Development of hospital pharmacy services at transition of care points: a scoping review.

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2024

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ABSTRACT

Background:

Several hospital pharmacy services exist, which take place at different interfaces of patient care. Although they are an important tool for improving medication safety, they are not yet sufficiently implemented in hospitals around the world.

Objective:

This scoping review aims to summarize different hospital pharmacy services at transition of care points in order to identify development trends and practice patterns in high-income countries over the past decade.

Methods:

A literature search of four databases (PubMed, PubPharm, Cochrane Library (Ovid) and ScienceDirect) since 2011 was conducted. A detailed search strategy was developed and refined with the help of a research librarian. Title, abstract and full text selection was carried out by two researchers independently. The study was reported in accordance with the PRISMA-ScR items to ensure quality standard reporting. Only studies originating from developed countries and published in the English language were included. The data obtained were extracted and summarized using a data extraction form developed to meet the studies research aims.

Results:

Out of the 5456 search results, 65 studies met the inclusion criteria. These originated from Europe (n=29), North America/Canada (n=28), Australia (n=7) and Asia (n=1). Individual transition of care services, such medication reconciliation and medication review, on admission and discharge were the main focus of published literature practice patterns between 2011 and 2016, after which a more holistic transition of care (TOC) service started to emerge that follows patients across all transition of care points during their hospital stay. Facilitators and barriers were consistently dependent on resources and infrastructure. Clinical and economic outcomes show a mixed picture.

Conclusion:

Pharmaceutical services developed during the past decade to more holistic TOC services. Large scale, high-quality studies are needed to reliably determine clinical and economic benefit.

This article has been accepted for publication in *European Journal of Hospital Pharmacy*, 2024 following peer review, and the Version of Record can be accessed online at https://doi.org/10.1136/ejhpharm-2023-003836.

Implication for practice:

Key messages

- What is already known on this topic?
  Hospital pharmacy services at transition of care points can increase patient and drug therapy safety. However, they are not yet sufficiently implemented worldwide.
- What this study adds?
  A global geographical overview of existing clinical hospital pharmacy services, their development trends and practice patterns to aid the development of future services in other countries.
- How this study might affect research, practice or policy?
  Evidence about the effectiveness of clinical hospital pharmacy services in relation to drug therapy and patient safety and can help new services to be developed. The Scoping Review (ScR) has highlighted the gaps in evidence for hospital pharmacy services at transition of care points.

Background:

Transition of care as defined by the World Health Organization (WHO) refers to the "*various points where a patient moves to, or returns from, a particular physical location or makes contact with a health care professional for the purposes of receiving health care*" (1). These include transition between home, hospital, residential care settings and consultations with different health care providers in out-patient facilities. They present a risk to patient safety as the complex combination of processes, technologies and human interactions require accurate transition of information between the relevant healthcare providers (2). The WHO considers that nearly every patient who moves across a care interface is affected by unintended medication errors.

Medication errors are defined as *'any preventable event that may cause or lead to inappropriate medication use or patient harm, while the medication is in the control of the health care professional, patient, or consumer*' (3). They can occur during the entire medication process, which includes ordering/prescribing, transcribing and verifying, dispensing and delivering, administering, monitoring and reporting (4). Medication errors can not only lead to adverse effects or harm to the patient, but are also reflected in the costs to the healthcare system. It is estimated that $42 billion in annual global health care costs are attributable to medication errors across all sectors (5).

In 2017-2018 the National Health Service (NHS) in the UK paid £1.63 billion in litigation costs due to safety deficiencies (6) and in the US $102.4 – 165.7 billion are annually wasted due to "Failure of Care Delivery", including components such as "hospital-acquired conditions and adverse events" (7). A problem also recognized by the European Commission (8). In order to tackle the unreasonable cost and risk of largely avoidable medication errors the WHO set out a clear vision with the recently published "Global Patient Safety Action Plan 2021 - 2030: Towards eliminating avoidable harm in healthcare" (9) to reduce avoidable patient harm caused by unsafe healthcare practices and is directed at all healthcare providers across all sectors.

Given pharmacists expertise in drug therapy and medication safety, they are key in preventing medication-related risks and errors (10). The establishment of clinical pharmacy services in hospital practice has evolved at a different pace across different countries over the past two decades (11). Despite the unrefutable evidence of its benefit, pharmacist involvement at all transition of care points is not yet standard practice. Therefore the aim of this scoping review was to summarize the type of and experiences with hospital pharmaceutical services at transition of care interfaces in order to identify development trends and practice patterns in high-income countries (12, 13) over the last ten years to inform the development of future services in line with the WHO Global Patient Safety Action Plan 2021 – 2030.

Methods:

The scoping review methodology was chosen as it provides an overview of a broad body of literature which allows the identification of publication trends and gaps in the knowledge on service provision. The updated scoping review methodology as described by Joanna Briggs Institute (JBI) 2020 was used (14).

Information sources and search strategy

An extensive search of four databases (PubMed, Cochrane Library (Ovid), Science Direct and PubPharm) was conducted. Key words such as 'clinical pharmacy', 'hospital' and 'medication review' connected with Boolean operators, wild-cards and truncations (AND, OR, NOT, '', (), "", *) were used. A detailed search strategy was created with the help of a research librarian to allow refinement of the search string for each database. The search was limited to original studies (defined as any study, that tests a hypothesis in order to add new knowledge to a specific topic and that can be considered as a primary source), randomised controlled trials (RCTs) and systematic reviews (SRs) published in the English language with an available full-text between 2011 – 2021 in high-income countries according to the definition of the World Bank (12, 13). The study aimed to include the development of transition of care services in comparable healthcare systems around the world. As third world countries often have different economical and population pressures that define the service provision of their healthcare services, it was considered appropriate by the research team to exclude them.

Inclusion criteria included all types of hospital pharmacy services (e.g. medication reconciliation, medication analysis and medication management) at transition of care points (admission, internal transition and discharge). The search excluded the provision of simple medication plans, deprescribing of individually targeted medication (e.g. 'antimicrobial stewardship'; proton pump inhibitor), outpatient i.v. medicine administration (e.g. Vancomycin; cytotoxics), veteran services, transplant patients, palliative care patients, children and adolescents up to 17 years of age, pharmacy technicians, students, trainees, key performance indicators, telepharmacy, and electronic prescriptions.

Views and attitudes of healthcare professionals were excluded as the primary aim of this review was to identify development trends and practice patterns of hospital pharmacy services at transition of care interfaces. A separate review and analysis of qualitative research to explore the barriers and facilitators of these services and their implementation in daily practice through the eyes of the healthcare professionals is planned.

Screening and quality assurance

To ensure quality and eliminate bias, title, abstract, full text screening and data extraction were completed independently by two researchers (JTS/AEW) using the pre-determined inclusion and exclusion criteria as defined by the study protocol. Discrepancies were discussed or resolved with the help of a third independent researcher (BBM). An additional hand-search of the reference list of full-text studies was carried out to achieve an exhaustive list of all current and relevant studies (Figure 1).

Data extraction process

Data obtained were extracted and summarized using a bespoke data extraction form developed and evaluated for face and content validity by the research team in line with the research question, inclusion and exclusion criteria. The following data were extracted: title, authors, journal, year of publication, country of origin, study structure/methodology, study duration, objective, study population, population size, setting, ward, hospital pharmaceutical service, interface, type of intervention, duration of intervention, control group, outcome, and results. The study was reported in accordance with the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) items to ensure quality standard reporting.

Results:

Study characteristics

The complete final search after removal of duplicates yielded 5456 unique records (Figure 1). After screening, 60 full texts met the previously defined inclusion and exclusion criteria. Through additional review of the reference lists, a further 5 full texts were identified and included. In total, 65 full texts were included. Studies mainly originated from North America (n=30), Europe (n=30), Australia (n=8) and Asia (n=1) (Supplementary Tables 2, 5 & 8) and ranged from prospective/retrospective studies, pre-post analysis, pilot studies, RCT's to SRs, meta-analysis, and umbrella reviews.

Development trends and practice patterns of hospital pharmacy services at care interfaces

As development trends and practice patterns have emerged by geographical regions, results are presented accordingly to reflect this. Moreover, studies are presented according to their year of publication in order to make development trends more visible. By far the most common hospital pharmacy service reported focused on admission to hospital (n=49). This was most frequently reported in European hospital practice (Supplementary Table 2) and mainly included services such as best possible medication history (BPMH) and medication reconciliation.

Europe

European studies (n=29) were published between 2013 – 2021 (with a peak in 2016) mainly in France (n=6), Spain (n=5), Denmark (n=4), and The Netherlands (n=3) (Figure 2). The studies focused primarily on medication reconciliation on admission (n=22) combined with a BPMH (n=12) or as a stand-alone service (n=10) (Supplementary Table 2). While no meta-analysis was carried out the total number of patients included in these studies equated to 27 258. Supplementary tables 3 and 4 indicate if an improvement in medication safety was achieved or not.

