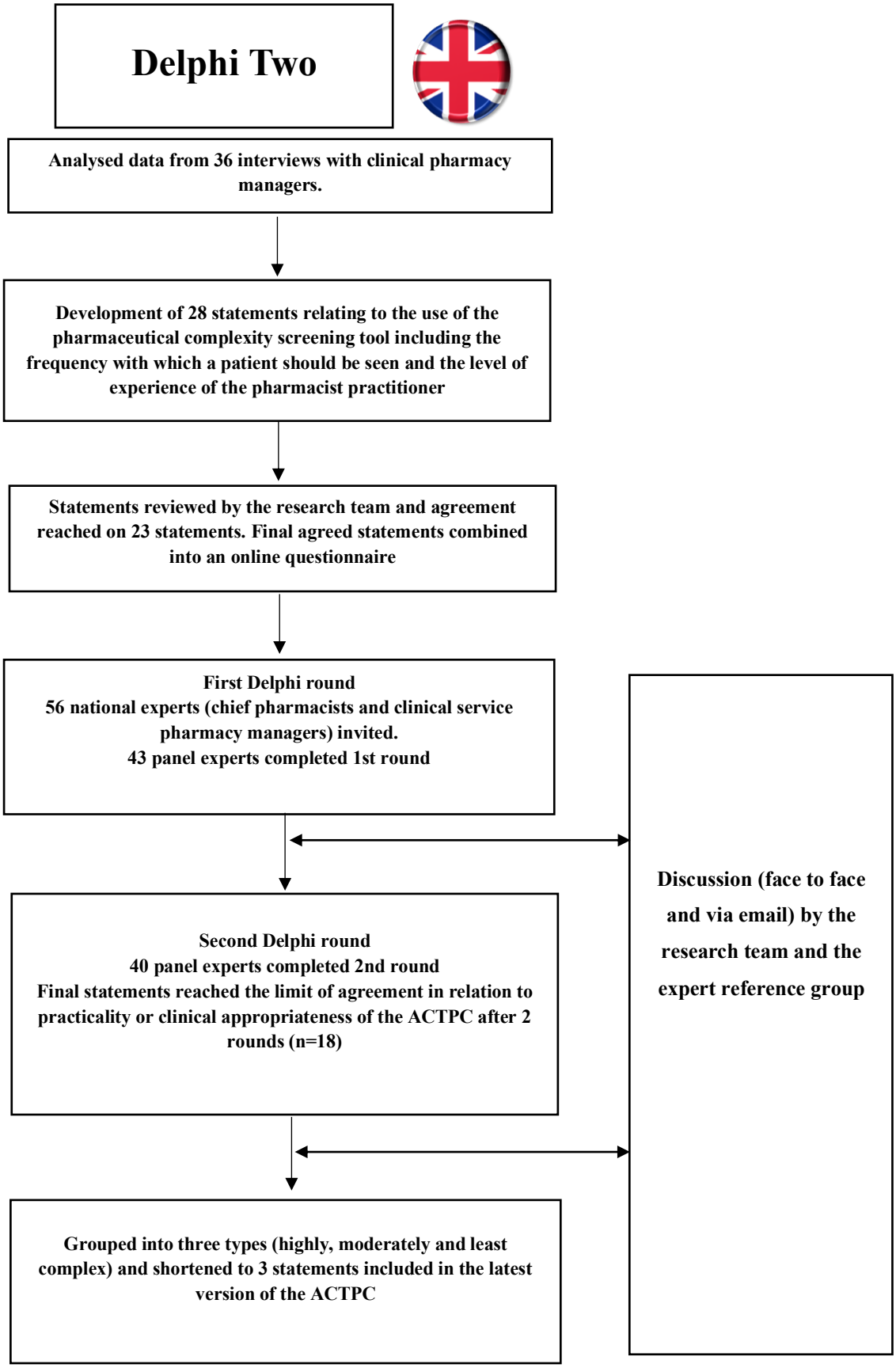

***Figure 9**: Overview of Delphi Two: gaining consensus on practicality and clinical appropriateness*

***Table 10**: Statements included in Delphi Two (both rounds).*

No.	Statements relating to the use of the pharmaceutical complexity screening tool	Practicality & Clinical appropriateness	Delphi Two - Round 1 (N= 43)						Delphi Two - Round 2 (N= 40)					
			Median	IQR	Number of panellists who rated the statements for their practicality or clinical appropriateness of the pharmaceutical complexity screening tool			Agreement on the Statement in relation to its practicality or clinical appropriateness of the pharmaceutical complexity screening tool	Median	IQR	Number of panellists who rated the statements for their practicality or clinical appropriateness of the pharmaceutical complexity screening tool			Agreement on the Statement in relation to its practicality or clinical appropriateness of the pharmaceutical complexity screening tool
					1-3	4-6	7-9				1-3	4-6	7-9	
1	The pharmacist can use the tool before medicine reconciliation	Practicality	5	(3-7)	13	16	14	33%	5	(4-6)	8	24	8	20%
2	The pharmacist can use the tool during or after medicine reconciliation	Practicality	7	(6-8)	3	12	28	65%	7	(7-8)	4	5	31	78%
3	The tool can be used by the technician before medicine reconciliation	Practicality	4	(2-6)	21	12	10	23%	4	(3-5)	17	21	2	5%
4	The tool can be used by the technician during or after medicine reconciliation	Practicality	5	(3-7)	16	16	11	26%	5	(4-6)	9	28	3	8%
5	The pharmacy staff can ask the nurses for information to identify if the patient falls into the red criteria	Practicality	5	(3-7)	15	16	12	28%	5	(4-6)	7	31	2	5%
6	Highly complex patients should be seen within the first 1-6 hours of admission then daily	Practicality	5	(3-7)	14	15	14	33%	5	(3-6)	12	24	4	10%
7		Clinical appropriateness	8	(7-8)	3	6	34	79%	8	(7-8)	2	5	33	83%
8	Highly complex patients should be seen within the first 6-12 hours of admission then daily	Practicality	7	(5-8)	6	14	23	53%	7	(5-7)	5	14	21	53%
9		Clinical appropriateness	8	(6-8)	3	11	29	67%	8	(7-8)	2	4	34	85%
10	Highly complex patients should be seen within the first 12-24	Practicality	8	(7-9)	2	6	35	81%	8	(7-8)	2	3	35	88%
11		Clinical appropriateness	7	(4-9)	9	9	25	58%	7	(5-8)	1	15	24	60%

	hours of admission then daily													
12	Highly complex patients should be seen by an experienced clinical pharmacist. (According to how your trust defines experience).	Practicality	7	(6-8)	1	12	30	70%	7	(6-8)	0	11	29	73%
13		Clinical appropriateness	8	(8-9)	0	2	41	95%	8	(8-9)	0	1	39	98%
14	Highly complex patients should be seen by a clinical pharmacist	Practicality	8	(7-9)	2	6	35	81%	8	(7-9)	0	6	34	85%
15		Clinical appropriateness	7	(6-9)	2	17	24	56%	7	(6-8)	1	11	28	70%
16	Moderately complex patients should be seen within the first 24 hours of admission then daily	Practicality	7	(6-8)	3	11	29	67%	7	(6-8)	1	11	28	70%
17		Clinical appropriateness	8	(7-9)	1	8	34	79%	8	(7-8)	0	6	34	85%
18	Moderately complex patients should be seen within the first 24 hours of admission then every two days	Practicality	8	(7-9)	2	5	36	84%	8	(7-8)	0	4	36	90%
19		Clinical appropriateness	6	(5-8)	5	17	21	49%	6	(5-7)	3	21	16	40%
20	Moderately complex patients should be seen within the first 24 hours of admission then every three days	Practicality	8	(7-9)	3	8	32	74%	8	(7-9)	0	6	34	85%
21		Clinical appropriateness	4	(3-5)	18	18	7	16%	4	(3-5)	15	19	6	15%
22	Moderately complex patients should be seen within the first 24 hours of admission then every five days	Practicality	8	(5-9)	9	6	28	65%	8	(7-9)	1	6	33	83%
23		Clinical appropriateness	2	(1-3)	34	9	0	0%	2	(1-2)	35	5	0	0%
24	Moderately complex patients should be seen by an experienced clinical pharmacist (According to how your trust defines experience).	Practicality	6	(4-7)	6	17	20	47%	6	(5-7)	2	24	14	35%
25		Clinical appropriateness	7	(6-8)	6	15	22	51%	7	(6-7)	0	16	24	60%
26	Moderately complex patients should be seen by a clinical pharmacist	Practicality	8	(7-9)	0	5	38	88%	8	(7-8)	0	1	39	98%
27		Clinical appropriateness	8	(7-9)	0	8	35	81%	8	(7-8)	0	3	37	93%
28	Least complex patients should be seen within the first 24 hours of admission then twice weekly	Practicality	8	(7-8)	3	5	35	81%	8	(7-8)	0	4	36	90%
29		Clinical appropriateness	7	(6-8)	5	10	28	65%	7	(6-8)	2	10	28	70%
30		Practicality	8	(6-9)	7	6	30	70%	8	(7-9)	2	4	34	85%

31	Least complex patients should be seen within the first 24 hours of admission then once weekly	Clinical appropriateness	5	(3-7)	14	18	11	26%	5	(3-6)	10	27	3	8%
32	Least complex patients should be seen within the first 24 hours of admission then before being discharged	Practicality	8	(6-9)	6	7	30	70%	8	(7-8)	1	6	33	83%
33		Clinical appropriateness	4	(2-5)	21	16	6	14%	4	(2-5)	17	18	5	13%
34	Least complex patients should be seen by a clinical pharmacist	Practicality	8	(7-9)	3	7	33	77%	8	(7-8)	1	6	33	83%
35		Clinical appropriateness	8	(6-9)	2	10	31	72%	8	(6-8)	0	10	30	75%
36	Least complex patients should be seen by a clinical pharmacist or pharmacy technician	Practicality	8	(7-9)	1	9	33	77%	8	(7-8)	0	6	34	85%
37		Clinical appropriateness	6	(5-7)	5	21	17	40%	6	(5-7)	2	24	14	35%
38	Complexity criteria should be in three levels to distinguish between others: red for highly complex, amber for moderately complex and green for least complex	Practicality	8	(7-9)	0	6	37	86%	8	(7-8)	0	2	38	95%
39		Clinical appropriateness	8	(7-8)	1	5	37	86%	8	(7-8)	0	4	36	90%
40	Complexity criteria should be in three levels to distinguish between others: Level 1 for highly complex, Level 2 for moderately complex and Level 3 least complex	Practicality	6	(5-8)	7	16	20	47%	6	(5-7)	6	22	12	30%
41		Clinical appropriateness	6	(5-7)	9	13	21	49%	6	(5-7)	8	19	13	33%

Notes: **IQR:** The interquartile range.

Table 11: *Median scores and number of statements scored in each point in the RAND importance scale.*

RAND practicality/clinical appropriateness scale	Round 1 (Statements N=23)		Round 2 (Statements N=23)	
	Practicality	Clinical appropriateness	Practicality	Clinical appropriateness
Number of statements with a median score 7-9 (High)	16	11	16	11
Number of statements achieving median score 9 (High)	0	0	0	0
Number of statements achieving median score 8 (High)	12	7	12	7
Number of statements achieving median score 7 (High)	4	4	4	4
Number of statements with a median score 4-6 (equivocal)	7	6	7	6
Number of statements achieving median score 6 (equivocal)	2	3	2	3
Number of statements achieving median score 5 (equivocal)	4	1	4	1
Number of statements achieving median score 4 (equivocal)	1	2	1	2
Number of statements achieving median score 1-3 (Low)	0	1	0	1
Number of statements achieving median score 3 (Low)	0	0	0	0
Number of statements achieving median score 2 (Low)	0	1	0	1
Number of statements achieving median score 1 (Low)	0	0	0	0

Many panel members provided detailed comments to explain their responses; these were summarised for all statements. Table 12 shows some examples of panellist's comments where consensus was achieved.

***Table 12**: Examples of panel members' comments about the statements that achieved consensus.*

Statements where consensus achieved in relation to its practicality or clinical appropriateness of the pharmaceutical complexity screening tool	Example panellist comments
The pharmacist can use the tool during or after medicine reconciliation	Useful to assess during medicine reconciliation but would be more useful to prioritise who to see first. This allows a better use of resources and ensures that decisions are being made using accurate and up to date information.
Highly complex patients should be seen within the first 6-12 hours of admission then daily	This helps with the patients admitted later in the evenings. Depends on the provision of services.
Highly complex patients should be seen by an experienced clinical pharmacist. (According to how your trust defines experience).	In an ideal world, yes but this is unlikely with current pharmacist staffing. However, junior pharmacists are always encouraged to escalate queries and often do.
Moderately complex patients should be seen within the first 24 hours of admission then daily	All patients should be seen by a pharmacist within 24hrs of admission. Practicality within 24 hours depends on staffing on the admissions ward and throughput of patients.
Moderately complex patients should be seen by a clinical pharmacist	Could be seen by a broader range of experienced pharmacists. With appropriate supervision in place.
Least complex patients should be seen within the first 24 hours of admission then twice weekly	This seems very sensible, as long as all issues identified and resolved on contact with the pharmacy team.
Least complex patients should be seen by a clinical pharmacist	A junior pharmacist (less than 12 months qualified) could see this category of patients with clear referral criteria for when to discuss with a clinical or experienced pharmacist.
Complexity criteria should be in three levels to distinguish between others: red for highly complex, amber for moderately complex and green for least complex	Prefer colour coding approach. Traffic light ratings are visual and good understanding.

After completing both Delphi One and Delphi Two, the Adult Complexity Tool for Pharmaceutical Care (ACTPC) was developed. The tool (ACTPC-Form 2) consists of three criteria: red (highly complex), amber (moderately complex) and green (least complex) (Appendix 5.A). In light of panellists' comments, and the need for pharmacy teams to prioritise patients for medicines reconciliation, it was decided to place the red criteria in

separate form, ACTPC-Form 1 (Appendix 5.B), thus allowing pharmacists, or indeed other trained staff, to swiftly identify newly admitted high-risk patients. Form 1 contains the 'red' criteria only and form 2 contains all three criteria: 'red' (highly complex), 'amber' (moderately complex) and 'green' (least complex) and is used to classify patients into differing complexity levels (red, amber, green) requiring different levels of pharmaceutical care during or after medicines reconciliation

5.4 Discussion

The overall aim of this study was to rigorously and systematically develop a complexity screening tool for pharmaceutical care, which can be used by clinical pharmacists to triage new patients according to the level of pharmaceutical care required. The ability to identify complex patients quickly and accurately presents a challenge for pharmacy services but it is a challenge that, if met, will enable the appropriate and effective use of the pharmacy workforce to ensure the safety of patients.[30] Patient safety is a continuing concern prioritised on both national and international agendas. The Global Patient Safety Challenge: Medication Without Harm, published by the World Health Organization in 2017, points to the criticality of this issue, and outlines the WHO's global initiative to bring down the incidence of severe and avoidable medication- related harm by 50% by 2022.[31]

To our knowledge, this is the first study conducted to develop a comprehensive tool combining internationally agreed components as well as nationally agreed standards for frequency of review and necessary pharmacist experience for each complexity level. The ACTPC encompasses two main sections, these are clinical related factors (e.g., an organ transplant patient) and medication related factors (e.g., high-risk medicines). The ACTPC guides clinical pharmacists to apply their judgement to identify patients at high-risk of DRPs requiring clinical pharmacist intervention and allows them to respond flexibly dependent upon the specific patient circumstances. Clinical judgement is important in managing

DRPs[32] and our tool allows clinical pharmacists to apply this judgment when necessary using the ACTPC.

The ACTPC could be used by any clinical pharmacy team to triage new patients at the point of their admission, prior to any pharmacist intervention, on an adult acute medical unit according to the complexity of their likely pharmaceutical needs. This tool may support the clinical pharmacy team by ensuring that highly complex patients, who are at greatest risk of preventable harm due to medication, are seen most quickly and most frequently by an appropriately experienced clinical pharmacist. Conversely, it will ensure that those patients who are at the lowest risk of preventable harm due to medication will be seen later by another appropriately experienced pharmacy professional, who may be a junior pharmacist or a trained senior technician. ACTPC may save clinical pharmacy services' time and resources but could also allow a better involvement of pharmacy technicians. The fact that low complexity patients might be seen by technicians was highlighted by the expert panel comments, however the tool was primarily developed for use by pharmacists. Therefore, minor modification of form 1 to reduce dependence on professional judgement and to set clear parameters for tool components could facilitate technician use.

To enhance the accuracy of our findings and ensure their practical relevance, ACTPC was developed by integrating the findings from a systematic review, interviews with clinical pharmacy managers, existing unpublished tools used across NHS settings nationwide and the experience and expertise of 84 leaders and experts in clinical pharmacy management and medication safety worldwide. Positive consensus was obtained on 92 tool components that are believed to identify those patients at the greatest risk of DRPs. In agreement with previous quantitative studies, we identified expected and well-known tool components in our study. Valuable insight was gained from a panel of worldwide experts into drug-related issues that healthcare professionals are confronted with in practice. These experts have also

provided their opinion as to which tool components are important or unimportant. Since the study included most existing tool components found in the literature and practice, no other components were added by the expert panel. There is strong evidence that suggests that the ACTPC may be the most comprehensive tool as the number of the risk factors that achieved consensus were high. However, the application of 92 criteria was considered too time consuming and unrealistic to use in practice and were, therefore, condensed into groups to reduce the number of components. This approach concurred with the view that prioritisation needs to be efficient and practical[30] and that short and easy to use tools can be supportive in daily practice achieving outcomes with a reasonable effort.[32]

Effective prioritisation does not merely focus on identifying patients with defined high-risk characteristics[30] but also ensures optimal use of the available pharmacy workforce. Pharmacists with little experience can be overwhelmed with the number of tasks they are required to do, such as handling a fast turnover of patients, managing patients with several co-morbidities and numerous medications. Without guidance on prioritisation, less experienced pharmacists may focus their time on tasks they find most enjoyable, or least stressful, or potentially only perform tasks that are deemed urgent by ward staff.[8] ACPTC provides guidance on the appropriate frequency of clinical pharmacist input and appropriate competency level of pharmacy staff assigned to each complexity level. This guidance was generated by consensus from over 43 senior practising pharmacists thus providing validity and robustness to our tool. The ability to match a pharmacists' experience to the complexity of patients' pharmaceutical needs is novel. Our previous study found that only seven hospitals had tools that had incorporated this ability to assign experience, and some of these hospitals were using the same tool.[21] Yet, this is a crucial aspect of optimising NHS resources as set out in the Lord Carter Review that stated the need to improve pharmacy workflow for the delivery of high quality and efficient patient care.[14]

5.4.1 Comparison with previous work

The existing literature on risk factors for adverse drug events[33,34] or drug related problems[35] can serve as a source of information when developing a patient complexity tool. The literature highlighted various methods for pharmaceutical complexity tool development such as literature review with consensus methods [36–43] or literature review with statistical methods.[44–46] Only three studies conducted in the UK used the consensus method to develop a prediction tool for use in hospital settings.[39,40,43] However, they gave limited details on the method of expert involvement and the process of the literature review for the selection of predictors. Furthermore, in two studies, the panelists comprised only of pharmacists[40,43] unlike our study that included experts from wider range of disciplines.

No gold standard method exists for the development of electronic or non-electronic tools. However, electronic tools may only operate with limited data available in the electronic records. For instance, Ayrshire & Arran NHS Trust's system only used data about medicines, and data about laboratory results were not included.[47] Furthermore, there are still many hospitals that do not have electronic patient records or electronic prescribing and therefore these electronic methods are not available to their hospital pharmacy teams. There is clearly a need to develop an approach for identifying patients' pharmaceutical complexity that does not rely on complex algorithms or availability of electronic data and could be widely adopted across the NHS. However, with the continuing drive for hospitals to shift to digital systems,[48] there is hope that in the future, the ACTPC tool could be incorporated into automated systems such as electronic health records systems. This approach may reduce the time required for completion of the tool and allow for detection of changes in real-time.

5.4.2 Study strengths and limitations

This study had a number of strengths: the tool was developed using a robust method where the information was collected in several ways: from the literature, interview findings and tools currently used in practice. The Delphi technique facilitated panellists in providing their comments efficiently and anonymously, while enriching the virtual 'discussion' in both rounds for the study. The recruitment and engagement of panel members is a key element to the success of any Delphi study.[49] Thus, panellists from a range of relevant professional groups: physicians, academics and clinical pharmacists were recruited to the study so as to provide a broad perspective of skilled, knowledgeable professionals working in the field of clinical pharmacy and medication safety. Having the opportunity to collect survey results online allowed for a wider geographic representation of the panel's expertise.

The number of panel members who responded in both Delphi studies matches or exceeds expert panel numbers in comparable Delphi surveys with a different focus.[50–54] This indicates that the results are consistent and stable. We employed purposive and snowball sampling techniques to overcome selection bias within the sample population. However, such approaches mean that participants are not subject to random selection and therefore there is the possibility that some selection bias may have taken place. For instance, in this study, most participants were based in Europe, however, this is in part due to the fact that most prioritisation tools have been developed in this region.[20] At this moment, it is difficult to ascertain the influence of the experts' origin and background on the results. Therefore, we acknowledge the fact that the design of the tool may have been influenced and explained by the composition of Delphi panelist group. The commitment of the panelists to the development of the tool is clear from the response rates in the Delphi rounds in the current study; these were 80.5% in Delphi One and 93% in Delphi Two respectively. Furthermore, the agreement on tool components was also high at 87%. Despite being based on a rigorous

development method, the draft ACTPC Tool may not include some relevant medicine or patient related components. However, to ensure the tool was comprehensive, we drew on the clinical expertise of the panelists to suggest additional points. Furthermore, the draft tool was evaluated by the expert reference group and by clinical pharmacists in practice. Such steps were implemented to ensure rigor and reduce methodological shortcomings in tool development.

Whilst the method was rigorous, the Delphi panel methodology is still opinion-based and different suggestions may be made on the same components by other healthcare practitioners. Finally, the tool will need to be tested for feasibility and applicability in practice as well as its use beyond the triage of medical admissions.

5.5 Conclusion

This Delphi study led to the development of a comprehensive pharmaceutical care complexity screening tool for use on admission to hospital. Its development was based on robustly collected data with input from national and international experts. ACTPC-Form 1 was developed to prioritise patients for medicines reconciliation facilitating the prompt identification of newly admitted high-risk patients. ACTPC-Form 2 was developed to classify patients during or after medicines reconciliation into differing complexity levels (red, amber, green), each level requiring different levels of pharmaceutical care. Application of the ACTPC could lead to greater patient-centred pharmaceutical care, improve patient safety and assist in workforce planning and resource utilisation by ensuring that the right pharmacists see the right patients at the right time. Implementation of the ACTPC in different hospital settings should be undertaken to explore its feasibility and acceptability in practice.

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None

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Contributors:

M.A. managed and led on data collection and analysis. D.S., M.T. and P.L. supervised all research activities. A.A. and S.W. were involved in identified and reviewed the initial list of potential components. M.A. drafted the initial version of the manuscript. D.S., M.T., S.W. and P.L. critically revised the manuscript.

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5.7 Study Two Appendices

Appendix 5.A: Adult Complexity Tool for Pharmaceutical Care- ACTPC-Form2

MANCHESTER 1824
The University of Manchester

Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form 2)

ACTPC

Patient name | Admission date/time

Patient hospital number | Ward

This tool does not override the responsibility to make decisions appropriate to the circumstances of the individual patient, therefore it is not mandatory to apply the recommendations in the tool.

Criteria Scope	Criteria	Red, Amber and Green Criteria Descriptions	Tick
Demographic Criteria	***Age***	Age > 70 years old	☐
	Weight	Extreme weight (frail/obese) < 50 KG / > 120 KG	☐
	Allergy	Previous history of severe allergic reaction to medication	☐
	Pregnancy	Pregnant or breast-feeding	☐
Clinical Related Criteria	***Priority Diseases***	Patient has any of the following diseases and is in an **unstable condition** according to your clinical judgement: Endocarditis ☐ Hyperthyroid crisis ☐ NSTEMI/STEMI ☐ Parkinson disease ☐ Epilepsy ☐ Decompensated heart failure ☐ Myasthenia gravis ☐ G6PD deficiency ☐ Porphyria ☐ Severe asthma ☐	☐
		All conditions above if stable or severe gastric absorption problems ☐	☐
	Infectious Diseases	Patient has any of the following diseases and is in an **unstable condition** according to your clinical judgement: Meningitis ☐ Sepsis ☐ HIV ☐ Tuberculosis (TB) ☐	☐
		All conditions above if stable ☐	☐
	Acute Kidney Injury	Stage 3: a rise in creatinine ≥ 3 times the baseline value	☐
		Either Stage 1 or Stage 2: a rise in creatinine from 1.5 to 2.9 times the baseline value	☐
	Chronic Kidney Disease	Severely decreased: GFR ≤ 29 ml/minute	☐
		Decreased GFR 30 - 59 ml/minute	☐
	Hepatic Impairment (LFT'S)	Severe hepatic impairment (LFT'S ≥ 3 times the upper limit of normal)	☐
		Moderate hepatic impairment (LFT'S < 3 times the upper limit of normal)	☐
	Hospitalisation	Patient had at least one admission in the last month (Discharged < 30 days ago)	☐
	Miscellaneous	An organ transplant	☐
		Patient has any of the following characteristics: Palliative care ☐ Uncontrolled pain ☐ National early warning score ≥ 5 ☐ Nil by mouth or has swallowing difficulties ☐ Abnormal laboratory results NOT related to medication (Excluding renal and liver) ☐	☐
Medication Related Criteria	***Polypharmacy***	Prescribed ≥ 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
		Prescribed ≥ 15 regular medicines without complex regimen e.g. No drug-drug or drug-disease interactions	☐
		Prescribed < 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
	Medication Risk	Prescribed any high-risk medicines** or medicines requiring TDM** with documented or suspected toxic or subtherapeutic effect	☐
		Prescribed any high-risk medicines** or medicines requiring TDM** without documented or suspected toxic or subtherapeutic effect	☐
	Treatment Interaction	Drug interaction with documented or suspected toxic or subtherapeutic effect	☐
		Drug interaction BUT no documented or suspected toxic or subtherapeutic effect	☐
	Drug related problems	Patient admitted due to an adverse drug reaction	☐
		Prolonged QT secondary to medicines** (No relevance to the reason of admission)	☐
		Falls secondary to medicines** (No relevance to the reason of admission)	☐
	Miscellaneous	Abnormal laboratory results related to medication or if dose adjustment/omissions are required	☐
		Restricted antibiotics**	☐
		Intravenous glucose> 20%	☐
		Continuous IV infusion excluding standard fluid replacement	☐

** Provided on the back of this tool

Criteria Range	Risk level	Complexity level	Pharmacist practitioner level
The patient has one or more red criteria	High risk	Highly complex- ideally should be seen in the first 6-12 hours BUT not greater than 24 hours of admission then daily	Experienced clinical pharmacist
The patient has one or more amber criteria	Moderate risk	Moderately complex- should be seen in the first 24 hours of admission then every one or two days	Clinical pharmacist
The patient stable with no acute issues AND he/she DOES NOT have any red or amber criteria	Low risk	Least complex- should be seen in the first 24 hours of admission then twice weekly	Clinical pharmacist

Complexity level can be changed at any time if patient's circumstances change			Overall assessment of pharmaceutical care complexity		
Date	**Time**	**Pharmacist**	**Red**	**Amber**	**Green**

High risk medication list
(This list is not exhaustive)

Anticoagulants: e.g. Heparin, LMWH, Warfarin, DOACs (Apixaban, Dabigatran, Rivaroxaban, Edoxaban) | **Anti-Psychotics**: e.g. Clozapine, Depot Injections | **Chemotherapy** | **Antiepileptic medication**: e.g. Sodium Valproate, Lamotrigine, Levetiracetam, Phenytoin | **Antiretrovirals for HIV and Hepatitis C:** e.g. Darunavir, Emtricitabine, Lamivudine, Tenofovir | **Immunosuppressants**: e.g. Azathioprine, Cyclosporine, Mercaptopurine, Methotrexate, Mycophenolate, Tacrolimus | **Narrow Therapeutic Index:** e.g. Aminophylline, Digoxin, Lithium, Phenytoin, Theophylline | **Opiates:** e.g. Buprenorphine, Naloxone, Fentanyl , Morphine, Methadone, Oxycodone | **Parkinson's disease medication**: e.g. Co-beneldopa , Co-careldopa, Entacpone , Rasagiline | **IV Antibiotics**: e.g. Vancomycin, Gentamicin, Amikacin, Tobramycin, Rifampicin, Erythromycin, Clarithromycin | **IV Inotropes**: e.g. Milrinone , Dopamine, Dobutamine, Isoprenaline, Vasopressors | **Antifungals**: e.g. Amphotericin, High dose or extended course duration of Triazole | **Total parenteral nutrition (TPN)** | **Immunoglobulins, Insulin, Corticosteroid, Intravenous beta-Blocker** | **Potassium infusion > 40 mmol/1L**

Medicines causing QT prolongation and Torsades de Pointes (This list is not exhaustive)

Antimicrobial: e.g. Azithromycin, Erythromycin, Clarithromycin, Moxifloxacin, Ketoconazole | **Antimalarial drugs**: e.g. Pentamidine, Quinine, Chloroquine | **Androgen antagonists**: e.g. Bicalutamide, Flutamide | **Antipsychotics**: e.g. Chlorpromazine, Haloperidol, Droperidol, Quetiapine, Olanzapine, Amisulpride, Thioridazine, Sulpiride, Zuclopenthixol, Clozapine, Olanzapine, Quetiapine, Risperidone, Lithium, Chloral hydrate, Pimozide | **Tricyclic antidepressants**: e.g. Amitriptyline, Doxepin, Imipramine, Nortriptyline, Desipramine | **Other antidepressants**: e.g.Mianserin, Citalopram, Escitalopram, Venlafaxine, Bupropion, Moclobemide | **Antiarrhythmics**: e.g. Quinidine, Procainamide, Disopyramide, Flecainide, Sotalol, Amiodarone, Dronedarone Antihistamines: Diphenhydramine, Hydroxyzine, Loratadine, Mizolastine, **Gonadorelin analogues** / **antagonists**: e.g. Buserelin, Goserelin, Leuprorelin, Degarelix **Immunosuppressant**: e.g. Tacrolimus | **Antidiuretic hormone**: e.g. Vasopressin | **Thiazide diuretics** | **Other agents**: e.g. Adenosine, Papaverine , Domperidone, Metoclopramide, Methadone (in doses greater than 100 mg), Ondansetron, Sildenafil, Solifenacin, Tizanidine, Tolterodine, Droperidol, Levomepromazine, Hydroxychloroquine

Patients prescribed restricted antibiotics
(This list is not exhaustive)

Amphotericin, Liposomal amphotericin, Amikacin, Cephalosporins (e.g. ceftriaxone, cefuroxime, cefalexin, ceftazidime), Carbapenems (e.g. Meropenem, ertapenem), Chloramphenicol, Daptomycin, Echinocandin antifungals (e.g. caspofungin, anidulafungin), Fidaxomicin, Fosfomycin, Linezolid, Meropenem, Piperacillin/ Tazobactam, Posaconazole, Quinolone (e.g. ciprofloxacin, levofloxacin), Tigecycline, Tobramycin IV, Vancomycin, Voriconazole

Medicines that may increase falls risk
(This list is not exhaustive)

Analgesics: e.g. Opioids, NSAIDs | **Anticholinesterase inhibitors**: e.g. Donepezil, Rivastigmine, Galantamine | **Antidepressants**: e.g. Tricyclics, selective serotonin reuptake inhibitors (SSRIs) and others | **Anti-diabetic drugs**: e.g. insulin, Glibenclamide, Gliclazide, Tolbutamide | **Anti-epileptics**: e.g. Phenytoin, Carbamazepine, Gabapentin, Pregabalin, Primidone, Sodium Valproate | **Anti-histamines**: e.g. Chlorphenamine | **Anti-muscarinic drugs**: e.g. Oxybutynin, Solifenacin | **Anti-psychotics**: e.g. Haloperidol, Risperidone, Olanzapine, Chlorpromazine, Prochlorperazine | **Cardiovascular drugs**: e.g. ACE inhibitors, Diuretics, Beta-blockers, Calcium channel blockers, Others e.g. Digoxin, Amiodarone, Nitrates, Statins | **Parkinson's disease drugs**: e.g. Co-careldopa, Co-beneldopa, Entacapone | **Proton-pump inhibitors** (**PPIs**) & **H2-receptor antagonists**: e.g. cimetidine, ranitidine in combination with other anticholinergic agents. | **Sedatives**: e.g. benzodiazepines, clomethiazole, zopiclone

Pharmacist's Comments

Appendix 5.B: Adult Complexity Tool for Pharmaceutical Care- ACTPC-Form1

MANCHESTER 1824
The University of Manchester

Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form 1)

ACTPC

Patient name | Triage date/time

Patient hospital number | Ward

This tool does not override the responsibility to make decisions appropriate to the circumstances of the individual patient, therefore it is not mandatory to apply the recommendations in the tool.

