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The impact of hospital-based post-discharge pharmacist medication review on patient clinical outcomes: A systematic review

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ABSTRACT

Background: Clinical pharmacists have been shown to identify and resolve medication related problems post-discharge, however the impact on patient clinical outcomes is unclear.
Aims: To undertake a systematic review to identify, critically appraise and present the evidence on post-discharge hospital clinics that provide clinical pharmacist medication review; report the patient clinical outcomes measured; and describe the activities of the clinical pharmacist.
Methods: Published studies evaluating a patient clinical outcome following a post-discharge hospital clinic pharmacy service were included. All studies needed a comparative design (intervention vs control or comparator). Pubmed, Embase, CINAHL, PsycnINFO, Web of Science, IPA and APAIS-Health databases were searched to identify studies. The type of clinic and the clinical pharmacist activities were linked to patient clinical outcomes.
Results: Fifty-seven studies were included in the final analysis, 14 randomised controlled trials and 43 non-randomised studies. Three key clinic types were identified: post-discharge pharmacist review alone, inpatient care plus post-discharge review and post-discharge collaborative clinics. The three main outcome metrics identified were hospital readmission and/or representation, adverse events and improved disease state metrics. There was often a mix of these outcomes reported as primary and secondary outcomes. High heterogeneity of interventions and clinical pharmacist activities reported meant it was difficult to link clinical pharmacist activities with the outcomes reported.
Conclusions: A post-discharge clinic pharmacist may improve patient clinical outcomes such as hospital readmission and representation rates. Future research needs to provide a clearer description of the clinical pharmacist activities provided in both arms of comparative studies.

1. Introduction

Transitions of care increase the risk of patients experiencing medication related problems (MRPs). This is in part due to patients commonly experiencing multiple medication changes during their hospital admission,[1,2] and poor or inaccurate communication about these changes at discharge between healthcare providers and/or the patient.[3,4] MRPs are common after discharge from hospital,[5,6] which can lead to patients experiencing adverse drug events (ADEs), medication-related harm, and readmission to hospital.[7–10] The risk of readmission due to worsening health or medication-related harm is approximately three times higher in patients with chronic conditions, impaired renal function, previous history of an ADE and those taking multiple medications.[4,11–14]

The rate of hospital readmissions due to MRPs ranges from 3 to 64% (median 21%), and up to 64% of these have been considered potentially preventable.[15,16] Improving medication management in the post-discharge period is likely to reduce hospital readmissions; a key health service target to improve health outcomes and reduce healthcare costs.[11,16–20] A recent randomised controlled trial (RCT) of a collaborative pharmacist-general practitioner review within 7 days of hospital discharge demonstrated a significant reduction in the rate of hospital readmissions and representations.[21] Similarly, a recent meta-analysis by Tomlinson *et al* demonstrated telephone follow-up after discharge from

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hospital is associated with reduced hospital readmissions.[22] This study however, did not exclusively focus on pharmacist-led interventions, the telephone follow-up services varied, and interventions did not necessarily include clinical pharmacist medication review.

A meta-analysis by Mekonnen *et al*, demonstrated that pharmacist-led medication reconciliation and/or medication review and/or patient education at hospital transitions of care (admission or discharge to hospital) reduced all-cause readmissions, all-cause representations, and composite ADE-related hospital readmission and representations.[23] Likewise, a systematic review exploring the role of the pharmacist in reducing hospital readmissions found medication therapy management (MTM) or pharmacist-led care coordination resulted in patients being less likely to be readmitted.[18] However, these two studies focused on clinical pharmacist activities provided predominantly during hospitalisation.

An area of emerging service implementation and research is post-discharge models of pharmacy care. These pharmacy services are offered within a variety of healthcare settings including community pharmacies, primary care, ambulatory care or home-based services, with varying effects on patient clinical outcomes.[24–28] A recent approach to post-discharge clinical pharmacy models is a hospital or healthcare service located post-discharge clinic. However, in the literature there is limited consensus on the patient clinical outcomes reported and the impact of the clinical pharmacist in this post-discharge clinic based setting. In particular, there is a lack of clarity of which clinical pharmacist activities are important when implementing such services. To address this gap in the literature we conducted a systematic review to identify the outcomes reported and the clinical pharmacists' activities described.

The aim of this systematic review is to identify, critically appraise and present the evidence on post-discharge hospital clinics that provide clinical pharmacist medication review, their reported patient clinical outcomes, and describe the clinical pharmacist activities undertaken during the review.

2. Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[29] The online systematic review platform Covidence was used to manage the screening and review of included studies.[30] The protocol was registered with the international prospective register of systematic reviews (PROSPERO; CRD42018086431).[31]

2.1. Search strategy

The Pubmed, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsychINFO, Web of Science, International Pharmaceutical Abstracts (IPA) and Australian Public Affairs Information Service – Health (APAIS-Health) databases were searched from 01/01/1990 to 20/10/2020. Search terms and keywords were identified in discussion by the authorship team. A librarian assisted with designing the search strategy. The search strategy was designed in Pubmed using the following medical subject heading terms and text words: *medication therapy management, pharmacists, pharmacy, patient discharge, outpatients, hospital outpatient clinics, ambulatory care, medicine*, medication*, review*, service*, reconcil*, follow up, clinic(s), and pharmaceutical.* Synonymous terms combined with words for pharmacist, follow up, post discharge and clinics were also used (see Appendix 1 for detailed search terms). Search terms were adapted according to the capabilities of each particular database.

After removal of duplicates and screening titles, two reviewers (JC and, NC or HF) independently screened and evaluated the remaining abstracts for full-text review. Disagreement between reviewers was resolved through discussion and if required, by seeking advice from a third reviewer (MB).

2.2. Types of studies, intervention, and outcomes included

Experimental studies, both randomised and non-randomised, that reported a patient clinical outcome (such as hospital readmission or representation) as a primary or secondary outcome were eligible for inclusion in the systematic review. Study characteristics included patients who received a medication review by a clinical pharmacist, delivered in a post-discharge hospital clinic or clinic setting with access to inpatient medical records. This systematic review defines medication review as 'a structured evaluation of patients' medicines with the aim of optimising medicines use and improving health outcomes.[32] Studies that described medication reconciliation only as the clinical pharmacist intervention were excluded. Likewise, studies that described medication review undertaken by other health care professionals such as medical officers or nurses were also excluded. Patient clinical outcomes were defined as hospital readmissions or representations, adverse events (AEs) and ADEs or disease state metrics. The term 'clinical pharmacist' is used to refer to pharmacist activities extending beyond the review of a single medication or the medication supply role of the pharmacist.