A study by Belda-Rustarazo et al. (2015) evaluated the occurrence of reconciliation errors and their possibility to cause harm [dataset] (15). Out of 814 patients, 525 (64.5%) had at least one reconciliation error on admission (mean of 2.2 +/- 1.3 errors per patient) and 235 (32.4%) patients at discharge. The most frequent reconciliation error was drug omission (73.6% on admission and 71.4% at discharge) with 39% (n=not given) of the errors on admission and 51% (n= not given) at discharge having a reported potential to cause moderate or severe harm. Patients who had more pre-admission drugs or more comorbidities were at higher risk for medication errors on admission ($p < 0.001$). This was also reflected at discharge where patients with a longer hospital stay (12.9 days, n= 235 vs. 11.0 days, n= 491; p= 0.03) and a mean number of 9.6 drugs (compared to a mean number of drugs of 8.6; p= 0.04) were at an increased risk of medication errors. The most frequent cause of discrepancies on admission (n= 1175 reconciliation errors) and at discharge involved medication for the cardiovascular system (26.2% & 14.1%), nervous system (23.4% & 29.5%) as well as blood and blood forming organs (15.1% & 20.9%). These results were echoed by several other studies [dataset] (16, 17) with Marinović et al. (2016) stating that an increased number of preadmission medications (OR 1.19; 95% CI, 1.10-1.29; $p< 0.001$) is the strongest predictor of unintentional medication discrepancies (UMDs). The odds of experiencing at least one medication error increased by 19% for each additional drug. Moreover, the occurrence for UMDs was reported to be 38 times higher if there was no pharmacist intervention [dataset] (18).

Carrying out a BPMH or medicine reconciliation, takes on average 30min [25min – 74min] [dataset] (18-20) with an average time of 32min (10 – 90min) is spent on a medication review [dataset] (21). Acceptance rates of clinical pharmacists' interventions by physicians varied from 39-100% [dataset] (20, 22, 23).

An improvement in the quality of prescribing, drug-related readmissions, all cause readmissions, length of in-hospital stay, patient satisfaction and cost were reported in a SR by Graabaek et al. (2013) [dataset] (22). A Dutch study estimated that for every 1000 Euros spend on a pharmacist performing medication reconciliation in an Intensive Care Unit (ICU), treatment costs of 2480 Euros could be avoided [dataset] (24).

Although several studies underline a positive effect of clinical pharmacy services, some studies show mixed or no effects [dataset] (25, 26). In Slovenia, the unintentional discrepancies that were already identified on hospital admission (88.3%; 218/247) remained during patients' hospital stay [dataset] (27). Only a small amount (11.7%; 29/247) could be resolved during hospitalization, but this was not statistically significant (intervention group: 14.5%; 18/124; control group: 8.9%; 11/123; x^2-test, p= 0.244). Furthermore, the physicians' acceptance rate of reported unintentional discrepancies by the pharmacists was only 27.0% (10/37).

North America / Canada

North American / Canadian studies (n=28; Figure 3) primarily focused on medication review and medication reconciliation during discharge activities (n=21) (Supplementary Table 5). The peak of which was in 2015. Supplementary tables 6 and 7 show whether an improvement in medication safety was achieved. Overall, 23 933 patients were included across 19 studies. Additional studies reported on a variety of other transition of care services from multidisciplinary follow-up visits [dataset] (28) to microbiologic test screening [dataset] (29).

Comparing the frequency of at least one medication error per patient on admission, a study from the USA (25.5%; 132/517 patients) [dataset] (30) showed a lower percentage compared to a European study (44.6%, 744/1670 patients) [dataset] (16). Buckley et al. found 3.5 +/- 2.3 medication errors (mean+/- SD) per patient [dataset] (30) while Dufay et al. showed a median of 2 medication errors per patient (range 1-9) [dataset] (16). The most frequent error type was omission (79.7%), followed by wrong dose (12.6%) and wrong frequency (4.3%) which is comparable to the results reported across Europe [dataset] (16). A strong association was seen between the number of discharge medications and the incidence of UMDs (OR 8.5; 95% CI 2.8, 25.5; $p < 0.001$). Patients with one or more identified UMD at discharge had a significantly longer length of stay (LOS) in hospital compared to patients with no discrepancies (6.0 +/- 4.2 vs 4.3 +/- 3.3 days; Wilcoxon rank-sum test; $p= 0.017$) [dataset] (31). One study estimated that the effective utilization of clinical pharmacists in hospital practice, saved a net value of between $445,267 and $5,7 million in healthcare expenditure over 5 years (confirmed by a sensitivity analysis) [dataset] (30).

Reports of interdisciplinary transition of care teams (TOC) in North American hospital practice have been emerging since 2015. These interdisciplinary healthcare teams are responsible for the safe management of the patients' transitions across hospital interfaces [dataset] (32-37). Clinical pharmacists are embedded in TOC teams, as well as in multidisciplinary or rapid response teams. Reported benefits of such teams include a significant reduction in 30-day readmission rates (14.3%, 10/70 patients) compared to a physician-only team (34.3%, 24/70 patients; Fisher's exact test; $p = 0.010$) [dataset] (28); a 58.3% relative risk reduction of 30-day hospital readmission [dataset] (28); a physicians' acceptance rate of 96% (46001/47918) for medication recommendations by pharmacists [dataset] (37); and a significant reduction in the median time to medication administration (Wilcoxon signed rank test; $p= 0.004$) [dataset] (38).

Australia and Asia

Australia shows a diverse publication pattern with no specific focus on any given transition of care point or clinical pharmacy service (Supplementary Table 8). These studies were published from 2013 – 2017 and supplementary tables 9 and 10 summarize if medication safety was improved or not. Tong et al. (2017) [dataset] (39) showed a significant reduction in UMDs at discharge if pharmacists took responsibility for writing the medical discharge summary (Wilcoxon rank sum test; $p< 0.01$), with an absolute risk reduction of 46.5% (95% CI; 40.7 – 52.3%). The number needed to treat (NNT) to prevent one UMD per discharge summary was 2.2 (95% CI; 1.9 – 2.5).

In a small, single center study by Khalil et al. (2016) [dataset] (40), who's aim was to implement and evaluate the impact of a pharmacist-led medication reconciliation on admission, a significant reduction of the error rate from 4.41 UMDs in the control group (n=54) to 0.52 UMDs in the intervention group (n=56) (student t-test; $p < 0.0001$) was reported. The healthcare workflow on admission was reported to result in a 30min time efficiency per patient.

A SR and meta-analysis involving 15 525 adult patients summarized that studies that include multiple (two or more) transition of care points could no longer identify a positive difference in the number of UMDs between intervention and control groups [dataset] (41).

A Korean SR and meta-analysis included 6893 patients [dataset] (42). The pooled results showed a significant reduction of 68% in patients who received medication reconciliation by pharmacy personnel (RR 0.32, 95% CI 0.19 – 0.53, $p < 0.0001$; I^2= 94% heterogeneity) and the quantity of events associated with medication discrepancies by 88% (RR 0.12, 95% CI 0.06 – 0.26, $p < 0.00001$) compared to usual care.

Discussion:

This scoping review highlights the lack of consistent implementation of hospital pharmacy services across all transition of care points in high-income countries. Despite the plentiful evidence of its positive impact on the prevention of UMDs, readmission rates, LOS, and patient safety. It shows a clear triangulation between polypharmacy/ poor health literacy; increased risk of UMDs; and resultant healthcare cost as well as the positive impact pharmacist involvement has on the multidisciplinary healthcare workflow. While North American hospital pharmacy services focuses mainly on medication review and medication reconciliation at discharge they show a reduced baseline frequency of unintended medication errors which may be a direct result of their advanced integration of interdisciplinary teams and healthcare education. The recent emergence of transition of care teams (TOC) in northern America marks a further development in interdisciplinary healthcare practice which may set a useful standard for pharmacist integration in European healthcare practices. However large scale, high-quality studies that reliably determine clinical and economic benefit of clinical pharmacy services are still lacking.

A study carried out in North America back in 2003 found that 78% fewer preventable ADEs occurred when pharmacists participated in multidisciplinary ward rounds (43). In 2018, a TOC program which included a pharmacist, lowered the total healthcare costs at 180 days after discharge by $2,139 per patient (intervention vs. control group) (44) and according to their budget impact analysis, doubling the eligible patient population would have led to $25 million of cost savings for the healthcare system (45). Despite these and similar studies (46, 47) hospital pharmacy services are not yet implemented consistently across high income countries. Lack of time and human resources, as well as poor communication between healthcare professionals are only some of the barriers that might hinder the implementation of clinical pharmacy services (48).

A Finnish study published in 2014 stated that about 2/3rds of the European countries have implemented some form of medication review with varying complexity, but that these are not yet rolled out nationwide (49). This is likely a symptom of the different underlying healthcare structures across Europe and resulting implementation complexity. Implementation is a multi-factorial process (50) with many studies using specific underpinning theoretical research frameworks to better understand the factors that affect clinical pharmacy service implementation in any given healthcare context (51).

Including hospital pharmacists in multidisciplinary teams can save time for other healthcare professionals and make workflows more efficient [dataset] (38, 40). A study by Grill et al. (2019) showed that clinical pharmacists in the ED saved 69.8 hours of total physician time over the study period, equating to 75min per a 10 hours shift (52). Patients receive better treatment and achieved better outcomes due to effective, interdisciplinary collaboration of healthcare professionals (53, 54). Despite this, pharmacists and physicians agree that insufficient time and the need to work with many different specialists, still pose some barriers in the pharmacist-physician collaboration (54, 55) irrespective of a willingness to collaborate in order to optimize patient care (56).