Criteria Scope	Criteria	Red Criteria Descriptions	Tick
Clinical Related Criteria	***Priority Diseases***	Patient has any of the following diseases and is in **an unstable condition** according to your clinical judgement: Endocarditis ☐ Hyperthyroid crisis ☐ NSTEMI/STEMI ☐ Parkinson disease ☐ Epilepsy ☐ Decompensated heart failure ☐ Myasthenia gravis ☐ G6PD deficiency ☐ Porphyria ☐ Severe asthma ☐	☐
	Infectious Diseases	Patient has any of the following diseases and is in **an unstable condition** according to your clinical judgement: Meningitis ☐ Sepsis ☐ HIV ☐ Tuberculosis (TB) ☐	☐
	Acute Kidney Injury	Stage 3: a rise in creatinine ≥ 3 times the baseline value	☐
	Chronic Kidney Disease	Severely decreased: GFR ≤ 29 ml/minute	☐
	Hepatic Impairment (LFT'S)	Severe hepatic impairment (LFT'S ≥ 3 times the upper limit of normal)	☐
	Miscellaneous	An organ transplant	☐
Medication Related Criteria	***Polypharmacy***	Prescribed ≥ 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
	Medication Risk	Prescribed any high-risk medicines** or medicines requiring TDM** with documented or suspected toxic or subtherapeutic effect	☐
	Treatment Interaction	Drug interaction with documented or suspected toxic or subtherapeutic effect	☐
	Drug related problems	Patient admitted due to an adverse drug reaction	☐
	Miscellaneous	Abnormal laboratory results related to medication or if dose adjustment/omissions are required	☐

Guidance

- **This tool ACTPC-Form1 (With red criteria only) is for use directly on admission at ADULT ACUTE MEDICAL UNIT.**
- **Patients who meet any of these criteria/identified as clinically unstable are immediately rated as 'RED' and are a high priority for both initial medicines reconciliation and continuing clinical review.**
- **The complexity level can be changed at any time if the patient's circumstances change.**
- **Patients who have any red criteria can be downgraded depending on clinical condition and/or medication changes by using ACTPC-Form2**

High risk medication and medicines requiring TDM list (Not exhaustive list)

Anticoagulants: e.g. Heparin, LMWH, Warfarin, DOACs (Apixaban, Dabigatran, Rivaroxaban, Edoxaban) **Anti-Psychotics:** e.g. Clozapine, Depot Injections **Chemotherapy | Antiepileptic medication:** e.g. Sodium Valproate, Lamotrigine, Levetiracetam, Phenytoin **Antiretrovirals for HIV and Hepatitis C:** e.g. Darunavir, Emtricitabine, Lamivudine, Tenofovir **Immunosuppressants:** e.g. Azathioprine, Cyclosporine, Mercaptopurine, Methotrexate, Mycophenolate, Tacrolimus | **Narrow Therapeutic Index:** e.g. Aminophylline, Digoxin, Lithium, Phenytoin, Theophylline | **Opiates:** e.g. Buprenorphine, Naloxone, Fentanyl , Morphine, Methadone, Oxycodone | **Parkinson's disease medication:** e.g. Co-beneldopa , Co-careldopa, Entacpone , Rasagiline | **IV Antibiotics:** e.g. Vancomycin, Gentamicin, Amikacin,Tobramycin, Rifampicin,Erythromycin,Clarithromycin | **IV Inotropes:** e.g. Milrinone , Dopamine, Dobutamine, Isoprenaline, Vasopressors | **Antifungals:** e.g. Amphotericin, High dose or extended course duration of Triazole | **Total parenteral nutrition (TPN) Immunoglobulins, Insulin, Corticosteroid, Intravenous beta-Blocker | Potassium infusion > 40 mmol/1 L**

Criteria Range	Risk level	Complexity level	Pharmacist level
The patient has one or more red criteria	**High risk**	**Highly complex- ideally should be seen in the first 6-12 hours BUT not greater than 24 hours of admission then daily**	**Experienced clinical pharmacist**

Complexity level can be changed at any time if patient's circumstances change			Overall assessment of pharmaceutical care complexity	
Date	Time	Pharmacist's comments	Red	Non-red (i.e. amber or green)

6. Chapter Six: Study Three

Title	Assessing the feasibility and impact of the adult complexity tool for pharmaceutical care (ACTPC) on patient outcomes and pharmacist workload: a pre and post prospective feasibility study in three UK hospitals
Type	Original article
Authors	Meshal A. Alshakrah, Douglas T. Steinke, Mary P. Tully, Aseel S. Abuzour, Steven D. Williams, Penny J. Lewis
Status	In publication format but not yet submitted *

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*Note. Formatting and layout for this chapter are consistent with the requirements for journal publication. In addition, references from the paper are placed at the end of the chapter rather than at the end of the thesis.

Assessing the feasibility and impact of the adult complexity tool for pharmaceutical care (ACTPC) on patient outcomes and pharmacist workload: a pre and post prospective feasibility study in three UK hospitals

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Abstract

Background: Hospital pharmacists are a key player in enhanced patient care, yet financial and resource limitations within the National Health Service (NHS) mean not all patients can be reviewed by clinical pharmacists on a daily basis. This gap in pharmaceutical care provision may not be a problem for some patients but deleterious for others. It is therefore necessary that a reliable, simple screening tool is used that directs pharmaceutical care to patients with the most urgent or complex needs. Ideally, such a tool would not depend on complex algorithms or the availability of electronic data. Hence, the Adult Complexity Tool for Pharmaceutical Care (ACTPC) has been developed, which could enhance patient safety and help ensure effective use of the pharmacy workforce.

Objective: To assess the feasibility of the ACTPC tool in the hospital setting and identify the most effective ways to measure its impact on patient outcomes and pharmacist workload patterns.

Methods: A pre-post ACTPC implementation prospective study was conducted at three NHS acute hospital trusts. Data on the following outcomes were collected before and after implementation: the number and types of prescribing errors and pharmacist interventions, the amount of time pharmacists spent on tasks, patient perceptions of safety, length of patient stay in hospital and 30-day readmission rate. Data were analysed using SPSS version 23.0 and descriptive and inferential analysis was carried out using the Mann Whitney U test and Chi-square analysis.

Results: Of 408 patients, 209 were reviewed by pharmacists before the implementation of ACTPC while 199 were reviewed after. Data on prescribing errors (PE) and interventions was successfully collected pre- and post-implementation of ACTPC. The number of patients receiving doses of erroneous medications reduced significantly from 58 patients (28%) to

36 (18%) (p=0.020). The number of patients who received doses of erroneous high-risk medications reduced from 19 (9%) to 9 (5%). There was also a reduction in the number of patients who had a serious PE (n=11; 5% vs n=6; 3%) and the number who had missing doses of time critical medications (TCMs) (n=23; 11% vs n=14; 7%). The data also demonstrated tool validity; it identified those patients at greater risk of medication related problems. Collecting data on length of stay (LoS) and readmission rate were difficult, as it was not feasible in this time limited study to collect patient identifiable data.

Conclusion

The study successfully met its original objective, determining that the tool was practical and feasible across three hospital sites. It also highlighted specific feasibility issues for consideration in a future study. Wider testing and development of the tool would include extending beyond Acute Medical Unit (AMU), greater use of technician workforce and use of technology.

6.1 Introduction

Improved patient safety in healthcare environments is a global concern.[1] Errors involving medications, such as prescribing, dispensing, administrating and monitoring errors are a contributing factor to this concern.[2–4] This is specifically important given the fact that medicines are the most commonly used intervention in healthcare settings.[5] Recently, the World Health Organisation (WHO) launched their third Global Patient Safety Challenge, Medication Without Harm. It aims to minimise the global burden of severe and avoidable medication-related harm by 50%, by 2022.[6] Drug related problems (DRPs) may extend hospital stays, and increase the risk of patient morbidity and mortality.[7,8] Hospitals in the UK are seeing rising numbers of admissions every year [9] and 85% of all acutely admitted adult patients have at least one drug related problem.[10]

Acute medicine is defined as "*part of general internal medicine (GIM) concerned with the immediate and early specialist management of adult patients suffering from a wide range of medical conditions who present to, or from within, hospitals, requiring urgent or emergency care*".[11] Acute medicine is not based around a body system, disease or patient characteristic. Acute medicine aims to provide patients with the very best clinical experience.[12] It was reported that 46% of patients admitted to an acute medical unit experienced a prescribing error.[13] Therefore, actions on acute medicine need to be timely, organised, well-led and delivered by senior staff.[12]

The optimisation of medicine use is a key component of pharmaceutical care, which is undertaken by hospital clinical pharmacists.[14] The process of pharmaceutical care includes the prevention, identification and resolution of DRPs.[15] However, clinical pharmacy services face limited resources. Therefore, the ability to accurately screen and identify those patients at greatest risk of preventable adverse drug events would be of great benefit, enabling appropriate allocation of costly staff resources.[16,17] In other words, there is a need

to target resources of clinical pharmacy services to those patients that are most in need of clinical pharmacist's expertise, and in this respect, there is an increasing need to guide junior pharmacists in the delivery of their work. Therefore, developing innovative solutions to identify patients that can be at a higher risk of adverse drug events or adverse drug reactions is a priority. A number of approaches have been utilised. A systematic review of current pharmacy prioritisation tools found studies relating to eight UK based tools and nine international tools.[16] Many used electronic patient data as a basis for screening patients and determining priority. However, electronic tools may only operate with limited data available in the electronic records. Furthermore, many hospitals do not have electronic patient records or electronic prescribing and therefore these methods are not available to many pharmacy teams. There is a need to develop an approach for identifying patients' pharmaceutical complexity that does not rely on complex algorithms or availability of electronic data and that could be widely adopted across the NHS. Therefore, a paper-based Adult Complexity Tool for Pharmaceutical Care (ACTPC) has been developed based on a systematic literature review,[16] qualitative study of current UK based tools[18] and a Delphi approach.[19] Detailed information can be found elsewhere.[19] The ACTPC aims to be a simple and convenient tool for use by the pharmacy team on patient admission to hospital. The ACTPC could lead to improved patient safety and better workforce planning and resource utilisation, by ensuring that appropriate pharmacists see the right patients at the right time, although this has not been tested as of yet. Therefore, the aim of this study is to assess the feasibility and acceptability of the ACTPC on the acute medical units of three UK National Health Service hospitals and identify the most efficient and effective ways to measure the impact of the tool on patient outcomes and pharmacist workload patterns. Furthermore, this feasibility study will inform the design of a future randomised controlled study of the tool's effectiveness.

6.2 Methods

6.2.1 Study design and setting

A pre-post prospective study was conducted within the adult acute medical units (AMU) of three NHS acute hospital trusts during October-December 2019 in England. Site A has 54 beds and about 1100 monthly admissions, as well as 7 pharmacy employees. On weekends, admissions pharmacists have coverage from 7 a.m. to 8 p.m. and 9 a.m. to 5.15 p.m. Site B has 49 beds and two pharmacists, with an average of 800 admissions per month. On weekdays, an admissions pharmacist is available from 9 a.m. to 5 p.m., and on weekends, from 9 a.m. to 1 p.m. Site C has 56 beds and 6 pharmacy employees, with an average of 622 admissions per month. Admissions pharmacists provide cover from 8 a.m. to 5.30 p.m. weekdays and 9 a.m. to 5 p.m. weekends.

Hospital A and C used an electronic prescribing system at the time of the data collection. The second hospital (Hospital B) used paper prescription charts for inpatients and either handwritten or transcribed electronically generated discharge prescriptions. Data was collected on three individual days (Monday to Friday) over a three-week period in the AMU before the implementation of the paper-based ACTPC and three individual days over a three-week period after implementation. One week between the pre and post phases was given to introduce the tool and allow staff to get used to using the tool. The AMUs had an average of 28 beds. Data collection included; the number and types of prescribing errors and interventions made, length of patient stay in hospital and 30-day readmission rate. The amount of time pharmacists spent on tasks before and after ACTPC implementation in two hospitals (hospital A and B) was collected separately to identify resource implications.

6.2.2 Data collection

An electronic data collection form using Form$^{2™}$ was designed to help with data collection. Form$^{2™}$ was chosen because it is readily available to the University of Manchester, easy to use and has been used in previous studies.[20] The form does not include any identifiable data about the screened patients. Ten clinical pharmacists working on AMU completed a form for each patient on data collection days. Before beginning the pre-implementation phase, hospital pharmacists working on the AMU in each participating hospital were trained on how to use the ACTPC and data collection forms. The training session provided a general overview of the study's aims, a definition and a discussion of prescribing errors, the electronic data collection form and step-by-step instructions explaining how to collect data. Pharmacists were provided with the paper-based ACTPC tool and an explanation of how it works. In addition, three theoretical case studies were provided to pharmacists to work through using the tool in order clarify and solidify their understanding during the training session. An information booklet was also provided detailing information on the study requirements and how to use electronic forms. The process of data collection is illustrated in Figure 10

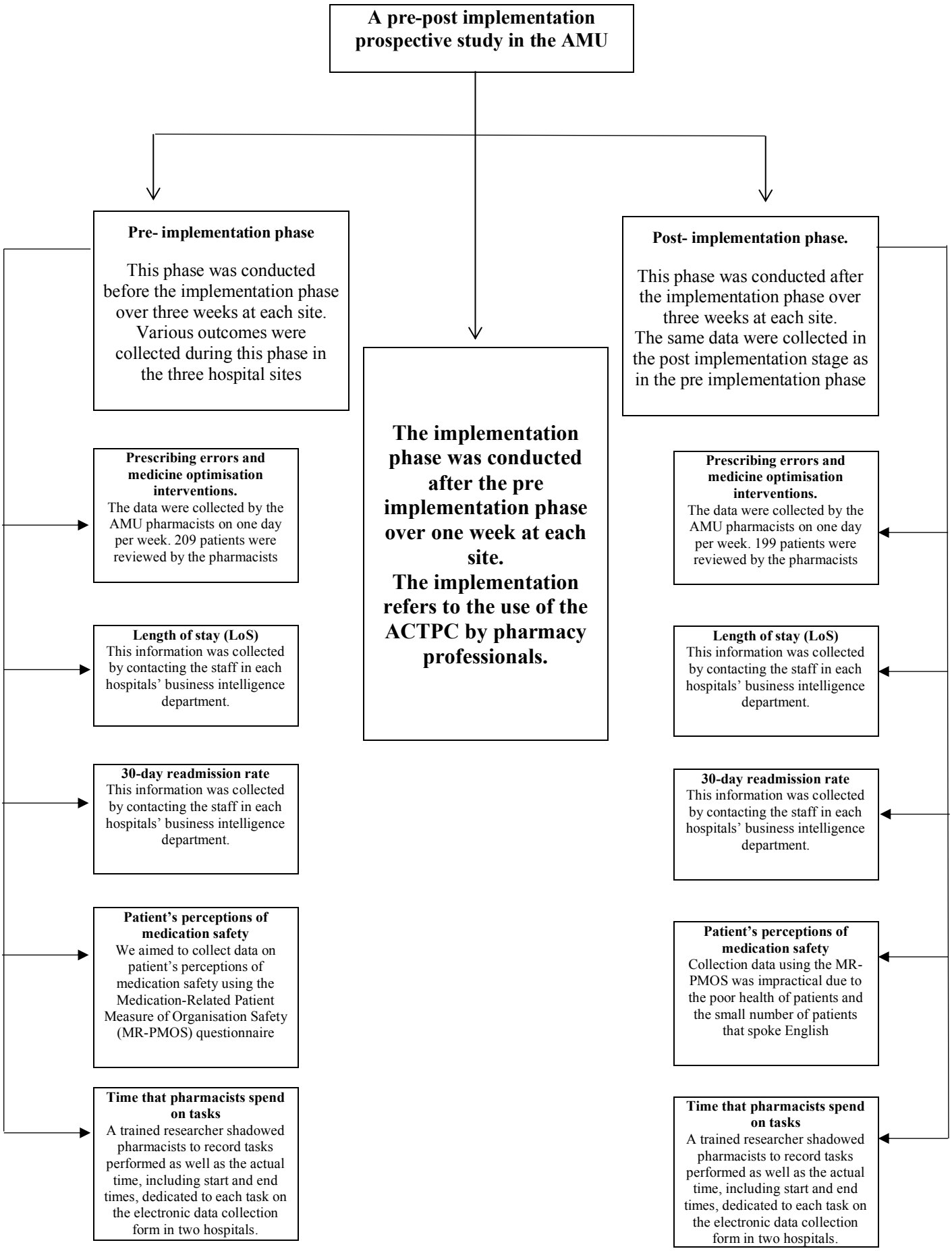

***Figure 10**: Overview of the process of data collection for the feasibility study*

6.2.2.1 Data on prescribing errors (PE) and interventions

Data collection included: the number of prescribed medicines including pre- admission medicines and newly prescribed medicines after admission, the number and nature of any prescribing errors and the number and type of interventions made by the AMU pharmacists. Identifying and correcting prescribing errors, optimisation (improving a patient's medication to increase treatment efficacy), or consultation given to the patients and/or the healthcare professionals, are all examples of pharmacist interventions.[21] Ward-based clinical pharmacists check inpatient prescriptions at, or soon after patient admission, when medicines reconciliation is undertaken. Furthermore, the hospital pharmacists performed the screening exercise on all new and rewritten inpatient medication orders to identify prescription errors as part of their routine practice. For the purpose of this study, we used an established definition of a prescribing error as ''*one which occurs when, as a result of a prescribing decision or prescription- writing process, there is an unintended, significant reduction in the probability of treatment being timely and effective, or an increase in the risk of harm when compared with generally accepted practice*''.[22] Prescribing errors (PEs) did not include regular medicines that were omitted on admission. The EQUIP study criteria for error categorisation and severity classification were used (Appendix 6.A).[23] Patient based prescribing error rates were calculated by dividing the total number of patients with prescribing errors by the total number of patients reviewed. In addition, data collection included the number and type of omitted medicines before medicine reconciliation including time critical medicines. Time-critical medications (TCMs) are medications at a greater risk of causing harm if not administered in a timely manner.[24] TCMs included different classes/groups such as insulin, Parkinson's disease medications and anti-coagulants. The list of TCM developed by the Medicines Governance Northern Ireland Team was used in this study (Appendix 6.B).[24] Furthermore, the data collection form

included a section for reporting actual patient harm. Actual patient harm is defined as '*A serious adverse reaction corresponds to any untoward medical occurrence that at any dose results in death, is life-threatening, requires inpatient hospitalisation or prolongation of existing hospitalisation, results in persistent or significant disability or incapacity, is a congenital anomaly/birth defect*'.[25]

6.2.2.2 Data on length of stay (LoS)

Length of stay was calculated by summing the number of days each individual was in hospital from the point of admission to the AMU to the point of discharge from the AMU to home. This information was collected by contacting the staff in each hospitals' business intelligence department and by asking them to provide the aggregated data of the LoS within a period of three weeks before the implementation of the tool and three weeks after the implementation. The standard deviation for the average LoS was not provided by the NHS business centre.

6.2.2.3 Data on patient readmission

Patient readmission rates within 30 days of discharge from hospital was collected from the hospitals' business intelligence department in each participating hospital. The department was contacted to first obtain the aggregated number of patients admitted and discharged from the AMU (denominator) during the pre and post-implementation period then the aggregated number of those patients who were readmitted to all hospital wards within the 30-day period (numerator) to establish the rate of readmission. The readmission rate is the aggregated number of readmissions (numerator) divided by the aggregated number of discharge patients (denominator). The readmission rate data were collected separately for both the pre and post-implementation phases.

6.2.2.4 Data on patient's perceptions of medication safety

We aimed to collect data on patient's perceptions of medication safety using the Medication-Related Patient Measure of Organisation Safety (MR-PMOS) questionnaire. This questionnaire has been developed to measure patients' views on medication safety and has been used previously by one of the research team on an admissions ward of a teaching hospital.[26]

6.2.2.5 Data on the amount of time that pharmacists spend on tasks

Changes in pharmacists' work patterns in two hospitals (hospitals A and B) were collected pre and post-intervention. Fifteen work tasks for pharmacists were identified following an extensive literature review and discussion with the research team (Appendix 6.C). A list of these activities was compiled and a data collection form developed. This data collection form was embedded in an electronic application (Form^{2TM}). All task descriptions and definitions included in our data collection tool were adapted from previous time and motion studies.[27–30] Face and content validity testing of the form was undertaken by two pharmacists and suggested amendments implemented. The modified categories were pilot-tested during the first observational session in each hospital to ensure the classification worked in practice. Similar to other time and motion studies[30,31], the data were collected by task, not per patient. This would avoid missing certain tasks from the record and therefore provide a realistic picture of how pharmacists distribute their workload. No patient information was recorded.

A trained researcher (AA) shadowed pharmacists to record tasks performed, as well as the actual time, including start and end times, dedicated to each task on the electronic data collection form. The time taken for each activity was recorded under the appropriate task category in the data collection form. To ensure data quality at the end of each observed shift, the observer (AA) and the researcher (MA) met to discuss and resolve any issues.

Pharmacist recruitment

To recruit pharmacists providing clinical pharmacy services to the AMU, an information session was held outlining the study purpose and methods. A participant information sheet and a copy of the consent form were given to all AMU pharmacists to fill in after a period (48 hours) reflection. Following signed consent, pharmacists were assigned a study identification number. Demographic information regarding participants' length of experience was collected. Pharmacists ranged in experience from 1.7 to 11 years.

6.2.3 Data analysis

Data on feasible outcome measures to evaluate the tool, including time to perform pharmacist tasks, were analysed and examined to determine the most appropriate outcome measures for a future cluster randomised control trial. Descriptive statistics were performed comparing pre and post-intervention outcomes using parametric and non-parametric tests where appropriate. Kruskal-Wallis Rank and Chi-square tests were performed when comparing data from three hospital sites. Data were analysed using SPSS version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp). P-values <0.05 were considered statistically significant.

6.2.4 Ethical approval

Ethical approval for the study was obtained from the NHS Research Ethics Committee Wales (19/YH/0285), and Health Research Authority (HRA) (project ID 261401).

6.3 Results

This feasibility study included several outcome measures and the results for each outcome are presented separately below:

6.3.1 Prescribing errors (PE) and interventions

Before combining the results of all three hospitals, we performed statistical tests to find out the extent of any differences between hospitals and whether these differences were significant or not. Although the data were collected from all admitted patients to the AMU wards in three different hospitals without any inclusion/exclusion criteria, the findings show that there was no statistical difference in the pre-implementation phase, as well as in the majority of variables in the post-implementation phase. There was a slight difference in the post-implementation cohort in the age group and the number of doses received before identification of prescribing errors. Since the difference was small and only apparent in the second group, it did not prevent us from combining the results of all three hospitals in each group (Appendix 6.D).

A total of 408 patients from three different hospital sites were included in the analysis. Of these, 209 patients were reviewed by pharmacists before the implementation of ACTPC while 199 were reviewed after the implementation of ACTPC. Tables 13 and 14 show that there was no significant difference in the majority of the age groups and the number of prescribed medicines before and after implementation. Therefore, we could say that the populations were comparable in terms of age groups and number of prescribed medicines before and after the intervention was introduced. The data collection in this feasibility study did not capture the population gender or comorbidity variables.

Table 13 gives the pre-implementation data showing the largest patient group belonging to the age group 81-90 years (47, 22%) while post-implementation, the greatest number of patients fell into the age group 71-80 (53, 27%).

Table 13: *Overall age distribution for patients before and after implementing ACTPC in three hospitals*

Age groups	Before implementation (N=209)		After implementation (N=199)		P value
	Numbers of patients	Percent	Numbers of patients	Percent	
18-30	13	6%	8	4%	0.314
31-40	19	9%	8	4%	0.062
41-50	7	3%	18	9%	0.028
51-60	24	11%	16	8%	0.316
61-70	43	21%	27	14%	0.060
71-80	39	19%	53	27%	0.054
81-90	47	22%	48	24%	0.696
>90	17	8%	21	11%	0.40
Total	209	100%	199	100%	

Table 14: *Distribution of the number of medicines among admitted patients before and after ACTPC implementation in three hospitals*

Variables	Before implementation (N=209)		After implementation (N=199)		P value
	Total	Mean	Total	Mean	
Number of medicines prescribed per patient	2240	10.7	2103	10.5	0.561

During pre-implementation phase, 2240 medicines were prescribed for 209 patients admitted to the AMU wards at three hospitals (Table 14). The mean number of prescribed medicines per patient was 10.7. While there were 199 patients in the post-implementation phase who were prescribed a total of 2103 medicines and the mean number of medicines prescribed per patient was 10.5.

The highest number of prescribed medicines for each patient was between ten and fourteen in the pre-ACTPC implementation phase (n= 830, 37%) while 15 or more medicines was highest in the post-implementation phase (n= 944, 45%) (Figure 11).

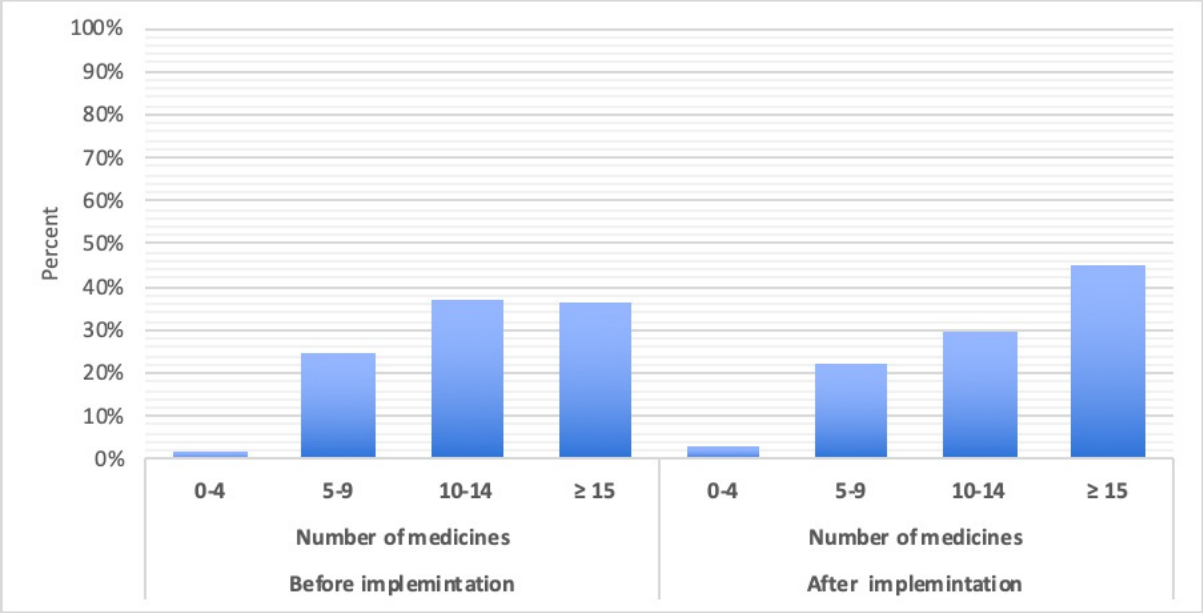

Figure 11: *Number of medicines on admission to the AMU in the pre and post ACTPC implementation in the three hospitals*

As shown in Table 15, the patient based prescribing error rates changed between pre- and post-implementation with a significant reduction in the post-implementation cohort (41% and 28% respectively) (p=0.004). There was also a reduction in the number of patients with all severity categories of prescribing errors post ACTPC implementation (104 vs 61 patients). It should be noted that patients could have errors in more than one severity category. Furthermore, there is a significant decrease in the number of patients who received doses of medication before identification of prescribing errors (28% vs 18%) (p=0.020). The number of patients who received doses of high-risk medicines (HRMs) reduced from 19 patients (9%) pre-implementation to 9 patients (5%) after implementing the ACTPC. Data on actual patient harm were captured in the data collection form, however, no actual patient harm was recorded. In terms of pharmacist interventions, a total of 330 interventions (1.6 interventions per patient) were documented before ACTPC implementation and 172 interventions (0.9 intervention per patient) after implementation.

Table 15: *Prescribing errors and their severity among patients reviewed by pharmacists before and after ACTPC implementation in the three hospitals*

Variables	Before implementation (N=209)		After implementation (N=199)		P value
	Total	Percent	Total	Percent	
Number of patients who have prescribing errors	86	41%	55	28%	0.004
Number of patients who have serious prescribing errors	11	5%	6	3%	0.256
Number of patients who have significant prescribing errors	47	22.5%	29	15%	0.04
Number of patients who have minor prescribing errors	46	22%	26	13%	0.017
Number of patients who received doses before identification of prescribing errors	58	28%	36	18%	0.020
Number of patients who received doses of high-risk medications before identification of prescribing errors	19	9%	9	5%	0.068

Six HRM classes were identified (Table 16) including; anticoagulants, opioids, insulin, Parkinson's disease medicines, antiepileptics, intravenous antibiotics and immunosuppressants. In the pre-implementation phase, 30 HRMs had prescribing errors and 19 patients had received doses of HRMs before identification of the errors. In contrast, the number of HRMs in the post-implementation phase decreased to 18 and only nine patients received doses before identification of the error during the post-implementation.

***Table 16**: High-risk medicines containing prescribing errors and their respective number of received doses before and after ACTPC implementation*

Class of Medicines	Before implementation (N=209)			After implementation (N=199)		
	Number of medicines	Number of HRM doses received	Number of patients who received doses of HRMs	Number of medicines	Number of HRM doses received	Number of patients who received doses of HRMs
Anticoagulants	15	9	6	9	10	6
Opioids	10	20	10	2	0	0
Insulin	2	1	1	4	3	2
Parkinson's Disease medicines	1	1	1	0	0	0
Antiepileptic	1	2	1	1	2	1
IV antibiotics (Vancomycin)	1	2	1	0	0	0
Immunosuppressants	0	0	0	2	0	0
Total	30	35	19*	18	15	9

**One patient received two HRMs classes.*

Regarding time critical medicines (TCMs), during the pre-implementation phase, 23 patients (11%) had missed doses of time critical medicines (Table 17). After implementing the ACTPC, a total of 14 patients (7%) had omitted doses of TCMs. As illustrated in Table 16, there was a reduction in the number of patients who had omitted doses of TCMs (11% vs 7%) (p=0.162) post-implementation of the ACTPC.