Included studies were those that utilised a telephone or virtual review method as well as face to face clinic appointment or a combination of these. Eligible studies included an intervention and control or comparator design, therefore descriptive studies were excluded. Studies published from 01/01/1990 when the concept of pharmaceutical care became widely described, through to 20/10/2020 were included. Only full-length original articles published in English were included. Reference lists of all included reports were reviewed for additional relevant publications. Studies involving paediatrics, cancer care and mental health were excluded.

2.3. Data extraction and synthesis

One author (JC) extracted data from included studies entering the data into Microsoft Excel™. The extracted data included general information (first author, year of publication); study design; patient characteristics (sample size, gender, age); method (inclusion and exclusion criteria, control or comparator or usual care, clinical pharmacist activity components, co-involved healthcare provider(s)); study outcomes; and conclusions.

The risk of bias assessment was undertaken by two reviewers (JC and, NC or HF) using the Cochrane tool for assessing risk of bias (RoB), RoB 2.0 for randomised controlled trials (RCTs),[33] and the Risk Of Bias In Non-randomised Studies – of Interventions (ROBINS-I) for non-randomised studies.[34] Disagreement between reviewers was resolved by seeking advice from a third reviewer (MB).

3. Results

3.1. Study selection

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram (Fig. 1) shows the selection process for eligible studies. A total of 18,173 were identified and after the removal of duplicates, 11,346 citations were screened and 10,729 were excluded. One article was identified through other sources and included for full-text review. Of the 617 full-text articles that were reviewed, 57 were included in the final analysis. Just over half of the studies (31/57) achieved a statistically significant improvement in at least one patient outcome,[24,28,35–62] most commonly readmission to hospital.

3.2. Study design and characteristics

A summary of study characteristics and outcomes is provided in Tables 1a and 1b. The studies originated from eight different countries: one each from Brazil,[39] Denmark,[63] Ireland,[50] Northern Ireland,[51] and Vietnam[64]; two studies were from the United Kingdom (UK)[65,66]; three

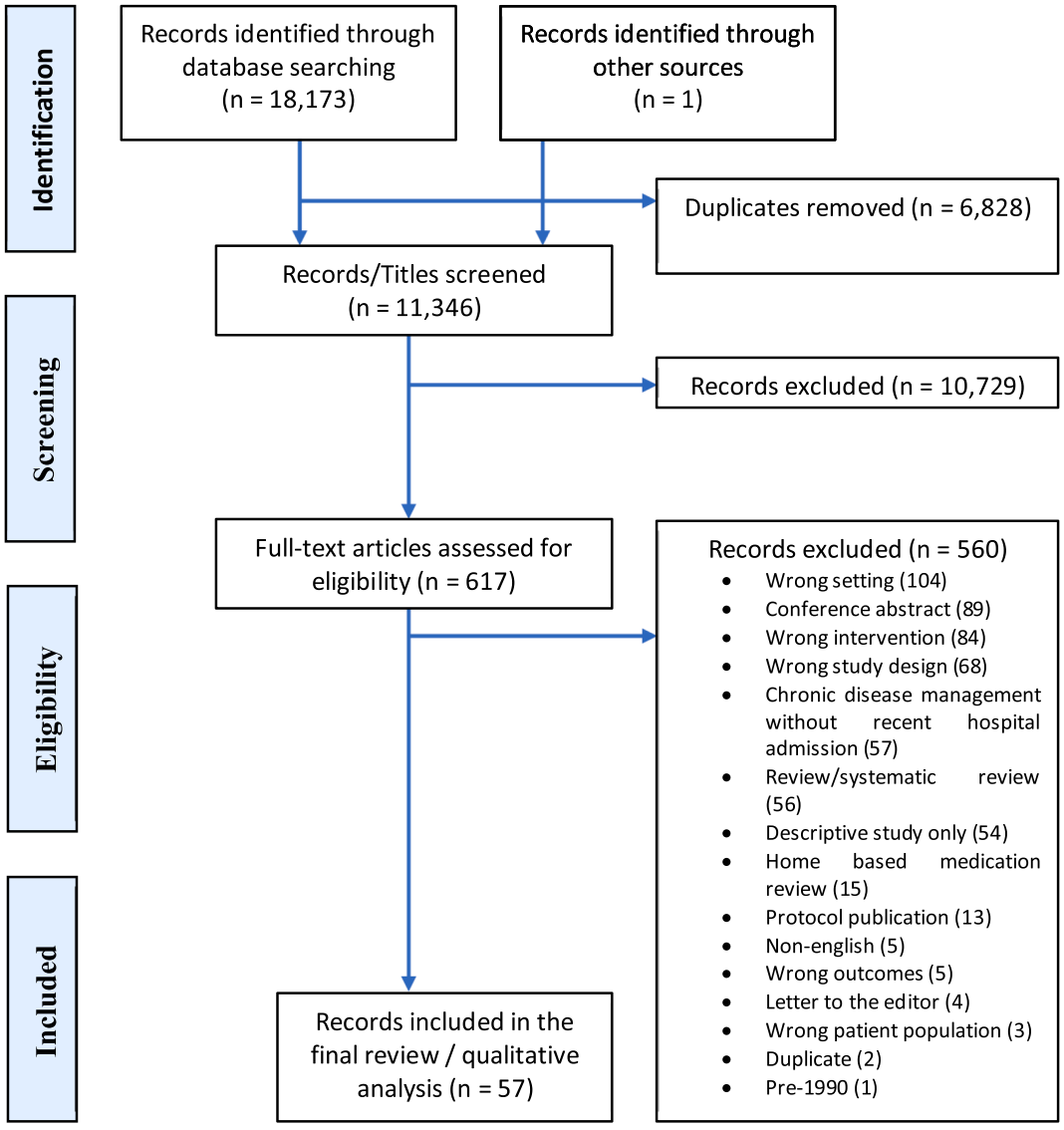

Fig. 1. PRISMA flow diagram of screening process.

from China[61,62,67]; and the remaining 47 were from the United States (US).[24,28,35–38,40–48,52–60,68–89] Study sample sizes ranged from 50 to 43,711 (median = 246.5). Study characteristics were tabulated (Table 1a) to describe study inclusion criteria, clinical pharmacist activities constituting intervention and the control or comparator group, as well as outcomes or conclusions with statistical results if available (Table 1b).