Considering the WHO global patient safety action plan (9) to eliminate avoidable harm in healthcare by 2030 and the FIP Pharmaceutical workforce Development Goals (57) more large

scale, high-quality studies are needed that reliably determine clinical and economic benefit of clinical pharmacy services integration into patient care at transition of care points.

Conclusion:

Hospital pharmacy services at transition of care points show a large variation in implementation and practice complexity across high-income countries. The reporting of an inconsistent benefit in relation to improving patients drug therapy safety due to a lack of large scale quality studies was also noted. Much more needs to be done to develop safe and effective clinical pharmacy services at care interfaces alongside well thought out robust studies evaluating their impact on patient safety.

Strengths and limitations

To our knowledge this is the first study to summarize the global geographical development and trends of clinical pharmacy services at transition of care points associated with hospital practice. Independent screening of search results minimized the risk of bias and omission. The study quality was further enhanced by the use of the PRISMA-ScR reporting system and the input of a research librarian to develop a refined keyword search strategy. The focus on high income countries may limit the generalizability of the results and may add to the under-representation of countries in high-impact general medical journals. As telepharmacy was considered a special service, which has particularly evolved during the COVID-19 pandemic, the research team decided to exclude this service from the search due to the extensive body of evidence, which would require a SR on its own. Important developing trends regarding telepharmacy might have been missing due to this decision. Quality assessment of the included studies is not required in a scoping review methodology but consequently does not allow for an evaluation of the individual study results.

Contributors: JTS conducted the searches. Title, abstract, full text screening and data extraction was independently completed by JTS and AEW. In case of discrepancies, a third researcher was involved (BBM).

Funding: The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Acknowledgements: We especially thank Mag. Birgit Böhmdorfer-McNair PhD, aHPh (BBM) for helping us to reach a consensus when selecting studies and Mag. Anton Walder for his help with refining the search strategy.

Competing interests: None declared.

Ethics approval: Not applicable.

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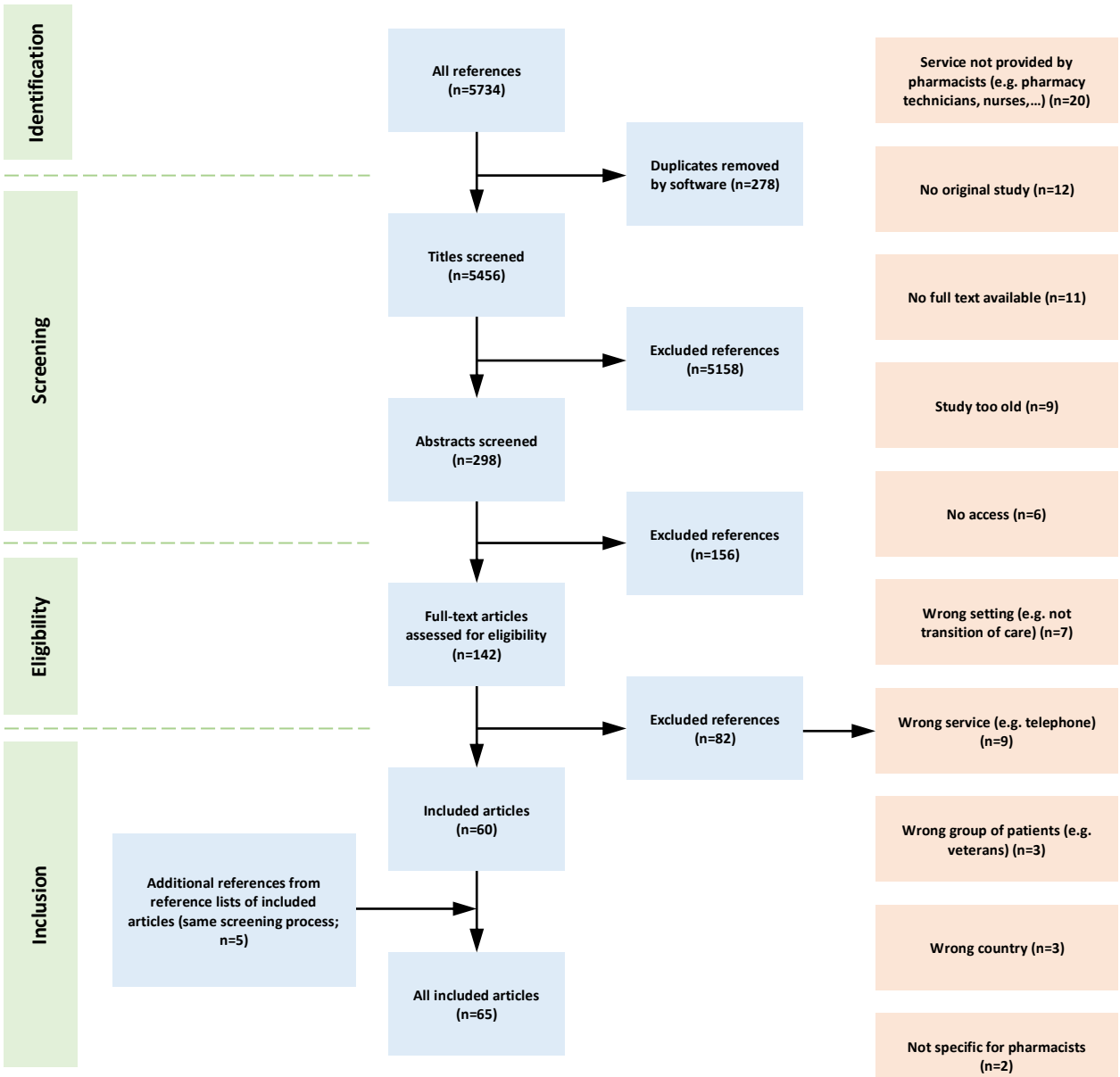