***Table 17:** Distribution of TCMs missing and doses among admitted patients before and after ACTPC implementation in three hospitals*

Variables	Before implementation (N=209)		After implementation (N=199)		P value
	Total	Percent	Total	Percent	
Number of patients who have missing doses of time critical medications on admission	23	11%	14	7%	0.162

The results in Table 18 demonstrate that there were a total of eight classes of TCMs that had missed doses in the pre implementation phase and seven classes after implementation phase. Before ACTPC implementation, the total number of omitted doses of TCMs was 44 and the number of missed doses ranging from zero to 13. The highest number of patients who missed doses of TCMs were those under anti-infective and opioid classes (six patients in each class). In post-implementation, the total number of omitted doses of TCMs was 23. The number of missed doses ranging from zero to eight. The highest number of patients who missed doses of TCMs after the implementation of the ACTPC were those receiving insulin (5 patients). There were five patients that missed doses of two medicine classes during the pre-implementation phase compared to one patient after the implementation phase.

***Table 18**: Number of missing doses and number of patients for various classes of time critical medicines before and after the implementation of ACTPC in three hospitals*

Class of Medicines	Before implementation (N=209)		After implementation (N=199)	
	Number of missed doses	Number of patients who have missed doses	Number of missed doses	Number of patients who have missed doses
Anticoagulants	4	2	1	1
Anti-infectives	13	6	4	2
Antiplatelets and thrombolytics	5	4	2	2
Opioids	9	6	4	2
Anticonvulsants	6	4	3	2
Parkinson's Disease medicines	1	1	0	0
Insulin	3	2	8	5
Corticosteroids	3	3	0	0
Antiretrovirals	0	0	1	1
Immunosuppressants	0	0	0	0
Total	44	28**	23	15*

***Five patients had missed doses of two classes.*
**One patient had missed doses of two classes.*

6.3.1.1 Overall validation of using ACTPC at three hospitals

The pharmaceutical complexity level was not reported for 20 patients in the three hospitals and these were excluded from analysis. The overall results showed that 38.5% of patients (n=69) were assigned to highly complex (red), 42.5% of patients (n=76) assigned to moderately complex (amber) and 19% of patients (n=34) assigned to least complex (green) at the three hospitals (Figure 12). It is interesting to note that 64% of the highly complex patients were 71 years old and above.

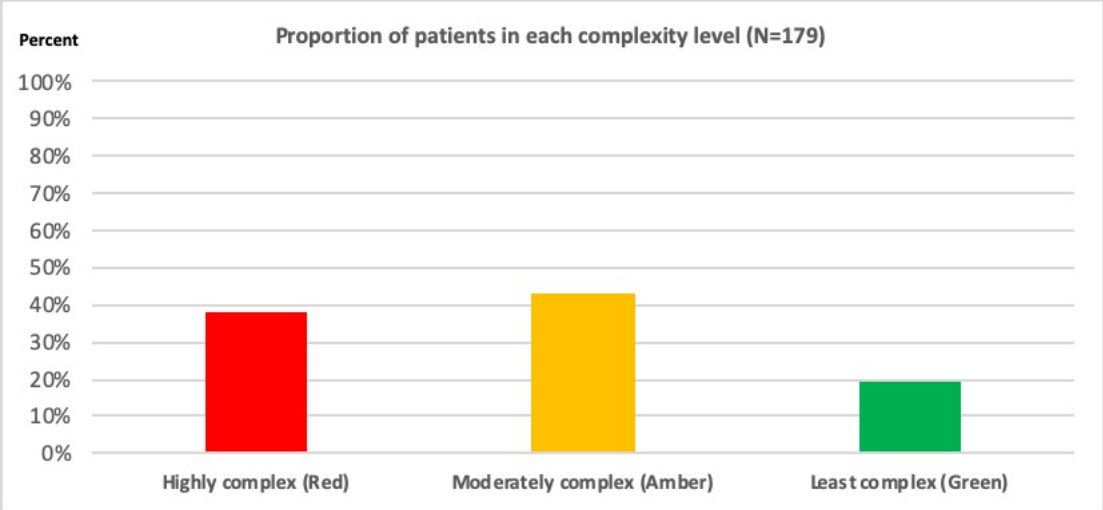

Figure 12: *Proportion of patients in each complexity level*

As shown in Figure 13, 36% of the highly complex patients were taking 15 or more medicines. In contrast, 41% of the least complex patients were taking four or less medicines. The proportion of the highly complex patients increased proportionally with the increase in the number of medicines taken. Whereas, the proportion of the least complex patients (Green) decreased proportionally with the increase in the number of medicines taken. This finding suggests that there is an association between the number of medicines and the patients' complexity levels.

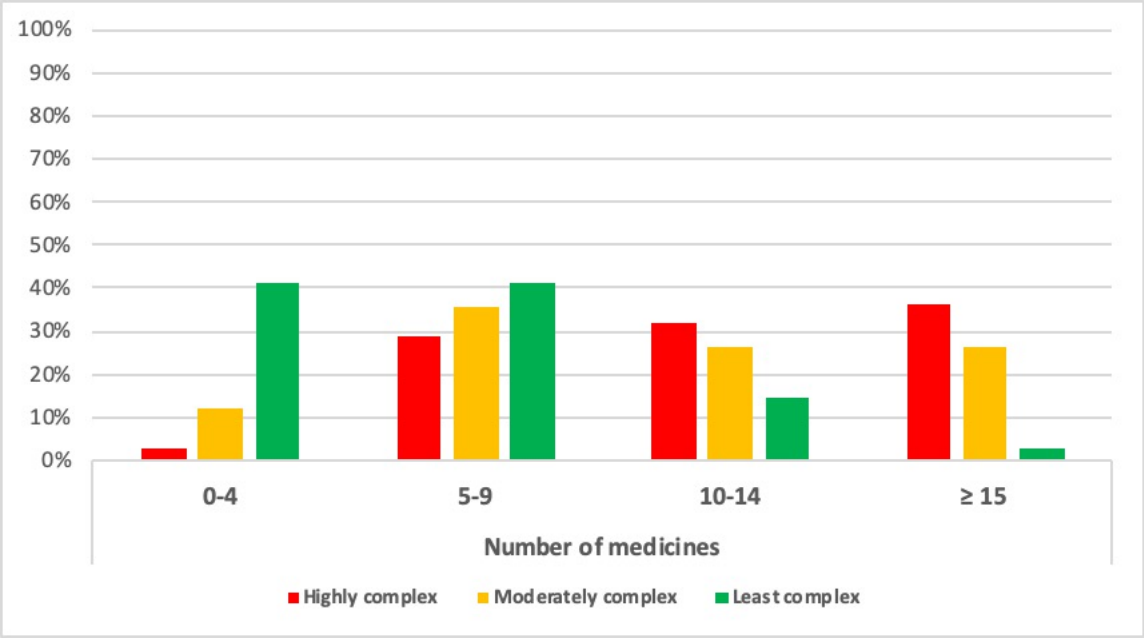

Figure 13: *Patients' complexity levels and number of prescribed medicines taken at three hospitals*

In Table 19, the patients with high and moderate complexity levels had a higher number of missing doses for all medicines and TCMs in particular. Those patients also had the highest number of serious prescribing errors, significant prescribing errors, had received doses of all medicines and HRMs in particular before identification of prescribing errors and had received interventions from AMU pharmacists.

Table 19: *Proportion of patients in each complexity levels and number of missing doses and prescribing errors in three hospitals*

Category	Total	Complexity levels					
		Red		Amber		Green	
Number of patients reviewed**	179	69	38.5%	76	42.5%	34	19.0%
Number of patients who have medicines missing on admission	85	34	40.0%	39	45.9%	12	14.1%
Number of patients who have TCMs missing on admission	23	11	47.8%	9	39.1%	3	13.0%
Number of patients who have missing doses of TCMs on admission	14	8	57.1%	5	35.7%	1	7.1%
Number of patients who has prescribing errors	49	28	57.1%	18	36.7%	3	6.1%
Number of patients who received doses before identification of prescribing errors	32	21	65.6%	10	31.3%	1	3.1%
Number of patients who received doses of HRMs before identification of prescribing errors	8	7	87.5%	1	12.5%	0	0.0%
Number of patients who have serious prescribing errors	6	5	83.3%	1	16.7%	0	0.0%
Number of patients who have significant prescribing errors	23	14	60.9%	7	30.4%	2	8.7%
Number of patients who have minor prescribing errors	25	13	52.0%	11	44.0%	1	4.0%
Number of patients who have interventions	81	32	39.5%	39	48.1%	10	12.3%
Number of interventions	155	59	38.1%	81	52.3%	15	9.7%

** *Complete data were not available on 20 patients and these were excluded from analysis*

6.3.2 Length of stay data

The average length of stay at hospital A, B and C is shown in Table 20 for three weeks before and after the implementation of the ACTPC. However, it was difficult to calculate the overall length of stay at all participating hospitals, as we could not collect patient identifiable data.

Table 20: *Average length of stay in hospital A, B and C in days*

Hospital	Before implementation	After implementation
A	1.3	1.2
B	1.4	1.5
C	3.3	3.8

6.3.3 Patient readmission data

Out of the total 1109 discharges from AMU at all three hospitals, 133 patients were readmitted during the pre-implementation phase. The rate of readmission was 12%. The readmission rate during post-implementation was 13.9%, with 137 readmissions reported from 983 discharges.

6.3.4 Patient's perceptions of medication safety

Due to the poor health of patients and the small number of patients that spoke English, data collection using the MR-PMOS was impractical and this approach was deemed unfeasible for a subsequent study.

6.3.5 Time that pharmacists spend on tasks

The pharmacists were observed for 44 hours and 10 minutes across both hospitals. The actual time recorded in the electronic data collection form for all activities totalled 28 hours and 58 minutes.

A comparison pre-implementation to post-implementation in the task analysis found significant differences (Appendix 6.E). Therefore, results of the observed time spent on each task for each hospital are presented separately.

6.3.5.1 Hospital A

During 20 hours and 40 minutes of observation, 416 tasks were recorded – 237 before ACTPC implementation and 179 after ACTPC implementation. Pharmacists before ACTPC implementation were observed for (10h:40min) and after ACTPC implementation for (10h:00min). On average, pharmacists were completed 22.2 tasks every hour during pre ACTPC and 18 tasks every hour post ACTPC.

Table 20 shows the mean time, in minutes, spent for various tasks. There was no significant change in the case of all activities before and after ACTPC implementation, except the pathology results review (Table 21).

Table 21: *Comparison of time spent of the tasks recorded in hospital A before and after ACTPC implementation*

Tasks	Pre ACTPC implementation		Post ACTPC implementation		P value
	Mean (Minutes)	SD	Mean (Minutes)	SD	
Medicine reconciliation	1.9	1.5	2.6	1.8	0.326
Clinical review	2.8	2.7	2.5	1.7	0.738
Medication chart review	2.3	1.6	2.8	1.4	0.112
Pathology results review	0.5	0.5	0.7	0.3	0.003
Discussion with patients	0.6	0.6	1	1.5	0.667
Discussion with HCPs	2	1.7	3.2	6	0.733
Meeting rounds	28	0	0	0	--
Documentation	1.9	1.4	2.5	3.4	0.946
Drug information	0.93	0.8	0.6	0.7	0.155
Stock	2.5	2.8	1.6	0.87	0.959
Discharge	1.6	0.4	3	2.4	0.151
Using Phone/Fax	1.4	1	2.3	1.6	0.762
In transit	0.96	0.83	0.35	0.2	0.097
Social interaction	0.5	0.4	1.13	1.4	0.298
Other activities	0.9	1.1	0.88	1	0.937

SD: Standard deviation

6.3.5.2 Hospital B

During 23 hours and 30 minutes of observation, 433 tasks were recorded – 181 before ACTPC implementation and 252 after ACTPC implementation. Pharmacists before ACTPC implementation were observed for (11h:21min) and after ACTPC implementation for (12h:09min). On average, pharmacists were completed 16 tasks every hour during pre ACTPC and 21 tasks every hour post ACTPC.

Table 22 describes the mean time, in minutes, spent for various tasks in hospital B, there was a significant change in the medication chart review, pathology results review, discussion with HCPs and in-transit tasks before and after ACTPC implementation. The time spent on activities for the medication chart review (p=0.024), discussion with HCPs (p=<0.001) and in-transit tasks (p=<0.001) significantly decreased in hospital B after the

ACTPC implementation. However, the time spent on activities for pathology results review significantly increased after implementation (p=0.004).

Table 22: *Comparison of time spent of the tasks recorded in site B before and after ACTPC implementation*

Activities	Before ACTPC implementation		After ACTPC implementation		P value
	Mean (Minutes)	SD	Mean (Minutes)	SD	
Medicine reconciliation	3	1.8	3	0.7	0.657
Clinical review	2.9	1.6	1.9	1.3	0.49
Medication chart review	1.9	1.8	1	0.8	0.024
Pathology results review	0.6	0.5	1	0.5	0.004
Discussion with patients	2.2	1.4	2.3	2.8	0.410
Discussion with HCPs	5.6	4.1	1.5	1.3	<0.001
Meeting rounds	20.6	-	17.2	12.2	0.833
Documentation	3.1	1.6	2.2	1.7	0.164
Drug information	2	1.1	1.6	1.3	0.613
Stock	0.6	0.38	1.5	1.3	0.486
Discharge	5.5	2.5	3.1	2.5	0.229
Using Phone/Fax	5.1	5.7	2.2	2.5	0.142
In transit	2.5	1.5	0.6	0.4	<0.001
Social interaction	0.7	0.5	0.6	0.4	0.620
Other activities	1.6	1.3	1	1.2	0.030

SD: Standard deviation

6.4 Discussion

The overall aim of this study was to assess the feasibility of the ACTPC to aid the targeted delivery of patient focussed clinical pharmacy services in hospital. We have demonstrated that the ACTPC, which was developed to prospectively identify those patients most likely to benefit from pharmacist review, was feasible for use in an acute medical setting. As far as we know, this is the first study to investigate the impact of a prioritisation tool on prescribing errors, length of stay, readmission rate and pharmacist time.

Our findings led to greater understanding of how to effectively measure the impact of the ACTPC on different outcomes. From the results of our feasibility study, ACTPC implementation may help reduce the number of erroneous medications reaching patients, including reducing the number of erroneous high-risk medicines (HRMs), that are more likely to cause serious patient harm. HRMs have been categorised and declared eligible for special consideration by the Institute of Safe Medication Practises in the USA, and the

National Patient Safety Agency in the UK.[32,33] An increased focus on these high-risk medications could lead to reduced length of hospital stay, reduced disability, a decrease in life threatening conditions as well as reduced deaths by almost 50%.[34] It is very important to note that none of the errors that reached a patient in this feasibility study caused actual harm. Perhaps this could be explained because most errors were intercepted and reported before they caused harm[23] and the sample size was not large enough to generate further information on the actual patient harm.

The ACTPC also had an impact on the omission of time critical medicines. The number of patients missing doses of TCMs reduced. Although the absolute numbers were small, this reduction is clinically significant. If omitted these medicines pose a risk to patient safety.[23] Avoidance of medication errors is of great benefit to patients, as errors are associated with patient harm. The unsafe use of medicines has been identified as a main cause of preventable harm in the context of healthcare[35], the World Health Organisation (WHO) is committed to developing a greater understanding of these processes, and reducing medication-related harm all over the globe. [36]

Importantly, the data collected in our feasibility study demonstrated the tool's validity in identifying patients at greater risk of prescribing errors. The high-risk patients have a higher frequency of omitted TCMs and of serious prescribing errors. These findings not only validate the feasibility of collecting such data but also the potential usefulness of the ACTPC for the early detection of drug related problems. If those high-risk patients are identified in an adequate and timely manner, drug-related problems can be largely prevented or managed at the onset.[17] This will not only enhance the procedures of medication safety, but will also ensure optimum patient outcomes as well.[16,17]

Our findings also show that the highly complex patients were found to be older, and while this is not a significant result, it can be linked to previous findings where older patients have

been identified to have more severe medication errors.[37] This can also be linked to the fact that elderly patients are at a higher risk of adverse drug events due to various factors, including physiological changes which affect the pharmacokinetics and pharmacodynamics of drugs, impaired cognition as well as frailty syndromes.[38–41] Furthermore, this feasibility study found that highly complex patients were also taking a higher number of medications. It has also been established that the greater the number of medications an individual takes, the higher the risk of experiencing harm.[42,43] It was reported that the risk for adverse drug interactions rose from 13% for patients taking two medications to 82% for patients taking seven or more medications.[44]

This feasibility study provides insight into how pharmacy teams could use the ACTPC form 1 to triage new patients at the point of admission before pharmacist intervention, especially by technicians or shift-working pharmacists. However, tailoring form 1 for technician use is warranted, to reduce reliance on professional judgement and to set clear parameters for tool components.

An important issue emerging from collecting data on LoS is that the data was difficult to collect. It was not feasible in this time-limited study to collect individual patient data for length of stay. However, in the future, we would seek to obtain this data through a different process if possible. Readmission rate overall was captured but individual patient numbers would allow us to determine readmission rate more accurately. Furthermore, data collected on LoS and readmission rate coincided with the December holiday period in one of the participating hospitals, which may affect patient LoS and readmission rate. A study found patients who were discharged from the hospital during the December holiday were at higher risk of both increased readmission and reduced follow-up.[45]

The collection of data on patient views was not feasible in this study, however, using alternative methods of data collection should be explored in future studies, for instance,

collecting data after the patient has been discharged or whilst the patient is less acutely unwell.

Pharmacist's task data were collected at two sites. Approximately 29 hours of task data was recorded due to practicality. This may have been due to the large number of tasks required to be recorded or the fact that there were a lot of things happening at the same time. Furthermore, the data collection form was developed to capture the pharmacists time in minutes and seconds. However, the Form$^{2™}$ did not support the recording of time in seconds, so the observer recorded this manually and this may require more time in recording the tasks and inability to record all tasks that occur at the same time. Also, the observer was not a hospital pharmacist and therefore may not have enough training to recognise the individual tasks as they were happening.

The data collected showed that the amount of time spent on documentation was not significantly different pre and post-implementation, indicating that form completion may not add to workload. However, there was an increase in time reviewing pathology results that may be related to the tool use. It could indicate that the tool leads the pharmacists to thoroughly review lab results in order to know whether the patient is highly complex or not. In hospital A, fewer chart reviews were conducted post-implementation but this was not the case in hospital B. There is a potential for the number of medication chart reviews to decrease post-implementation, as not all patients will need daily pharmacist review; however, due to the fast turnover of patients on AMU it is unlikely to have an impact in this setting.

6.4.1 Strengths and Limitations

A key strength of this study is that data were collected across three hospitals within three large NHS trusts, adding depth and breadth to the data collection process. Furthermore, the

pre and post-study design also lends credibility to the study as it allows for evidence about the effectiveness of an intervention to be developed.[46] It is also helpful in evaluating the impact of these interventions over the short term.[46,47] Another strength of the study is using different methods and multiple data collection techniques, which allows to build on the existing research knowledge in this area. Standardised training was provided across the participating sites, and data collection was facilitated by use of an electronic data collection form to ensure data quality and avoid missing data.

Furthermore, the generalisability of the study could be limited given the fact that the study was confined to three sites in in England only.

Other limitations of the study include that prescription errors were identified by pharmacists as part of their normal workday, which is a common method collection of prescription error data.[23] In cases where pharmacists either failed to identify a prescription error, or failed to record these errors, this would underestimate the actual error rate. In order to combat data collection fatigue, data was recorded one day per week, with multiple pharmacists involved. This could mean that despite the training provided for the data collection process, there could be potential variations in the data collection practises, based on the individual practises of the pharmacists involved.

The time and motion study had some limitations including the use of the direct observation approach, which could mean that the pharmacists may have become conscious of the fact that they were being observed, potentially changing their behaviour. A further limitation included the small sample size of observed pharmacists (it was smaller than the original plan as one of the hospitals was excluded from the time and motion study). This may limit the applicability of results to other organisations and the variety of experience amongst the different pharmacy staff may have impacted their responses relating to patient and medicines activities. Another limitation of the time and motion study related to the difficulty

that the observer had in recording tasks. This could have been improved by spending a greater amount of time in the hospital prior collecting data.

A further limitation pertains to the inclusion of the acute medical units only, as the practises on other wards may be different. The AMU unit was chosen for this feasibility study as it was seen to be a good test site for the impact of the tool on patient outcomes and pharmacist workload patterns, given the fact that there is a heavy prescription and medication administration workload in this ward.[11–13]

6.4.2 Testing the effectiveness of the ACTPC

This study aimed to assess the feasibility and acceptability of the ACTPC and identify the most efficient and effective ways to measure the impact of the tool on patient outcomes and pharmacist workload patterns, regardless of the number of patients reviewed. The study successfully met its objective, determining that the ACPTC tool was practical and feasible across three hospital sites. In addition, testing different outcomes for the evaluation of the effectiveness of the ACTPC were possible. It also identified specific feasibility issues that would need consideration in the planning of a future definitive study.

These considerations include providing pharmacists with more time to gain familiarity with the tool; for example, four weeks prior to data collection. Furthermore, collecting data on LoS and readmission rate should be collected at patient level using hospital identification numbers. This would allow us to determine LoS and readmission rate specifically for patients who had been screened using the tool. Moreover, a further time and motion study should be conducted which focuses on the most important activities carried out by the pharmacist that have a direct relationship with patients, medication and HCPs only (to the exclusion of other tasks). Furthermore, future studies might determine how many patients are reviewed by the ward pharmacists with and without implementing the tool, to see the

time spent with each individual patient with different complexity levels. This study should be conducted for a full work day; for example, from nine am to five pm. It would record how many patients were reviewed during the day and the amount of time taken with each patient, considering the patient's complexity level and the time of each task for each patient. Also, the experience of the referring pharmacist might be taken into consideration, to determine whether there a difference between less and more experienced pharmacists in relation to the absence/presence of the tool. Furthermore, the view of the tool users should be considered. A final consideration would be the amount of time saved and redistributed to more complex patients after using the tool, because patients with low complexity levels do not need daily reviews.

6.5 Conclusion

This feasibility study provides quantitative insights into the effects of implementing ACTPC on the number and severity of PEs that reach patients, omitted TCMs and ward pharmacists' activities. The findings of this feasibility study have demonstrated the validity of the tool in the identification of patients who are at a greater risk of drug related problems. This feasibility study was able to test different outcomes for the evaluation of the effectiveness of the ACTPC. The effectiveness of a tool can be asserted by the number and severity of medication errors that reach patients, as well as the omitted TCMs. The tool used was ascertained to be feasible across three hospital sites; however, it needs to be implemented and used within the context of the organisation in consideration. The workforce composition constraints at present does not allow a complete allocation of the most experienced pharmacists to the most complex patients. The tool can be further developed by wider testing beyond AMU, greater technology input as well as greater use of the technician workforce.

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None

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Contributors:

M.A. managed and led on data collection and analysis. D.S., M.T. and P.L. supervised all research activities. A.A. collected data on the time and motion study. M.A. drafted the initial version of the manuscript. D.S., M.T., S.W. and P.L. critically revised the manuscript.

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6.7 Study Three Appendices

Appendix 6.A: EQUIP Study Criteria for Error Severity Classification Scheme

Potentially lethal error	An error is defined as potentially lethal if it could have one or more of the following consequences: o The serum level resulting form such a dose is likely to be in the severe toxicity range based on common dosage guidelines, e.g. serum theophylline concentrations greater than 30 micrograms per ml. More than 10 times the dose of chemotherapy agent o The drug being administered has a high potential to cause cardiopulmonary arrest in the dose ordered. o The drug being administered has a high potential to cause a life-threatening adverse reaction, such as anaphylaxis, in light of the patient's medical history. o The dose of a potentially life saving drug is too low for a patient having the disease being treated. o The dose of a drug with a very low therapeutic index is too high (ten times the normal dose)
Serious error	An error is defined as serious if it could have one or more of the following results: o The route of drug administration ordered is inappropriate, with the potential of causing the patient to suffer a severe toxic reaction. o The dose of the drug prescribed is too low for a patient with serious disease who is in acute distress o The dose of a drug with a low therapeutic index is too high (four to ten times the normal dose) o The dose of the drug would result in serum drug levels in the toxic range, e.g. theophylline levels 20-30 micrograms per ml. o The drug orders could exacerbate the patient's condition, e.g. drug-drug interaction or drug-disease interaction. o The name of the drug is misspelled or illegible creating a risk that the wrong drug might be dispensed including errors in decimal points or units if the error could lead to the dose being given o High dosage (ten times) normal of a drug without a low therapeutic index
Significant error	o An error is defined as significant if it could have one or more of the following results: The dose of the drug with low therapeutic index is too high (half – four times the normal dose).

	○ The dose of the drug is too low for a patient with the condition being treated. ○ The wrong laboratory studies to monitor a specific side effect of a drug are ordered e.g. CBC and reticulocyte counts are ordered to monitor gentamicin toxicity. ○ The wrong route of administration for the condition being treated is ordered e.g. the inadvertent change from IV to oral therapy for the treatment of bacterial. ○ Meningitis. ○ Errors ordering fluids are made e.g. specific additives needed for complete therapy are omitted or incompatible fluids are ordered. ○ Errors of omission whereby patient's regular medication is not prescribed either on admission, during a rewrite and on discharge.
Minor error	An error is defined as minor if it could have one or more of the following results: ○ Duplicate therapy was prescribed without potential for increased adverse effects ○ The wrong route was ordered without potential for toxic reactions or therapeutic failure ○ The order lacked specific drug, dose, dosage strength, frequency, route or frequency information ○ Illegible, ambiguous or non-standard abbreviations. ○ An errant order was written that was unlikely to be carried out given the nature of the drug, dosage forms, route ordered, missing information etc Examples include, simvastatin prescribed in the morning rather than at night. Bisoprolol – two puffs four times a day.

Appendix 6.B: TCMs list produced by the Medicines Governance Team Northern Ireland

Critical medicines where timeliness of administration is crucial

This is a list of medicines where timeliness of administration in crucial to minimise harm for patients. Every effort should be made to avoid omitted and delayed doses of critical medicines. Staff must follow trust procedures for obtaining supply and escalating to medical staff should an omission or delay occur.

- A **delay** is a dose administered more than two hours beyond the prescribed time
- An **omitted dose** is any dose that is not administered before the next dose is due
- **This list is a guide and is not intended to be exhaustive**

Class of medicines/or generic name of medicine	Examples	Potential consequence of omission or delay
STAT doses of any medicine (prescribed for immediate administration)	e.g. Loading doses, first dose antibiotics, resuscitation medicines, emergency intravenous fluids	Any medicine that is deemed urgent enough to be prescribed as a 'STAT' on the front of the Medicine Kardex
Anticholinesterases	e.g. pyridostigmine / neostigmine	Loss of symptom control (increased spasms) and patient distress
Anticoagulants	e.g. Enoxaparin, warfarin, rivaroxaban, apixaban, dabigatran, edoxaban	Risk of thrombus and serious embolic episode. For DVT/PE and ACS treatment
Anticonvulsants	e.g. Epilim®, Tegretol ®, levetiracetam, lacosamide, perampanel, phenytoin, phenobarbital, zonisamide, primidone	Loss of seizure control
Antidotes	e.g. phytomenadione, naloxone, flumazenil, dried prothrombin complex, IV glucose, IV glucagon, idarucizumab (dabigatran reversal agent)	Failure to reverse toxicity resulting in patient harm.
Anti-infectives (injectable route/ oral first dose)	Antibiotics Antifungals Antivirals	Potential worsening of systemic infection and deterioration of condition. Management of sepsis, first dose anti-infectives must be given immediately.
Antiplatelets and thrombolytics (for acute indications)	e.g. Aspirin, clopidogrel, dipyridamole, prasugrel, ticagrelor, alteplase	Progression of thrombus and risk of serious embolic episode.
Antiretrovirals	e.g. Efavirenz, ritonavir, raltegravir, Symtuza®, Triumeq®, Genvoya®, Biktarvy®	Leads to viral replication and detectable viral load increasing the risk of resistance, treatment failure and increased transmission risk on contact where doses have been delayed or omitted
Bronchodilator (injectable or nebulised route)	e.g. Salbutamol, terbutaline	Management of respiratory emergencies.
Chemotherapy (injectable route)		Delay in treatment / disruption of chemotherapy regimen scheduling. Treatment failure
Clozapine		Missed doses or delayed doses may lead to the need for re titration resulting in worsening of the mental state and prolonged hospital stays.
Corticosteroids	e.g. Methylprednisolone, hydrocortisone, dexamethasone, prednisolone	Treatment failure in acute conditions or flare up when used in the long-term management of inflammatory disorders. Risk of acute adrenal insufficiency with abrupt withdrawal after a prolonged period of corticosteroid use (Addisonian crisis)
Desmopressin (treatment of cranial diabetes insipidus)		Risk of serious hypernatraemia
End of life medication	e.g. Midazolam, levomepromazine, glycopyrronium bromide	Poor symptom control
Immunoglobulin		
Immunosuppressants	e.g. tacrolimus, sirolimus, mycophenolate, azathioprine, ciclosporin	Risk of rejection due to sub therapeutic levels
Insulin	e.g. Novorapid®, Novomix 30®, Lantus®, Toujeo®, Tresiba®, Abasaglar®	Poor glycaemic control and potential for symptomatic hyperglycaemia; Management of diabetic ketoacidosis (DKA).
Medicines for active bleeding	e.g. Omeprazole infusion, terlipressin injection, tranexamic acid injection	Medical emergency, to treatment major peptic ulcer or peptic ulcer bleeding.
Opioids (all routes)	e.g. Morphine, diamorphine, fentanyl, oxycodone, buprenorphine patches	Loss of pain control and patient distress
Oxygen		Management of respiratory emergencies, Myocardial infarction
Parenteral electrolyte replacement	e.g. Calcium, potassium, phosphate infusion, sodium bicarbonate, magnesium	Deterioration in clinical condition or compromised breathing. Magnesium used in arrhythmias, pre-eclampsia and severe acute asthma
Parkinson's Disease medicines	e.g. Co-beneldopa, co-careldopa, rotigotine patches, Stalevo®	Loss of symptom control and major distress to the patient.

Produced by the Regional Medicines Governance team and approved by the Health and Social Care Board's Regional Medicines Safety Group March 2019. This replaces the list produced by the Regional Medicines Governance team November 2010 and updated 2016.