3.3. Design

The 57 studies comprised of 14 RCTs,[39,43,44,51,54,57,61–64,67,72,74,77] and 43 non-randomised studies (Table 1a).[24,28,35–38,40–42,45–50,52,53,55,56,58–60,65,66,68–71,73,75,76,78–89] The non-randomised studies consisted of 11 retrospective pre-post or segmented time-series studies,[38,47,53,59,65,66,70,73,81,82,84] 9 retrospective cohort,[36,40,41,45,58,60,75,76,87] 6 prospective observational,[35,37,71,78,83,86] 6 quasi-experimental prospective,[28,48,51,56,83,88] 6 retrospective non-randomised,[46,52,68,69,79,86] 4 retrospective studies with matched controls,[24,49,55,80] and 1 case study.[42]

3.3.1. Clinic type

Study interventions were classified into three clinic types (Tables 1a and 1b): post-discharge clinic pharmacist review only (21/57),[24,36,43,44,46,50–53,55,64,66,71,73–75,79,80,84,87,89] inpatient clinical pharmacist service with post-discharge clinic pharmacist follow-up (23/57),[38,39,42,45,47–49,54,56–58,61–63,67,70,72,77,78,81,83,86,88] and post-discharge collaborative clinic (a clinic pharmacist with other health care professionals) (13/57).[28,35,37,40,41,59,60,65,68,69,76,82,85]

3.3.2. Delivery method

Delivery of the clinical pharmacist medication review service varied and included: 29 by phone or predominantly by phone,[38,39,44–47,50,52,54–59,62,63,66,67,69–72,74,78,79,81,83,84,88] 18 face-to-face in a clinic setting,[35–37,40,41,43,48,53,60,61,64,65,69,76,80,82,87,89] 4 by phone and face-to-face clinic visit,[28,42,85,86] 3 face-to-face clinic or by phone,[49,75,77] 2 face-to-face clinic, by phone or virtually,[24] and 1 face-to-face clinic visit and phone.[51]

3.3.3. Patient follow up

A single post-discharge follow-up visit was provided in 30 studies,[35,37,38,40–49,52,55–58,65,69,72,74–76,78–82,89] two post-discharge follow-ups in 19 studies,[24,28,36,39,51,59,63,64,66,68,70,71,73,77,83–86,88] and three or more post-discharge follow-up contacts per patient in 8 studies.[50,53,54,60–62,67,87] Time to first contact by the clinical pharmacist

Table 1a
Study characteristics of included studies categorised by clinic type (n = 57).

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
Clinic Type: Post-discharge Clinic Pharmacist Review Only (n = 21)						
Andres *et al* 2019, USA[36]	Retrospective cohort study (single centre)	Clinic (2+)	n = 455 (257)	Admitted with stroke (haemorrhagic or ischaemic) or TIA	Scheduled for stroke prevention clinic but not seen or did not attend, received usual care	Pharmacist stroke prevention clinic F/U ≤30 days post-D/C then weekly to annually as needed - adjust modifiable risk factors for stroke/TIA in line with CPA - lab monitoring - patient education
Budlong *et al* 2018, USA[24]	Retrospective, complexity-matched control study (multi-centre)	Clinic or phone or virtual (2)	n = 43,711 (1,291)	18+ years	Inpatient pharmacist service (not defined), no MTM post-D/C	Pharmacist MTM program ± CMM service provided within 30-days of D/C (median 6 days) - adjust certain meds according to collaborative practice agreement (if PCP within Fairview HS)
Cole *et al* 2019, USA[71]	Prospective pilot study (single centre)	Phone (2)	n = 88 (76)	18+ years, moderate-high risk for readmission[a], contacted by TOC nurse and referred to TOC pharmacist	Unable to be contacted or declined pharmacist F/U, received usual care	Pharmacist chart review and phone F/U ≤2 days post-D/C - med reconciliation - CMR/CPP - address patient concerns and identify MRPs - recommendations to PCP Second pharmacist phone F/U 14-21 days post-D/C - review/address MRPs
Fisher et al 2020, USA[73]	Pre-post, prospective cohort study (multi-centre)	Clinic or phone or virtual (2)	n = 142 (46)	Primary or secondary diagnosis of HF or COPD	Pharmacist med reconciliation and education at D/C, nurse phone F/U at 2 and 7 days post-D/C	Pharmacist phone F/U ≤7 days post-D/C - med reconciliation - disease state counselling Second pharmacist phone or clinic F/U ≤21 days post-D/C
Haag *et al* 2016, USA[74]	RCT (single centre)	Phone (1)	n = 50 (25)	60+ years, independent-living elderly, enrolled at the local CTP[b]	CTP program included home visit by a nurse practitioner within 3 business days of D/C (review/change meds either directly or via discussion with PCP) +/- follow-up phone calls as needed	- CMM Pharmacist MTM program preferably within 3-7 days of D/C - comprehensive med review - identify and resolve all MRPs - optimise meds - recommendations communicated to CTP provider via EMR
Hahn *et al* 2019, USA[75]	Retrospective cohort study (single centre)	Phone or clinic (1+)	n = 98 (35, High Intensity, 28 Low Intensity)	18+ years, admission for HF exacerbation	Pharmacist discharge patient education (in hospital)	High Intensity: MTM with CPA clinic F/U within 10 days post-D/C: - med adherence - patient education - ordering referrals - med therapy changes - ordering pathology - provide prescriptions - admit patients to ED - provide further F/U as needed Low Intensity: MTM pharmacist phone or clinic F/U within 10 days post-D/C: - med reconciliation - med adherence - patient education - med recommendations to physician
Hawes *et al* 2014, USA[43]	RCT, pilot study (single centre)	Clinic (1)	n = 61 (24)	Received primary care at health care system's outpatient family medicine centre, Year 1: meet 1 of 3 criteria: specific presenting	Inpatient clinical pharmacist service (round with medical team daily, review and monitor meds for safety/effectiveness, make recommendations for	Care transitions clinic visit with pharmacist ~3 days post-D/C and prior to posthospitalisation PCP visit - complete med history