Figure 1 PRISMA-ScR chart

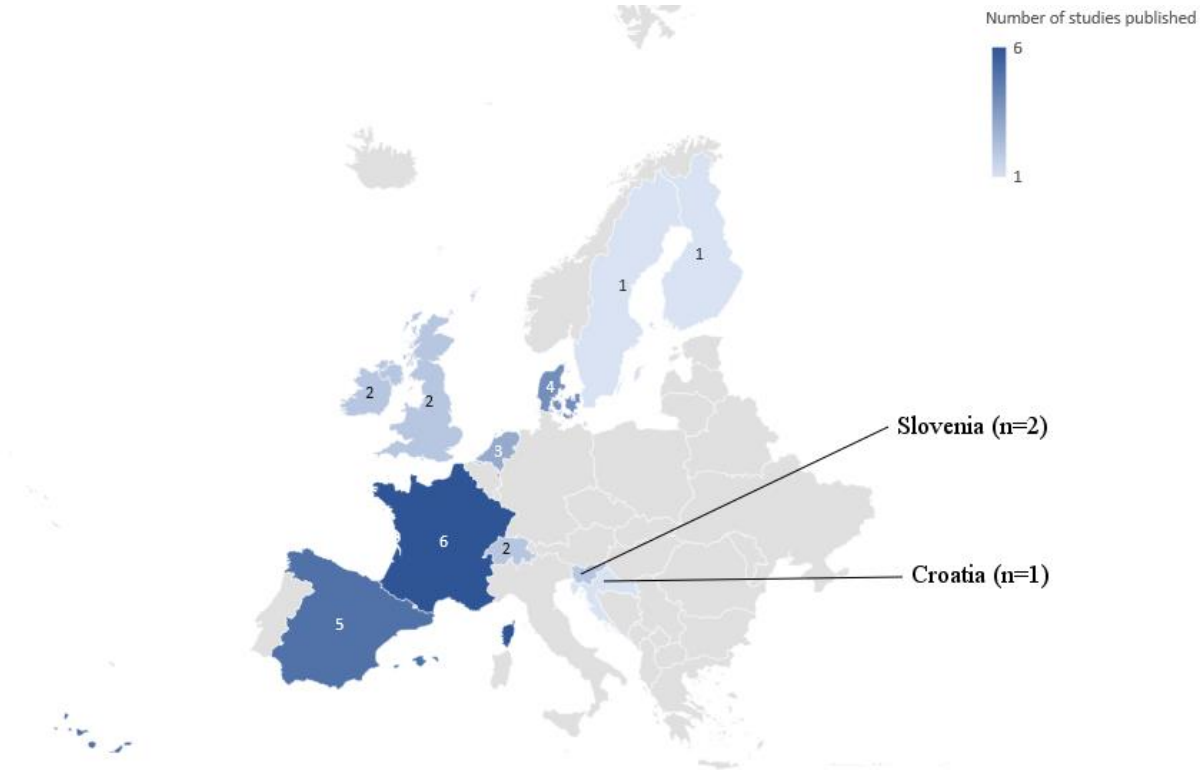

Figure 2 Number of studies published in Europe

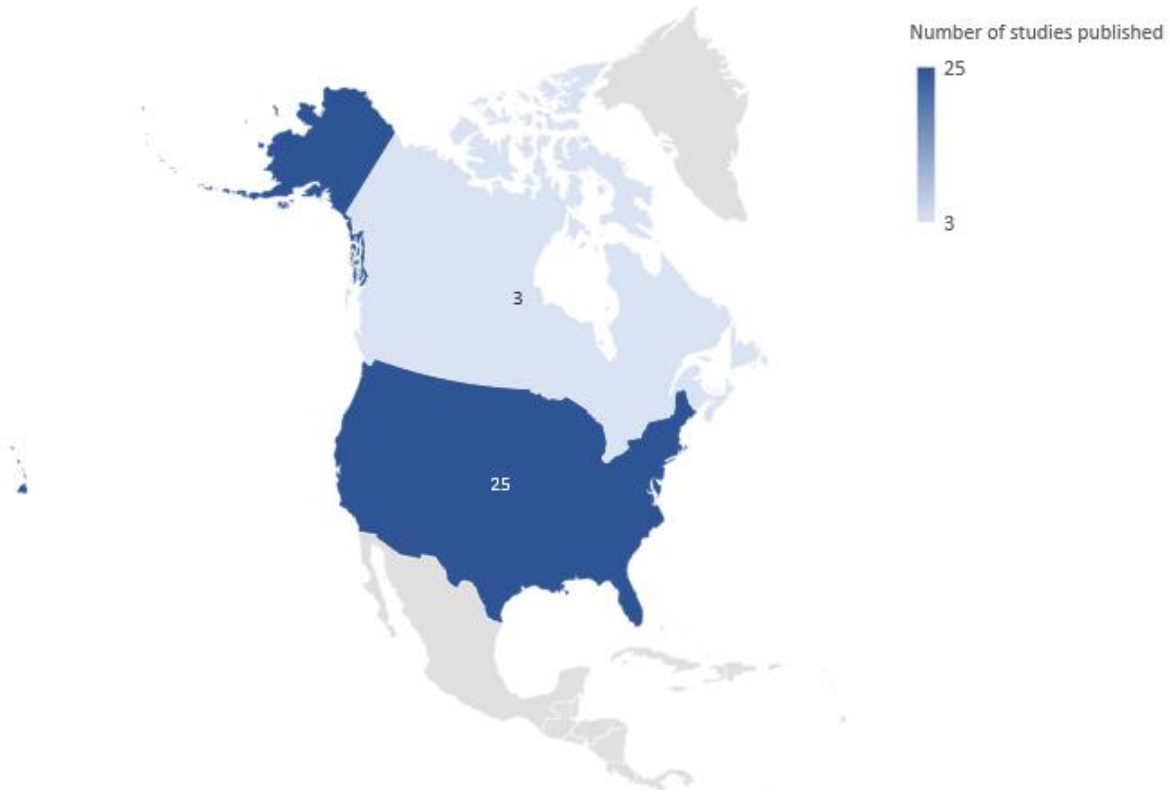

Figure 3 Number of studies published in North America / Canada

Supplement

Supplementary Table 1 Number of hits per database

Database	**Number of hits**
PubMed	3758
ScienceDirect	1281
PubPharm	362
Cochrance Library (Ovid)	333
Total	**5734**

Supplementary Table 2 Studies from Europe; (ScR = Scoping Review)