Appendix 6.C: Task and information tool descriptions

Work Task	Description
Medication Reconciliation	A formal process of ensuring patients' prescribed medication matches with what they are actually taking.
Clinical Review	Assessing the clinical status of patients, including an overview of their medical notes.
Medication Chart Review	Undertaking a review of the medication orders of patients to ensure appropriate drug dosage, drug route, and dosage form.
Pathology Results Reviews	Undertaking a review of the pathology results for patients, including the activities related to therapeutic drug monitoring.
Medication related discussion with patients or their relatives	Discussions with patients or their relatives to clarify a medication order
Medication related discussion with health care professionals	Discussion with health care professionals to clarify a medication order.
Word rounds or meetings	Participating in ward rounds or meetings.
Documentation	Documentation on paper, computers, patient notes, ward lists.
Drug information	Looking up information sources (electronic or hard copy), drug protocols, and hospital formulary.
Stock	Undertaking activities relating to the supply, storage, and checking ward medication stock such as main medication cabinet, Injections cabinet, refrigerator and nutrition supplement
Patient discharge	Checking and preparing discharge letters, discharge medications, and providing discharge counselling to the patient and/or their relatives/carers.
Using the phone/fax for work purpose	Undertaking activities relating to obtaining information from outpatient pharmacists, GPs via phone and/or fax and answering pager bleeps.
In transit	Travel on ward between tasks
Social interaction	All non-work communication such as meal/tea breaks, personal calls
Other activities	Any other activities not included above

Appendix 6.D: Summary of the results to check the difference between hospitals before combine them-Prescribing error and pharmacist interventions study

Chi-square Test		
Categorical variables	**P value**	
	Pre-ACTPC	**Post-ACTPC**
Patient ages	0.217	0.035
Patients who have medicines missing on admission	0.139	0.868
Patients who have TCMs missing on admission	0.077	0.733
Patients who have missing doses of time critical medications on admission	0.248	0.732
Patients who received doses of high-risk medications before identification of prescribing errors	0.247	0.047

Kruskal-Wallis Test		
Continuous variables	**P value**	
	Pre-ACTPC	**Post-ACTPC**
Medicines missing on admission	0.055	0.956
Missing doses on admission	0.048	0.329
Missing doses of time critical medications on admission	0.237	0.714
Doses received before identification of prescribing errors	0.278	0.018

Appendix 6.E: Summary of the results to check the difference between hospitals before combine them-Time and Motion study

Mann-Whitney U Test		
Continuous variables	**P value**	
	Pre-ACTPC	**Post-ACTPC**
Medicine reconciliation	0.040	0.107
Medication chart review	0.243	<0.001
Discussion with HCPs	0.002	0.822
Discussion with patients	0.014	<0.001
Documentation	0.018	0.731
Drug information	0.021	0.074
Discharge	0.017	0.949
In transit	0.010	0.120

7. Chapter Seven: General Discussion, Proposed recommendations and Conclusion

Pharmacists in hospitals play an important role in patient care by ensuring that medications are used safely and efficiently. It has been estimated that nearly one out of every ten hospital prescriptions contain an error,[166] affecting 36-44% of patients,[167] and that pharmacists play a critical role in detecting and correcting these errors to ensure patient safety.[168] Clinical pharmacy services aim to offer a service in which clinical pharmacists attend each hospital ward and attempt to review each patient on a regular basis from Monday to Friday. This service involves ensuring patients are prescribed and receive their regular medication, that new medication prescribed is safe and appropriate and any necessary monitoring is undertaken.[5] However, pharmacy departments face various barriers, including decreased funding, staffing shortages, and a growing number of elderly admissions with multimorbidities and polypharmacy, as well as a demand for seven-day clinical pharmacy services.[32,51,83] These barriers mean that there may not be resources to deliver the same level of clinical pharmacy service to all inpatients which could have negative impact on patient safety.[48]

Patient safety is a high priority concern on national and international agendas. The criticality of this issue is highlighted in the Global Patient Safety Challenge: Medication Without Harm, published by the World Health Organization in 2017. In this, the WHO committed to halving the incidences of severe and avoidable medication related harm over the next five years.[13] The recognition of unsafe medication practises, as well as the high prevalence of medication errors, was the main reason for this initiative, which aims to reduce and control the avoidable harm caused to patients. The estimated global cost of these errors comes to approximately 42 billion US dollars, which means that it is not only a global health issue,

but also an issue of economic concern.[13] The Short Life Working Group (SLWG, 2018) in the UK developed recommendations on reducing medication errors and enhancing medication safety in line with the directives issued by the WHO.[169] The SLWG was established in September 2017 by the Department of Health and Social Care in England to provide advice to the Secretary of State for Health and Social Care on the medication error and safety programme to improve medication safety. The SLWG met four times between September and December 2017, and came up with recommendations to create positive change in medicines safety.[169] These recommendations call for a prioritisation of interventions to improve medication safety, including the development of a prioritised and comprehensive system of metrics on medication errors so that these errors can be identified and rectified at their source of origin.[169] Furthermore, the NHS recently developed a new strategy setting out how the NHS will continuously improve patient safety.[170] This strategy also highlighted that adopting evidence-based tools to support patient safety and developing innovative solutions to resolve emerging threats at their point of origin is therefore a priority.[170]

The aim of this thesis is in line with these recommendations of the Short Life Working Group as well as with the new plans and strategies of the NHS. The overall aim of this study was to develop a complexity screening tool for pharmaceutical care rigorously and systematically, which can be used by the hospital pharmacy team to triage new patients according to the level of pharmaceutical care required. The ability to reliably screen and classify which patients need the most pharmacy input and which would not, will minimise patient risk and support hospital pharmacy teams by allowing for more effective staffing allocation.[10]

The results from each study in this thesis demonstrate that this aim was successfully achieved. To our knowledge, this is the first study to develop a comprehensive screening

tool based on current knowledge and understanding of national and international tools combined with expert consensus.

7.1 Summary of Findings for Each Study

7.1.1 Study One: Patient prioritisation for pharmaceutical care in hospital: A systematic review of assessment tools

Nineteen studies involving 17 risk assessment tools were included in this review. The findings of the systematic review indicate that there is an increased interest in developing prioritisation tools for pharmacy services over the last few years. Most tools were developed in Europe (13/17 tools, 76.5%) with the UK leading with 8 tools (47%). Ten out of 17 tools (59%) were validated. The most common risk factors that were included in the published tools were also identified in this review as follows in descending order of prevalence: high-risk medication (15/17 tools, 88%), drugs requiring monitoring (15/17 tools, 88%), polypharmacy (13/17 tools, 76.5%), use of total parenteral nutrition/nasogastric tube (3/17 tools, 17.6%), high-cost medication, and number of intravenous and unlicensed medication (1 tool each, 6%).

The review also showed that most tools have been developed in the electronic format with the view to expedite the retrieval of patient information as well as to reduce the use of paperwork. These tools will only operate within hospitals that use electronic records and there is a need to develop an approach for identifying patients' pharmaceutical complexity that does not rely on complex algorithms or availability of electronic data and could be widely adopted across the NHS.

This review also highlighted that the assessment tools were heterogeneous in their content, targeting diverse patient groups and clinical settings making generalisation and adoption difficult. Furthermore, keys themes identified from this review were the positive impact of risk assessment tools on both patient care and provision of pharmacy services as well as the

limitations of risk assessment tools. There is a lack of a measurable and quantifiable impact that these assessment tools have on their patients. In other words, we do not know how these tools may help to prevent the harm that is caused from medication use.

In summary, the findings from this systematic review revealed that there is wide variation in the design and development of prioritisation tools, and very little formal evaluation has been carried out.

7.1.2 Study Two: Development of the adult complexity tool for pharmaceutical care (ACTPC) in hospital: a modified Delphi study

Over 300 components were extracted from the interview data[117] and systematic review.[7] One hundred and nine tool components were included according to our inclusion criteria in Delphi One. These were divided into two classes; medicine related (n=65) and clinical condition related components (n=44). Forty-one experts completed the first round Delphi and 33 completed the second round. The expert panel members consisted of 32 pharmacists and nine medical doctors from seven different countries. After the second round, 92 components had a median score of 7 or more on the 9-point Likert scale, and were classified as important. Panellists added no new components. Components were grouped and shortened to 33 items (e.g. all individual high-risk medicines were grouped into a high-risk medicine category). The final items were included in the first draft of the ACTPC, which stratified patients into three levels-highly, moderately or least complex.

Delphi Two had 23 statements based on analysis of interview data,[117] relating to ACTPC use, including frequency of patient review and pharmacist experience for each complexity level. Forty-three experts from different NHS trusts completed the first questionnaire and 40 completed the second. After two Delphi rounds, consensus was reached on 18 (87%) statements. The research team reviewed the statements that reached agreement then grouped

them into three types (highly, moderately and least complex) and shortened them to three statements which were then included in the latest version of the ACTPC. After two Delphi studies, the ACTPC tool was developed and designed in conjunction with the expert reference group (ERG). In light of panellists' comments, it was decided two forms were necessary. ACTPC-Form 1, contains only red criteria descriptors (pharmaceutically highly complex descriptors) allowing swift identification of highly complex patients on admissions and for use before medicines reconciliation. ACTPC-Form 2, contains all three criteria: 'red' (high), 'amber' (moderate) and 'green' (low) and is for use during or after medicines reconciliation. The ACTPC-Form 2 stratified patients into three levels-highly, moderately or least complex requiring different levels of pharmaceutical care. This study used a systematic and consensus driven methodology, which ensured that the ACTPC was able to report on components that had international consensus as well as recommendations that were nationally agreed upon. Furthermore, the ACPTC provides guidance on the appropriate frequency of clinical pharmacist input and appropriate competency level of pharmacy staff assigned to each complexity level.

7.1.3 Study Three: Assessing the feasibility and impact of the adult complexity tool for pharmaceutical care (ACTPC) on patient outcomes and pharmacist workload: a pre and post prospective feasibility study in three UK hospitals

The feasibility study tested multiple outcomes for evaluating the effectiveness and validity of ACTPC. A pre-post ACTPC implementation prospective study was conducted at three NHS acute hospital trusts. Data on prescribing errors (PE) and interventions was successfully collected pre- and post-implementation of ACTPC. The number of patients receiving doses of erroneous medications reduced significantly from 58 patients (28%) to 36 (18%). Furthermore, the number of patients who received doses of erroneous high-risk medications reduced from 19 (9%) to 9 (5%). It is important to note that this reduction is

not statistically significant, but it may be considered clinically significant because HRMs are more likely to cause serious patient harm when they are used in error. There was also a non-significant reduction in the number of patients who had serious PE (n=11; 5% vs n=6; 3%) and the number of patients who had missing doses of time critical medications (TCMs) (n=23; 11 vs n=14; 7%). Although the absolute numbers were small, these reductions are clinically significant. These findings not only validate the feasibility of collecting such data but also the potential usefulness of the ACTPC for the early detection of those patients with characteristics that put them at risk of developing drug related problems.

The data collected also demonstrated tool validity as patients with high and moderate complexity levels had higher numbers of serious and significant prescribing errors, including missing doses of TCMs, therefore identifying those patients at greater risk of medication related problems.

Collecting data on length of stay (LoS) was difficult, as it was not feasible in this time-limited study to collect patient identifiable data.

An analysis of the data collected from the time and motion study showed that there was no significant difference in the amount of time required for documentation for pre- and post-implementation, highlighting the fact that completing the form did not necessarily add to the workload of the data collectors. However, there was an increase in time for reviewing pathology results that may be related to tool completion.

7.2 Interpretation of Findings

The existing literature on the development of pharmaceutical complexity tools highlighted that tools are purported to have benefits regarding patient care and pharmacy services delivery.[7,117] However, some of these benefits are based on the opinions of those who use and apply the tools, and they are not always supported by robust evidence.[7] Overall, the tools are designed to reduce pharmacists' workload and help them work more effectively.[7]

Some hospitals have implemented locally developed screening tools to prioritise patients for pharmaceutical care.[117] These have not been methodically developed for routine use,[7–9] there is a lack of agreement as to what such a tool should comprise and no impact evaluation has been conducted.[7] Therefore, this study used a systematic and consensus driven methodology, which ensured that the ACTPC included components that had international consensus as well as recommendations that were nationally agreed upon. To our knowledge, this is the first study to quantify the impact of a systematically developed tool on the number and severity of PEs that reached patients, omitted TCMs, and the activities of ward pharmacists. An important finding of this study was that the data collected during feasibility testing validated the tool for its ability to identify patients at a higher risk of developing drug related problems.

The effectiveness of the tool was also evaluated through the testing of multiple outcomes in this feasibility study. The number and severity of prescribing errors that reach patients and the omission of time critical medicines were the considered outcomes. These can be measured to validate the effectiveness of a prioritisation tool to signal to the pharmacy team those patients who need greater clinical input. While data on patient harm was collected, the analysis of the data did not reveal any actual patient harm. Early detection and prevention of patient harm in healthcare is a worldwide concern.[171] In theory, the optimal aim would be to do no harm. This target, however, is not achievable since some harms are unavoidable in clinical practice.[172] For instance, some adverse drug reactions occur in the absence of any error in the medication use process [172] In our feasibility study, it was difficult to identify patient harm over such as short time scale on the admissions ward. Thus, the actual patient harm was a difficult outcome to collect data on. Furthermore, it was collected by pharmacists who working in the participating hospitals, therefore, it may be susceptible to reporting bias. Hence, this approach might benefit from recruitment of a dedicated

researcher rather than relying on pharmacists to collect data alongside their daily role. Furthermore, a future RCT study with a larger sample size should be used to generate further information in relation to this outcome. Patients would be enrolled to the study so that patient level data could be collected and patients followed more precisely to measure their outcomes during their hospital stay.

Despite the fact that this was a feasibility study, the results of this study show that with the use of this tool, the number of patients who received erroneous medication doses was reduced significantly. Moreover, there was a reduction in the number of patients who received doses of high-risk medications and omitted doses of TCMs. Although the sample size was too small to show a statistically significant difference, this reduction highlighted the clinically significant impact of the ACTPC on the omission of doses of TCMs and also received doses of erroneous HRMs. Worldwide, MEs result in 2% to 5% of all hospital admissions, many of which are deemed preventable.[173,174] Medication related harm is experienced by up to 30% of hospitalised patients,[175–177] and 7% of them experience severe harm.[177] This leads to increased hospital stays for the affected patients, as well as increased patient morbidity and mortality, as well as healthcare costs.[178]

Furthermore, the testing of multiple outcome measures for this feasibility study generated a greater understanding of how the impact of prioritisation tools can be measured using LoS, re-admission rate and the time spent by pharmacists. In addition, this feasibility study gave us a good idea of what could be done in a different way to collect data on the selected outcomes in a future study. For instance, data on LoS and readmission rates can be collected through hospital identification numbers at the level of the patients. This would allow a more specific data collection process for patients, thereby enabling the identification of patients who have been screened through the use of the tool.

Data on patient views should be collected differently, such as collecting questionnaire data for patients who are not acutely ill, or when patients have been discharged from the hospital. In addition, the Patient and Public involvement members (who have experience of being in hospital) can be involved in collecting the patient questionnaire data. Having members of the public may make patients more relaxed and improve their experience of completing the questionnaire.

Future studies can be designed to look into the number of patients that are reviewed by the pharmacists on the ward, with and without the implementation of the tool, in order to assess the amount of time required for reviewing the differing complexity levels in individual patients.

The feasibility study was also able to prove that the ACTPC form 1 can be helpful in classifying new patients at the time of their admission, by the hospital pharmacy teams, according to the complexity of their likely pharmaceutical needs. This can be done before any pharmacist intervention, on an adult acute medical unit.

It is very important to note that the ACTPC should not be used alone. It should be used in conjunction with medication reconciliation, in other words, medicine reconciliation should be done either before or with the ACTPC form 2. Medication reconciliation (MR) is an important element of patient safety. In cases where medication reconciliation is not conducted during the admission process patient safety is compromised.[20] This may require additional treatment or prolonged hospitalisation due to drug related problems having gone unidentified at the time of admission, and persisting for an extended period of time.[20] Thus, the ACTPC allows pharmacists to prioritise patients on the basis of their pharmaceutical needs for a timely medication reconciliation as well as a daily review for the highly complex patients. This would allow for enhanced patient safety through a prompt identification,

solution, and prevention of drug related problems by clinical pharmacists. The findings from our qualitative work reported that the ACTPC users thought the tool effectively prioritised complex patients, highlighting who was high-risk and preventing adverse drug events.[179] Furthermore, daily reviews of patients by clinical pharmacists are essential to ensure that patients get the required pharmaceutical care, and to ensure that their conditions do not deteriorate. Nevertheless, patients who fall under 'amber' or 'green' criteria, might not be seen on a daily basis. Those patients can be upgraded or downgraded depending on their clinical condition or medication changes. It is therefore necessary that there is effective communication between different staff looking after these patients, such as clinicians and nurses, to alert relevant changes or deterioration to the pharmacy team if necessary.

The feasibility study also indicated that the ACTPC Form 1 can be effectively used by technicians and shift-working pharmacists.

The deployment of the ACTPC may improve the productivity of pharmacy staff and enable the redeployment of staff to more person-centred roles as the clinical and technical roles of pharmacy team members (clinical pharmacists and pharmacy technicians) are growing rapidly. With growing demand on healthcare services, effective staffing models must be integrated into hospital workforce planning.[180,181] The findings from the qualitative work in our feasibility study demonstrated that technicians using form 1 felt the tool upskilled them and prioritised their workload so they could supply critical medication faster.[179] However, there is a need to modify the ACTPC Form 1 so that it is suitable for technician use, with clear parameters for components, reducing the need to rely on professional judgement.

The literature demonstrates the positive impact of the evolving role that pharmacy technicians, with specific training, may have on pharmacy services and patient care.[15,182–184] The changing pharmacy technician role includes, but is not limited to, taking a history of a patient's medication use, reconciling a patient's medicines from one setting to another

and communication with the multidisciplinary team to streamline patient care.[182,185] The evolving pharmacy technician role contributes significantly to releasing pharmacists' time for more clinical activities.[185] The ACTPC can assist pharmacy technicians in increasing their clinical role. For example, ACTPC form 1 being deployed prior the MR process can release time and capacity for improving clinical pharmacy services. In other words, the application of the ACTPC form 1 by pharmacy technicians could allow clinical pharmacists to organise their work and perform more clinical tasks such as prescribing. Potential benefits of widespread adoption of pharmacist prescribing in secondary care include improved prescribing safety, more effective pharmacist medication reviews, expanded scope of practice with greater pharmacist incorporation into acute patient care pathways, and increased professional or work satisfaction.[186]

Digitalisation of the ACTPC could improve patient outcomes and optimise health system efficiencies. The ACTPC would greatly benefit from its digitalisation to allow for automatic completion of the tool as well as for real time updates. This would enable patient risk to be iteratively estimated and monitored in real time. Digital health is expected to play a critical role in enhancing medication safety.[187] The NHS long term plan requires all hospitals to move to digital records by 2023.[188] The increasing availability of hospital digital data, as well as machine learning modelling methods, presents an exciting opportunity to gain deeper insights and enhance patient care quality.[187]

7.3 Strengths of the Programme of Work

This study had several strengths. Firstly, the use of a systematic approach allowed the programme to be subdivided into three different studies. A set of methods for the development and application of the ACTPC were used based on current evidence and the consensus of national and international experts.

At the development stage, tool development followed a comprehensive process of information collection from various sources, including existing literature, interview findings, and an assessment of the tools currently in use. The tool components were then refined by a study reference group, comprised of academics, members of the study's Patient Public Involvement (PPI) group, and the chief pharmacists at the participating hospitals. The inclusion of PPI at this stage significantly influenced the design and development of the tool, and highlighted key issues for consideration. One of these issues was the question of whether patients would want to have the knowledge of the frequency of their reviews. The questions of whether complexity status should be shared with patients, and how it should be shared, are key lines of enquiry for the future study.

Furthermore, a large group of experts were involved in the assessment of the tool components in the consensus stage. These experts came from the three relevant professional expert groups of clinicians, academics, and clinical pharmacists. Their inclusion allowed for the development of a broader perspective as well as relevant representation of skilled, knowledgeable professionals in the field, including clinical pharmacy and medication safety leaders. The number of experts in these groups who responded to both our Delphi studies is similar to, or higher than, the number of experts in other comparable Delphi studies.[164,189–192]

In addition, the before-and-after design was undertaken with the application of the tool in a hospital setting. This allowed for an assessment of the tool based on its feasibility in line with current practice. To our knowledge, the before-and-after design has not yet been applied in evaluating any developed tool in the area of patient prioritisation for clinical pharmacy services. The before-and-after design offers better evidence about intervention effectiveness than other non-experimental designs as well as being useful in demonstrating the immediate impacts of short-term programs.[193]

Furthermore, direct observation and self-completed data collection forms, were used to assess the feasibility of recording outcomes. Combining different types of methods within a single study allows for triangulation,[194] which helps to minimise the limitations inherent in each of these methods when used individually, thereby enhancing the validation of the research findings.[194]

Finally, pilot studies are critical when it comes to determining if research procedures are workable, and if the data generated is reliable and valid.[194,195] In this context, piloting was used throughout the study at various stages to refine the different processes used, for example, the Delphi questionnaires and the data collection forms in the feasibility study were all piloted. Piloting also allowed for identification of issues pertaining to the applicability and availability of the required data in the feasibility testing phase.[196]

7.4 Limitations

Alongside its merits the study encountered some limitations which need to be given due consideration in the context of the findings of the study. The systematic review conducted for this study excluded any articles and studies that were not in the English language. While the majority of studies are published in the English language,[197] this exclusion criteria could mean that research studies in other languages could have identified the development of tools that were not considered in this study. For this reason, future research studies could look at studies published in languages other than English.

Also, the use of the Delphi method, while a comprehensive and rigorous method is still subjective and opinion-driven.[198] This means that healthcare practitioners may come to different conclusions and suggestions about the same components.

Another limitation is the generalisability of the study to a larger population or different organisational contexts, such as healthcare systems in other countries. The study was conducted in three hospitals in England. While a number of different methodologies and a

systematic approach were used, the applicability of the findings are difficult to generalise to different contexts. Future studies may look at the application of the tool into other systems, including the potential for process modification and validation.[199]

Another limitation is associated with the direct observation approach adopted in the time and motion study. There is the possibility that the pharmacists may have changed their behaviours because they could have become conscious of being observed. Moreover, the differing experiences of the pharmacy staff may have influenced their responses when it came to reporting on patients and medication activities.

Also, this study included only AMUs, as these were seen to be appropriate to the assessment of the impact of the tool on patient outcomes as well as the workload distribution in pharmacists. The AMUs were also chosen as a significantly large amount of prescribing and medication administering takes place in these units. The ACTPC was designed for use on admission to hospital but the impact on the tool on longer stay wards should be explored. This could be a limitation to the findings of this study as different wards may adhere to different practices.[200,201]

7.5 Implications of the Research to Practice Summary

- The use of the ACTPC will focus staff resource on highly complex patients. It would also prioritise patients in a way that means less complex patients would not need to be reviewed daily. This would free up pharmacists' time allowing them to attend to the most in need patients promptly. This means that the hospital resources would be optimised for effective use.

- The adoption of this tool would allow for the prioritisation of patients based on their individual needs, rather than their association with certain clinical areas. This leads

to enhanced patient safety by allowing clinical pharmacists to divert their attention and review to highly complex patients.

- There is a need to develop implementation strategies regarding the use of the tool at various levels of pharmacy input, based on the risk categorisation of patients. This means that pharmacy managers and other stakeholders will need to reassess their approach to risk management and governance, and make appropriate changes where needed.

- There is an opportunity for this tool to be used as a guide for the identification of required data, for instance, the number of patients taking more or less than 15 medicines in the hospital ward in which the tool was used. These can then be used to identify realistic goals along the applicability of the tool and their potential limitations.

- Patients on high-risk medication are susceptible to prescription errors. These errors carry financial and non-financial costs, including high mortality rates, which affects society overall as well as its healthcare system in particular. It is therefore imperative that interventions are designed to identify and reduce these errors as a matter of priority. The adaption of the ACTPC may reduce errors that could cause patient harm. However, further study, with larger sample size, is required.

- A regular evaluation of the tool would allow for consistent improvement, as well as the identification of training opportunities.
- In practice, the use of the tool is expected to encourage the development of a culture of quality improvement in healthcare and patient safety. In this respect, relevant professionals, such as pharmacists, pharmacist technicians and nurses, need to be

supported with suggestions on prioritising patients at high-risk and managing their time effectively.

7.6 Suggestions and Recommendations for Further Research Summary

- In order to assess the generalisability of the use of the tool, it is necessary to conduct studies that test the external validation of the tool. This includes its validation in a new cohort. Such studies will allow for the tool to be refined in terms of its accuracy as well as its components.

- Further studies may be required to assess the cost effectiveness of the tool when compared to current practises. It is also essential to test the compatibility of the tool with the current practices to ensure that it can be used to change the behaviour of the pharmacists, and to achieve better patient outcomes.
- Future studies can employ a mixed-method approach to examine adherence to tool use by pharmacists and risk factors for non-adherence.

- Future studies could use consensus methods to generate specific definitions for some components that rely on pharmacist clinical judgment such as those using the term ‘unstable condition’. This would allow the tool to be adapted for optimal technician use.
- A future study, using consensus methods such as the Delphi technique, could develop a referral system to be used by the wider healthcare team to refer patients for pharmacy review.

- There is certainly further research required in order to explore patient's views of prioritisation of pharmacy services as well as exploring the potential impact of the tool on patient quality of life.

7.7 Preliminary study outline for further study

Study design

A pragmatic stepped wedge cluster-randomized trial of ACTPC to determine definitively its effectiveness in improving patient care and pharmacy service efficiency, with the hospital as the unit of randomization. A pragmatic trial would be most suitable as this type of trial will allow for the real-world constraints of practice. Pragmatic trials evaluate the effects of health service interventions under the human, financial, and logistic constraints of typical, real world situations.[202] The stepped wedge design will ensure that all hospitals have the opportunity to use the ACTPC, as participation as a control group is not an attractive prospect to clinical pharmacy managers who are eager to implement a tool.

Population:

Patients who admitted to the acute care hospitals in different regions of the UK including Northern Ireland, England, Scotland and Wales.

Sample size

To be determined with input by a statistician with information from the feasibility study and other studies of the outcomes of interest to determine the effect size of interest.

Data Collection

The pharmacists (tool users) should be given more training time to gain familiarity with the tool and its usage; for example, four weeks prior to data collection. Data collection is planned for different outcomes including, the number and severity of PEs that reach patients, any medication related harm caused, number of omitted TCMs, length of patient stay in hospital, 30-day readmission rate, patient experience and the amount of time that pharmacists spend on tasks.

Length of stay (LoS) and 30-day readmission

These two outcomes can be collected by contacting staff in each of the hospitals' business intelligence departments and asking them to provide the data through hospital identification numbers at the level of the patient instead of aggregated LOS of the ward.

The number and severity of PEs

The number and severity of PEs that reach patients and omitted TCMs are appropriate outcomes to demonstrate if a prioritisation tool is effective in signalling to the pharmacy team those patients who require greater clinical input. Data can be collected by either the hospital pharmacists, or a dedicated researcher, at each participating hospital using Form^{2TM} that was developed and used in our feasibility study. Hospital pharmacists or a trained researcher can perform the screening exercise on all new and rewritten inpatient medication orders to identify prescription errors.

The amount of time pharmacists spends on tasks (Time and Motion Study)

A time and motion study should be conducted focussing on the most important activities carried out by the pharmacists. These should be activities associated only with patient interaction, medication and interaction with other HCPs. The electronic data collection form for the time and motion study that was developed in our feasibility study can be used. However, further piloting is suggested. Some modifications are also suggested, such as the addition of a second's field in Form2™. If this is not practicable, the use of a validated software form is suggested that is used in other time and motion studies, for example, Work Observation Method by Activity Timing (WOMBAT).[203–205]

Patient experience

One of these two approaches could be used. The first one, data on patient views of medication safety will be collected using the Medication-Related Patient Measure of Organisation Safety (MR-PMOS) questionnaire. This questionnaire has been developed to measure patients' views on medication safety and has been used previously by one of the

research team on an admissions ward of a teaching hospital.[206] The eligibility criteria for patients taking part in this part of the study will include all those admitted to hospital for more than 24hrs, those patients who are able to read, understand and speak English and less acutely unwell patients or patients after they have been discharged from hospital.

The second approach may include the exploration of patients' views of patient prioritisation for pharmacy services via telephone or face-to-face interviews. All approaches will be co-designed with a PPI group.

Economic analysis

To explore the economic impact of implementing the tool, the above data will be used. A cost-consequences analysis (CCA) will be used to present disaggregated cost and outcomes (MR-PMOS, errors avoidance and detected) of implementation. Costs of implementation, from the perspective of the NHS, will include pharmacist staff costs plus any training costs and stationary/printing costs (identified and collated by study researchers). The overall cost of implementation will be calculated using reported resource use and published unit cost data.[207,208] Published unit cost data will be used with LoS and readmission rate data, and in consultation with the PPI group, to estimate the cost of patients' use of NHS resources during the study period.

Process evaluation

We will conduct an assessment of impact of the tool on work processes. All pharmacists who work in participating hospitals as well as key stakeholders such as ward clinicians and nurses will be invited for interview. This will explore positive and negative views of the tool and appropriateness. We will explore how the tool was used by participants both through interviews and observation of practice. Interviews will be recorded with consent and transcribed verbatim. Detailed field notes will be taken during observations. This

'process evaluation' can reveal the mechanisms and processes responsible for the result in the target group, whether successful or unsuccessful, and it is thought to contribute significantly to the development of potentially successful quality improvement interventions.[187]

7.8 Reflection on the Research Process:

A reflection on the research process allows the researcher to critically analyse and reflect upon the environment as well as the researcher's own role within that environment.[209] Effective reflection is undertaken when the researcher is able to have a higher sense of self as well as the research environment. This self-awareness allows for an appropriate analysis of the experiences that inform the choices of the research methods, the sample population, and analysis of the findings.[209]

My academic background in pharmacy as well as work experience in the same equipped me with the relevant knowledge, skills and abilities that were not only relevant for the research study itself, but also to the practical evaluation of the research findings. As an extension, undertaking the systematic literature review and the Delphi studies enhanced my theoretical knowledge in the subject, and the process of getting them published in peer reviewed journals gave me invaluable knowledge on this process.

I was able to build on my existing theoretical knowledge through the quantitative part of the study as it allowed me to get first-hand information about healthcare research procedures in the healthcare settings included in the sample. I also got first-hand experience in conducting research involving human participants and the ethical elements involved in such studies. In addition, I learned how to involve experts in the research process. The ethical aspects of the research study were further enhanced by the fact that the sample population were pharmacists and patients.

Working with my research supervisors to refine the problems associated with data collection in the UK also enhanced my understanding of the ethical approval process and the details involved in amending the research protocol and its rewording to secure this approval. I also learned about the practices governing these issues in UK hospitals as well as the policies and procedures that these institutions follow, which is significant in my own professional development and learning. I was also able to refine my skills in working with others, and learned how to collaborate with other team members for the successful completion of this project.

Additionally, I learned how to develop case vignettes for the identification of patient complexity levels which were provided to the pharmacists in order to establish and clarify their understanding of the tool use.

For the data collection process, I had to identify and recruit participants for the Delphi studies and pharmacists for the feasibility study. This process allowed me to improve my communication skills, and also helped me use my previous experience appropriately to develop the technical language that was most effective in securing participant support for data collection. I was able to assess the strengths of mixed methodology studies for their benefit in developing transferable skills inherent in the development of research design, ethical approval, securing collaborators for the research process, and the process of data extraction and data analysis. I was also able to learn new skills as a part of the qualitative element of the study, such as using the NVivo software. This helped me make the most effective choice when it came to methods for data analysis. Involvement in this research process allowed me to identify the most relevant knowledge when it came to my own research interests and the choice of the most appropriate methods for these interests. These skills have enhanced my knowledge as a researcher considerably.

The process of undertaking my PhD in a new culture has been a very enlightening one, despite its challenges. I had to balance the research process with family responsibilities whereby my wife was also studying for a doctorate degree. This meant that we had to share the responsibilities of our two daughters. I believe this journey is an example for my daughters who may be inspired into patience and positive thinking. Further, it may push them forward to think about higher education abroad. The last few months of my degree brought a new challenge in the form of COVID-19 and the ensuing circumstances, such as lockdown. This presented even more, new challenges for me to navigate, creating the need to consult with my team members and supervisors online. On the one hand, it allowed me more time to balance my work-life, and also introduced new and novel ways of working. On the other hand, I was made even more aware of the many things that we usually take for granted in life, such as the ability to move freely around, social relationships, and the importance of the workplace environment as I adjusted to working from home. I have learnt about flexibility and adaptability in these times, and have also realised the full impact of human relationships in our lives.