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
				condition, >3 hospitalisations in 5 years, 8+ scheduled meds at D/C; Year 2: 8+ scheduled meds at D/C	optimisation, collaborate with medical team to create BPDML for all study patients)	- identify and resolve med discrepancies - create current med list - counselling on appropriate med use
Jack *et al* 2009, USA[44]	RCT (single centre)	Phone (1)	n = 749 (370)	18+ years, have a phone, speak English	No intervention, inpatient care not defined	Nurse DA: arrange follow-up appointments, confirm med reconciliation, patient education with individualised instruction booklet that was sent to PCP; Clinical pharmacist: phoned patients 2-4 days post-D/C - reinforce D/C plan - review meds - MRPs communicated to PCP or DA
Kilcup *et al* 2013, USA[79]	Ad-hoc, non-randomised, retrospective comparison, observational cohort study (multi-centre)	Phone (1)	n = 494 (243)	High-risk for readmission[c]	Care management liaison nurse phoned 1-2 days post-D/C, received usual care	Usual care + pharmacist phone follow-up 3-7 days post-D/C - med therapy assessment and reconciliation - discrepancies noted in Group Health EMR and encounter sent to PCP or specialist
Layman *et al* 2020, USA[80]	Retrospective review, and retrospective propensity-matched observational analysis (single centre)	Clinic (1)	n = NS (114), n = 61 (32)	Admission diagnosis of HF or COPD exacerbation, required urgent F/U for insulin titration, BP management or lab monitoring, seen in ED and have no assigned PCP	No pharmacist post-D/C F/U, received usual care	CPS clinic F/U within 14 days post-D/C - med modification - med reconciliation - adherence and ADE assessment - physical assessment - lab test or imaging requests - referral to specialty services or ancillary services - patient education and support supplies
Liu *et al* 2019, USA[46]	Retrospective chart analysis (single centre)	Phone (1)	n = 833 (166)	All patients D/C home from ED, observation unit or inpatient unit	Phone call not attempted or unable to be reached by phone for any reason, received usual care	Pharmacy student or pharmacist phone follow-up 2-14 days post-D/C - med reconciliation - assess med safety and adherence - identify MRPs - med education - provide script refills - make therapeutic interchanges and resolve MRPs
Miller *et al* 2016, USA[84]	Retrospective, segmented time-series, chart analysis (single centre)	Phone (2)	n = NS (314)	4+ maintenance medications on D/C, discharged home	Not specified	Pharmacy technician and pharmacist contacted patient by phone within 3 days of D/C - CMM - med list - med action plan - documentation of services/ interventions - follow-up 14-30 days after initial review
Nguyen *et al* 2018, Vietnam[64]	RCT (single centre)	clinic (2)	n = 166 (79)	Discharge diagnosis of unstable angina or MI	Outpatient F/U every 2-4 weeks to assess health and disease progress and issue prescriptions, received usual care	Pharmacist clinic F/U within 7 days post-D/C - provide patient education - assess med experiences - provide med aids Pharmacist phone F/U within 14 days post-D/C - assess med issues - patient education
Odeh *et al* 2019, Ireland[50]	Pragmatic, prospective, quasi-experimental study (single centre)	Phone (3)	n = 422 (211)	18+ years, polypharmacy (≥10 meds) for chronic illness	Not specified	Pharmacist phone F/U within 10 days, at 30 days and 90 days post-D/C

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
						- med review - identify MRPs - MRPs resolved with PCP/nurse/ community pharmacist
Odeh *et al* 2020, Northern Ireland[51]	RCT (single centre)	Clinic + clinic/ phone (2)	n = 62 (31)	18+ years, admitted to a study ward for an acute/ unscheduled medical admission and met at least 1 high-risk criteria[d]	Standard post-D/C care with no hospital-based pharmacist F/U	Pharmacist clinic F/U within 14 days post-D/C - med reconciliation - lab test review - med review - patient education - assess med adherence - patient med action plan - recommendations to PCP and hospital physician
Paquin *et al* 2015, USA[52]	Retrospective, non-randomised quality improvement initiative secondary data analysis (single centre)	Phone (1)	n = 501	65+ years, delirium risk[e] or prescribed a dementia medication	Not specified	Pharmacological Intervention in Late Life (PILL) service, pharmacist telephone follow-up within 5 days of D/C - med review - med reconciliation - med safety check - call with caregiver
Pett *et al* 2016, USA[53]	Retrospective, pre-post chart review (single centre)	Clinic (1-6; average = 3.7)	n = 61	Paediatric and adult Native American, referred by medical provider, diagnosis of asthma, ≥ 1 pharmacy asthma clinic visit in previous 12 months	Not specified	Pharmacist-provided asthma education and medication management in ambulatory care clinic following an asthma-related hospitalisation or ED visit - asthma control test - med history - brief physical exam (incl. auscultation and peak flow monitoring) - prescriptive authority for med management - patient education (disease + medication use + self-management using action plan)
Rebello *et al* 2017, USA[55]	Retrospective, non-randomised secondary data analysis, quality improvement initiative, matched controls (multi-centre)	Phone (1+)	n = 200 (100)	65+ years, in need of medication management support[f], discharged home	Not specified	Pharmacist phone follow-up 7 days post-D/C - evaluate efficacy of the Rural PILL program - med reconciliation - assess adherence - identify PIMs - liaison with discharging physician as needed - recommendations to PCP - follow-up calls as needed
Shaya *et al* 2015, USA[87]	Non-randomised, historical controls, proof of concept study (single centre)	Clinic (4)	n = 101 (28)	18+ years, attended endocrinology practice clinic, English speaking, T1DM or T2DM, recent transition of care experience (hospitalisation, ED/urgent care/paramedic/ acute care visit)	Returned to endocrinology clinic following urgent or emergent care, minimum 1 HbA1c lab value post-urgent episode, minimum 6 months follow-up data accessible via EMR, received usual care	Pharmacist provided 6 month, 4-visit process (post-D/C, then follow-up at 1 month, 3 months and 6 months) - med reconciliation - med list - med action plan - patient education - lab monitoring - evaluation of patient response to treatment - regular communication with patient caregivers and in-practice provider
Westberg *et al* 2014, USA[89]	Prospective, group matched-controlled study (single centre)	Clinic (1)	n = 405 (135)	65+ years, diagnoses identified as high risk for readmission[g], no previous hospital MTM program; additionally: PCP affiliated with the hospital	Standard medical care with no CMM, received usual care	Pharmacist CMM visit within 14 days post-D/C and prior to post-hospitalisation PCP visit - additional phone call or face to face if 3+ MRPs identified