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Allende Bandrés MÁ; 2013; Spain	To quantify and analyse discrepancies detected in treatment prescribed to patients admitted to an internal medicine unit, and which required clarification from the prescribing physician, i.e. unjustified discrepancies.	Retrospective descriptive study	2473 (admission), 1150 (discharge); Discharge: five or more drugs	Admission, discharge	Medication reconciliation	866 discrepancies were found in a total of 446 patients. Pharmacist intervention was accepted by the prescribing physician in 807 (93 %) of the discrepancies detected, classified as reconciliation errors or unjustified discrepancies (UJD).
Graabæk T; 2013; Denmark	To identify, assess and summarize the literature investigating the effect of pharmacist-led medication reviews in hospitalized patients.	Systematic review	The number of included participants in the studies varied from 100 to 2405 patients, with six studies including more than 500 patients. The study size was not reported in eight of the studies.	Various	Medication history, Medication reconciliation, Participation in ward rounds, Medication report to general practitioner (GP), Follow-up at home (not all applicable to every study)	The pharmacist interventions were well implemented with physicians' acceptance rates from 39% to 100%. The 10 controlled studies generally show a positive effect on medication use and costs, satisfaction with the service and positive as well as insignificant effects on health service use. Several outcomes were statistically insignificant, but these were predominantly associated with low sample sizes or low acceptance rates.
Galvin M; 2013; Ireland	To describe the contribution of the accident and emergency (A&E) based clinical pharmacist to medication reconciliation for adult patients on admission to acute hospital in Ireland and identify ways to further improve the process.	Prospective observational study	134 patients; Adults admitted via the accident and emergency department, from a non-acute setting, reporting the use of at least three regular prescription medications.	Admission	Medication reconciliation	There were 447 interventions by the clinical pharmacist regarding apparently unintentional discrepancies, a mean of 3.3 per patient. In total, 227 (50 %) interventions were accepted and discrepancies resolved.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Leguelinel-Blache G; 2014; France	To assess the impact of implementation of medication reconciliation (MR) by clinical pharmacists in the admission care process.	Prospective study	394 patients; All patients over 18 years old, admitted in infectious and tropical disease (ITD) and general medicine (GM) units during the study period	Admission	BPMH, medication reconciliation	Proactive MR reduced the percentage of patients with at least one unintended medication discrepancy (UMD) compared with retroactive process (respectively 2.1% vs. 45.8%, $p < 0.001$).
Belda-Rustarazo S; 2015; Spain	To determine the frequency of reconciliation errors at hospital admission and discharge and the drugs involved and to evaluate associated risk factors and the potential of the errors to cause harm.	Prospective observational study	841 patients; > 65 years or the receipt of ≥ 5 drugs in their habitual pre-admission treatment.	Admission, discharge	BPMH, medication reconciliation	At least one reconciliation error was detected in 525 (64.5%) patients at admission, with a mean of 2.2 ± 1.3 errors per patient and in 235 (32.4%) patients at discharge.
Curatolo N; 2015; France	To implement and sustain a medication reconciliation (MR) process at admission in the orthopaedic surgery (OS) and gastrointestinal surgery (GS) units	A step by step approach based on PDSA cycles (plan-do-study-act) was adopted in order to gradually test changes and implement a MR process at admission in GS and OS.	Cycle 1: 91 patients, cycle 2: 100 patients, cycle 3: 55 patients; adult patients (more than 18 years old) admitted in OS or GS for an expected length of stay of at least 48 h.	Admission	BPMH, Medication reconciliation	Cycle 1, by showing a rate of 0.65 UMDs at admission (95 % CI 0.39–0.91), underlined the need for a MR process Cycle 2 showed how the close-collaboration between pharmacy and surgery units could help to reduce mean UMDs per patients at admission (0.18; 95 % CI 0.09–0.27) ($p < 0.001$) Cycle 3 allowed the optimization of the MR process by reducing the delays of the best possible medication history availability.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
García-Molina Sáez C; 2016; Spain	To analyse the effectiveness of a computerized pharmaceutical intervention to reduce reconciliation errors at discharge and to characterize the type and seriousness of the errors identified.	Quasi-experimental interrupted time-series study	321 patients; All patients who had been following a course of pharmacological treatment before admission to the cardio-pneumology unit and were discharged from the same in February, March and April 2013 were included.	Admission, discharge	Medication reconciliation	The mean percentage of reconciliation errors per patient in the first period of the study was 42.18%, falling to 19.82% during the intervention period (p= 0.000). When the intervention was withdrawn, the mean percentage of reconciliation errors increased again to 27.72% (p= 0.008). The difference between the percentages of pre- and post-intervention periods was statistically significant (p= 0.000; every period lasted 23 days).
Gallagher J; 2016; Ireland	To perform a cost-effectiveness evaluation of the SPRM/CDSS program (structered pharmacist review of medication/clinical decision support software) based on its application in an RCT in an older population in order to reduce in-hospital ADRs.	RCT	361 (intervention), 376 (control); ≥ 65 years	Admission	Medication history, medication review	SPRM/CDSS strategy was dominant compared with usual pharmaceutical care, showing improved outcomes in terms of ADRs experienced, alongside a reduction in associated costs.
Dufay E; 2016; France	To explore the clinical impact of medication reconciliation and to assess the number of inpatients who had experienced at least one medication error (ME) and the severity of potential harm associated with these MEs detected by medication reconciliation.	Prospective observational study	1670 patients; 65 years and over admitted through the emergency department.	Admission	Medication reconciliation	1799 medication errors were recorded among the 1670 patients subjected to medication reconciliation who were hospitalised from the emergency department. At least one medication error occurred for 744 (44.6%) of these patients.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Lind KB; 2016; Denmark	To investigate the effect of a clinical pharmacist (CP) intervention on length of stay (LOS) in an AAU (Acute Admission Unit).	Prospective, cluster randomised study	232 + 216 = 548 patients; Patients aged ≥18 years, taking ≥4 drugs daily	Admission	Medication reconciliation	The mean LOS was 342 (95% CI 323 to 362) min in the intervention group and 339 (95% CI 322 to 357) min in the control group, which was not statistically significantly different.
Marinović I; 2016; Croatia	To evaluate the clinical pharmacist-led medication reconciliation process in clinical practice by quantifying and analyzing unintentional medication discrepancies at hospital admission.	Observational prospective study	411 patients; Aged 18 years and older and taking at least one regular prescription medication.	Admission	BPMH, medication reconciliation	In 411 patients included in the study, 1200 medication discrepancies were identified, with 202 (16.8%) being unintentional. One or more unintentional medication discrepancy was found in 148 (35%) patients.
Marvin V; 2016; UK	To provide seamless, high-quality medicines reconciliation from admission through to discharge for all patients, and improve communication with community service providers	Qualitative and quantitative improvement project	Unclear (10 patients a week for 18 months)	Admission, discharge	Medication history, medicines reconciliation	Statistical process control analysis showed reliable documentation (complete, verified and intentional changes clarified) of current medication on 49.2% of patients' discharge summaries. This appears to have improved (to 85.2%) according to a poststudy audit the year after the project end.
Renaudin P; 2016; France	To examine the impact of in-hospital pharmacist-led medication reviews in paediatric and adult patients.	Systematic review and meta-analysis	4805 participants; One RCT study has been conducted with children, whereas most studies have been conducted in patients over 65 years of age.	Discharge, follow up	Medication reconciliation, treatment review and medication liaison services	The readmission rates did not differ between the experimental group and the control group (RR= 0.97, 95% CI 0.89; 1.05, p= 0.470).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Bosma BE; 2017; The Netherlands	To determine the effect of the TIM (Transfer ICU Medication reconciliation) program on the number of medication transfer errors (MTEs) at admission to and at discharge from the ICU.	Prospective observational study with a before and after design	133 patients (calculated); Criteria set by study performers must apply	Admission, discharge	BPMH, medication reconciliation	NA
Breuker C; 2017; France	To evaluate the prevalence of ME at admission and discharge of hospitalization in diabetic and non-diabetic patients, and determine their potential clinical impact.	Prospective observational study	904 (admission), 865 (discharge); All patients aged above 18 years old admitted to the department during the study period and hospitalized for at least 24h.	Admission, discharge	BPMH, medication reconciliation	Clinical pharmacists allowed correcting ME in 176/904 (19.5%) patients at admission and in 86/865 (9.9%) patients at discharge.
Gustafsson M; 2017; Sweden	To assess whether comprehensive medication reviews conducted by clinical pharmacists as part of a healthcare team reduce drug-related hospital readmission rates among people with dementia or cognitive impairment.	RCT	460 patients; ≥65 years with dementia or cognitive impairment	Admission, inpatient	Medication reconciliation, medication review, ward rounds	During the 180 days of follow-up, 18.9% (40/212) of patients in the intervention group and 23.0% (50/217) of those in the control group were readmitted for drug-related reasons.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Nielsen TRH; 2017; Denmark	To investigate the clinical effect of a clinical pharmacist (CP) intervention upon admission to hospital on inpatient harm and to assess a potential educational bias.	RCT	593 patients; Adult patients taking ≥4 medications daily	Admission	Medication history, medication reconciliation, medication review and entry of proposed prescriptions into the electronic prescribing system	The CP intervention at admission to hospital had no statistically significant effect on inpatient harm.
Bosma LBE; 2018; The Netherlands	To determine the effect of a medication reconciliation program performed by pharmacists on the proportion of patients with MTEs (medication transfer errors) both at ICU admission and ICU discharge.	Prospective study with a pre- and post-design	266 patients in the pre-intervention and 212 in the post-intervention phase at admission and 203 and 177 at discharge; Patients were included when they used at least one medicine at home and when the ICU length of stay exceeded 24 h.	Admission, discharge	BPMH, medication reconciliation	At admission 45.1% of the patients had at least 1 MTE pre-intervention compared to 14.6% in the post-intervention phase, a reduction of 67.6% (ORadj 0.18 (95% CI 0.11–0.30), adjusted for APACHE IV). At discharge 73.9% of the patients had at least 1 MTE pre-intervention, compared to 41.2% in the post-intervention phase, a reduction of 44.2% (ORadj 0.24 [95% CI 0.15–0.37], adjusted for APACHE IV).
Cheema E; 2018; UK	To update the previous assessment of pharmacist-led medication reconciliation by restricting the review to randomized controlled trials (RCTs) only.	Systematic review and meta-analysis	6038 patients; At least 18 years	Discharge	Medication reconciliation, tailored patient counselling and provision of telephonic advice to patient's post-hospital discharge	Pharmacists-led interventions led to an important decrease in favour of the intervention group, with a pooled risk ratio of 42% (RR 0.58, 95% CI 0.49 to 0.67, p<0.0000) in medication discrepancy.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Juanes A; 2018; Spain	To assess the clinical impact on DNO (drug-related negative outcomes) of a pharmaceutical care programme focusing on the resolution of potential drug-related problems	RCT	118 patients were included, 59 in each group; Criteria set by study performers must apply	Admission, internal (ED), discharge	Medication reconciliation, medicine review	Fewer patients in the intervention group (IG) had drug-related negative outcomes (37 (62.7%) vs 47 (79.7%) in the control group (p= 0.042)). Fewer drug-related negative outcomes per patient occurred in the IG (56 (0.95 per patient) vs 85 (1.44 per patient) in the control group (p= 0.01)).
Leguelinel-Blache G; 2018; France	No specific study aims were provided (only outcomes).	RCT (study protocol)	630 patients, Patients aged at least 65 years hospitalized in one of the participating care units and having given their consent to be called for a 30-day and 90-day follow-up can be enrolled.	Admission	BPMH, medication reconciliation, medication review	NA
Bosma LBE; 2019; The Netherlands	To develop a prognostic multivariable model in patients discharged from the ICU to predict who is at increased risk for potentially harmful medication transfer errors (PH-MTE) after ICU discharge	Cohort study	258 patients	ICU discharge	BPMH, Medication reconciliation	One hundred and sixty-five (64%) patients suffered 383 PH-MTE. Most frequently found MTE after ICU discharge were omissions in home medications (72%). Of these PH-MTE, 66 (17.2%) had a pADE = 0.4 (medium likelihood score) and 2 (0.5%) had a pADE = 0.6 (high ADE likelihood score), resulting in 21.9% of the patients having a medium likelihood of an ADE (0.4≤ pADE<0.6) and 12.7% having a high likelihood of an ADE (pADE≥0.6).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Cebron Lipovec N; 2019; Slovenia	To review the published systematic reviews and meta-analyses investigating the content and effect of pharmacy-supported interventions at transitions of care.	Umbrella review	(162 original studies)	Admission or discharge	Medication reconciliation or composite interventions	A positive effect on either medication discrepancies or (potential) ADEs was observed in all reviews.
Graabæk T; 2019; Denmark	To investigate the effect of a pharmacist-led medicines management model among older patients at admission, during inpatient stay and at discharge on medication-related readmissions.	RCT	600 patients (control (usual care): n=200; ED (intervention): n=200; STAY (intervention): n=200) ; Criteria set by study performers must apply	Admission, inpatient, discharge	Both the ED group and the STAY group received a pharmacist-led medication review (including patient interview and medication reconciliation) on admission. Furthermore, patients in the STAY group transferred to a specialized ward received a medication review during inpatient stay together with patient counselling and a medication report at discharge.	The pharmacist identified 920 medication-related problems with 57% of the recommendations accepted by the physician.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Nachar C; 2019; Switzerland	To assess the feasibility and main obstacles to the implementation of a medication reconciliation (MR) process in a Swiss hospital and to develop a standardised method which can be used in similar healthcare systems.	Prospective, observational single-centre and single-ward study	147 patients; Enrolled patients were hospitalised with symptomatic heart failure (New York Heart Association scoring >I) and discharged home.	Admission, discharge	BPMH, medication reconciliation	At least one discrepancy was identified among 94% of the patients on admission, with 4.1 discrepancies found per patient (mainly omissions). At discharge, 83% of the patients had at least one discrepancy, with 2.3 discrepancies found per patient (mainly unintentional substitutions). The majority (86%) of pharmaceutical interventions to adjust the discharge prescriptions were accepted by the physician.
Schepel L; 2019; Finland	To explore the extent and range of clinical pharmacy services in Finnish hospitals to promote medication safety in 2011 and 2016.	National online survey	(24 hospital pharmacies)	Admission	Drug information to ward personnel, medication reconciliation, inducting ward personnel, and developing the medication-use process	Clinical pharmacy services were provided by 51% of the responding units in 2011, whereas by 85% in 2016.
De Lorenzo-Pinto A; 2020; Spain	To determine if an advanced medication review carried out in the emergency department (ED) increases the number of pharmacotherapy recommendations (PR) and the severity of the detected prescribing errors.	Analytic observational prospective cohort study	102 patients; All adult patients hospitalised through the ED with at least one pharmacotherapy recommendation (PR) were included.	Admission	Pre: prescription review, Post: advanced medication review	In the PRE phase, the number of PR per patient was 1.1, and in the POST phase, this value increased by 53% to 1.7 PR per patient (p= 0.014), especially in the case of PR related to home medications. The physician acceptance rate was 87.9% in the PRE phase and 93% in the POST phase. The severity of prescribing errors was higher in the POST phase (p= 0.004).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Ceschi A; 2021; Switzerland	To assess the impact of medication reconciliation at hospital admission on a composite postdischarge health care use variable.	RCT	1702 patients; Aged 85 years or older, with more than 10 medications at hospital admission, or meeting both conditions.	Admission	BPMH, medication reconciliation	In time-to-event analyses at study closeout, unplanned all-cause hospital visits to the ED occurred similarly in the intervention and control groups (p= 0.08).
Jošt M; 2021; Slovenia	To evaluate the impact of pharmacist-led medication reconciliation at hospital admission on medication errors (ME) and adverse drug events (ADEs) in a hospital in a Central Eastern European country.	RCT	120 patients; The study included adult patients admitted to general medical wards and regularly taking at least one medication.	Admission	BPMH, medication reconciliation	There were no differences between the intervention and control group in the occurrence of unintentional discrepancies (p= 0.481) or adverse drug events (p= 0.801).