7.9 Conclusions

The development of patient prioritisation tools to improve pharmacotherapy by clinical pharmacy services is a complicated process. While several prioritisation tools have been developed to help pharmacists to identify patients at increased risk of adverse medication related outcomes, most of them have insufficient development and validation processes. This thesis therefore, systematically developed a comprehensive pharmaceutical care complexity screening tool based on robustly collected data with input from national and international experts, the ACTPC, which can be used by the hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs. To my

knowledge, this is the first study to develop a comprehensive screening tool based on current knowledge and understanding of national and international tools combined with expert consensus. ACTPC was found practical and feasible across three hospital sites. The feasibility study recommends further research be carried out to test the ACTPC in a larger study for its effectiveness in reducing actual patient harm and improving the delivery of patient centred pharmaceutical care. More radical organisational changes to pharmacy service delivery maybe required in some hospitals to ensure the most experienced pharmacist sees the most complex patients. Furthermore, to explore the use of the tool including beyond AMU and greater use of technician workforce and technology are key areas for development of the ACTPC.

7.10 Thesis References

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7.11 Thesis Appendices

Appendix 1: Study One data extraction form

Name of reviewer						
Citation of paper						
Country						
Publication year		**Study period**				
Study's research question / aim						
STUDY DESIGN DETAILS						
Setting of study	**Teaching hospital**		**General hospital**		**Other (Please state)**	
Patients included	**Adults**		**Children**		**Both**	
Sample Size						
Specialties/wards included/ excluded (please indicate which)						
Study method	**Retrospective**					
	Prospective					
	Other (state)					
Outcome measure (if present)						
What strategies were used to ensure rigour Validity						

How were ethical issues addressed?					
Any other relevant additional information about the design of the study					
RESULTS					
Tool/Instrument used by researchers to identify high risk patients	**Electronic**				
	Manual				
Risk Factors which were considered	**Drug Related**		**Patient Related**		
	Polypharmacy		**Age**		
	Number of IV medicine		**Renal function**		
	High alert medicine		**Liver function**		
	Adverse drug reactions		**An organ dysfunction**		
	Therapeutic drug monitoring (TDM)		**Multiple organ dysfunction**		
	Use of total parenteral nutrition or tube (TPN/NGT)		**Patient with comorbidities**		
	High risk and narrow therapeutic window medicines		**Number of readmissions to hospital within 12 months post-discharge.**		
	high cost medicines		**Number of previous emergency admissions**		
	Medicines needing monitoring (Anticoagulants, Insulin, Digoxin, Gentamicin, Vancomycin)		**Reason for admission,**		
	Immunosuppressants		**Time since patient admitted to the hospital**		

	Unlicensed medicines		**Other (state)**	
	Extended duration antibiotic prescribing			
	Medicines related to specific disease states (for example, epilepsy, Parkinson's disease)			
	Drug interactions			
	Administration issues			
	Drug specific issues			
	Other (state)			
Benefits				
Limitations				
Other information from study which may be important to capture				
Any important limitations of the study				

Appendix 2: Example of Delphi One (Round One)

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit

Page 1

Dear Colleague,

You have been identified as an expert in the area of pharmaceutical risk, pharmaceutical complexity/risk tools and/or clinical pharmacy services management.

The aim of this exercise is to produce an international consensus statement, using the Delphi approach, on the components of a pharmaceutical complexity tool. The complexity tool can be used by any hospital pharmacy team to triage new patients at their **point of admission**, prior to any pharmacist intervention, on an **adult acute medical unit** according to the complexity of their likely pharmaceutical needs. This tool will support the clinical pharmacy team by ensuring that the sickest patients, who are at greatest risk of preventable harm due to medication, are seen most quickly and most frequently by an appropriately experienced clinical pharmacist. Conversely, it will ensure that those patients who are at the lowest risk of preventable harm due to medication will be seen later by an appropriately experienced pharmacy professional, who may be a junior pharmacist or atechnician.

You will take part in either one or two Delphi exercises. This is the first Delphi exercise which consists of a list of statements relating to possible components of a pharmaceutical care complexity screening tool. Rankings from all participants from the first stage will be summarised and returned to you for you to see, so that you can re-rank your agreement in comparison with other members of the expert panel.

This Delphi exercise will take approximately 20-30 minutes. Please note that you will be given a fortnight to complete each Delphi questionnaire round. Further rounds within each Delphi may run, until a consensus is reached (no more than 3 rounds for each Delphi). If you decide to take part, you will receive a £20 gift voucher for each Delphi exercise you complete. In addition, you will be acknowledged in any study outputs, unless you request otherwise.

If you decide to complete this exercise over a number of sittings, you may click 'save' and return to the survey by copying the URL link provided to you in the email. You will not be able to return to the survey if you click 'done'.

Please click next to begin this Delphi exercise.

Thank you for your time and consideration.

Best Regards,

Dr Penny Lewis

School of Health Sciences
University of Manchester
penny.lewis@manchester.ac.uk

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit

Page 2

Demographic data (round one Delphi)

2. Please state your title and full name*

Title	
Full name	

3. Would you like to be acknowledged in any research outputs?

- ○ Yes
- ○ No

4. Please provide your email address to receive feedback and the second round questionnaire*

5. Professional background

- ☐ Pharmacist
- ☐ Medical Doctor
- ☐ Psychologist
- ☐ Other, please specify

6. Which of the following best describes your experience in the area of pharmaceutical risk*

- ☐ Researcher
- ☐ Writing and/or developing pharmaceutical complexity tools or processes
- ☐ Experience in the use of pharmaceutical complexity/priority tools or processes
- ☐ Other, please specify

7. Please write a brief description of your experience in the area of pharmaceutical risk and/or pharmaceutical complexity screening tools*

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit

Page 3

Below is a list of potential components for a pharmaceutical complexity screening tool that would be used on patients at their **point of admission** onto an **adult acute medical unit**. Please score how important each component is, on a scale of 1-9, for inclusion into this pharmaceutical complexity tool. You may write additional comments. There will also be a section for additional comments on the overall Delphi survey.

Each indicator is rated on a 9-point scale, where 1 represents the lowest and 9 the highest rating. Please consider using the full range of the scale from 1 to 9.

- Please rate each indicator in relation to its importance for inclusion into a pharmaceutical complexity screening tool
- If you think that an indicator is NOT important, please score it low on the importance scale (i.e. 1, 2 or 3)
- If you are not sure (uncertain) about the importance of the indicator, please give a mid-range score (i.e. 4, 5 or 6)
- If you think that an indicator should be considered important, please score it high on the importance scale (i.e. 7, 8 or 9)

If you were using a pharmaceutical complexity screening tool to prioritise patients to receive pharmacy services at their point of admission onto an adult acute medical unit, how important would it be to include the following factors in the complexity tool? The presence or absence of these factors would be used to indicate the pharmaceutical complexity of a patient.

8. The patient is:

	Unimportant				Uncertain			Important	
	1	2	3	4	5	6	7	8	9
1. Between 16-18 years of age	○	○	○	○	○	○	○	○	○
2. Between 60-65 years of age	○	○	○	○	○	○	○	○	○
3. Between 66-70 years of age	○	○	○	○	○	○	○	○	○
4. Over 71 years of age	○	○	○	○	○	○	○	○	○
5. Pregnant or breast-feeding	○	○	○	○	○	○	○	○	○
6. Extreme weight (frail/obese)	○	○	○	○	○	○	○	○	○
7. Prescribed 5 or more regular medicines	○	○	○	○	○	○	○	○	○
8. Prescribed 10 or more regular medicines	○	○	○	○	○	○	○	○	○
9. Prescribed 15 or more regular medicines	○	○	○	○	○	○	○	○	○
10. Nil by mouth or have swallowing difficulties	○	○	○	○	○	○	○	○	○
11. With an ileostomy or colostomy	○	○	○	○	○	○	○	○	○
12. Taking medicines as part of a clinical trial	○	○	○	○	○	○	○	○	○
13. An organ transplant patient	○	○	○	○	○	○	○	○	○
14. Predicted to undergo surgery/procedure	○	○	○	○	○	○	○	○	○
15. A palliative care patient	○	○	○	○	○	○	○	○	○

Please include any other medicines/factors you believe should be added to the above list and justify your suggestion.

You may also insert any comments/justification to your selections by stating which medication/factors you are commenting on.

Appendix 3: Example of Delphi One (Round Two)

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit

Dear Colleague,

Thank you for completing the first-round questionnaire of this Delphi study.

The aim of this study is to produce an international consensus statement, using the Delphi approach, on the components of a pharmaceutical complexity tool. The complexity tool can be used by any hospital pharmacy team to triage new patients according to the complexity of their likely pharmaceutical needs, at their point of admission on an adult acute medical unit, and prior to any pharmacist intervention. This tool will support the clinical pharmacy team by ensuring that the sickest patients, who are at greatest risk of preventable harm due to medication, are seen most quickly and most frequently by an appropriately experienced clinical pharmacist. Conversely, it will ensure that those patients who are at the lowest risk of preventable harm due to medication will be seen later by an appropriately experienced pharmacy professional, who may be a junior pharmacist or atechnician.

This is the second-round questionnaire, where we provide you with feedback from the first round and ask you to re-rate the risk factors. In this questionnaire, you are provided with three types of feedback from the first round. For each risk factor, the feedback includes:

1- A summary of the group comments.

2- The median score, which is the middle number scored by the respondents in the first round. 3- Your individual previous score.
During this round, you are asked to RE-RATE, on the same 9-point scale, a set of risk factors contained in this questionnaire for their importance for inclusion into a pharmaceutical complexity tool, in light of the group feedback and comments. Please note that the practicality of inclusion of particular risk factors will be explored in a subsequent Delphi study; this survey concentrates solely on importance. If you have any comments, you may write your comments in the space available on each page (this is optional).

This Delphi exercise will take approximately 30-40 minutes. Please note that you will be given a fortnight to complete this second-round Delphi questionnaire. If you decide to take part, you will receive a £20 gift voucher for completion of both Delphi rounds. In addition, you will be acknowledged in any study outputs, unless you request otherwise.

If you decide to complete this exercise over a number of sittings, you may click 'save' and return to the survey by copying the URL link provided to you in the email. You will not be able to return to the survey if you click 'done'.

Please click next to begin this Delphi exercise.

Thank you for your time and consideration.

Best Regards,

Mr Meshal Alshakrah
meshal.alshakrah@postgrad.manchester.ac.uk
Dr Penny Lewis
penny.lewis@manchester.ac.uk
School of Health Sciences University of Manchester

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit (R41)

Demographic data (round Two Delphi) **Page 2**

1. Please state your title and full name* Title
   Full name

2. Please provide your email address to receive feedback*

Developing a pharmaceutical care complexity tool for patients at their point of admission to an adult acute medical unit

Clinical conditions

Page 3

Below is a list of potential components for a pharmaceutical complexity screening tool that would be used on patients at their **point of admission** onto an **adult acute medical unit**. Please score how important each component is, on a scale of 1-9, for inclusion into this pharmaceutical complexity tool. You may write additional comments in the boxes if you wish, but this is not required. There will also be a section for additional comments on the overall Delphi survey at the end.

Each indicator is rated on a 9-point scale, where 1 represents the lowest and 9 the highest rating. Please consider using the full range of the scale from 1 to 9.

- Please rate each indicator in relation to its importance for inclusion into a pharmaceutical complexity screening tool
- If you think that an indicator is NOT important for inclusion, please score it low on the importance scale (i.e. 1, 2 or 3)
- If you are not sure (uncertain) about the importance of the indicator, please give a mid-range score (i.e. 4, 5 or 6)
- If you think that an indicator should be considered important for inclusion, please score it high on the importance scale (i.e. 7, 8 or 9)

If you were using a pharmaceutical complexity screening tool to prioritise patients to receive pharmacy services at their point of admission onto an adult acute medical unit, how important would it be to include the following factors in the complexity tool? The presence or absence of these factors would be used to indicate the pharmaceutical complexity of a patient.

3. **The patient is between 16-18 years of age**

Number of respondents giving comments = 14 Summary of the group comments:

1. Younger people 16-18 tend to be on few meds. Not important
2. A young patient on only a couple of medications could be a high priority because of their individual circumstances.

Your previous score	Median
4	3

My final rating is*

Unimportant			Uncertain				Important	
1	2	3	4	5	6	7	8	9
○		○	○	○	○	○	○	○

4. Do you have any comments about the potential tool component? **(Optional comments)**

5. **The patient is between 60-65 years of age**

Number of respondents giving comments = 14 Summary of the group comments:

1. Age is not important, it is more the diseases and number of drugs taken and also the sum of the two. Some diseases may count more than others.
2. Age IS NOT important. Complexity can be ascertained from age and can be better reflected by medical condition and medications taken.
3. Prioritisation on basis of age is redundant for most age groups in my view. Other than age (e.g. confusion, co-morbidity) would better guide prioritisation.
4. Age of the patient is by far the strongest predictor of the requirement for Pharmaceutical intervention using multivariable analysis.

Your previous score	Median
7	6

My final rating is *

Appendix 4: Example of Delphi Two (Round One)

Dear Colleague,

You have been identified as an expert in the area of clinical pharmacy services management and we would like your assistance with an NIHR funded research project that aims to develop and assess the feasibility and acceptability of a pharmaceutical care complexity screening tool to aid the targeted delivery of clinical pharmacy services in hospitals.

Over the past 12 months we have been developing this pharmaceutical complexity screening tool. So far, we have obtained consensus on the necessary components of the tool by using the Delphi approach. One hundred and nine complexity tool components were identified and grouped into three component types (demographic, clinical related and medication related). These were then reduced to 31 items for inclusion into a complexity screening tool.

This complexity tool will be used by any hospital pharmacy team to triage new patients at their point **of admission**, prior to any pharmacist intervention, on an **adult acute medical unit** according to the complexity of their likely pharmaceutical needs. This tool will support the clinical pharmacy team by ensuring that the highly complex patients, who are at greatest risk of preventable harm due to medication, are seen most quickly and most frequently by an appropriately experienced clinical pharmacist. Conversely, it will ensure that those patients who are at the lowest risk of preventable harm due to medication will be seen later by another appropriately experienced pharmacy professional, who may be a junior pharmacist or a technician.

The aim of this exercise is, using the same Delphi approach, reach consensus on the appropriate frequency of clinical pharmacist input for each complexity level and appropriate competency level of pharmacy staff assigned to each complexity level.

This is the second Delphi exercise (you may or may not have taken part in the first Delphi exercise) which consists of a list of statements relating to the use of the pharmaceutical complexity screening tool including the frequency with which a patient should be seen and the level of experience of the pharmacist practitioner. These statements were developed based on data from interviews with 36 clinical pharmacy managers. Rankings from all participants from the first round will be summarised and returned for you to see, so that you can rank your agreement in comparison with other members of the expert panel. Therefore, participating in this Delphi exercise involves completing two or three questionnaires that will be sent to you several weeks apart.

This Delphi exercise will take approximately 10-20 minutes. Please note that you will be given a fortnight to complete this first-round Delphi questionnaire. If you decide to take part, you will receive a £20 gift voucher for completion of all Delphi rounds. A further round within this Delphi may run, until a consensus is reached (but there will be no more than three rounds in total). In addition, you will be acknowledged in any study outputs, unless you request otherwise.

If you decide to complete this exercise over a number of sittings, you may click 'save' and return to the survey by copying the URL link provided to you in the email. You will not be able to return to the survey if you click 'done'.

Please click next to begin this Delphi exercise.

Thank you for your time and consideration.

Best Regards,

Mr Meshal Alshakrah

meshal.alshakrah@postgrad.manchester.ac.uk

Dr Penny Lewis

penny.lewis@manchester.ac.uk

Division of Pharmacy and Optometry

University of Manchester

Please state your title and full name*

Title

Full name

What is your current job role?*

What hospital/trust do you currently work at? *

Please provide your email address to receive feedback*

The pharmaceutical complexity screening tool includes different risk factors. These risk factors were explored and agreed during the Delphi 1 exercise- these risk factors would be identified in patients at their **point of admission to an adult acute medical unit.** The patient will then be classified as highly, moderately or least complex based on the presence or absence of those factors. Patients who meet one or more red criteria are rated as 'RED' and are classified as highly complex. Furthermore, patients who meet one or more amber criteria are rated as 'AMBER' and are classified as moderately complex. However, if the patient is stable with no acute issues and does not have any red or amber criteria they are rated as 'GREEN' and are classified as least complex. Please see the attached tool for details (Adult Complexity Tool for Pharmaceutical Care).

Below is a list of statements relating to the use of the pharmaceutical complexity screening tool including the frequency with which a patient should be seen and the level of experience of the pharmacist practitioner. Please score, on a scale of 1-9, the practicality and also clinical appropriateness of these statements. You may write additional comments about each statement. There will also be a section for additional comments on the tool itself and the overall Delphi survey.

Each statement is rated on a 9-point scale, where 1 represents the lowest and 9 the highest rating. Please consider using the full range of the scale from 1 to 9:

- Please rate each statement in relation to its practicality or clinical appropriateness of the pharmaceutical complexity screening tool;
- If you think that a statement is NOT practical or clinically appropriate, please score it low on the scale (i.e. 1, 2 or 3)
- If you are not sure (uncertain) about the practicality or clinically appropriate of the statement, please give a mid-range score (i.e. 4, 5 or 6)
- If you think that a statement should be considered practical or clinically appropriate, please score it high on the scale (i.e. 7, 8 or 9)

If you were using a pharmaceutical complexity screening tool to prioritise patients to receive pharmacy services at their point of admission onto an adult acute medical unit, **how practical or clinically appropriate would it be to include the following statements in the complexity tool?**

The statements will identify the frequency with which the patient should be seen, and the level of expertise required from a clinical pharmacist.

Patient name:		Admission date/time:	Ward:
Patient hospital number:		Diagnosis:	Pharmacist:
Age:	Allergies:	Triage date/time:	
Weight:			

Adult complexity tool for pharmaceutical care (ACTPC-Form2)

Criteria Scope	Criteria	Red, Amber and Green Criteria Descriptions	Tick
Demographic Criteria	*Age*	Age ≥ 70 years old	
	Weight	Extreme weight (frail/obese) < 50 KG / > 120 KG	
	Allergy	History of severe allergic reaction	
	Pregnancy	Pregnant or breast-feeding	
Clinical Related Criteria	*Acute Kidney Injury*	Stage 1: a rise in creatinine from 1.5 to 1.9 times the baseline value	
		Stage 2: a rise in creatinine from 2 to 2.9 times the baseline value	
		Stage 3: a rise in creatinine ≥ 3 times the baseline value	
	Chronic Kidney Disease	Mildly to moderately decreased: GFR 45-59 ml/minute	
		Moderately to severely decreased: GFR 30-44 ml/minute	
		Severely decreased: GFR ≤ 29 ml/minute	
	Hepatic Impairment (LFT'S)	Moderate hepatic impairment (LFT'S < 3 times the upper limit of normal)	
		Severe hepatic impairment (LFT'S ≥ 3 times the upper limit of normal)	
	Infectious Diseases	Patient has any of the following diseases but is in a stable condition according to your clinical judgement: Meningitis☐ Sepsis☐ HIV☐ Tuberculosis(TB)☐	
		Patient has any of the following diseases and is in an unstable condition according to your clinical judgement: Meningitis ☐ Sepsis ☐ HIV ☐ Tuberculosis(TB) ☐	
	Priority	Patient has any of the following diseases but is in a stable condition according to your clinical judgement: Endocarditis☐ Hyperthyroid crisis☐ NSTEMI/STEMI☐ Parkinson disease☐ Epilepsy☐ Mental health conditions☐ Decompensated heart failure☐ Myasthenia gravis☐ G6PD deficiency☐ Porphyria☐ Gastric absorption problems☐	

The pharmacist can use the tool before medicine reconciliation

My rating is*

	Low				Uncertain				High
	1	2	3	4	5	6	7	8	9
Practicality	○	○	○	○	○	○	○	○	○

Do you have any comments about the statement above? **(Optional comments)**

The pharmacist can use the tool during or after medicine reconciliation

My rating is*

	Low				Uncertain				High
	1	2	3	4	5	6	7	8	9
Practicality	○	○	○	○	○	○	○	○	○

Do you have any comments about the statement above? **(Optional comments)**

Appendix 5: Example of Delphi Two (Round Two)

Dear Colleague,

Thank you for participating in the previous round of this Delphi. In order to create a consensus amongst yourselves, the experts, we ask that you please complete this FINAL round.

The complexity tool will be used by any hospital pharmacy team **to triage new patients at their point of admission**, prior to any pharmacist intervention, **on an adult acute medical unit** according to the complexity of their likely pharmaceutical needs. This tool will support the clinical pharmacy team by ensuring that the highly complex patients, who are at greatest risk of preventable harm due to medication, are seen most quickly and most frequently by an appropriately experienced clinical pharmacist. Conversely, it will ensure that those patients who are at the lowest risk of preventable harm due to medication will be seen later by another appropriately experienced pharmacy professional, who may be a junior pharmacist or a technician.

The aim of this study is, using the same Delphi approach, reach consensus on the appropriate frequency of clinical pharmacist's input for each complexity and competency level of pharmacy staff assigned.

This is the second-round questionnaire, where we provide you with feedback from the first round and ask you to re-rate a list of statements relating to the use of the pharmaceutical complexity screening tool including the frequency with which a patient should be seen and the level of experience of the pharmacist practitioner. In this questionnaire, you are provided with three types of feedback from the first round. For each statement, the feedback includes:

1. **A summary of the group comments.**
2. **The median score, which is the middle number scored by the respondents in the first round.**
3. **Your individual previous score.**

During this round, you are asked to RE-RATE, on the same 9-point scale, a set of statements contained in this questionnaire for their practicality or clinical appropriateness of the pharmaceutical complexity screening tool, in light of the group feedback and comments. If you have any comments, you may write your comments in the space available on each page (this is optional).

This Delphi exercise will take approximately 10-20 minutes. Please note that you will be given a fortnight to complete this second-round Delphi questionnaire. If you decide to take part, you will receive a £20 gift voucher for completion of both Delphi rounds. In addition, you will be acknowledged in any study outputs, unless you request otherwise.

If you decide to complete this exercise over a number of sittings, you may click 'save' and return to the survey by copying the URL link provided to you in the email. You will not be able to return to the survey if you click 'done'.

Please click next to begin this Delphi exercise.

Thank you for your time and consideration.

Best Regards,

Mr Meshal Alshakrah

meshal.alshakrah@postgrad.manchester.ac.uk

Dr Penny Lewis

penny.lewis@manchester.ac.uk

Division of Pharmacy and Optometry

University of Manchester

Please state your title and full name*

Title

Full name

Please provide your email address to receive feedback*

The pharmaceutical complexity screening tool includes different risk factors. These risk factors were explored and agreed during the Delphi 1 exercise- these risk factors would be identified in patients at their **point of admission to an adult acute medical unit.** The patient will then be classified as highly, moderately or least complex based on the presence or absence of those factors. Patients who meet one or more red criteria are rated as 'RED' and are classified as highly complex. Furthermore, patients who meet one or more amber criteria are rated as 'AMBER' and are classified as moderately complex. However, if the patient is stable with no acute issues and does not have any red or amber criteria they are rated as 'GREEN' and are classified as least complex. Please see the attached tool for details (Adult Complexity Tool for Pharmaceutical Care).

Below is a list of statements relating to the use of the pharmaceutical complexity screening tool including the frequency with which a patient should be seen and the level of experience of the pharmacist practitioner. Please score, on a scale of 1-9, the practicality and also clinical appropriateness of these statements. You may write additional comments in the boxes if you wish, but this is not required. There will also be a section for additional comments on the overall Delphi survey at the end.

Each statement is rated on a 9-point scale, where 1 represents the lowest and 9 the highest rating. Please consider using the full range of the scale from 1 to 9:

- Please rate each statement in relation to its practicality or clinical appropriateness of the pharmaceutical complexity screening tool;
- If you think that a statement is NOT practical or clinically appropriate, please score it low on the scale (i.e. 1, 2 or 3)
- If you are not sure (uncertain) about the practicality or clinically appropriate of the statement, please give a mid-range score (i.e. 4, 5 or 6)
- If you think that a statement should be considered practical or clinically appropriate, please score it high on the scale (i.e. 7, 8 or 9)

If you were using a pharmaceutical complexity screening tool to prioritise patients to receive pharmacy services at their point of admission onto an adult acute medical unit, **how practical or clinically appropriate would it be to include the following statements in the complexity tool?**

The statements will identify the frequency with which the patient should be seen, and the level of expertise required from a clinical pharmacist.

The pharmacist can use the tool before medicine reconciliation

Number of respondents giving comments = 34
Summary of the group comments:

- **The clinical questions can easily be answered without medicines reconciliation however, you could not answer the medication-related section without medicine reconciliation.**
- **Medicine reconciliation is performed prior to a full patient/medication review.**
- **Pharmacist more likely to review after drug history.**
- **Yes, but ideally after when all information is available.**
- **Would be helpful before reconciliation as it would guide prioritisation but time and resources to complete may be an issue and some of the answers may not be possible until during the reconciliation process.**
- **Based on clinical notes and presentation, it would be possible to prioritise patients prior to a full medicine reconciliation being completed.**

Your previous score	Median
2	5

My final rating is*

	Low				Uncertain				High
	1	2	3	4	5	6	7	8	9
Practicality	○	○	○	○	○	○	○	○	○

The pharmacist can use the tool during or after medicine reconciliation

Number of respondents giving comments = 21
Summary of the group comments:

- **Useful to assess during medicine reconciliation but would be more useful to prioritise who to see first.**
- **This allows a better use of resources and ensures that decisions are being made using accurate and up to date information.**
- **More likely to be carried out as part of medicine reconciliation.**
- **This is more likely and practical.**
- **This would be the most straight forward time.**
- **Before this stage the pharmacist should know the priority to see the patient.**

Your previous score	Median
7	7

My final rating is*

	Low				Uncertain				High
	1	2	3	4	5	6	7	8	9
Practicality	○	○	○	○	○	○	○	○	○

Appendix 6: Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form1)

MANCHESTER 1824 The University of Manchester

Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form 1)

ACTPC

Patient name | Triage date/time

Patient hospital number | Ward

This tool does not override the responsibility to make decisions appropriate to the circumstances of the individual patient, therefore it is not mandatory to apply the recommendations in the tool.

Criteria Scope	Criteria	Red Criteria Descriptions	Tick
Clinical Related Criteria	***Priority Diseases***	Patient has any of the following diseases and is in **an unstable condition** according to your clinical judgement: Endocarditis ☐ Hyperthyroid crisis ☐ NSTEMI/STEMI ☐ Parkinson disease ☐ Epilepsy ☐ Decompensated heart failure ☐ Myasthenia gravis ☐ G6PD deficiency ☐ Porphyria ☐ Severe asthma ☐	☐
	Infectious Diseases	Patient has any of the following diseases and is in **an unstable condition** according to your clinical judgement: Meningitis ☐ Sepsis ☐ HIV ☐ Tuberculosis (TB) ☐	☐
	Acute Kidney Injury	Stage 3: a rise in creatinine ≥ 3 times the baseline value	☐
	Chronic Kidney Disease	Severely decreased: GFR ≤ 29 ml/minute	☐
	Hepatic Impairment (LFT'S)	Severe hepatic impairment (LFT'S ≥ 3 times the upper limit of normal)	☐
	Miscellaneous	An organ transplant	☐
Medication Related Criteria	***Polypharmacy***	Prescribed ≥ 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
	Medication Risk	Prescribed any high-risk medicines** or medicines requiring TDM** with documented or suspected toxic or subtherapeutic effect	☐
	Treatment Interaction	Drug interaction with documented or suspected toxic or subtherapeutic effect	☐
	Drug related problems	Patient admitted due to an adverse drug reaction	☐
	Miscellaneous	Abnormal laboratory results related to medication or if dose adjustment/omissions are required	☐

Guidance

- **This tool ACTPC-Form1 (With red criteria only) is for use directly on admission at ADULT ACUTE MEDICAL UNIT.**
- **Patients who meet any of these criteria/identified as clinically unstable are immediately rated as 'RED' and are a high priority for both initial medicines reconciliation and continuing clinical review.**
- **The complexity level can be changed at any time if the patient's circumstances change.**
- **Patients who have any red criteria can be downgraded depending on clinical condition and/or medication changes by using ACTPC-Form2**

High risk medication and medicines requiring TDM list (Not exhaustive list)

Anticoagulants: e.g. Heparin, LMWH, Warfarin, DOACs (Apixaban, Dabigatran, Rivaroxaban, Edoxaban) **Anti-Psychotics:** e.g. Clozapine, Depot Injections **Chemotherapy** | **Antiepileptic medication:** e.g. Sodium Valproate, Lamotrigine, Levetiracetam, Phenytoin **Antiretrovirals for HIV and Hepatitis C:** e.g. Darunavir, Emtricitabine, Lamivudine, Tenofovir **Immunosuppressants:** e.g. Azathioprine, Cyclosporine, Mercaptopurine, Methotrexate, Mycophenolate, Tacrolimus | **Narrow Therapeutic Index:** e.g. Aminophylline, Digoxin, Lithium, Phenytoin, Theophylline | **Opiates:** e.g. Buprenorphine, Naloxone, Fentanyl , Morphine, Methadone, Oxycodone | **Parkinson's disease medication:** e.g. Co-beneldopa , Co-careldopa, Entacpone , Rasagiline | **IV Antibiotics:** e.g. Vancomycin, Gentamicin, Amikacin, Tobramycin, Rifampicin, Erythromycin, Clarithromycin | **IV Inotropes:** e.g. Milrinone , Dopamine, Dobutamine, Isoprenaline, Vasopressors | **Antifungals:** e.g. Amphotericin, High dose or extended course duration of Triazole | **Total parenteral nutrition (TPN) Immunoglobulins, Insulin, Corticosteroid, Intravenous beta-Blocker** | **Potassium infusion > 40 mmol/1 L**

Criteria Range	Risk level	Complexity level	Pharmacist level
The patient has one or more red criteria	**High risk**	**Highly complex- ideally should be seen in the first 6-12 hours BUT not greater than 24 hours of admission then daily**	**Experienced clinical pharmacist**

Complexity level can be changed at any time if patient's circumstances change			Overall assessment of pharmaceutical care complexity	
Date	**Time**	**Pharmacist's comments**	**Red**	**Non-red (i.e. amber or green)**

Appendix 7: Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form2)

MANCHESTER 1824
The University of Manchester

Adult Complexity Tool for Pharmaceutical Care (ACTPC-Form 2)

ACTPC

Patient name | Admission date/time

Patient hospital number | Ward

This tool does not override the responsibility to make decisions appropriate to the circumstances of the individual patient, therefore it is not mandatory to apply the recommendations in the tool.