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
						- pharmacist liaised with PCP to resolve MRPs
Yang *et al* 2017, UK[66]	Case-cohort, pre-post study (multi-centre)	Phone (2)	n = 1,970 (62)	18+ years, home-dwelling, discharged from ED or general medicine wards, access to a working phone, English-speaking or lives with someone who speaks English	No phone follow-up, received usual care	Pharmacist phone follow-up within 14 days of D/C at 2-7 days (~15mins) and after 10 days (~8 mins) post-D/C - med management support - med reconciliation - med review - patient education/intervention where needed
Clinic type: Inpatient Clinical Pharmacist Service with Post-discharge Clinic Pharmacist Follow-up (n = 23)						
Bae-Shaw *et al* 2020, USA[38]	Retrospective, pre-post, cohort study with difference-in-difference (DID) approach (single centre)	Phone (1)	n = 4,745 (1,776)	18+ years, admitted with primary diagnosis of HF, MI, pneumonia or COPD	Not specified	Pharmacist phone F/U to address MRPs Pharmacist inpatient service: - identify and resolve MRPS on admission - optimise meds - pre-order D/C meds - resolve insurance-related issues prior to D/C - patient education Pharmacist phone F/U 3 days and 15 days post-D/C to reinforce patient education
Bonetti *et al* 2018, Brazil[39]	RCT (single centre)	Phone (2)	n = 133 (66)	18+ years, admitted to cardiology ward with primary diagnosis of stable angina, ACS, HF, valvular disease, arrythmias or HTN	Inpatient med review and recommendations to cardiologist	Pharmacist inpatient service - patient education (discharge meds) - med review - recommendations to cardiologist - med list (info leaflet?) Pharmacist phone call 2-3 days and 30-days post-D/C
Budiman *et al* 2016, USA[70]	Non-randomised, historical control study (single centre)	Phone (2)	n = 135 (40)	18+ years, presenting condition: STEMI who received stents	No Pharmacist transition of care support, received usual care	- assess med issues - MedAL Pharmacist inpatient service - BPMH - MedAL - med reconciliation - med/lifestyle education - med list - delivery of D/C meds Pharmacist Case Manager provided 2 interventions; "Minimal" group:
Farris *et al* 2014, USA[72]	RCT (single centre)	Phone (1)	n = 945 (314 Enhanced/ 315 Minimal)	18+ years, English or Spanish speaking, cardiovascular-related conditions[h] and/or asthma or COPD	Med reconciliation at admission (according to hospital policy), nurse D/C patient education, med list; D/C summary transcribed and received by mail	- admission history - med reconciliation - patient education (inpatient and D/C) - D/C med list - med recommendations to inpatient team "Enhanced" group: "Minimal" and pharmacist phone call 3-5 days post-D/C
Fera *et al* 2014, USA[42]	Case study (single centre)	Phone (1) + clinic or home visit as needed	n = 134 (66)	Target diseases: COPD and HF, as well as CTP consultation for polypharmacy	Patients not reached by phone post-D/C, received usual care	- faxed med care plan to community physician and pharmacy Primary Care Resource Centre Pharmacist phone follow-up within 3 days of D/C Pharmacist inpatient service - pharmacist CTP inpatient med review - patient education

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
						- identified and addressed med issues prior to D/C
Ho *et al* 2014, USA[77]	RCT, block randomisation (multi-centre)	Clinic or phone (2)	n = 253 (129)	Presenting complaint: ACS (MI or unstable angina)	Standard hospital D/C instructions (e.g. numbers to call, follow-up appointments, diet and exercise advice), med list, and educational information about cardiac meds	Pharmacist-led med reconciliation and tailoring within 7-10 days of D/C - patient education - collaborative care with PCP or cardiologist - voice messaging 1 monthly for 12 months (educational and med refill reminder calls)
Jones *et al* 2018, USA[78]	Prospective, case-matched control pilot study (single centre)	Phone (1)	n = 68 (34)	18+ years, discharged home from a pilot unit, identified as high risk for readmission by integrated electronic health record risk score	D/C from non-pilot unit, received usual care	Pharmacist post-D/C phone F/U ≤3 days of D/C Pharmacist inpatient service - pharmacist notified case manager + social worker to complete expedited assessment - referrals and PCP follow-up - pharmacist admission med history - med reconciliation at admission and D/C - D/C med education
Kirkham *et al* 2014, USA[45]	Retrospective cohort study (multi-centre)	Phone (1)	n = 19,659 (692)	All patients discharged home	Daily rounds in hospital ward by outpatient pharmacist	Pharmacist phone follow-up 2-3 days post-D/C (opt-in) CTP - bedside delivery of post-D/C meds by pharmacy technician or pharmacist +/- pharmacist education (patient requested)
Lisenby *et al* 2015, USA[81]	Pilot study, historical control (single centre)	Phone (1)	n = 108 (43)	19+ years, diagnosis: pneumonia and any of the following: admission within 6 months, 5+ scheduled medications, COPD or HF	Nurse provided standard education +/- med reconciliation, antibiotic treatment by physician and home health follow-up phone call	Pharmacist post-D/C phone call within 2-4 days of D/C (for HF and Pneumonia) - address medication adherence - ADEs or questions Pharmacist inpatient service - med reconciliation - med review/recommendations - D/C counselling
March *et al* 2020, USA[47]	Retrospective review and pre-post study (single centre)	Phone (1)	n = 1,728 (414)	Patients admitted to general medicine/surgery, cardiology or neurology units with ≥5 meds and/or anticoagulant/ antiplatelet/ insulin/ sulfonylurea and cardiovascular-related condition and/or DM-related condition and/or prior hospital admission within 30 days	No pharmacist input OR D/C education only OR post-D/C phone follow-up only	Post-D/C pharmacist phone follow-up - assess adherence and - review med concerns - D/C med reconciliation - MRP resolution - D/C patient education - D/C med list - written disease state information
McFarland *et al* 2020, USA[48]	Quasi-experimental, matched interrupted time series study (multi-centre)	Clinic (1+)	n = 484 (242)	Primary or secondary diagnosis of diabetes, hypertension, COPD or HF), seen in clinic or reached by phone by the patient aligned care team or cardiology clinical pharmacy specialist after discharge	MDT round (provide medication recommendations, education, med reconciliation on D/C)	CMM pharmacist post-D/C clinic ≤10 days of D/C (instead of physician or NP) - disease state education - med optimisation CMM pharmacist inpatient service - recommendations for med optimisation relating to specified condition - referred patient for post-D/C follow-up - discharge patient education and disease state educational material
Miller *et al* 2020, USA[83]	Pilot study (multi-centre)	Phone (2)	Phase 2: n = 5,871 (3,711, phase 2); Phase 3: n = NS (9,676 1	Medicare beneficiaries 65+ years, discharged home with HF, COPD, MI, DM or pneumonia (phase 2);	No pharmacist D/C med reconciliation, inpatient case management personnel provide a brief phone call to patients 48 hours post-D/C,	Pharmacist phone follow-up 7 days and 21 days post-D/C - med review