Supplementary Table 3 Europe (Admission): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Admission Europe	YES	NO	UNCLEAR	NA	Outcome	Comment
Galvin M; 2013; Ireland	✓				Unintentional discrepancies	
Leguelinel-Blache G; 2014; France	✓				Patients with at least one UMD	
Curatolo N; 2015; France	✓				UMDs	
Gallagher J; 2016; Ireland	✓			✓	ADRs; Associated costs	
Dufay E; 2016; France			✓		Medication errors	No comparison
Lind KB; 2016; Denmark				✓	Number of documented medications; LOS (length of stay), Physician time	
Marinović I; 2016; Croatia			✓		Medication discrepancies	No comparison
Nielsen TRH; 2017; Denmark		✓			CP (Clinical Pharmacist) intervention	Comparison, no statistical significance
Leguelinel-Blache G; 2018; France					NA	Study protocol
Schepel L; 2019; Finland			✓		Clinical pharmacy services	Services were offered more frequently, but it is not evident whether this led to an improvement in drug therapy safety
De Lorenzo-Pinto A; 2020; Spain	✓		✓		PR rate (Pharmacotherapy recommendation), Physician acceptance rate, Severity of prescribing errors	Severity of prescribing errors: increased in post phase, but unclear if statistically significant
Ceschi A; 2021; Switzerland			✓	✓	ADEs, Proportion of patients with unplanned all-cause hospital visits within 30 days after initial discharge	ADEs: Unclear if statistically significant
Jošt M; 2021; Slovenia		✓			Occurrence of unintentional discrepancies, Occurrence of adverse drug events	

Supplementary Table 4 Europe (Discharge): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Discharge Europe	YES	NO	UNCLEAR	NA	Service	Comment
Cheema E; 2018; UK	✓	✓		✓	Medication discrepancies, Potential/Preventable ADEs; Healthcare utilization	Medication discrepancies, Potential/Preventable ADEs, Healthcare utilization: comparison between groups

Supplementary Table 5 Studies from North America / Canada; (ScR = Scoping Review)