Criteria Scope	Criteria	Red, Amber and Green Criteria Descriptions	Tick
Demographic Criteria	***Age***	Age > 70 years old	☐
	Weight	Extreme weight (frail/obese) < 50 KG / > 120 KG	☐
	Allergy	Previous history of severe allergic reaction to medication	☐
	Pregnancy	Pregnant or breast-feeding	☐
Clinical Related Criteria	***Priority Diseases***	Patient has any of the following diseases and is in an **unstable condition** according to your clinical judgement: Endocarditis ☐ Hyperthyroid crisis ☐ NSTEMI/STEMI ☐ Parkinson disease ☐ Epilepsy ☐ Decompensated heart failure ☐ Myasthenia gravis ☐ G6PD deficiency ☐ Porphyria ☐ Severe asthma ☐	☐
		All conditions above if stable or severe gastric absorption problems ☐	☐
	Infectious Diseases	Patient has any of the following diseases and is in an **unstable condition** according to your clinical judgement: Meningitis ☐ Sepsis ☐ HIV ☐ Tuberculosis (TB) ☐	☐
		All conditions above if stable ☐	☐
	Acute Kidney Injury	Stage 3: a rise in creatinine ≥ 3 times the baseline value	☐
		Either Stage 1 or Stage 2: a rise in creatinine from 1.5 to 2.9 times the baseline value	☐
	Chronic Kidney Disease	Severely decreased: GFR ≤ 29 ml/minute	☐
		Decreased GFR 30 - 59 ml/minute	☐
	Hepatic Impairment (LFT'S)	Severe hepatic impairment (LFT'S ≥ 3 times the upper limit of normal)	☐
		Moderate hepatic impairment (LFT'S < 3 times the upper limit of normal)	☐
	Hospitalisation	Patient had at least one admission in the last month (Discharged < 30 days ago)	☐
	Miscellaneous	An organ transplant	☐
		Patient has any of the following characteristics: Palliative care ☐ Uncontrolled pain ☐ National early warning score ≥ 5 ☐ Nil by mouth or has swallowing difficulties ☐ Abnormal laboratory results NOT related to medication (Excluding renal and liver) ☐	☐
Medication Related Criteria	***Polypharmacy***	Prescribed ≥ 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
		Prescribed ≥ 15 regular medicines without complex regimen e.g. No drug-drug or drug-disease interactions	☐
		Prescribed < 15 regular medicines with complex regimen e.g. drug-drug or drug-disease interactions	☐
	Medication Risk	Prescribed any high-risk medicines** or medicines requiring TDM** with documented or suspected toxic or subtherapeutic effect	☐
		Prescribed any high-risk medicines** or medicines requiring TDM** without documented or suspected toxic or subtherapeutic effect	☐
	Treatment Interaction	Drug interaction with documented or suspected toxic or subtherapeutic effect	☐
		Drug interaction BUT no documented or suspected toxic or subtherapeutic effect	☐
	Drug related problems	Patient admitted due to an adverse drug reaction	☐
		Prolonged QT secondary to medicines** (No relevance to the reason of admission)	☐
		Falls secondary to medicines** (No relevance to the reason of admission)	☐
	Miscellaneous	Abnormal laboratory results related to medication or if dose adjustment/omissions are required	☐
		Restricted antibiotics**	☐
		Intravenous glucose> 20%	☐
		Continuous IV infusion excluding standard fluid replacement	☐

** Provided on the back of this tool

Criteria Range	Risk level	Complexity level	Pharmacist practitioner level
The patient has one or more red criteria	High risk	Highly complex- ideally should be seen in the first 6-12 hours BUT not greater than 24 hours of admission then daily	Experienced clinical pharmacist
The patient has one or more amber criteria	Moderate risk	Moderately complex- should be seen in the first 24 hours of admission then every one or two days	Clinical pharmacist
The patient stable with no acute issues AND he/she DOES NOT have any red or amber criteria	Low risk	Least complex- should be seen in the first 24 hours of admission then twice weekly	Clinical pharmacist

Complexity level can be changed at any time if patient's circumstances change			Overall assessment of pharmaceutical care complexity		
Date	Time	Pharmacist	Red	Amber	Green

High risk medication list
(This list is not exhaustive)

Anticoagulants: e.g. Heparin, LMWH, Warfarin, DOACs (Apixaban, Dabigatran, Rivaroxaban, Edoxaban) | **Anti-Psychotics**: e.g. Clozapine, Depot Injections | **Chemotherapy** | **Antiepileptic medication**: e.g. Sodium Valproate, Lamotrigine, Levetiracetam, Phenytoin | **Antiretrovirals for HIV and Hepatitis C:** e.g. Darunavir, Emtricitabine, Lamivudine, Tenofovir | **Immunosuppressants**: e.g. Azathioprine, Cyclosporine, Mercaptopurine, Methotrexate, Mycophenolate, Tacrolimus | **Narrow Therapeutic Index:** e.g. Aminophylline, Digoxin, Lithium, Phenytoin, Theophylline | **Opiates:** e.g. Buprenorphine, Naloxone, Fentanyl , Morphine, Methadone, Oxycodone | **Parkinson's disease medication**: e.g. Co-beneldopa , Co-careldopa, Entacpone , Rasagiline | **IV Antibiotics**: e.g. Vancomycin, Gentamicin, Amikacin, Tobramycin, Rifampicin, Erythromycin, Clarithromycin | **IV Inotropes**: e.g. Milrinone , Dopamine, Dobutamine, Isoprenaline, Vasopressors | **Antifungals**: e.g. Amphotericin, High dose or extended course duration of Triazole | **Total parenteral nutrition (TPN)** | **Immunoglobulins, Insulin, Corticosteroid, Intravenous beta-Blocker** | **Potassium infusion > 40 mmol/1L**

Medicines causing QT prolongation and Torsades de Pointes (This list is not exhaustive)

Antimicrobial: e.g. Azithromycin, Erythromycin, Clarithromycin, Moxifloxacin, Ketoconazole | **Antimalarial drugs**: e.g. Pentamidine, Quinine, Chloroquine | **Androgen antagonists**: e.g. Bicalutamide, Flutamide | **Antipsychotics**: e.g. Chlorpromazine, Haloperidol, Droperidol, Quetiapine, Olanzapine, Amisulpride, Thioridazine, Sulpiride, Zuclopenthixol, Clozapine, Olanzapine, Quetiapine, Risperidone, Lithium, Chloral hydrate, Pimozide | **Tricyclic antidepressants**: e.g. Amitriptyline, Doxepin, Imipramine, Nortriptyline, Desipramine | **Other antidepressants**: e.g.Mianserin, Citalopram, Escitalopram, Venlafaxine, Bupropion, Moclobemide | **Antiarrhythmics**: e.g. Quinidine, Procainamide, Disopyramide, Flecainide, Sotalol, Amiodarone, Dronedarone Antihistamines: Diphenhydramine, Hydroxyzine, Loratadine, Mizolastine, **Gonadorelin analogues / antagonists**: e.g. Buserelin, Goserelin, Leuprorelin, Degarelix **Immunosuppressant**: e.g. Tacrolimus | **Antidiuretic hormone**: e.g. Vasopressin | **Thiazide diuretics** | **Other agents**: e.g. Adenosine, Papaverine , Domperidone, Metoclopramide, Methadone (in doses greater than 100 mg), Ondansetron, Sildenafil, Solifenacin, Tizanidine, Tolterodine, Droperidol, Levomepromazine, Hydroxychloroquine

Patients prescribed restricted antibiotics
(This list is not exhaustive)

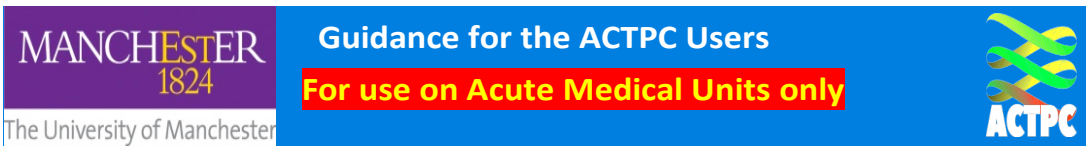
Amphotericin, Liposomal amphotericin, Amikacin, Cephalosporins (e.g. ceftriaxone, cefuroxime, cefalexin, ceftazidime), Carbapenems (e.g. Meropenem, ertapenem), Chloramphenicol, Daptomycin, Echinocandin antifungals (e.g. caspofungin, anidulafungin), Fidaxomicin, Fosfomycin, Linezolid, Meropenem, Piperacillin/ Tazobactam, Posaconazole, Quinolone (e.g. ciprofloxacin, levofloxacin), Tigecycline, Tobramycin IV, Vancomycin, Voriconazole

Medicines that may increase falls risk
(This list is not exhaustive)

Analgesics: e.g. Opioids, NSAIDs | **Anticholinesterase inhibitors**: e.g. Donepezil, Rivastigmine, Galantamine | **Antidepressants**: e.g. Tricyclics, selective serotonin reuptake inhibitors (SSRIs) and others | **Anti-diabetic drugs**: e.g. insulin, Glibenclamide, Gliclazide, Tolbutamide | **Anti-epileptics**: e.g. Phenytoin, Carbamazepine, Gabapentin, Pregabalin, Primidone, Sodium Valproate | **Anti-histamines**: e.g. Chlorphenamine | **Anti-muscarinic drugs**: e.g. Oxybutynin, Solifenacin | **Anti-psychotics**: e.g. Haloperidol, Risperidone, Olanzapine, Chlorpromazine, Prochlorperazine | **Cardiovascular drugs**: e.g. ACE inhibitors, Diuretics, Beta-blockers, Calcium channel blockers, Others e.g. Digoxin, Amiodarone, Nitrates, Statins | **Parkinson's disease drugs**: e.g. Co-careldopa, Co-beneldopa, Entacapone | **Proton-pump inhibitors (PPIs) & H2-receptor antagonists**: e.g. cimetidine, ranitidine in combination with other anticholinergic agents. | **Sedatives**: e.g. benzodiazepines, clomethiazole, zopiclone

Pharmacist's Comments

Appendix 8: The guideline of the ACTPC



The Adult Complexity Tool for Pharmaceutical Care (ACTPC) has been developed. This tool is mainly for use by pharmacists to aid in patient prioritisation. You have been provided with two forms for the ACTPC. The tool consists of three criteria: red, amber and green. Both tools contain the same red criteria descriptors. Form 1 contains the 'red' criteria only to help the pharmacist to identify a new high-risk patient admitted in AMU. Form 2 contains all three criteria: 'red' (high risk), 'amber' (moderate risk) and 'green' (low risk) and is used to classify patients into differing complexity levels (red, amber, green) requiring different level of pharmaceutical care.

The following guidelines on how the tools should be used are provided below. **The guidance does NOT replace your clinical judgement.**

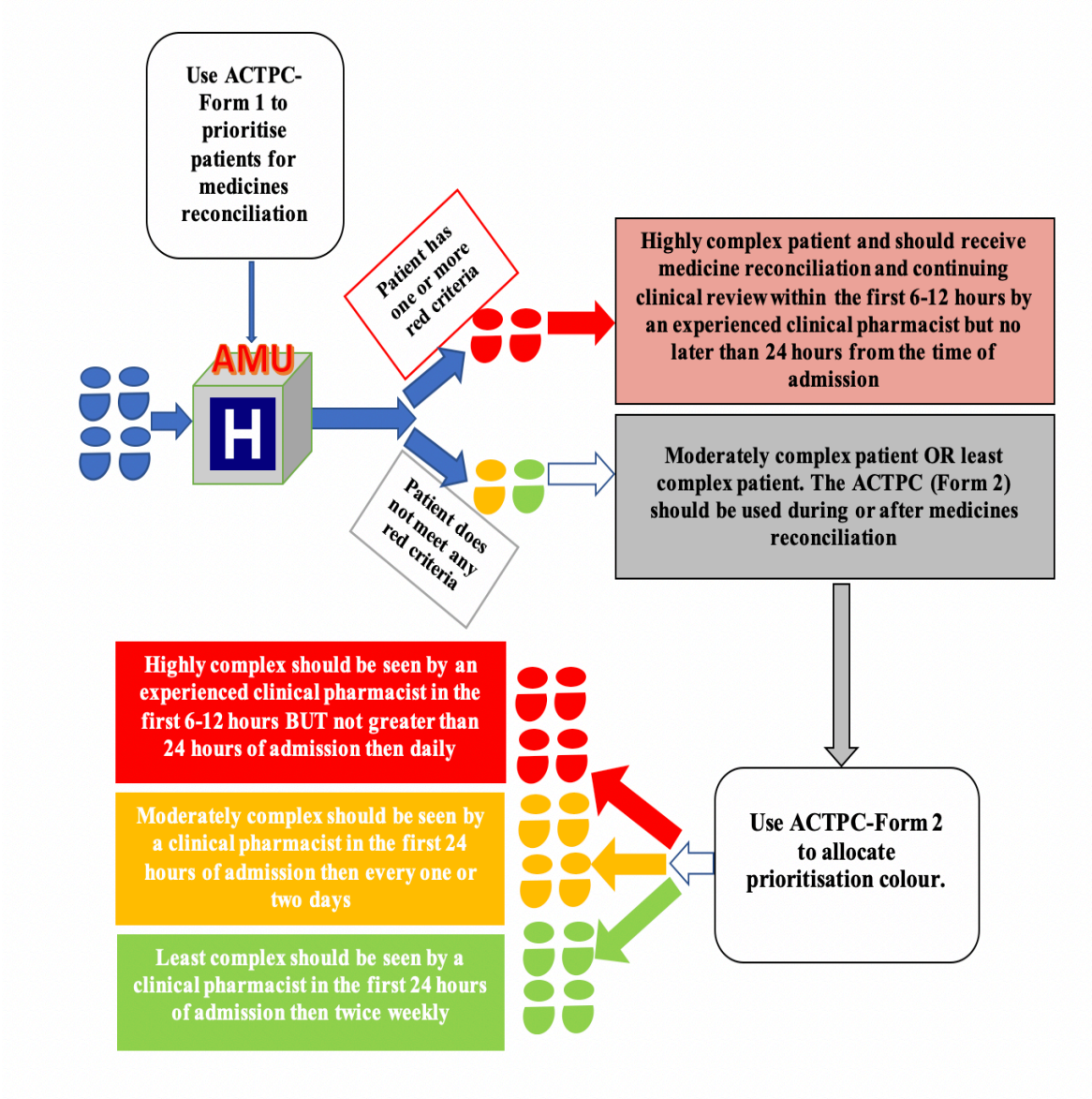
Guidelines for Form 1

- The ACTPC (Form 1) is for single use on patients admitted in Acute Medical Unit.
- Patients who meet any of the criteria in Form 1 will be identified as clinically unstable and will need to be immediately classified as 'RED'. This means that this is a highly complex patient and should receive medicine reconciliation and continuing clinical review within the first 6-12 hours by an experienced clinical pharmacist but no later than 24 hours from the time of admission. Following this, the patient should be seen daily by this grade of staff.
- Patients who do not meet any of the criteria in Form 1 will be classified as 'Non-RED'. This means that this is a moderately complex patient OR least complex patient. Then the ACTPC (Form 2) can be used
- Patients who fit into any red criteria descriptors can be downgraded to 'amber' and 'green' criteria depending on clinical condition and/or medication changes. Then the ACTPC (Form 2) can be used.

Guidelines for Form 2

- The ACTPC (Form 2) should be used on a daily basis during the patient's stay in the AMU.
- Patients who have one or more 'red' criteria will be identified as highly complex and should be reviewed daily by an experienced clinical pharmacist.
- Patients who have one or more 'amber' criteria will be identified as moderately complex and should be seen by a clinical pharmacist in the first 24 hours of admission, then every one- or two-days dependent on resources.
- Patients who are stable with no acute issues and have no 'red' or 'amber' criteria will be classified as 'green' and they will be identified as least complex and should be seen by a clinical pharmacist in the first 24 hours of admission, then twice weekly.
- Patients who fall under any 'amber' or 'green' criteria, can be upgraded or downgraded depending on their clinical condition / medication changes.

The below diagram summarises the guidelines for the ACTPC


Use ACTPC-Form 1 to prioritise patients for medicines reconciliation
AMU
Patient has one or more red criteria
Patient does not meet any red criteria
Highly complex patient and should receive medicine reconciliation and continuing clinical review within the first 6-12 hours by an experienced clinical pharmacist but no later than 24 hours from the time of admission
Moderately complex patient OR least complex patient. The ACTPC (Form 2) should be used during or after medicines reconciliation
Use ACTPC-Form 2 to allocate prioritisation colour.
Highly complex should be seen by an experienced clinical pharmacist in the first 6-12 hours BUT not greater than 24 hours of admission then daily
Moderately complex should be seen by a clinical pharmacist in the first 24 hours of admission then every one or two days
Least complex should be seen by a clinical pharmacist in the first 24 hours of admission then twice weekly

Appendix 9: Patient Information Sheet (PIS)

MANCHESTER 1824
The University of Manchester

Patient Information Sheet

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

You are invited to take part in a research study. The study is developing and assessing a pharmacy tool that will target the delivery of clinical pharmacy services to those patients most in need. Before deciding whether to take part please read the following information sheet. Please discuss it with others if you wish and ask if there is anything that is not clear or if you would like more information. Thank you.

About the research

- **Who will conduct the research?**

Meshal Alshakrah, PhD Student; **Dr. Douglas Steinke**, Senior Lecturer in Pharmacoepidemiology; **Dr. Mary Tully**, Clinical Reader in Pharmacy Practice; **Dr. Penny Lewis**, Clinical Lecturer in Pharmacy Practice. Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester.

- **What is the purpose of the research?**

We are developing a tool to identify patients with the most urgent or complex pharmacy needs so that pharmacists can promptly provide patients with the care they require. This study aims investigate how useful and practical this tool is.

- **Why have I been invited to participate?**

You are invited to take part because you have been admitted to the acute medical unit where the tool will be used. We will use a questionnaire to discover your views and experiences of medication safety. It is completely up to you whether or not you decide to take part in this study and your care will not be affected if choose not to participate.

- **Will the outcomes of the research be published?**

When complete, the results and conclusion will be part of a PhD thesis. It will be published in an academic journal, or presented as a poster at a research conference. Please contact the study team should you wish to receive a summary of the results at the end of the study.

- **Who has reviewed the research project?**

The project has been reviewed by the Research Ethics Committee in the NHS.

- **Who is funding the research project?**

The research is being funded by the National Institute for Healthcare Research.

What would my involvement be?

- **What would I be asked to do if I took part?**

If you agree to participate, the study will involve completing an anonymous questionnaire, asking about your experience of medication safety in hospital. The questionnaire should take you about 15-20 minutes to complete. The results will give us the patients' perspective about safety with medicines. You will be given this information sheet to keep and by completing the survey, it is understood that you are consenting to participate.

It is important to note that we will be unable to respond or take action in regards to specific complaints or concerns that you may have about your care as we will not have your name or details. Any complaints or concerns should be raised with the nurse in charge or alternatively [you can call the dedicated telephone line, 'Tell us Today', which will ensure that your concerns are passed on to a senior member of staff within an hour. The telephone number for Tell Us Today is 0161 701 1999]* include for MFT [you can contact the Patient Advice and Liaison Service (PALS) on 020 3299 3601 or visit the PALS office on the ground floor of the Hambleden Wing (open from 9am to 4.30pm, Monday to Friday).]* include for Kings College Hospital [you can contact the Patient Advice and Liaison Service (PALS) located in the main entrance of the hospital (Monday to Friday, 09:00 to 16:30) or by telephone on: 01204 390193 and via email PALS@boltonft.nhs.uk.]* include for Royal Bolton Hospital

- **Will I be compensated for taking part?**

No, you will not be compensated for your time.

- **What happens if I do not want to take part or if I change my mind?**

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and by completing the questionnaire, it is understood that you are consenting to participate in this study. You are still free to withdraw at any time without giving a reason and without detriment to yourself. However, it will not be possible to remove your questionnaire data from the project as we

will not be able to identify your specific data as it will not have your name on the questionnaire. This does not affect your data protection rights. If you decide not to take part you do not need to do anything further.

- **What are the possible benefits of taking part?**

There will be no direct benefit to patients from this study. However, the information we get from this element of the study will help to increase the understanding of patient's experience and views of medication safety.

- **What are the possible disadvantages, risks or side effects of taking part?**

We do not anticipate any problems or risks arising from participation in this study.

- **What if something goes wrong?**

In the event that something does go wrong and you are harmed during the research you may have grounds for a legal action for compensation against the University of Manchester but you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

Data Protection and Confidentiality

- **What information will you collect about me?**

In order to participate in this research project, we will not be collecting any information that could identify you, called "personal identifiable information". This questionnaire is anonymous, hence, you must not include any personal identifiable information about you or someone else in the questionnaire. To maintain confidentiality, the researcher will remove any personal identifiable information from the free text boxes, but your questionnaire will still form part of the dataset.

- **What are my rights in relation to the information you will collect about me?**

If you would like to know more about your different rights or the way we use your personal information to ensure we follow the law, please consult our Privacy Notice for Research. The full URL of the privacy notice is:
http://documents.manchester.ac.uk/display.aspx?DocID=37095

- **Will my participation in the study be confidential and my personal identifiable information be protected?**

Anonymous data is not covered by data protection law. However, we will still protect the data. This means the data from your questionnaire is kept secure, confidential and used only in the way you have been told it will be used. All researchers are trained with this in mind and only the study team have access to the data. Paper questionnaires will be kept

secure in a locked filing cabinet at the University of Manchester and computer data files will be stored securely. All data will be kept for 5 years following completion of the study. Individuals from The University of Manchester or regulatory authorities may need to look at the data collected for this study to make sure the project is being carried out as planned. All individuals involved in auditing and monitoring the study will have a strict duty of confidentiality to you as a research participant. They will not be able to identify you from the anonymous data that they may check.

What if I have a complaint?

If you have a complaint that you wish to direct to members of the research team, please contact the researchers at the addresses below:

- ***Mr Meshal Alshakrah***
  Telephone: 0161 2758363
  Email: meshal.alshakrah@postgrad.manchester.ac.uk
- ***Dr Penny Lewis***
  Telephone: 0161 2751806
  Email: Penny.Lewis@manchester.ac.uk

If you wish to make a formal complaint to someone independent of the research team or if you are not satisfied with the response you have gained from the researchers in the first instance then please contact The Research Governance and Integrity Officer, The University of Manchester by emailing: research.complaints@manchester.ac.uk or by telephoning 0161 2752674.
If you wish to contact us about your data protection rights, please email dataprotection@manchester.ac.uk or write to The Information Governance Office, Christie Building, The University of Manchester, Oxford Road, M13 9PL and we will guide you through the process of exercising your rights. You also have a right to complain to the Information Commissioner's Office about complaints. https://ico.org.uk/make-a-complaint/ Tel 0303 1231113

Contact Details

If you have any queries about the study or if you are interested in taking part then please contact the researcher**:**

Mr Meshal Alshakrah
Telephone: 01612758363
Email: meshal.alshakrah@postgrad.manchester.ac.uk

Dr Aseel Abuzour
Telephone: 01613061738
Email: aseel.abuzour@manchester.ac.uk

Appendix 10: Pharmacist/Pharmacy Technician Information Sheet

MANCHESTER 1824
The University of Manchester

Pharmacist/Pharmacy Technician Information Sheet (Observation Study)

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

Participant Information Sheet (PIS)

You are being invited to take part in a research study. The overall purpose of this research is systematically to develop and assess the feasibility and acceptability of the adult complexity tool for pharmaceutical care (ACTPC) to aid the targeted delivery of patient focussed clinical pharmacy services in hospitals. Before you decide whether to take part, it is important for you to understand why the research is being conducted and what it will involve. Please take time to read the following information carefully before deciding whether to take part and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Thank you for taking the time to read this.

About the research

- **Who will conduct the research?**

Meshal Alshakrah, PhD Student

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Douglas Steinke, Senior Lecturer in Pharmacoepidemiology

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Mary Tully, Clinical Reader in Pharmacy Practice

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Penny Lewis, Clinical Lecturer in Pharmacy

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

- **What is the purpose of the research?**

The above team at the University of Manchester are currently developing and testing a pharmaceutical complexity tool that can be used by clinical pharmacists to triage patients on admission to hospital and assign them a level of complexity. Those patients at greatest risk of preventable adverse drug events are reviewed promptly by an appropriately experienced clinical pharmacist. We have developed the adult complexity tool for pharmaceutical care (ACTPC). This current study aims to assess the feasibility of the ACTPC in acute medical units. It also aims to explore the perceptions of patients and health care professionals with regard to the acceptability, feasibility and transferability of the tool on these units. The study will be conducted at three NHS Hospitals in the UK.

- **Why have I been invited to participate?**

You are being invited to take part in this project because you are working in the acute medical unit ward (AMU) where the ACTPC will be used, and we would like to know how you use the tool and the process of assigning complexity to patients. It is completely up to you whether or not you decide to take part in this study. This information sheet describes the study and what it involves.

- **Will the outcomes of the research be published?**

Once the study is complete, the results and conclusion will be part of a PhD thesis. It will also be published at a later date in an academic journal, or presented as a poster at a research conference. Please speak with the study team, particularly the researcher (Meshal Alshakrah), should you wish to receive a summary of the results at the end of the study.

- **Who has reviewed the research project?**

The project has been reviewed by the Research Ethics Committee in NHS.

- **Who is funding the research project?**

The research is being funded by the National Institute for Healthcare Research.

What would my involvement be?

- **What would I be asked to do if I took part?**

If you wish to participate, you could be asked to do either one or both of the following:

1- You will be observed by the research associate one day a week for the duration of three weeks while you use the ACTPC with the aim of establishing how you use the tool and the process of assigning complexity to patients. The research associate will be taking notes of what you are doing in order to gather more information that will aid the researchers with understanding how the ACTPC is used in practice. At this stage, no personal identifiable data will be collected.

2- You will be observed by the research associate one day per week over a period of three weeks before and after the implementation of the ACTPC to quantify how pharmacists distribute their time across various daily tasks and interactions both with patients and other healthcare professionals. The research associate will record the time spent per task on the electronic data collection form in order to gather more information that will aid the researchers to identify the differences in work patterns on AMU with and without ACTPC. No personal identifiable data will be collected about the patients or colleagues that they interact with during the observation.

If you agree to take part in this study, you can indicate this to the researcher or respond via email. Then the researcher will provide you with the consent form in hard copy and give you a minimum of 24 hours to consent. After you sign the consent form, the chief investigator will arrange the training at a time convenient for you.

- **What happens if I do not want to take part or if I change my mind?**

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and will be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason and without detriment to yourself. However, it will not be possible to remove your data from the project once it has been anonymised and added to the dataset as we will not be able to identify your data. This does not affect your data protection rights.

- **What are the possible benefits of taking part?**

There will be no direct benefit to participants from this study. However, the information you provide will enable us to understand and evaluate the use of the ACTPC and the process of assigning complexity levels to patients.

- **What are the possible disadvantages, risks or side effects of taking part?**

We do not anticipate any problems arising from your participation in this study.

- **What if something goes wrong?**

In the event that something does go wrong and you are harmed during the research you may have grounds for a legal action for compensation against the University of Manchester but you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

Data Protection and Confidentiality

- **What information will you collect about me?**

In order to participate in this research project, we will need to collect information that could identify you, called "personal identifiable information". Specifically we will need to collect:

- Your name and contact details
- Number of years of experience as a hospital pharmacist

➢ **Under what legal basis are you collecting this information?**

We are collecting and storing this personal identifiable information in accordance with data protection law which protect your rights. These state that we must have a legal basis (specific reason) for collecting your data. For this study, the specific reason is that it is "a public interest task" and "a process necessary for research purposes".

➢ **What are my rights in relation to the information you will collect about me?**

You have a number of rights under data protection law regarding your personal information. For example, you can request a copy of the information we hold about you, including audio recordings.
If you would like to know more about your different rights or the way we use your personal information to ensure we follow the law, please consult our Privacy Notice for Research.
The full URL of the privacy notice is:
http://documents.manchester.ac.uk/display.aspx?DocID=37095

➢ **Will my participation in the study be confidential and my personal identifiable information be protected?**

In accordance with data protection law, The University of Manchester is the Data Controller for this project. This means that we are responsible for making sure your personal information is kept secure, confidential and used only in the way you have been told it will be used. All researchers are trained with this in mind, and your data will be looked after in the following way:
Only the study team at The University of Manchester will have access to your personal information, but they will anonymise it as soon as possible. Your name and any other identifying information will be removed and replaced with a random ID number. Only the research team will have access to the key that links this ID number to your personal information. Your consent form and contact details will be retained for 5 years. All information provided will be held in the strictest confidence using secure methods. It will be stored in a locked cupboard in a locked office at the University of Manchester, and electronic files will be password protected.
Please also note that individuals from The University of Manchester or regulatory authorities may need to look at the data collected for this study to make sure the project is being carried out as planned. This may involve looking at identifiable data. All individuals involved in auditing and monitoring the study will have a strict duty of confidentiality to you as a research participant.

Potential disclosures

If, during the study, you disclose information about misconduct or poor practice that has not already been reported to the trust governance committee, we have a professional obligation to report this or encourage you to do so. We will discuss this with you at the end of the observation.

What if I have a complaint?

If you have a complaint that you wish to direct to members of the research team, please contact the researchers at the addresses below:

- ***Mr Meshal Alshakrah***
  Telephone: 01612758363
  Email: meshal.alshakrah@postgrad.manchester.ac.uk

- ***Dr Penny Lewis***
  Telephone: 0161-275-1806
  Email: Penny.Lewis@manchester.ac.uk

- ***Dr Douglas Steinke***
  Telephone: 0161 275 2324
  Email: douglas.steinke@manchester.ac.uk

- ***Dr Mary Tully***
  Telephone: 0161 275 4242
  Email: Mary.P.Tully@manchester.ac.uk

If you wish to make a formal complaint to someone independent of the research team or if you are not satisfied with the response you have gained from the researchers in the first instance then please contact
The Research Governance and Integrity Officer, Research Office, Christie Building, The University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning 0161 275 2674.
If you wish to contact us about your data protection rights, please email dataprotection@manchester.ac.uk or write to The Information Governance Office, Christie Building, The University of Manchester, Oxford Road, M13 9PL at the University and we will guide you through the process of exercising your rights.
You also have a right to complain to the Information Commissioner's Office about complaints relating to your personal identifiable information. The full URL of the ICO's complaints procedure is
https://ico.org.uk/make-a-complaint/
Tel 0303 123 1113

Contact Details

If you have any queries about the study or if you are interested in taking part then please contact the research associate

Mr Meshal Alshakrah
Telephone: 01612758363
Email: meshal.alshakrah@postgrad.manchester.ac.uk

Dr Aseel Abuzour
Telephone: 01613061738
Email: aseel.abuzour@manchester.ac.uk

Appendix 11: Pharmacist/Pharmacy Technician Consent Form

MANCHESTER 1824
The University of Manchester

Pharmacist/Pharmacy Technician Consent Form (Observation Study)

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

Consent Form

If you are happy to participate please complete and sign the consent form below

	Activities	Initials
1	I confirm that I have read the attached information sheet (**Version__, Date __/__/__**) for the above study and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.	
2	I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and without detriment to myself. I understand that it will not be possible to remove my data from the project once it has been anonymised and forms part of the data set. I agree to take part on this basis.	
3	I agree that any data collected may be published in anonymous form in **academic books, reports or journals.**	
4	I understand that data collected during the study may be looked at by individuals from the University of Manchester or regulatory authorities for auditing and monitoring purposes. I give permission for these individuals to have access to my data.	
5	I understand that If, during the study, I disclose information about misconduct or poor practice that has not already been reported to the trust governance committee, the researcher has a professional obligation to report this or encourage me to do so. The researcher will discuss this with me at the end of the observation.	
6	Optional: I agree that the **researchers** may contact me in future about other research projects.	
7	Optional: I agree that the researchers may retain my contact details in order to provide me with a summary of the findings for this study.	
8	I agree to take part in this study.	

Data Protection

The personal information we collect and use to conduct this research will be processed in accordance with data protection law as explained in the Participant Information Sheet and the Privacy Notice for Research Participants. The full URL of the privacy notice is:
http://documents.manchester.ac.uk/display.aspx?DocID=37095

_____	_____	_____
Name of Participant	Signature	Date

_____	_____	_____
Name of the person taking consent	Signature	Date

[Insert details of what will happen to the copies of consent form e.g. 1 copy for the participant, 1 copy for the research team (original), 1 copy for the medical notes]

Appendix 12: Semi- Structure Interview Schedule for Healthcare Professionals and Stakeholders

Exploring the practicality and feasibility of using the Adult Complexity Tool for Pharmaceutical Care with the acute admission unit.