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
			service/ 3,881 both)	Medicare beneficiaries 65+ years (phase 3)	patient eligible but not enrolled in the program	- med and disease state education (phase 2) Pharmacist inpatient service - discharge med reconciliation - recommendations to inpatient physician + follow-up 7 days and 21 days post-D/C (phase 3)
Ni *et al* 2017, USA[49]	Non-randomised, matched control study (intervention single centre, control multi-centre)	Phone/ clinic (on request)	n = 1,227 (558)	High-risk patients[i], 5+ medications, admitted within last 45 days, Medicaid managed care members from study hospital (intervention group) or neighbouring hospital (control group)	Retrospective matched control, received usual care	Pharmacist ambulatory care transitions of care services (over the 30 days post-D/C) - D/C med reconciliation - med review - med education - facilitation insurance-related issues (re: med supply) - additional face-to-face assistance offered if required
O'Reilly *et al* 2020, USA[86]	Retrospective pilot study (single centre)	Phone + clinic (2)	n = 574 (23)	18+ years, admitted to internal medicine team, primary or secondary diagnosis of HF or COPD	Pharmacy technician admission med reconciliation and pharmacist inpatient service (pharmacist audit of med reconciliation, participation in MDT rounds, D/C med list based on physician med reconciliation)	Post-D/C pharmacist phone F/U ≤3 days of D/C - assess adherence, symptom improvement or patient concerns, and Post-D/C pharmacist clinic F/U 7-14 days post-D/C - med reconciliation - med and disease state education Pharmacist inpatient service - D/C med reconciliation - patient med and disease state education - MRPs identified and addressed with internal med team
Phatak *et al* 2016, USA[54]	RCT (single centre)	Phone (3)	n = 278 (137)	Discharged home, on >3 scheduled medications or 1+ high-risk medication[j], willing to participate in minimum 1 post-D/C phone call or experienced an ED visit or readmission within 30-days of D/C	Pharmacist med reconciliation (from physician's patient history) and med education from physician or nursing staff at D/C; 1 phone call at 30-days by pharmacist to assess study endpoints (ADEs, MEs)	Pharmacist post-D/C phone calls at 3, 14 and 30 days post-D/C - provide education - assess study endpoints (ADEs, MEs) Pharmacist inpatient service - D/C med reconciliation - pharmaceutical care plan - med review/recommendations - med education
Ravn-Nielsen *et al* 2018, Denmark[63]	RCT (multi-centre)	Phone (2)	n = 1,498 (498 Basic/ 497 Extended)	18+ years, polypharmacy (≥5 prescribed medications daily), Danish speaking, new acute admission	Standard care (i.e. no inpatient medication review, discharge education or follow-up by a clinical pharmacist)	"Extended" intervention group pharmacist post-D/C phone call 7 days and 6 months post-D/C Pharmacist inpatient service - "basic" intervention and - D/C med reconciliation - med education - med list - MRPs not dealt with by inpatient team sent to PCP - PCP/carer/primary care pharmacy contacted if needed "Basic" intervention group - structured patient-centred medication review soon after admission - recommendations to inpatient team
Rottman-Sagebiel *et al* 2018, USA[56]	Prospective, case-matched comparison study (single centre)	Phone (1)	n = 1,577 (388)	≥70 years and ≥12 meds or ≥65 years and dementia or ≥65 years and meds meeting Beers criteria or ≥65 years and ≥2 hospital admissions within 1 year or	Not specified	Pharmacist phone follow-up post-D/C within 2-3 days of D/C - med reconciliation - identify/rectify MRPs - patient education

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
				≥65 years and ≥3 ED visits within 1 year		- recommendations to PCP Pharmacist inpatient service - med reconciliation - patient education - recommendations to medical team
Schnipper *et al* 2006, USA[57]	RCT (single centre)	Phone (1)	n = 178 (92)	Patients admitted to 1 of 4 teams on general medicine service, discharged home and could be contacted 30 days after D/C, English speaking, cared for by BWH PCP or internal medicine resident, patient or carer provided informed consent	Routine review of med orders by a ward-based pharmacist and med education by a nurse at D/C	Pharmacist phone follow-up 3-5 days post-D/C Pharmacist inpatient service - med reconciliation - med review/recommendations - med education
Snyder *et al* 2020, USA[58]	Retrospective cohort study (single centre)	Phone (1)	n = 871 (379)	Medicare insurance beneficiaries, discharged home or to an assisted living facility following inpatient or observational stay in the general medical/surgical or intensive care unit, required primary care follow-up, PCP participated in the study	Not specified	Pharmacist phone F/U with patient/carer ≤2 days post-D/C - review D/C instructions - confirm receipt of D/C meds - med reconciliation - discharge education - identify/resolve MRPs - schedule PCP F/U if needed Pharmacist inpatient service - review of D/C instruction - confirm scheduling of PCP follow-up
Walker *et al* 2009, USA[88]	Quasi-experimental design, prospective (single centre)	Phone (2)	n = 724 (358)	18+ years, discharged home, high-risk for MRPs[k]	Interdisciplinary D/C round (attending physician, social worker and D/C coordinator nurse). Nurse provided: D/C instructions and med information, med list, med education and phone follow-up within 3 days to identify, triage and resolve post-D/C problems.	Pharmacist phone follow-up post-D/C at 3 days and 30-days Pharmacist inpatient service - pharmacist attended interdisciplinary D/C round - patient interview - med reconciliation - med review/recommendations - med action plan - med education - primary care liaison
Xu N *et al* 2019, China[61]	RCT (single centre)	Clinic (24)	n = 193 (98)	45-75 years, underwent PCI for CHD, able to read and understand the test questionnaire	No pharmacist intervention, received usual care	Pharmacist post-D/C adherence assessment (monthly) - med optimisation and adjustment - patient education Pharmacist inpatient service - developed individualised pharmaceutical care plan - med optimisation - patient education/smoking cessation/lifestyle advice prior to D/C
Xu H *et al* 2019, China[67]	RCT (single centre)	Phone (3)	n = 240 (120)	Primary diagnosis of STEMI, NSTEMI or unstable angina with ≥50% occlusion of 1+ major coronary arteries	No pharmacist intervention, dispensing pharmacist care.	Pharmacist post-D/C review with patient at 7 days, 1 and 3 months - med review and resolution of MRPs Pharmacist inpatient service - med review for secondary prevention of CHD - recommendations to treating physician - D/C med list - patient education/smoking cessation/lifestyle advice prior to D/C
Zhao *et al* 2015, China[62]	RCT (single centre)	Phone (6)	n = 85 (43)	18+ years, diagnosis of CHD by their physician	Conventional clinical care without pharmacist support	Pharmacist phone follow-up monthly for 6 months