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Buckley MS; 2013; USA	To determine the incidence of unintended admission medication discrepancies resolved by clinical pharmacists	Single-center, prospective, observational study	517 patients; Criteria set by study performers must apply	Admission	Medication reconciliation	More than 25% (n = 132) of patients had at least 1 error associated with a medication ordered on hospital admission. Pharmacists resolved a total of 467 admission medication errors (3.5 ± 2.3 errors/patient).
Eisenhower C; 2013; USA	To determine whether pharmacist-conducted medication reconciliation at discharge decreased medication discrepancies, leading to a corresponding reduction in 30-day all-cause readmission rates for patients aged 65 years and older with COPD (chronic obstructive pulmonary disease)	Not stated	29 patients; 65 years and older admitted for a COPD exacerbation	Discharge	Medication reconciliation	Pharmacist-conducted medication reconciliation at discharge decreased discrepancies for elderly patients admitted for exacerbation of COPD. The 30-day readmission rate was lower than the baseline rate (16.0% vs 22.2%). When comparing admissions with readmissions, a slight reduction in average length of stay and slight increase in cost was observed. A statistical significance was not reported.
Farley TM; 2014; USA	To determine if involving clinical pharmacist case managers in hospital care and discharge medication plan communication could reduce medication discrepancies after hospital discharge.	Prospective, randomized, blinded, controlled trial	592 patients; Criteria set by study performers must apply	Admission, discharge, follow up	Medication reconciliation (admission and discharge), Enhanced intervention: + discharge care plan and telephone call after discharge	The mean number of medication discrepancies per patient for the enhanced group being nearly half the number in the control group. However, this effect did not persist to 90 days post-discharge and did not extend to community pharmacy records.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Anderegg SV; 2014; USA	The impact of an innovative medication reconciliation and discharge education program on 30-day readmissions and emergency department (ED) visits was evaluated. The primary outcome was the composite of rates of readmissions and return to ED visits within 30 days of discharge.	Observational pre–post analysis	3316 patients; unclear	Admission, discharge	(1) medication reconciliation at transitions of care for every patient and discharge education for a high-risk subgroup, (2) new or expanded services in the preanesthesia testing clinic and ED, (3) a medication reconciliation technician team, and (4) pharmacist-to-patient ratios of 1:30 on acute care floors and 1:18 on critical care units.	No significant difference was observed between the preimplementation and postimplementation groups with regard to the primary outcome. It was estimated that potential annual savings associated with the observed reduction in ED visits (although it did not reach statistical significance) would comprise $16,146 in direct cost savings and $24,656 in total cost savings over the course of one year.
Wanbon R; 2015; Canada	To describe the current status of pharmacy services in Canadian EDs and potential barriers to implementing pharmacy services in this setting.	National survey	243 sites	Various	Order clarification, troubleshooting, medication reconciliation, and assessment of renal dosing were the services most commonly provided.	The large majority of pharmacy managers and ED managers identified the need for ED pharmacy services where such services do not yet exist
Sebaaly J; 2015; USA	The aim of this pilot study was to evaluate the accuracy of current admission medication reconciliation practices as well as the clinical and financial impact of a pharmacist verification of discharge medication reconciliation after completion by the discharge provider.	Prospective, cross-sectional pilot study	77 patients; Over 18 years, discharged from Monday to Friday	Admission, discharge	Medication review	Pharmacists performed 67 discharge medication reviews and identified 84 errors. Seventy-five percent were considered to be significant and 6% were considered to be serious.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Balling L; 2015; USA	The purpose of this quality improvement project was to assess the impact of a transition-of-care pharmacist during hospital discharge.	Not stated	1058 discharges	Discharge	Medication reconciliation; The pharmacist attended interdisciplinary discharge coordination meetings, ensured appropriate discharge orders, facilitated the filling of medications, and educated patients on discharge medications.	There were more readmissions per month in the control year versus the year of pharmacist involvement (median 27.5 vs. 25, p= 0.0369).
Bishop MA; 2015; USA	To determine whether inclusion of a pharmacist in the discharge medication reconciliation process identifies and corrects discrepancies.	Prospective, observational study	104 patients; Criteria set by study performers must apply	Discharge	Medication reconciliation	43/104 patients (41% (95% CI 32, 51)) had at least one medication discrepancy. There was a strong association with the number of discharge medications and the likelihood of a discrepancy (OR 8.5, *p*= <0.001 (95% CI 2.8, 25.5)).
Trang J; 2015; USA	To describe the impact of a pharmacist-led TCS (transition of care service) on acute health care utilization, clinic quality indicators, and identification and resolution of medication-related problems (MRPs).	Pilot study	30 patients; Criteria set by study performers must apply	Discharge, follow up	Medication reconciliation, medication review	The study shows that implementation of a pharmacist- managed transition of care service (TCS) can decrease acute health care utilization and improve clinic quality indicators such as blood pressure and glucose control. Pharmacists can also identify and resolve medication-related problems (MRPs) during key points in care transitions.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Cavanaugh JJ; 2015; USA	To compare hospital readmission rates and interventions in a multidisciplinary team visit coordinated by a clinical pharmacist practitioner with those conducted by a physician-only team within an internal medicine hospital follow-up program	Retrospective observational study	140 patient visits; A convenience sample of patients discharged from UNC Hospitals and seen in the UNC Internal Medicine Clinic (University of North Carolina) follow up program between May 2012 and January 2013 were included in this study.	Discharge	Medication review	Patients seen by the multidisciplinary team had a 30-day readmission rate of 14.3% compared with 34.3% in the physician-only team (P=0.010).
Philbrick AM; 2015; USA	To describe the number of medication discrepancies associated with subsequent medication reconciliations by a clinical pharmacist	Not stated	500 patients; Older than 18 years, had 10 or more medications on their electronic health record (EHR) medication list, and had not had a pharmacist-performed medication reconciliation in the prior 6 months.	Discharge	Medication reconciliation	Medication reconciliation was performed 752 times for 500 patients. A total of 5,046 discrepancies were identified, with more than one-half deemed clinically important. A mean (± SD) of 6.7 ± 4.6 discrepancies per visit (3.5 ± 3.2 clinically important) were identified.
Hohner E; 2016; USA	The implementation of an emergency department (ED)–based clinical pharmacist transitions-of-care (TOC) program is described.	Not stated	18 program participants; Patients with exacerbation of asthma, chronic obstructive pulmonary disease (COPD), or congestive heart failure (CHF).	Discharge (from ED)	Medication review	5 patients successfully followed up with a pharmacist after ED discharge. The mean time from the ED visit to follow-up for these 5 patients was 16.6 ± 8.6 days.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Hohl CM; 2017; Canada	To expand access to early in-hospital pharmacist-led medication review for high-risk patients to ensure prompt identification and treatment of adverse drug events and to optimize medications early within the hospital stay.	Pragmatic prospective controlled quality improvement evaluation study/Quasi-randomized design	10,807 high-risk patients, of whom 6,416 received medication review in the emergency department, and 4,391 usual care; Criteria set by study performers must apply	Admission	BPMH, medication review	The median number of hospital days was reduced by 0.48 days (95% confidence intervals [CI] = 0.00 to 0.96; p= 0.058) in the medication review group compared to usual care. Among patients under 80 years of age, the median number of hospital days was reduced by 0.60 days (95% CI = 0.06 to 1.17; p= 0.03). There was no significant effect on emergency department revisits, admissions, readmissions, or mortality.
Bagwell A; 2017; USA	Not specified	Not stated (Best practice paper)	Not specified	Admission	Lab review, complete patient assessment; specialty medications	Improved patient outcomes are demonstrated, validating the success and benefits of this specialty pharmacy model.
Feih J; 2017; USA	The effect of a pharmacist on a rapid response team (RRT) was investigated.	Retrospective, quasi-experimental study	This study evaluated 234 patients before and 157 patients after pharmacist involvement on an RRT; at least 18 years of age who experienced an RRT event between August and October 2012 (preinterventional group) or between March and May 2013 (postinterventional group).	Admission	Assist in review of the electronic medical record (EMR) for pertinent information (e.g., laboratory values, recent medication changes and administration), ensure appropriate medication prescribing, and expedite medication preparation and delivery when necessary.	The primary outcome, median time to medication administration from central pharmacy, was lower in the postinterventional group compared with the preinterventional group (32.0 minutes versus 64.5 minutes, p= 0.004). ICU admission rates following rapid response were not significantly different between the two groups.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Genord C; 2017; USA	This paper summarizes a pharmacist-led OEP (Opioid Exit Plan) practice model and the potential role that pharmacists and student pharmacists can have at the point of admission, during postoperative recovery, and on discharge in acute pain management patients.	Not stated	Unclear; The target patient populations for the pharmacist-led OEP were initiated in 3 different surgery areas based on various reasons	Admission, internal, discharge, follow up (colorectal)	Medication reconciliation, developing inpatient postoperative treatment plans, discharge counselling, follow up: pharmacist performs a medication evaluation.	A hospital pain management team operating a pharmacist-led OEP can be key to guiding the appropriate prescribing practice of opioids and assisting with transitions of care on discharge. Further outcomes-based evaluations of the practice model are planned and encouraged to validate and improve the pharmacist-led OEP practice.
Milfred-LaForest SK; 2017; USA	To perform a pilot evaluation of a pharmacist-led, multidisciplinary transitional care clinic for heart failure (HF) patients.	Pilot study	135 patients; ≥18 years, patients with HF	Discharge, follow up	Medication reconciliation	Medication discrepancies were detected in 53% of patients. Medications were optimized in 70%.
Jones CD; 2018; USA	1) To determine the feasibility of using a readmission risk score integrated into our electronic health record to identify patients for a pharmacist-led transitions of care (TOC) intervention, and 2) evaluate the feasibility and effect of the pharmacist-led TOC pilot on process measures and rehospitalization and ED visits at 30 and 90 days.	Pilot study	34 patients (intervention), 34 patients (control); Parkland readmission risk score (≥10), ≥ 18 years, plans for discharge	Admission, discharge, follow up	Medication history, admission and discharge medication reconciliation, discharge medication counselling; follow up telephone call	Readmission rates in pilot versus non-pilot patients, respectively, were 18% versus 24% (p= 0.547) at 30 days and 27% versus 39% (p= 0.296) at 90 days. The composite outcome of a readmission or ED visit in pilot versus nonpilot patients was 24% versus 30% (p= 0.580) at 30 days and 36% versus 49% (p= 0.319) at 90 days.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Brantley AF; 2018; USA	The development and implementation of a hospital wide, pharmacist-led transitions-of-care (TOC) program are described.	Prospective, single-center, quality improvement initiative	661 patients; All patients over the age of 18 admitted to the inpatient telemetry unit were included in this initiative.	4 phases of inpatient services (admission, inpatient, discharge medication reconciliation review, and discharge counselling) and a fifth component that included telephone follow-up 72 hours after discharge.	Medication reconciliation, medication review	A pharmacist completed 94% and 75% of admission and discharge medication reviews. A total of 1,579 interventions were documented—1,305 upon admission, and 274 upon discharge—for an average of 2.4 interventions per patient. The most common intervention categories documented for admission/discharge medication reconciliation were the addition of medications, removal of medications, and frequency clarifications. Patient and caregiver education on discharge was completed on 73% of patients.
Moye PM; 2018; USA	To determine whether pharmacy team–led post discharge intervention can reduce the rate of 30-day hospital readmissions in older patients with heart failure (HF)	Single-center cohort study	177 patients (97 intervention, 80 control); 60 years of age or older who were admitted to an academic medical center with a primary diagnosis of HF.	Discharge, follow up	Compile list of home medication and compare to inpatient medication orders à medication reconciliation; patient education, medication record, follow up phone calls	Twelve of 97 patients in the intervention group (12%) and 20 of 80 patients in the control group (25%) were readmitted to the hospital within 30 days of discharge (p= 0.03); 11 patients in the control group (55%) and 7 patients in the intervention group (58%) had HF-related readmissions (p= 0.85).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
McCarthy LM; 2019; Canada	To describe the Pharmacy Communication Partnership (PROMPT) program's approach to improving medication management for patients during transitions from hospital to the community	Multimethod cross-sectional study	100 patients; Criteria set by study performers must apply	Admission, discharge, follow up	Facilitate communication between pharmacists in different settings: faxing of the discharge prescription and medical discharge summary to a patient's community pharmacy, followed by a telephone call to the community pharmacist	The majority of community pharmacists (99%; n= 79/80) participating in the surveys considered the intervention to be helpful.
Bloodworth LS; 2019; USA	To improve the care of patients discharged from the University of Mississippi Medical patients discharged from the University of Mississippi Medical Center (UMMC) after treatment for AMI, HF, PNA, or COPD (acute myocardial infarction, heart failure, pneumonia or chronic obstructive pulmonary disease)	Prospective, randomized controlled trial	96 patients (intervention), 160 patients (control); Criteria set by study performers must apply	Discharge	Medication reconciliation	Positive outcomes in overall reduced readmission rates were observed in the intervention group at 30, 60, 90, and 180 days, although statistical significance was not achieved because of limited enrolment.
Campbell MJ; 2019; USA	To describe the scope of direct patient care services provided by EM (emergency medicine) pharmacists in an academic medical center.	Retrospective, single-center, chart review	3567 direct patient care activities	Admission	Facilitation of medical histories; drug therapy recommendations	The most common activities were facilitation of medication histories (n=1300) and drug therapy recommendations (n=1165).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Fosnight S; 2020; USA	Unclear	Not stated	284 patients	Admission, internal, discharge, follow up (if necessary)	Medication history verification using 2 sources (pharmacy assistant); comprehensive medication review; an adherence interview; collaboration with prescribers to clarify reconciliation issues and to optimize therapy; addressing medication adherence barriers; new medication counselling, with verification of affordability; discharge reconciliation, with just-prior-to-discharge medication counselling; flagging patients for follow-up; and a postdischarge phone call to those patients who were flagged for follow-up.	When comparing metrics for all intervention patients to baseline metrics from the same months of the previous year, the readmission rate was decreased from 21.0% to 15.3% and mean length of stay decreased from 5.3 days to 4.4 days.
Loborec SM; 2020; USA	Evaluating the impact of privileging pharmacists to manage microbiologic test results for patients discharged from the emergency department (ED)	Single-center, retrospective pre-post study	The pre-implementation group yielded 92 results, whereas the postimplementation group had 86 results, which were included in the analysis; At least 18 years of age and discharged from the ED with subsequent positive microbiologic tests.	Discharge	Microbiologic test screening	1.1% of reviewed microbiologic test results (1 of 92) was erroneous prior to implementation of pharmacist privileging compared with 2.3% (2 of 86) after implementation (p= 0.6105).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Martirosov AL; 2020; USA	To describe the activities of critical care and ambulatory care pharmacists in a multidisciplinary transitions-of-care (TOC) service for critically ill patients with pulmonary arterial hypertension (PAH) receiving PAH medications	Retrospective chart review–based study	Unclear; Patients admitted to any ICU area who were prescribed a medication for treatment of PAH	Admission, discharge	Medication history, telephone follow up	Collaboration by a PAH multidisciplinary team, critical care pharmacist, and ambulatory care pharmacist can improve TOC related to PAH medication access for patients with PAH.
Miller D; 2020; USA	Preventing 30-day readmissions	Pilot studies	3,711 patients in the PTOC (Pharmacy Transitions of Care) group and 2,160 patients in the non-PTOC group; Medicare beneficiaries 65 years of age or older who were discharged to a home setting or assisted living facility with a core-measure disease state.	Discharge, follow up	Medication reconciliation, telephonic follow up	Reduction in 30-day readmissions.
Lineberry E; 2021; USA	To develop a real-time notification system within the electronic health record (EHR) for targeted discharge prescription review, to establish an associated emergency medicine pharmacist (EMP) workflow, and to evaluate the intervention rate achieved through targeted discharge prescription review.	Single-center, retrospective review	378 prescriptions	Discharge	Prescription review	EMPs reviewed 378 discharge prescriptions and a total of 158 prescriptions were identified as having at least one medication-related problem (MRP). Of these, 70 prescriptions were intervened upon thereby resulting in an 18.5% intervention rate.