SEMI-STRUCTURED INTERVIEW SCHEDULE FOR HEALTHCARE PROFESSIONALS AND STAKEHOLDERS

The purpose of the interview is to explore your experiences of a tool that pharmacists have implemented on AMU to prioritise patients to receive pharmacy service and your views on its practicality and usefulness.
Confidentiality is assured at all times and information analysed or reported from this interview will not enable anyone to recognise you. Patient information is not required; if however, patients are mentioned during interview their details will be immediately removed from all records.
The interview will last approximately 20 minutes and the areas to be covered include a few questions about yourself and then a discussion about your thoughts on the tool and it's implementation.
The interview will be audio-recorded unless you are opposed to this. The files will be kept securely for five years after the study is completed then destroyed.
Do you have any questions before starting the interview?

Background

- **Can you tell me a little bit about yourself?**
  - Profession
  - Band
  - How long in post and how long working on AMU.
  - Previous roles

- **What are your experiences of the tools? (if not sure what the tools are, provide short description)**

- **Can you tell me your thoughts on the ACTPC tools and their use on AMU?**
  - Impact on role
  - Perceived impact on pharmacist presence
  - Perceived impact on patients

    - Ability to refer patients when necessary

- **What do you think are the benefits of the tools?**
    - Time
    - Safety
    - Efficiency and workload (including numbers of patients seen)
    - Ability to detect complex patients
    - Differences between ACTPC 1 and 2

- **What are the barriers to using the tools?**
    - Potential missing of patients whose condition/treatment changed
    - Efficiency and workload (including numbers of patients seen)
    - Practicality
    - Differences between ACTPC 1 and 2

- **Do you think the ACTPC should be used in general hospital wards as well and why?**

- **Would you like to change/modify the tools? If so how?**

- **Is there anything else that you feel would be important to tell me that we have not yet covered?**

Exploring the practicality and feasibility of using the Adult Complexity Tool for Pharmaceutical Care with the acute admission unit.

SEMI-STRUCTURED INTERVIEW SCHEDULE FOR PHARMACISTS

The purpose of the interview is to explore your experiences of using the ACTPC tools and your views on their practicality and usefulness.
Confidentiality is assured at all times and information analysed or reported from this interview will not enable anyone to recognise you. Patient information is not required; if however, patients are mentioned during interview their details will be immediately removed from all records.
The interview will last approximately half an hour and the areas to be covered include a few questions about yourself and then a discussion about the tools.
The interview will be audio-recorded unless you are opposed to this. The files will be kept securely for five years after the study is completed then destroyed.
Do you have any questions before starting the interview?

Background

Can you tell me a little bit about yourself?

- Experience in pharmacy and band
- How long in post and how long working on AMU.

Application of tool

- **Can you tell me about how you used the ACTPC 1 tool?**
  - At what point in the medicines use process
  - Less experienced pharmacists see less acute patients and vice versa
  - Referral of red patients to senior pharmacists
  - Involvement of other HCPs
- **Can you tell me about how you used the ACTPC 2 tool?**
  - At what point in the medicines use process
  - Less experienced pharmacists see less acute patients and vice versa
  - Referral of red patients to senior pharmacists
  - Involvement of other HCPs

- **Were patients ever referred to you by another HCP because their condition or treatment had changed? How did this process work?**

Usefulness of tool

- **Do you think the ACTPC 1 is an effective tool for prioritising patients prior to medicines reconciliation?**
  - Why?

    - What impact did the tool have?
        - Types of patients seen
        - Safety
        - Medicines optimisation
        - Worklood
- **Do you think the ACTPC 2 is an effective tool for prioritising patients during/after medicines reconciliation?**
    - Why?
    - What impact did the tool have?
        - Types of patients seen
        - Safety
        - Medicines optimisation

If not covered above:

- **Did you experience an impact on workload due to using the tools and why?**
- **Did you perceive an impact on safety/prescribing errors? If so, how?**
- **Did you perceive an impact on medicines optimisation? If so, how?**
- **Did the tool facilitate less experienced pharmacists to identify more complex patients?**

<u>Benefits and barriers</u>

- **What do you think are the benefits of the tools?**
    - Time
    - Safety
    - Efficiency and workload (including numbers of patients seen)
    - Ability to detect complex patients
    - Differences between ACTPC 1 and 2

- **What barriers or problems have you faced when using the tools?**
    - Time
    - Safety
    - Efficiency and workload (including numbers of patients seen)
    - Practicality
    - Differences between ACTPC 1 and 2

<u>Future use and improvement</u>

- **Do you think the ACTPC should be used in general hospital wards as well and why?**

- **Were you at all concerned that you may miss patients?**

- **How did you find the mix of red, amber and green patients?**

- **What were your experiences of the training you received in using the tool?**

- **How did you find the process of completing the forms?**
    - Were the ACTPC forms difficult/simple to complete?

- **Would you like to change/modify the ACTPC? If so how?**
    - Individual risk factors
    - RAG categories
    - The recommended review periods
    - The experience of pharmacists

- **Is there anything else that you feel would be important to tell me that we have not yet covered?**

Appendix 13: Healthcare Professional Information Sheet

MANCHESTER 1824
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Healthcare Professional Participant Information Sheet Including Nurses, Doctors, Pharmacy Technicians and Pharmacists (Interview Study)

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

Participant Information Sheet (PIS)

You are being invited to take part in a research study. The overall purpose of this research is systematically to develop and assess the feasibility and acceptability of the adult complexity tool for pharmaceutical care (ACTPC) to aid the targeted delivery of patient focussed clinical pharmacy services in hospitals. Before you decide whether to take part, it is important for you to understand why the research is being conducted and what it will involve. Please take time to read the following information carefully before deciding whether to take part and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Thank you for taking the time to read this.

About the research

- **Who will conduct the research?**

Meshal Alshakrah, PhD Student

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Douglas Steinke, Senior Lecturer in Pharmacoepidemiology

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Mary Tully, Clinical Reader in Pharmacy Practice

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

Dr. Penny Lewis, Clinical Lecturer in Pharmacy Practice

Division of Pharmacy and Optometry, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester

- **What is the purpose of the research?**

The above team at the University of Manchester are currently developing and testing a pharmaceutical complexity tool that can be used by clinical pharmacists to triage patients on admission to hospital and assign them a level of complexity. Those patients at greatest risk of preventable adverse drug events are reviewed promptly by an appropriately experienced clinical pharmacist. We have developed the adult complexity tool for pharmaceutical care (ACTPC). This current study aims to assess the feasibility of the ACTPC in acute medical units. It also aims to explore the perceptions of patients and health care professionals with regard to the acceptability, feasibility and transferability of the tool on these units. The study will be conducted at three NHS Hospitals in the UK.

- **Why have I been invited to participate?**

You are being invited to take part in this project because you are working in the acute medical unit ward (AMU) where the ACTPC will be used, and we would like to obtain your views on the acceptability, feasibility and transferability of the ACTPC in an interview. It is completely up to you whether or not you decide to take part in this study. This information sheet describes the study and what it involves.

- **Will the outcomes of the research be published?**

Once the study is complete, the results and conclusion will be part of a PhD thesis. It will also be published at a later date in an academic journal, or presented as a poster at a research conference. Please speak with the study team, particularly the researcher (Meshal Alshakrah), should you wish to receive a summary of the results at the end of the study.

- **Who has reviewed the research project?**

The project has been reviewed by the Research Ethics Committee in NHS.

- **Who is funding the research project?**

The research is being funded by the National Institute for Healthcare Research.

What would my involvement be?

- **What would I be asked to do if I took part?**

If you agree to take part in this study, you can indicate this to the researcher or respond via email. Then the researcher will provide you with the consent form in hard copy and give you a minimum of 24 hours to consent. After you sign the consent form, the chief investigator will arrange the interview with you, at a time convenient to yourself.

The interview will be held at the hospital in a private room. The semi-structured interview is anticipated to take about 15-20 minutes and you will be asked to answer specific

questions to obtain your perceptions of the acceptability, feasibility and transferability of the ACTPC. The interview will be audio recorded. Then, the recordings will be transcribed verbatim for analysis by a University-approved transcribing company which holds a confidentiality agreement with the University of Manchester. Your comments will be combined with the comments of other healthcare professionals to help us understand the practicality of the ACTPC.

- **What happens if I do not want to take part or if I change my mind?**

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and will be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason and without detriment to yourself. Should you withdraw during the interview, the recording will cease and the audio file will be deleted. However, it will not be possible to remove your data from the project once it has been anonymised and added to the dataset as we will not be able to identify your data. This does not affect your data protection rights.

- **What are the possible benefits of taking part?**

There will be no direct benefit to participants from this study. However, the information you provide will enable us to understand and evaluate healthcare professionals' perceptions about the acceptability, feasibility and transferability of the ACTPC.

- **What are the possible disadvantages, risks or side effects of taking part?**

We do not anticipate any problems arising from your participation in this study.

- **What if something goes wrong?**

In the event that something does go wrong and you are harmed during the research you may have grounds for a legal action for compensation against the University of Manchester but you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

Data Protection and Confidentiality

- **What information will you collect about me?**

In order to participate in this research project, we will need to collect information that could identify you, called "personal identifiable information". Specifically we will need to collect:

- Your name and contact details
- Your current job
- Your speciality
- Number of years' experience

The recording will consist of voice only and it will be obtained during a face to face semi-structured interview.

- **Under what legal basis are you collecting this information?**

We are collecting and storing this personal identifiable information in accordance with data protection law which protect your rights. These state that we must have a legal basis (specific reason) for collecting your data. For this study, the specific reason is that it is "a public interest task" and "a process necessary for research purposes".

- **What are my rights in relation to the information you will collect about me?**

You have a number of rights under data protection law regarding your personal information. For example, you can request a copy of the information we hold about you, including audio recordings.
If you would like to know more about your different rights or the way we use your personal information to ensure we follow the law, please consult our Privacy Notice for Research.
The full URL of the privacy notice is:
http://documents.manchester.ac.uk/display.aspx?DocID=37095

- **Will my participation in the study be confidential and my personal identifiable information be protected?**

In accordance with data protection law, The University of Manchester is the Data Controller for this project. This means that we are responsible for making sure your personal information is kept secure, confidential and used only in the way you have been told it will be used. All researchers are trained with this in mind, and your data will be looked after in the following way:
Only the study team at The University of Manchester will have access to your personal information, but they will anonymise it as soon as possible. Your name and any other identifying information will be removed and replaced with a random ID number. Only the research team will have access to the key that links this ID number to your personal information. Your consent form and contact details will be retained for 5 years. All information provided will be held in the strictest confidence using secure methods. It will be stored in a locked cupboard in a locked office at the University of Manchester, and electronic files will be password protected. Audio recordings and the transcripts will be kept until data analysis is complete and then destroyed.
Please also note that individuals from The University of Manchester or regulatory authorities may need to look at the data collected for this study to make sure the project is being carried out as planned. This may involve looking at identifiable data. All individuals involved in auditing and monitoring the study will have a strict duty of confidentiality to you as a research participant.

Potential disclosures

If, during the study, you disclose information about misconduct or poor practice that has not already been reported to the trust governance committee, we have a professional obligation to report this or encourage you to do so. We will discuss this with you at the end of the interview.

What if I have a complaint?

If you have a complaint that you wish to direct to members of the research team, please contact the researchers at the addresses below:

- ***Mr Meshal Alshakrah***
  Telephone: 01612758363
  Email: meshal.alshakrah@postgrad.manchester.ac.uk

- ***Dr Penny Lewis***
  Telephone: 0161-275-1806
  Email: Penny.Lewis@manchester.ac.uk

- ***Dr Douglas Steinke***
  Telephone: 0161 275 2324
  Email: douglas.steinke@manchester.ac.uk

- ***Dr Mary Tully***
  Telephone: 0161 275 4242
  Email: Mary.P.Tully@manchester.ac.uk

If you wish to make a formal complaint to someone independent of the research team or if you are not satisfied with the response you have gained from the researchers in the first instance then please contact
The Research Governance and Integrity Officer, Research Office, Christie Building, The University of Manchester, Oxford Road, Manchester, M13 9PL, by emailing: research.complaints@manchester.ac.uk or by telephoning 0161 275 2674.
If you wish to contact us about your data protection rights, please email dataprotection@manchester.ac.uk or write to The Information Governance Office, Christie Building, The University of Manchester, Oxford Road, M13 9PL at the University and we will guide you through the process of exercising your rights.
You also have a right to complain to the Information Commissioner's Office about complaints relating to your personal identifiable information. The full URL of the ICO's complaints procedure is
https://ico.org.uk/make-a-complaint/
Tel 0303 123 1113

Contact Details

If you have any queries about the study or if you are interested in taking part then please contact the research associate:

Mr Meshal Alshakrah
Telephone: 01612758363
Email: meshal.alshakrah@postgrad.manchester.ac.uk

Dr Aseel Abuzour
Telephone: 01613061738
Email: aseel.abuzour@manchester.ac.uk

Appendix 14: Healthcare Professional Consent Form

MANCHESTER 1824
The University of Manchester

Healthcare Professional Participant Consent Form

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

Consent Form

If you are happy to participate please complete and sign the consent form below

	Activities	Initials
1	I confirm that I have read the attached information sheet (**Version__, Date __/__/____**) for the above study and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.	
2	I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and without detriment to myself. I understand that it will not be possible to remove my data from the project once it has been anonymised and forms part of the data set. I agree to take part on this basis.	
3	I agree to the interviews being audio recorded.	
5	I agree that any data collected may be published in anonymous form in academic books, reports or journals.	
6	I understand that data collected during the study may be looked at by individuals from the University of Manchester or regulatory authorities for auditing and monitoring purposes. I give permission for these individuals to have access to my data.	
	I understand that If, during the study, I disclose information about misconduct or poor practice that has not already been reported to the trust governance committee, the researcher has a professional obligation to report this or encourage me to do so. The researcher will discuss this with me at the end of the interview.	
7	Optional: I agree that the researchers may retain my contact details in order to provide me with a summary of the findings for this study.	

8	I understand that there may be instances where during the course of the **interview** information is revealed which means that the researchers will be obliged to break confidentiality and this has been explained in more detail in the information sheet.	
9	I agree to take part in this study.	

Data Protection

The personal information we collect and use to conduct this research will be processed in accordance with data protection law as explained in the Participant Information Sheet and the Privacy Notice for Research Participants**. The full URL of the privacy notice is:**
http://documents.manchester.ac.uk/display.aspx?DocID=37095

_____	_____	_____
Name of Participant	Signature	Date

_____	_____	_____
Name of the person taking consent	Signature	Date

Appendix 15: Medication-Related Patient Measure of Organisational Safety (MR-PMOS) Questionnaire

Medicine Safety: A Patient's Perspective

What this questionnaire is about…

This questionnaire aims to help us understand about safety with medicines from the patients' perspective and identify areas of strengths and weakness within hospitals. It contains factors that have been identified by patients themselves that may affect their safety with medicines when in hospital.

A guide to filling in this questionnaire:

- Please read each statement carefully, keeping in mind this is about your **current** stay in hospital.
- Circle one option for each question.
- If you have had no experience of a situation or do not know the answer to a question, please circle N/A for "not applicable or don't know".
- This questionnaire should take you between 10-15 minutes to complete.

The questionnaire is anonymous, so we don't need to know your name

Please make sure you fill in the date you have completed this questionnaire:

Date: .....

Please indicate your level of agreement with the following statements.
Please remember this questionnaire is about your current stay in hospital.

Statement	strongly disagree	disagree	neither agree or disagree	agree	strongly agree	Not applicable/ don't know	Additional comments
1. I was always treated with dignity and respect.	1	2	3	4	5	N/A	
2. After a shift change, staff seemed to know important information about my medicines.	1	2	3	4	5	N/A	
3. Staff caring for me seemed to always be able to get advice about my medicines from pharmacy staff when needed.	1	2	3	4	5	N/A	
4. A doctor changed my medicines and other staff didn't seem to know about it.	1	2	3	4	5	N/A	
5. I got answers to all the questions I had regarding my medicines.	1	2	3	4	5	N/A	
6. I knew what the different roles of staff were with regards to my medicines.	1	2	3	4	5	N/A	
7. On at least one occasion, a member of staff didn't know how to use necessary equipment for my medicines.	1	2	3	4	5	N/A	
8. My medicines were not always given on time.	1	2	3	4	5	N/A	
9. When I heard staff talk about my medicines with others, the information they shared was correct.	1	2	3	4	5	N/A	
10. The ward environment made it difficult for *staff* to do their jobs with regards to my medicines e.g. poor lighting, extreme temperatures, position of nurses' station.	1	2	3	4	5	N/A	
11. I was on a ward that was not able to deal with my medicine needs.	1	2	3	4	5	N/A	

Please indicate your level of agreement with the following statements.
Please remember this questionnaire is about your current stay in hospital.

Statement	strongly disagree	disagree	neither agree or disagree	agree	strongly agree	Not applicable/ don' t know	Additional comments
12. I always had to wait too long after pressing my buzzer for a staff member to arrive with regards to my medicines.	1	2	3	4	5	N/A	
13. It was clear who was in charge of the staff on my ward.	1	2	3	4	5	N/A	
14. There was not enough clear space on the ward.	1	2	3	4	5	N/A	
15. There was always a member of staff available with the knowledge/skills to perform the necessary tasks regarding my medicines.	1	2	3	4	5	N/A	
16. I didn't know who to go to if I needed to ask a question about my medicines.	1	2	3	4	5	N/A	
17. On at least one occasion a member of staff appeared unable to carry out tasks regarding treatment that they should be able to do e.g. giving injections.	1	2	3	4	5	N/A	
18. The ward environment was comfortable for *patients* e.g. lighting levels, noise levels, temperature and cleanliness.	1	2	3	4	5	N/A	
19. With regards to my medicines, I felt that the attitude of staff towards me was good.	1	2	3	4	5	N/A	
20. I always knew who was responsible for my medicines.	1	2	3	4	5	N/A	

Please indicate your level of agreement with the following statements.
Please remember this questionnaire is about your current stay in hospital.

Statement	strongly disagree	disagree	neither agree or disagree	agree	Strongly agree	Not applicable/ don' t know	Additional comments
21. Staff always seemed to know what they should be doing with my medicines.	1	2	3	4	5	N/A	
22. Too few staff meant that things didn't get done on time e.g. attending to buzzers, helping patients with medicines.	1	2	3	4	5	N/A	
23. It concerned me that some members of staff gave me different information about my medicines.	1	2	3	4	5	N/A	
24. Staff appeared to wait a long time for medicines to arrive.	1	2	3	4	5	N/A	
25. Information that my health care team needed about my medicines/condition always appeared to be available.	1	2	3	4	5	N/A	
26. Staff appeared to work together as a team for the patients' benefit.	1	2	3	4	5	N/A	
27. There was equipment that appeared difficult for staff to use e.g. monitoring equipment.	1	2	3	4	5	N/A	
28. I have needed my medicines and there has been no-one available who was qualified to prescribe or give it.	1	2	3	4	5	N/A	
29. My test results seemed to always be available when required e.g. blood tests, urine tests.	1	2	3	4	5	N/A	
30. Nurses were sometimes unable to get help with medicines from other staff when they ask for it.	1	2	3	4	5	N/A	
31. Equipment needed for my treatment was always working properly.	1	2	3	4	5	N/A	

Please indicate your level of agreement with the following statements.
Please remember this questionnaire is about your current stay in hospital.

Statement	strongly disagree	disagree	neither agree or disagree	agree	strongly agree	Not applicable/ don' t know	Additional comments
32. Inexperienced doctors and nurses seemed to find it hard to prescribe or give me my medicines.	1	2	3	4	5	N/A	
33. Equipment and supplies were not always available when needed e.g. medication, drip stands, measuring cups.	1	2	3	4	5	N/A	
34. Staff always seemed to be in agreement with each other about my medicines and treatment.	1	2	3	4	5	N/A	
35. I always felt that staff listened to my concerns about my medicines.	1	2	3	4	5	N/A	
36. During my stay on this ward I felt that medicine safety was always a top priority.	1	2	3	4	5	N/A	
37. Please give any examples of safe/unsafe practice with regards to medicines that you have experienced or seen.							

Thank you for taking the time to complete this questionnaire. Your contribution is very important to us.

Appendix 16: Study Three Training Session Timetable

Time	Key point/theme	Training aid/tool	Objectives
Introduction			
14:00pm - 14:05 (5 min)	Open session: introduce study investigators, outline the structure of the session	Handouts showing session structure	To ensure the attendees understand the structure of the session
Main session			
14:05 - 14:25 (20 min)	Explain the background, aim and objectives of the study	PowerPoint slides showing the background, aim and objectives of the study	To confirm that the attendees are familiar with importance of the project
14:25 - 14:50 (25 min)	A-Provide the pharmacists with the ACTPC tool and explain how it works, including the guide. B-Four theoretical case studies will be provided to the pharmacists in order to establish and clarify their understanding of the tool use following the training session.	PowerPoint slides containing the tool the theoretical case	To establish and clarify their understanding of the tool use
14:50 -15:15 (25 min)	Briefly explain the data collection process, prescribing errors and medicine optimisation data collection guide.	PowerPoint slides showing how to use the app containing the form on the iPad Form2™. 3 iPads will be provided to the pharmacists during this session	To ensure that the attendees are confident using the app containing the Form2™ To establish and clarify their understanding of the data collection process before starting the data collection period
15:15 - 15:25 (10 min)	Open question session	Open question session	To assess their understanding and provide an opportunity to reflect upon their current practice and share their experience
Conclusion			
15:25 - 15:30pm (5 min)	Evaluation of training session	Copies of the evaluation form	To ensure whether the outcomes of training session have been achieved and any deficient could be avoided in the next training session

Appendix 17: The Guidance on How to Enter Data in the Form^{2}™ Application

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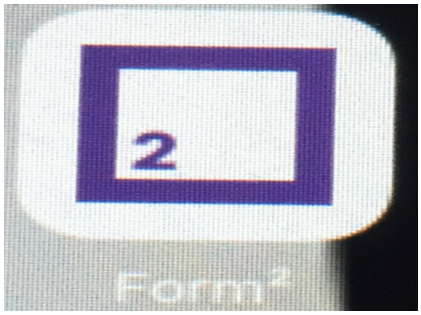
The guidance on how to enter data in the Form^{2}™application

1) Connect the iPad to the local wireless network;

2) Click on the Form^{2} application on the iPad;

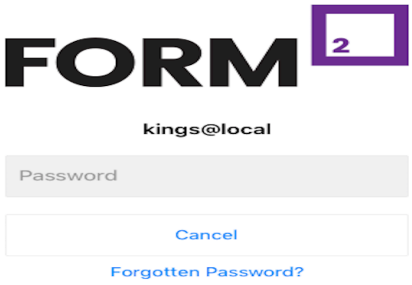


3) Enter the email you have been provided with;

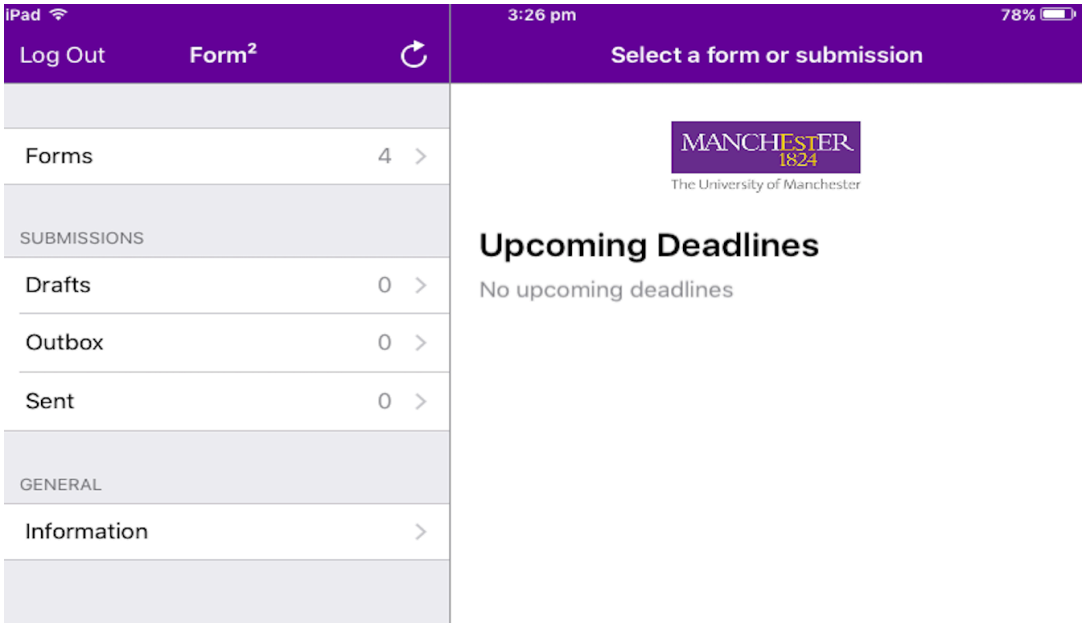
E-mail Address: _____

4) Enter the password you have been provided with (**in small letters and no space**);

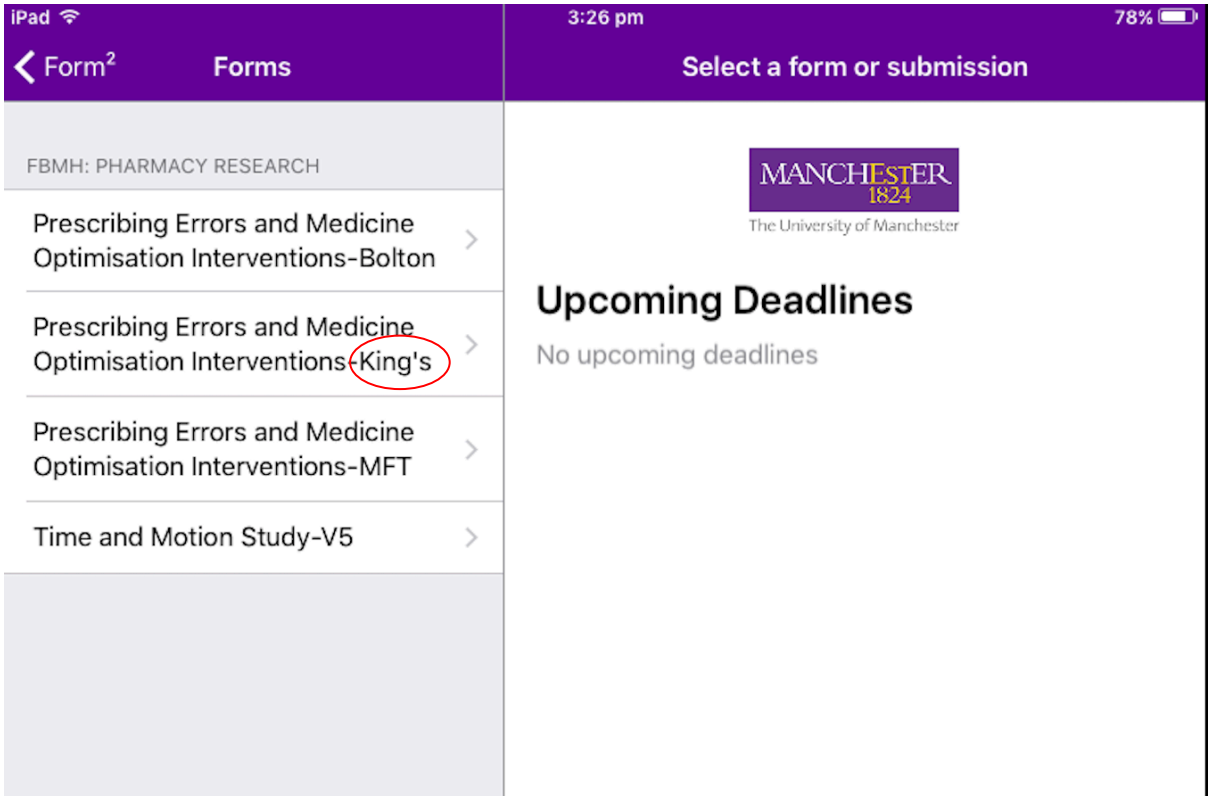
Password: _____



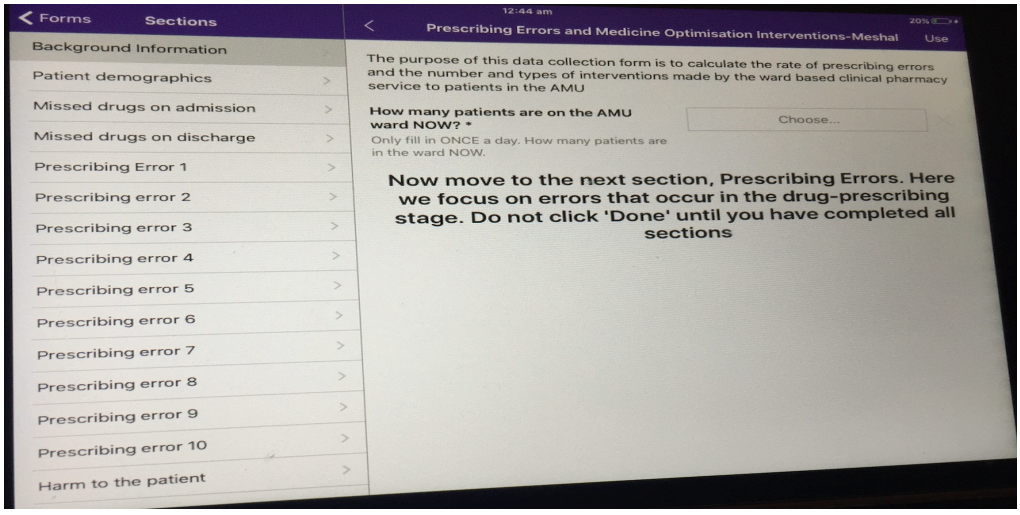
5) Once the application is open, click on the first link called Forms on the left-hand side of the screen;



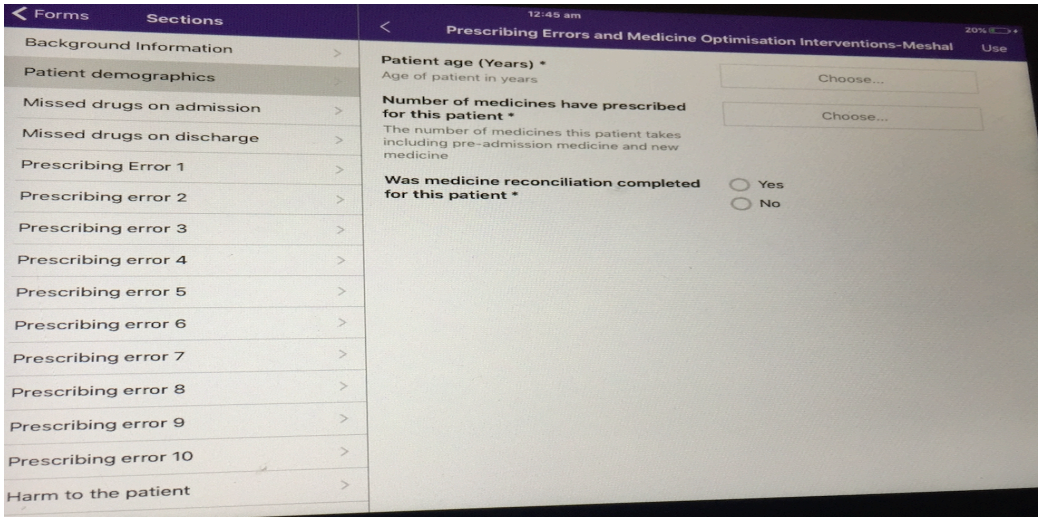
6) Click on the link called: Prescribing Errors and Medicine Optimisation Interventions-King's**;(Please make sure that you have chosen the right link which has your trust name on it).**



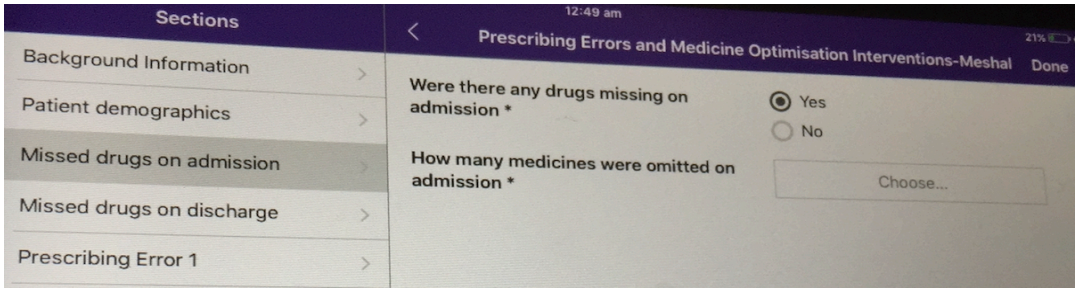
7) Several headings on the left-hand side will appear. Click on the first link called Background information. The question will appear on the right-hand side of the screen where will be asked to choose one of the options for how many patients there are on the AMU ward. You will be prompted to move to the next question of Patient Demographics.