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
				4+ drugs for heart conditions (e.g. antiplatelet, beta-blockers, ACEI, statin)		Pharmacist inpatient service - pharmacist med review - med/lifestyle education
Clinic Type: Post-discharge Collaborative Clinic; Clinic Pharmacist with Other Health Care Professionals (n = 13)						
Al-Bawardy *et al* 2019, USA[35]	Prospective, non-randomised study (single centre)	Clinic (1)	n = 154 (109)	Primary D/C diagnosis of HF	Failed to attend clinic appointment, received usual care	Pharmacist post-D/C clinic 7-10 days post-D/C - 1 hour education session with education booklet - med reconciliation - med review - med management within an agreed protocol - cardiologist review as needed Post-D/C physician clinic and pharmacist clinic
Arnold *et al* 2015, USA[37]	Prospective study (single centre)	Clinic (1)	n = 236 (98)	>50 years, >5 meds	Hospital follow-up visit by physician alone, received usual care	- med reconciliation - med review - monitoring of med therapy - optimisation of chronic disease management - identify MRPs - recommendations to physician TOC nurse contacted patient or care team within 3 days of D/C to enrol in program and provides care coordination with HP team. TOC pharmacist provided phone F/U ≤7 days post-D/C and 21 days post-D/C
Bingham *et al* 2019, USA[68]	Retrospective study (single centre)	Phone (2)	n = 456 (340)	18+ years, Primary D/C diagnosis of asthma or pneumonia or DM or HF or COPD or MI or THR/TKR or CKD or CABG, D/C home or to a N/H	Phone F/U by TOC nurse 1-3 days post-D/C; opted-out of TOC program or unable to be reached by TOC pharmacist, received usual care	- med reconciliation - identify MRPs - med review - adherence assessment - identify ADEs - patient education - F/U on first consult interventions Post-D/C physician or nurse practitioner clinic F/U and pharmacist clinic F/U
Borhanjoo et al 2019, USA[69]	Retrospective study (single centre)	Clinic (1)	n = 573 (422)	Patients at high risk of re-admission[l], primary D/C diagnosis HF or MI or pneumonia or DM	Post-D/C physician or nurse practitioner clinic F/U only, received usual care	- med reconciliation - med review - assess adherence - med education Care manager scheduled appointments and addressed barriers to care (e.g. transportation, obtaining medicines). Attending physician and CPP clinic appointment within 5 days of D/C. Pharmacist CPP service
Cavanaugh *et al* 2014, USA[40]	Retrospective cohort study (single centre)	Clinic (1)	n = 108 (54)	Patient with established PCP in University of North Carolina (UNC) Internal Medicine Centre	Not referred to the hospital follow-up clinic post-D/C, received usual care	- prescribe medication therapy and order appropriate monitoring tests within an agreed protocol - identify and discuss goals of care - med review - patient education - arrange follow-up Attending physician - patient history - physical exam - diagnosed new problems - address goals of care - assist with patient education
Cavanaugh *et al* 2015, USA[41]	Retrospective observational sub-	Clinic (1)	n = 140 (70)	Patient enrolled in University of North Carolina	Medical resident and attending physician follow-up clinic appointment within 7-	Attending physician and CPP clinic appointment within 7 days of D/C

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
	analysis study (single centre)			(UNC) Internal Medicine follow-up program	days of D/C, received usual care; care manager scheduled appointments and addressed barriers to care (e.g. transportation, obtaining medicines).	Pharmacist CPP service - med review - lifestyle interventions - patient education - order lab tests and meds within an agreed protocol Attending physician - patient history - physical exam
Hawes *et al* 2018, USA[76]	Retrospective cohort study (single centre)	Clinic (1)	n = 172 (86)	18+ years, D/C to community dwelling, established primary care with FMC provider and attended hospital follow-up visit within 30 days of D/C	PCP only visit, received usual care	PCP/CPP hospital follow-up visit within 30 days of D/C (average = 9.5 ± 7.3 days) with pharmacist-enhanced care - med reconciliation/ recommendations - patient education - face-to-face handover to PCP prior to PCP review - social workers available if needed
Khatib *et al* 2018, UK[65]	Retrospective pre-post study (single centre)	Clinic (1)	n = NS (270)	Admitted to cardiology with MI, attended post-MI medicines optimisation MDT clinic	Cardiologist only follow-up, received usual care	All patients completed "MYMEDS" questionnaire prior to clinic appointment Standard medicines optimisation clinic: consultant cardiology pharmacist and/or cardiologist review - med review - med optimisation - patient education - barriers to adherence identified and addressed - medication action plan - liaison with PCP Advanced medicines optimisation clinic ("MYMEDS" identified to be high risk): consultant cardiology pharmacist and/or cardiologist review - standard medicines optimisation clinic service and - extended med review
Mayzel *et al* 2020, USA[82]	Pre-post retrospective-prospective study (single centre)	Clinic (1)	n = 100 (50)	Patients discharged from any Cleveland Clinic Foundation Hospital and seen at Hillcrest's Family Medical/Internal Medicine Clinic	Phone F/U 2 days post-D/C from health practitioner (med reconciliation, address med concerns, confirm med changes, assess adherence, patient education); PCP clinic F/U 7-14 days post-D/C with medical assistant or nurse med reconciliation immediately prior	Usual care and pharmacist clinic F/U within 7-14 days of D/C immediately prior to PCP clinic F/U - med reconciliation - med review - adherence assessment - patient education - identify MRPs and address with PCP

Murphy *et al* 2019, USA[85]	Prospective, pre-post study (single centre)	Phone + clinic (2+)	n = 610: HF = 359, MI = 251 (193: HF = 100, MI = 93)	18+ years, primary admission diagnosis of HF or MI with planned follow-up with a cardiologist	Not specified	Nurse practitioner phone F/U 2-3 days post-D/C, pharmacist phone F/U 4-7 days post-D/C, cardiologist F/U ≤7 days post-D/C, additional MTM F/U ≤28 days post-D/C if needed, dietitian F/U 21 days post-D/C, cardiac rehab session 21 days post-D/C
						