Supplementary Table 6 North America / Canada (Admission): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Admission North America and Canada	YES	NO	UNCLEAR	NA	Outcome	Comment
Buckley MS; 2013; USA			✓		Medication errors	No comparison and it is not noted if the improvements were accepted
Hohl CM; 2017; Canada				✓	LOS (length of stay), Emergency department revisits, admissions, readmissions or mortality	Emergency department revisits, admissions, readmissions or mortality: no statistical significance
Bagwell A; 2017; USA				✓	Patient outcomes	Patient outcomes seem to have been improved, but no exact data on this
Feih J; 2017; USA				✓	Time to medication administration, ICU admission rates, Rates of medical emergency, Survival to hospital discharge	Time to medication administration has improved
Campbell MJ; 2019; USA			✓		Interventions (medication histories or drug therapy recommendations)	No comparison

Supplementary Table 7 North America (Discharge): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Discharge North America	YES	NO	UNCLEAR	NA	Outcome	Comment
Eisenhower C; 2013; USA	✓			✓	Medication discrepancies; 30-day readmission rate, LOS, Costs	30-day readmission rate: lower than baseline rate; LOS: not statistically significant; Costs: not statistically significant
Balling L; 2015; USA				✓	Readmissions per month	Lower in the control year vs. intervention year
Bishop MA; 2015; USA			✓	✓	Medication discrepancies; LOS	Medication discrepancies: no comparison; LOS: with discrepancies longer stay
Cavanaugh JJ; 2015; USA				✓	30-day hospital readmission, Medication interventions	30-day hospital readmission: compared with physician-only team; Medication interventions: similar between the groups
Philbrick AM; 2015; USA		✓			Clinically important discrepancies	Not statistically significant
Hohner E; 2016; USA					NA	Implementation of a TOC program is described
Bloodworth LS; 2019; USA				✓	Readmission rates at 30, 60, 90 and 180 days	Not statistically significant
Leary MH; 2019; USA				✓	LOS, Readmission rate	LOS und readmission rate: comparison pre vs. post group

Discharge North America	YES	NO	UNCLEAR	NA	Outcome	Comment
Loborec SM; 2020; USA				✓	Time to patient notification, Erroneous microbiologic test results	Time to patient notification: comparison; Erroneous microbiologic test results: not statistically significant
Lineberry E; 2021; USA			✓		MRPs (medication related problems)	Unclear if interventions were accepted

Supplementary Table 8 Studies from Australia and Asia; (ScR = Scoping Review)

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Elliott RA; 2013; Australia	To investigate the impact of pharmacist medication review, together with an educational intervention targeting inpatient clinical pharmacists and junior (intern and resident) medical officers (JMOs).	Before-after study	391 patients: 186 in the pre-intervention (usual care) group and 205 in the intervention group; 60 years and over who were discharged from the participating wards during the study periods.	Admission, inpatient, discharge	Medication reconciliation (admission and discharge), medication chart review (inpatient)	The mean increase in Medication Regimen Complexity Index (MRCI) score between admission and discharge was significantly smaller in the 205 intervention patients than in the 186 usual care patients (2.5 vs. 4.0, p= 0.02; adjusted difference 1.6, 95 %CI 0.3, 2.9).
Briggs S; 2015; Australia	To determine whether an experienced clinical pharmacist reviewing the medications of older patients in an ED setting could reduce hospital admissions	RCT	1021 patients were randomized; Criteria set by study performers must apply	Admission	Medication review	Lower admission rate (intervention group compared to control group).
Khalil V; 2016; Australia	To implement and evaluate the impact of a pharmacist-led admission medication reconciliation and charting service in a metropolitan hospital in an electronic medication management environment.	Prospective, parallel study	110 patients; Criteria set by study performers must apply	Admission	BPMH, medication reconciliation	Error rates per patient decreased significantly from 4.41 in the control group to 0.52 in the intervention group (relative reduction 88%; $p < 0.0001$). Error rates per medication order also decreased significantly from 0.43 in the control group to 0.05 in the intervention group (relative reduction 89%; $p < 0{\cdot}005$).

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Mekonnen AB; 2016; Australia	To investigate the available evidence regarding the impact of pharmacy-led medication reconciliation interventions in minimizing medication discrepancies at hospital transitions and to categorize these according to the target of the interventions (single transition interventions, multiple transition interventions).	Systematic review and meta-analysis	15 525 adult patients; Most studies recruited high-risk patients (including elderly patients, patients with multiple medications and patients at risk of medication-related events).	Admission, discharge, multiple transitions	BPMH (a few studies), medication reconciliation, medication review after medication reconciliation (some studies), electronic medication profile communication between community and hospital pharmacies (one study)	Pharmacy-led medication reconciliation programmes have an effect in minimizing medication discrepancies at hospital transitions. Meta-analysis has shown a substantial reduction of 66% in patients with medication discrepancies favouring the intervention carried out at single transitions (either admission or discharge). But, interventions targeting multiple transitions did not show a difference between the intervention and usual care groups.
Mekonnen AB; 2016; Australia	To systematically investigate the effect of pharmacist-led medication reconciliation programmes on clinical outcomes at hospital transitions	Systematic review and meta-analysis	21 342 patients; Most studies recruited high-risk patients (including elderly patients, patients with multiple medications and patients at risk of medication-related events). Five studies focused on a specific patient population, mainly patients with heart failure and chronic obstructive pulmonary disease (COPD).	Multiple transitions or discharge	Some studies compared comprehensive medication reconciliation programmes, for example, multifaceted interventions including telephone follow-up and/or home visit and patient counselling or both telephone/home visit and patient counselling. After medication reconciliation, a few studies additionally included a formal medication review.	The pooled relative risks showed a more substantial reduction of 67%, 28% and 19% in adverse drug event-related hospital revisits (RR 0.33; 95% CI 0.20 to 0.53), emergency department (ED) visits (RR 0.72; 95% CI 0.57 to 0.92) and hospital readmissions (RR 0.81; 95% CI 0.70 to 0.95) in the intervention group than in the usual care group, respectively.

Study author; (year); country	Aims and objectives (as stated by author)	Method of data collection (as stated by the author)	Participants (No.); Description of participants as stated	Interface	Service(s)	Key findings (relevant to this ScR objective)
Athuraliya N; 2017; Australia	To investigate the use of the AMHF (Admission Medication History Form) in acute medical wards of two hospitals.	Cross-sectional study	316 patients at John Hunter Hospital (with medication review 72 patients), 159 patients at Calvary Mater Newcastle (with medication review 37 patients)	All transfer of care points from admission to discharge of hospital	Medication review using AMHF	AMHF use in the medical wards of the two teaching hospitals was low, with use in less than 25% of admitted medical patients and around 40% of the doctors unaware of the form.
Tong EY; 2017; Australia	To evaluate whether pharmacists completing the medication management plan in the medical discharge summary reduced the rate of medication errors in these summaries.	RCT	832 patients; Only patients discharged during the pharmacists' working hours were included.	Discharge	Discharge summary medication management plans	Pharmacists completing medication management plans in the discharge summary significantly reduced the rate of medication errors (including errors of high and extreme risk) in medication summaries for general medical patients.
Choi YJ; 2019; Korea	To evaluate the effects of pharmacy-led medication reconciliation in minimizing medication errors and potential ADEs (PADEs) in patients receiving care in the ED based on currently available evidence.	Systematic review and meta-analysis	6893 patients; no limitations	Admission	Medication reconciliation or medication history services	Unlike usual care, pharmacy-led medication reconciliation significantly reduced the proportion of patients with medication discrepancies by 68% (response rate 0.32; 95% confidence interval (CI): 0.19-0.53, p< .0001) and the number of medication discrepancy events by 88% (response rate 0.12; 95% CI 0.06-0.26, p< .00001).

Supplementary Table 9 Australia and Asia (Admission): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Admission Australia and Asia	YES	NO	UNCLEAR	NA	Outcome	Comment
Briggs S; 2015; Australia				✓	Admission rate	
Khalil V; 2016; Australia	✓				Error rates per patient, Error rates per medication	Significant reduction in the intervention group
Canning ML; 2018; Australia				✓	Comparator medication histories (CMH) and BPMH comparison --> medication reconciliation	Key performance indicators
Choi YJ; 2019; Korea	✓				Medication discrepancies, Medication discrepancy events	

Supplementary Table 10 Australia (Discharge): This table gives an overview if an improvement in medication safety was achieved or not; (NA = not applicable)

Discharge Australia	YES	NO	UNCLEAR	NA	Outcome	Comment
Tong EY; 2017; Australia			✓		Medication errors	Unclear if interventions were accepted

Supplementary Table 11 References of all 65 included articles sorted by continents and year of publication

Europe

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