8) Click on Patient Demographics and follow the on-screen instructions on the right.

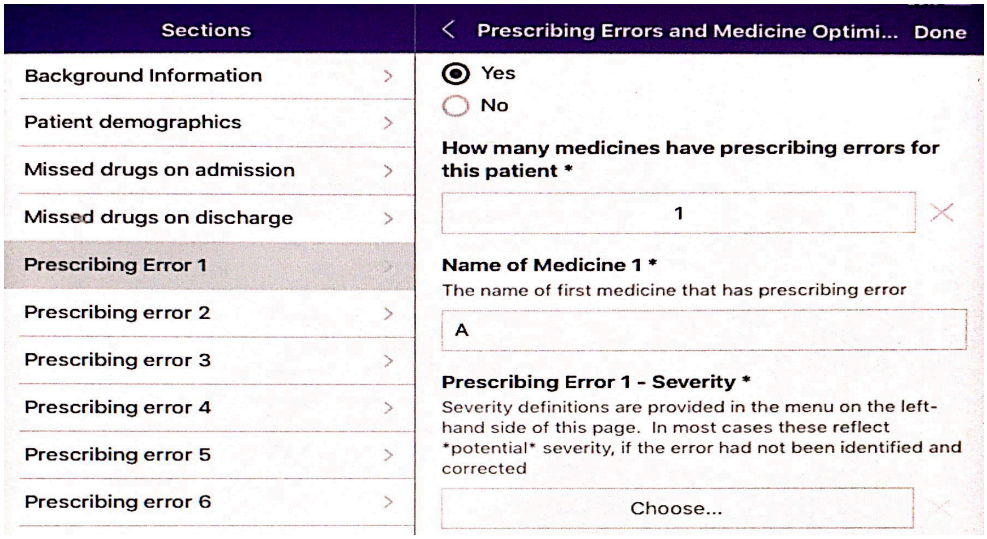


9) Click on the Missed drugs on admission. A choice of two questions will be given. If you select Yes, you are required to answer how many medicines were omitted on admission and state the name of the medicine in the space provided.



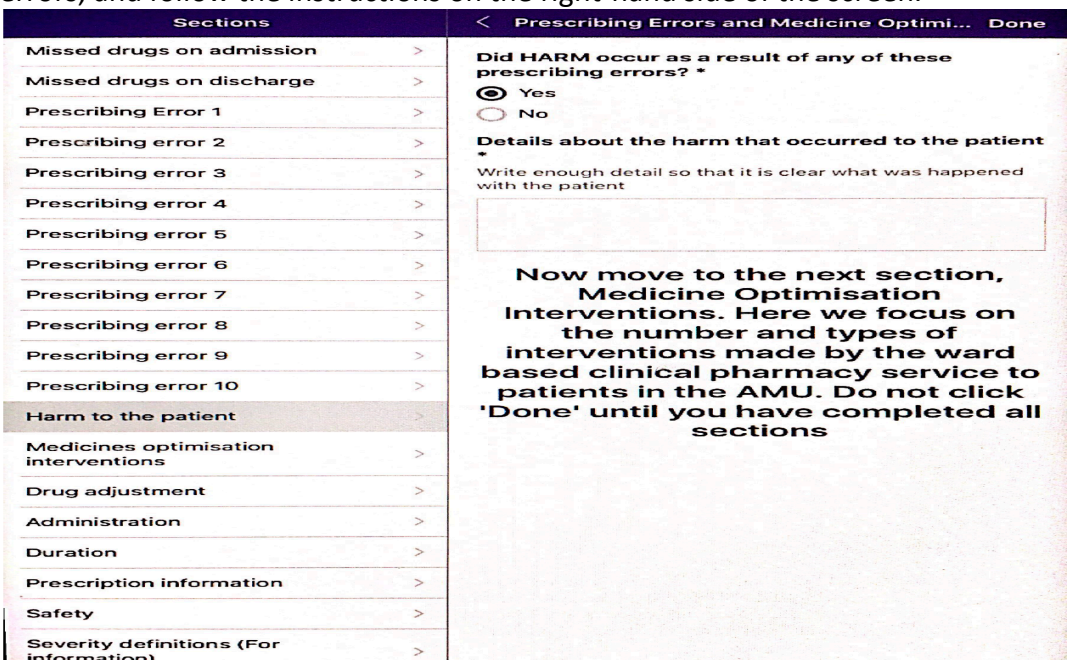
10) Click on Missed drugs on discharge and follow the same procedure as in steps 6 or 7.

11) Click on Prescribing error 1. Follow instructions that appear on the screen. For example, if you answer Yes, you will need to state how many prescribing errors were made for the patient and the name of each prescribing error and its severity. For more information on severity, click on the bottom left link called Severity definition (For information)). Follow the instructions to complete answering all the questions under the Prescribing error 1 link.

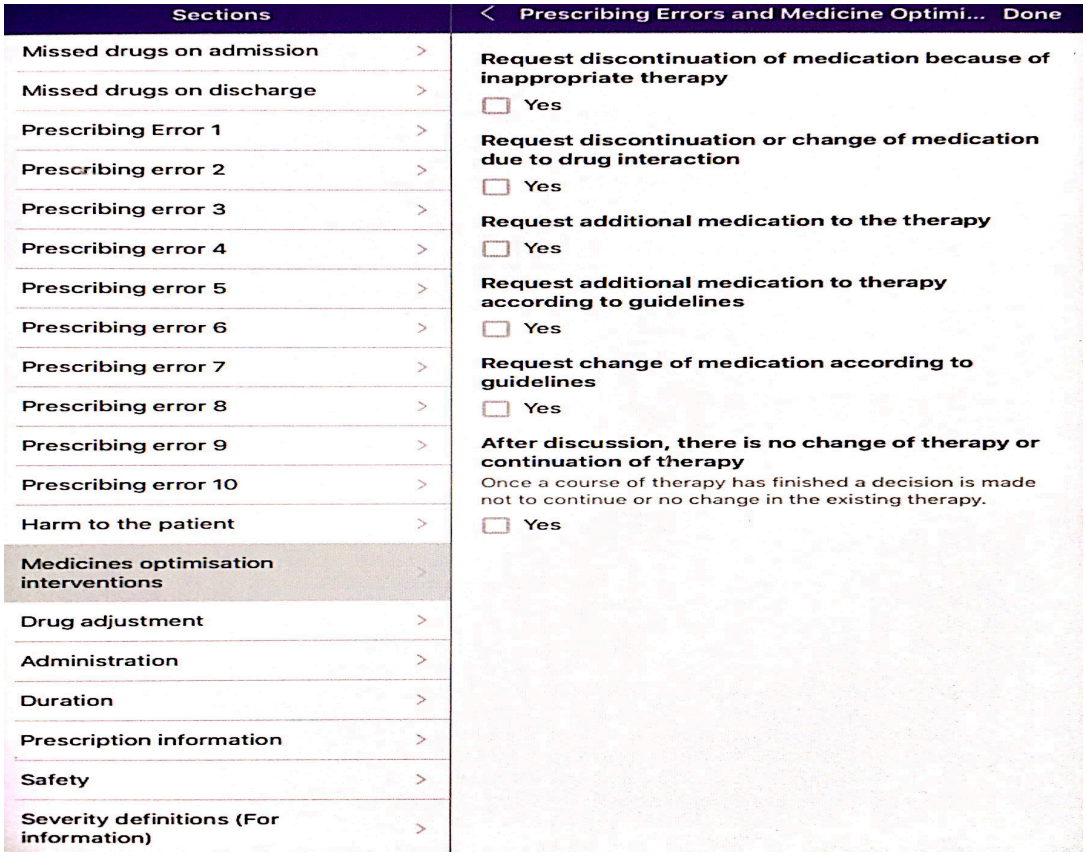


12) Repeat the same process as in Step 9 for the right number of the Prescribing error links if there were more than one prescribing error. For instance, if you stated that the patient has 3 prescribing errors, you are only required to answer the questions under three Prescribing error links, i.e. Prescribing error 1, 2 and 3.

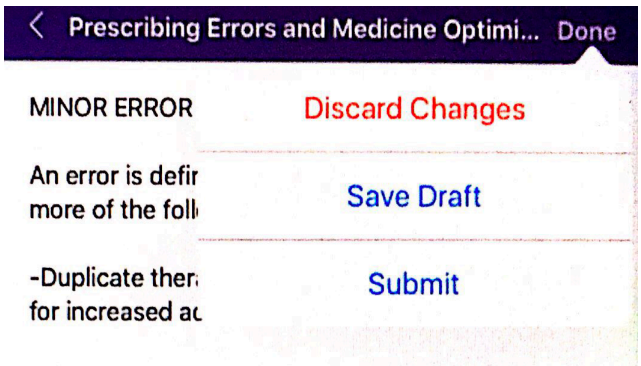
13) Click on the Harm to the patient link, which is the last link related to prescribing errors, and follow the instructions on the right-hand side of the screen.



14) Move to the next section called Medicine Optimisation intervention.
15) Bear in your mind that to avoid repetition, once you start answering question in this section named Medicine Optimisation Intervention, do not include any interventions related to prescribing errors which you have already mentioned in the section named Prescribing Errors.
16) Starting from Medicines optimisation interventions up to Safety, answer the Yes and No questions and fill any fields required.

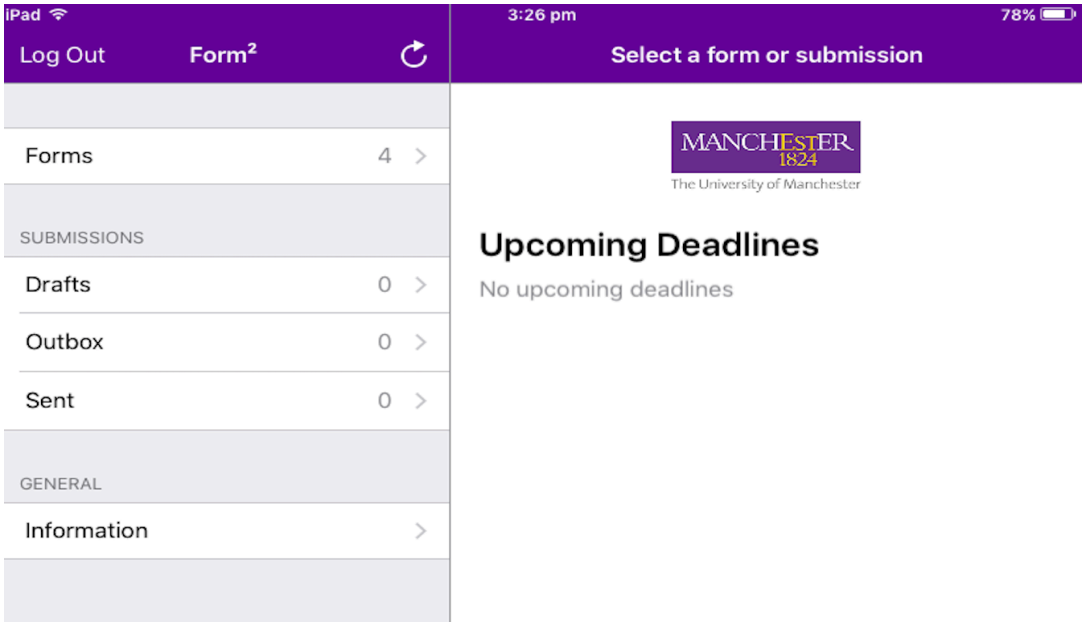


17) Once the form is completed, click Done in the top right-hand corner of the application. You will have three options to choose from. If you are ready to Submit the form, click Submit. If you want to make some changes or review the data you entered at a later stage, click Save draft. If the form has been saved as a draft, it can be found under the Drafts link on the left-hand side after the login.



18) Once you have completed entering the data for each patient, save or submit it.

19) At the end of the day, please log out of the Form^2 using the link called Log Out on the top left-hand side of the screen



- If you have any queries please contact the researcher:

  Mr Meshal Alshakrah

  Telephone: 01612758363

  Email: meshal.alshakrah@postgrad.manchester.ac.uk

Appendix 18: Study Three Case Studies

CASE 1:

Name	**Mr M.Q**
Sex	Male
Age	77 years
Weight	126 Kg
Presenting complaint	Admitted to hospital with 2x fresh PR bleed in the morning, unable to control his bowels after prostate cancer.
Past medical history	Atrial Fibrillation, Prostate Cancer, Hypertension (HTN), Right Heart Failure.
Allergy status	No known drug allergies
Medication on admission	Beclomethasone dipropionate (100mcg) 4 puffs Inhaled BD (twice daily), Bisoprolol 5 mg PO OM (in the morning), Furosemide 80 mg PO BD (twice daily), Losartan 50 mg PO OM (in the morning), Spironolactone 50 mg PO OM (in the morning), Warfarin 5 mg PO OD (Once daily), Loperamide 2 mg PO OM (in the morning) PRN.
On examination	No dizziness, no pain. Temp 36.5°C, BP 127/60 mmHg, Heart Rate 70 beats per minute, Height 1.67m

Overall assessment of pharmaceutical care complexity

- ☐ This is a highly complex patient. (Red)
- ☐ This is a moderately complex patient (Amber)
- ☐ This is a least complex patient (Green)

CASE 2:

Name	**Mr A. R**
Sex	Male
Age	63 years
Weight	76 Kg
Presenting complaint	Drowsiness and generalised weakness with history of poor appetite and dehydration. He was diagnosed with dehydration due to diarrhoea which resolved with rehydration.
Past medical history	Epilepsy
Allergy status	No known drug allergies
Medication on admission	Lansoprazole 30 mg PO OM (in the morning), Phenytoin 300mg PO ON (in the night).
On examination	Temp 37.4°C, BP 106/65 mmHg, Heart Rate 66 beats per minute, Height 1.61m

Overall assessment of pharmaceutical care complexity

- ☐ This is a highly complex patient. (Red)
- ☐ This is a moderately complex patient (Amber)
- ☐ This is a least complex patient (Green)

CASE 3:

Name	**Mr S.P**
Sex	Female
Age	36 years
Weight	58 Kg
Presenting complaint	Pain in the left elbow. She denies injury, fever, or other symptoms and has never experienced pain in her elbow previously.
Past medical history	Chronic Sinusitis
Allergy status	No known drug allergies
Medication on admission	Diclofenac 50 mg three times a day Paracetamol 1 g up to four times a day when required.
On examination	Severe pain is noted with elbow flexion, but no swelling is identified. No redness or fluid collection is noted. **The patient vital signs and lab results are normal**.

Overall assessment of pharmaceutical care complexity

- ☐ This is a highly complex patient. (Red)
- ☐ This is a moderately complex patient (Amber)
- ☐ This is a least complex patient (Green)

Appendix 19: Study Three Training Evaluation Form

Title of study: Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

Date of event: --/--/2019

Location of event:

Instructions: Please tick your level of agreement with the statements listed below	Strongly Agree	Agree	Disagree	Strongly Disagree	Not relevant to this event
1. The objectives of the training were met					
2. The presenters were engaging					
3. The presentation materials were relevant					
4. The content of the course was organised and easy to follow					
5. The trainers were well prepared and able to answer any questions					
6. The course length was appropriate					
7. The pace of the course was appropriate to the content and attendees					
8. The exercise were helpful and relevant					
9. The venue was appropriate for the event					

10. What was most useful?

11. What was least useful?

12. What else would you like to see included in this event? Are there any other topics that you would like to be offered training courses in?

13. Any other comments?

THANK YOU FOR COMPLETING THIS EVALUATION FORM. FEEDBACK RECEIVED WILL BE USED TO PROVIDE IMPROVEMENTS TO FUTURE EVENTS.

EVALUATION FORMS SHOULD BE HANDED TO THE TRAINERS AT THE END OF THE EVENT.

Appendix 20: Study Three University of Manchester Research Sponsor Letter

The University of Manchester

Faculty of Biology, Medicine & Health
The University of Manchester
Oxford Road
Manchester M13 9PT

www.manchester.ac.uk

18 July 2019

To whom it may concern

Sponsor Reference: NHS001570

Role of the Research Sponsor under the UK Policy Framework for Health and Social Care (2017) and the Medicines for Human Use (Clinical Trials) Regulations 2004 (SI2004/1031)

I hereby confirm that the University of Manchester would be prepared to accept the role of research sponsor as currently defined in the *UK Policy Framework for Health and Social Care (2017)* and the *Medicines for Human Use (Clinical Trials) Regulations 2004 (SI2004/1031),* in relation to the study:

Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital

I have been informed that this study will be led by **Penny Lewis** of The University of Manchester.

Sponsorship is subject to the following conditions:

1) The lead investigator for the study must be an employee of the University of Manchester. For student research the academic supervisor is considered to be the lead investigator.
2) An appropriate contract must be agreed between the University and the funding body.
3) The research must be reviewed and approved by appropriate ethics, NHS and regulatory bodies and registered in accordance with University insurance requirements.

To enable the sponsor to meet their responsibilities as listed in section 9.10 of the UK Policy Framework for Health and Social Care (2017), Chief Investigators are asked to adhere to the responsibilities as outlined in section 9.2 of the UK Policy Framework for Health and Social Care (2017) (available at: https://www.hra.nhs.uk/documents/1068/uk-policy-framework-health-social-care-research.pdf). In line with this requirement **Penny Lewis** must ensure that all involved in the research project understand and discharge their responsibilities in accordance with the agreed protocol and any relevant management, ethical and regulatory approvals.

If you have any queries about sponsorship of this project then please address them to Ms Lynne MacRae, Faculty Research Practice Manager, University of Manchester, 5.012 Carys Bannister Building, Dover Street, Manchester M13 9PT, or email fbmhethics@manchester.ac.uk.

Yours Faithfully,

Lynne MacRae

Lynne MacRae
Research Practice Governance Manager
Faculty of Biology, Medicine and Health

Dated: **18/07/2019**

MANCHESTER 1824
The University of Manchester

Faculty of Biology, Medicine & Health
The University of Manchester
Oxford Road
Manchester M13 9PT

www.manchester.ac.uk

18 July 2019

To whom it may concern

This is to confirm that, where appropriate, insurance policies held by the University of Manchester will cover the research project entitled **Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital** which we have been informed is being conducted by **Meshal AlshaKrah** under the supervision of **Penny Lewis.**

The University has insurance available in respect of research involving human subjects that provides cover for legal liabilities arising from its actions or those of its staff or supervised students. The University also has insurance available that provides compensation for non-negligent harm to research subjects occasioned in circumstances that are under the control of the University.

Provision of this insurance cover in respect of a specific project may be subject to the acceptance of the project by the University's insurers and is conditional upon the project receiving approval from an appropriate ethics committee.

Signed on behalf of the University of Manchester,

Lynne MacRae

Lynne MacRae
Research Practice Governance Manager
Faculty of Biology, Medicine and Health

Dated: **18/07/2019**

Appendix 21: Study Three HRA approval

Ymchwil Iechyd a Gofal Cymru
Health and Care Research Wales

NHS
Health Research Authority

Dr Penny Lewis
Room 1.34 1st Floor Stopford building Oxford Road
Manchester
M13 9PT

Email: hra.approval@nhs.net
HCRW.approvals@wales.nhs.uk

25 September 2019

Dear Dr Lewis

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital**
IRAS project ID:	**261401**
Protocol number:	**N/A**
REC reference:	**19/YH/0285**
Sponsor	**University of Manchester**

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The standard conditions document "*After Ethical Review – guidance for sponsors and investigators*", issued with your REC favourable opinion, gives detailed guidance on reporting expectations for studies, including:

- Registration of research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics, and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **261401**. Please quote this on all correspondence.

Yours sincerely,
Christie Ord

Approvals Specialist

Email: hra.approval@nhs.net

Copy to: *Ms Lynne Macrae*

Appendix 22: Study Three REC approval

NHS
Health Research Authority
Yorkshire and the Humber – Sheffield Research Ethics Committee

NHSBT Newcastle Blood Donor Centre
Holland Drive
Newcastle upon Tyne
NE2 4NQ

Telephone: 0207 1048084

Please note: This is the favourable opinion of the REC only and does not allow you to start your study at NHS sites in England until you receive HRA Approval

28 August 2019

Dr Penny Lewis
Room 1.34 1st Floor Stopford Building
Oxford Road
Manchester
M13 9PT

Dear Dr Lewis

Study title:	**Developing and assessing the feasibility of a pharmaceutical care complexity screening tool to aid the targeted delivery of patient focussed clinical pharmacy services in hospital**
REC reference:	**19/YH/0285**
Protocol number:	**N/A**
IRAS project ID:	**261401**

Thank you for your response dated 20 August 2019, responding to the Proportionate Review Sub-Committee's request for changes to the documentation for the above study.

The revised documentation has been reviewed and approved on behalf of the PR sub-committee by the Chair and Lead Reviewer.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Confirmation of Capacity and Capability (in England, Northern Ireland and Wales) or NHS management permission (in Scotland) should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified

otherwise).

Guidance on applying for HRA and HCRW Approval (England and Wales)/ NHS permission for research is available in the Integrated Research Application System.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations.

Registration of Clinical Trials

It is a condition of the REC favourable opinion that all clinical trials are registered on a publicly accessible database. For this purpose, clinical trials are defined as the first four project categories in IRAS project filter question 2. For clinical trials of investigational medicinal products (CTIMPs), other than adult phase I trials, registration is a legal requirement.

Registration should take place as early as possible and within six weeks of recruiting the first research participant at the latest. Failure to register is a breach of these approval conditions, unless a deferral has been agreed by or on behalf of the Research Ethics Committee (see here for more information on requesting a deferral: https://www.hra.nhs.uk/planning-and-improving-research/research-planning/research-registration-research-project-identifiers/

As set out in the UK Policy Framework, research sponsors are responsible for making information about research publicly available before it starts e.g. by registering the research project on a publicly accessible register. Further guidance on registration is available at: https://www.hra.nhs.uk/planning-and-improving-research/research-planning/transparency-responsibilities/

You should notify the REC of the registration details. We routinely audit applications for compliance with these conditions.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

After ethical review: Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study, including early termination of the study
- Final report.

The latest guidance on these topics can be found at https://www.hra.nhs.uk/approvals-amendments/managing-your-approval/.

Ethical review of research sites

The favourable opinion applies to all NHS/HSC sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" above).

Approved documents

The documents reviewed and approved by the Committee are:

Document	*Version*	*Date*
Evidence of Sponsor insurance or indemnity (non-NHS Sponsors only) [Sponsor Insurance Letter]	1	18 July 2019
Interview schedules or topic guides for participants [Interview schedule]	1	08 July 2019
IRAS Application Form [IRAS_Form_29072019]		29 July 2019
Letter from funder [Letter from funder]	1	08 July 2019
Letter from sponsor [Sponsor letter]	1	18 July 2019
Letters of invitation to participant [Letter of invitation to HCPs]	1	08 July 2019
Other [Appendix1-Adult Complexity Tool for Pharmaceutical Care-ACTCP-Form1]	1	08 July 2019
Other [Appendix2-Adult Complexity Tool for Pharmaceutical Care-ACTCP-Form2]	1	08 July 2019
Other [Appendix3_Guidance for the ACTPC users]	1	08 July 2019
Other [Appendix4- Training Schedule]	1	08 July 2019
Other [Appendix5-The guidance on how to enter data in the Form2 application]	1	08 July 2019
Other [Appendix6-Data Collection Sheet1- The Prescribing Errors and Medicine Optimisation Interventions Study]	1	08 July 2019
Other [Appendix9-Data Collection Sheet2-Time and Motion Study]	1	08 July 2019
Other [Data Management Plan]	1	12 July 2019
Other [Risk Assessment Form]	1	08 July 2019
Other [Insurance Assessment Form]	1	08 July 2019
Other [Gantt Chart]	1	08 July 2019
Other [A response to provisional openion]	1	20 August 2019
Participant consent form [Pharmacist consent form]	2	08 July 2019
Participant consent form [Healthcare professional consent form]	2	08 July 2019
Participant information sheet (PIS) [Pharmacist- (PIS)]	2	08 July 2019
Participant information sheet (PIS) [Healthcare professional - (PIS)]	2	08 July 2019
Participant information sheet (PIS) [Patient - Updated version]	3	20 August 2019
Research protocol or project proposal [Feasibility study protocol]	2	08 July 2019
Summary CV for Chief Investigator (CI) [Dr Penny Lewis (CI) CV]	1	08 July 2019
Summary CV for student [Student CV]	1	08 July 2019
Summary CV for supervisor (student research) [Dr Douglas Steinke-CV]	1	08 July 2019
Summary CV for supervisor (student research) [Dr Mary Tully-CV]	1	08 July 2019
Summary of any applicable exclusions to sponsor insurance (non-NHS sponsors only) [EL Certificate]	1	18 July 2019
Summary of any applicable exclusions to sponsor insurance (non-NHS sponsors only) [Combined TWIMC]	1	18 July 2019
Summary of any applicable exclusions to sponsor insurance (non-NHS sponsors only) [University of Manchester - 2019-20 To Whom It May Concern Letter (Clinical Trials, Medical Malpractice and PI).pdf]	1	18 July 2019
Validated questionnaire [Medication-Related Patient Measure of Organisational Safety (MR-PMOS) Questionnaire]	1	08 July 2019

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

Feedback

You are invited to give your view of the service that you have received from the Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance

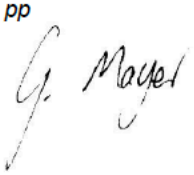
HRA Learning

We are pleased to welcome researchers and research staff to our HRA Learning Events and online learning opportunities– see details at: https://www.hra.nhs.uk/planning-and-improving-research/learning/

19/YH/0285	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project.

Yours sincerely
pp



Professor Basil Sharrack
Chair

Email: nrescommittee.yorkandhumber-sheffield@nhs.net

Enclosures: 'After ethical review – guidance for researchers'

Copy to: Ms Lynne Macrae – Research Dept, University of Manchester

Mr Meshal Alshakrah – Postgraduate Building, University of Manchester

Lead Nation - England

Appendix 23: Study Three HRA&HCRW amendments approval-A

Friday, November 1, 2019 at 16:06:07 Greenwich Mean Time

Subject: IRAS 261401. Amendment categorisation and implementation information
Date: Friday, 1 November 2019 at 14:03:18 Greenwich Mean Time
From: nrescommittee.yorkandhumber-sheffield@nhs.net
To: Penny Lewis
CC: MHS Ethics Applications, Meshal Alshakrah

Amendment Categorisation and Implementation Information

Dear Dr Lewis,

IRAS Project ID:	261401
Short Study Title:	Assessing the feasibility of a pharmaceutical care complexity tool
Date complete amendment submission received:	31 October 2019
Amendment No./ Sponsor Ref:	MA Oct 2019
Amendment Date:	29 October 2019
Amendment Type:	Non-substantial
Outcome of HRA and HCRW Assessment	**This email also constitutes HRA and HCRW Approval for the amendment,** and you should not expect anything further.
Implementation date in NHS organisations in England and Wales	35 days from date amendment information together with this email, is supplied to participating organisations **(providing conditions are met)**
For NHS/HSC R&D Office information	
Amendment Category	**A**

Thank you for submitting an amendment to your project. We have now categorised your amendment and please find this, as well as other relevant information, in the table above.

What should I do next?

Please read the information in IRAS, which provides you with information on how and when you can implement your amendment at NHS/HSC sites in each nation, and what actions you should take now.

If you have participating NHS/HSC organisations in any other UK nations please note that **we will** forward the amendment submission to the relevant national coordinating function(s).

If not already provided, please email to us any regulatory approvals (where applicable) once available.

When can I implement this amendment?

You may implement this amendment in line with the information in IRAS. Please note that you may only implement changes described in the amendment notice.

Who should I contact if I have further questions about this amendment?

If you have any questions about this amendment please contact the relevant national coordinating centre for advice:

- England – hra.amendments@nhs.net
- Northern Ireland – research.gateway@hscni.net
- Scotland – nhsg.NRSPCC@nhs.net
- Wales – HCRW.amendments@wales.nhs.uk

Additional information on the management of amendments can be found in the IRAS guidance.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/.

Please do not hesitate to contact me if you require further information.

Kind regards

Mr Paul Jay

Health Research Authority
Ground Floor | Skipton House | 80 London Road | London | SE1 6LH
E.hra.amendments@nhs.net
W. www.hra.nhs.uk

Sign up to receive our newsletter HRA Latest.

Appendix 24: Study Three HRA&HCRW amendments approval-B

Tuesday, November 26, 2019 at 14:11:14 Greenwich Mean Time

Subject: IRAS 261401. Amendment categorisation and implementation information
Date: Wednesday, 20 November 2019 at 16:32:55 Greenwich Mean Time
From: nrescommittee.yorkandhumber-sheffield@nhs.net
To: Penny Lewis
CC: MHS Ethics Applications, Meshal Alshakrah

Amendment Categorisation and Implementation Information

Dear Dr Lewis,

IRAS Project ID:	261401
Short Study Title:	Assessing the feasibility of a pharmaceutical care complexity tool
Date complete amendment submission received:	05 November 2019
Amendment No./ Sponsor Ref:	MA Oct 2019
Amendment Date:	31 October 2019
Amendment Type:	Non-substantial
Outcome of HRA and HCRW Assessment	**This email also constitutes HRA and HCRW Approval for the amendment,** and you should not expect anything further.
Implementation date in NHS organisations in England and/or Wales	35 days from date amendment information together with this email, is supplied to participating organisations **(providing conditions are met).**
For NHS/HSC R&D Office information	
Amendment Category	**B**

Thank you for submitting an amendment to your project. We have now categorised your amendment and please find this, as well as other relevant information, in the table above.

What should I do next?

Please read the information in IRAS, which provides you with information on how and when you can implement your amendment at NHS/HSC sites in each nation, and what actions you should take now.

If you have participating NHS/HSC organisations in any other UK nations please note that **we will** forward the amendment submission to the relevant national coordinating function(s).

If not already provided, please email to us any regulatory approvals (where applicable) once available.

When can I implement this amendment?

You may implement this amendment in line with the information in IRAS. Please note that you may only implement changes described in the amendment notice.

Who should I contact if I have further questions about this amendment?

If you have any questions about this amendment please contact the relevant national coordinating centre for advice:

- England – hra.amendments@nhs.net
- Northern Ireland – research.gateway@hscni.net
- Scotland – nhsg.NRSPCC@nhs.net
- Wales – HCRW.amendments@wales.nhs.uk

Additional information on the management of amendments can be found in the IRAS guidance.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/.

Please do not hesitate to contact me if you require further information.

Kind regards

Mr Paul Jay

Health Research Authority
Ground Floor | Skipton House | 80 London Road | London | SE1 6LH
E.hra.amendments@nhs.net
W. www.hra.nhs.uk

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