						- Pharmacist phone F/U
						  ▪ confirm adherence and understanding of med regime
						  ▪ assess disease state management
						  ▪ referral to NP if required for escalation of care

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Table 1a (*continued*)

Author, Year, Country	Study design (setting)	Method (No. of follow ups)	Sample size n = Total (I)	Inclusion criteria	Control or Comparator	Intervention
						- Pharmacist MTM clinic 7-14 days post-D/C ■ med review (CMM) ■ med education ■ disease state education ■ med list ■ med action plan Pharmacist inpatient service, dietitian education on healthy diet, cardiologist and/or nurse practitioner patient care and disease state education
Thurston *et al* 2019, USA[59]	Retrospective pre-post study (single centre)	Phone (2)	n = 362 (211)	Primary admission diagnosis of HF and at high risk for 30-day readmission based on risk assessment software program	No pharmacist med reconciliation or patient D/C education; readmission risk assessment, patient access to a scale at home, education class on CV disease, HF education pack, nurse post-D/C phone F/U 3 days post-D/C	- pharmacist education signs/symptoms of HF or MI/healthy diet/post-D/C meds - D/C med reconciliation Usual care and pharmacist inpatient service and pharmacist post-D/C phone F/U 14 and 30 days post-D/C Pharmacist post-D/C service - address MRPs Pharmacist inpatient service
Trang *et al* 2015, USA[28]	Prospective intervention, retrospective control study (single centre)	Phone + clinic (2)	n = 161 (74)	High-risk patients (minimum 1 criteria: 4+ medications for chronic diseases, oral anticoagulation, COPD, HF, DM, HIV, MI, Pneumonia), discharged from hospital or ED with PCPs at the PCMH	Informal registered nurse phone F/U post-D/C to schedule an appt with PCP, received usual care	- med history/reconciliation - med access review - D/C med list/patient education - HF self-monitoring folder Pharmacist Advancement of Transitions of Care to Home (PATCH) service with pharmacist phone follow-up $\leq$ 2 business days post-D/C and pharmacist clinic within 7-14 days post-D/C Pharmacist phone F/U - review med changes - identify issues with access to care - patient education and face-to-face meeting with the pharmacist Pharmacist clinic - comprehensive med review - med reconciliation - recommendations discussed with PCP - patient education
Wiegmann *et al* 2020, USA[60]	Retrospective cohort study (single centre)	Clinic (3)	n = 100 (50)	18+ years, seen by a physician in FMC within 14 days of D/C	Inpatient pharmacist service (clinical recommendations, D/C med rec and patient education) and physician post-D/C follow-up including physical exam, lab test monitoring and med rec	Pharmacist post-D/C clinic and PCP follow-up (ideally on the same day) - med reconciliation - chronic disease management (CMM)

Legend: ACEI = Angiotensin Converting Enzyme Inhibitor; ACS = Acute Coronary Syndrome; ADE = Adverse Drug Event (or Averse Drug Reaction); BPDML = Best Possible Discharge Medication List; BPMH = Best Possible Medication History; BWH: Brigham and Women's Hospital; CABG = Coronary Artery Bypass Graft; CHD = Coronary Heart Disease; CKD = Chronic Kidney Disease; CMM = Comprehensive Medication Management; CMR = Comprehensive Medication Review; COPD = Chronic Obstructive Pulmonary Disease; CPA = Collaborative Practice Agreement; CPP = Clinical Pharmacist Practitioner; CPS = Clinical Pharmacy Specialists; CTP = Care Transitions Program; CV = Cardiovascular; DA = Discharge Advocate; DID = Difference-in-difference; DM = Diabetes Mellitus; D/C = Discharge; ED = Emergency Department; EMR = Electronic Medical Record; FMC = Family Medicine Centre; F/U = Follow-up; HF = Heart Failure; HIV = Human Immunodeficiency Virus; HS = Health Service; HTN = Hypertension; I = intervention; MDT = Multi-disciplinary Team; ME = Medication Error; med = medication; MedAL = Medication Adherence and Literacy; MI = Myocardial Infarction; MRP = Medication Related Problem (or Drug Therapy Problem or Drug Related Problem); MTM = Medication Therapy Management; No. = number; NSTEMI = Non-ST Elevated Myocardial Infarction; N/H = Nursing Home; PATCH = Pharmacist Advancement of Transitions of Care to Home; PCI = Percutaneous Intervention; PCMH = Patient-centred Medical Home; PCP = Primary Care Provider; PILL = Pharmaceutical Intervention in Late Life; PIM = Potentially Inappropriate Medication; RCT = Randomised Controlled Trial; STEMI = ST Elevated Myocardial Infarction; THR = Total Hip Replacement; TKR = Total Knee Replacement; TIA = Transient Ischaemic Stroke; TOC = Transition of Care; T1DM = Type 1 Diabetes Mellitus; T2DM = Type 2 Diabetes Mellitus; UK = United Kingdom; UNC = University of North Carolina; USA = United States of America.

[a] Re-admission risk score: low $\leq$39, moderate = 40-59, high $\geq$60.

[b] CTP eligibility based on Elders Risk Assessment (ERA) index $\geq$ 16.

[c] High-risk criteria: current admission = readmission, complex care plans, primary diagnosis of chronic disease, medication changes during hospitalisation, concerns of ability to self-manage.
[d] High-risk criteria: ≥4 regular medications, ≥3 medication changes, concerns of ability to self-manage, ≥1 high-risk medication, ≥2 emergency hospital admissions in prior 6 months.
[e] Delirium risk: cognitive impairment, sensory impairment or dehydration.
[f] Medication management support: polypharmacy, cognitive impairment, CCF and age 75+ years.
[g] High-risk for readmission: CCF, dysrhythmias, genitourinary conditions, IHD and digestive disorders.
[h] Cardiovascular-related conditions: hypertension, hyperlipidaemia, CCF, CAD, MI, Stroke, TIA, receiving oral anticoagulation.
[i] High-risk patients: hospitalisation history, prescription medication utilisation, social history.
[j] High-risk medication: anticoagulant, antiplatelet, hypoglycaemic agents, immunosuppressants, anti-infectives.
[k] High-risk for medication-related problems: 5+ medications, 1 or more high-risk medication, medication requiring monitoring, 2+ medication changes, problems managing medications, dementia or confusion.
[l] Set of specific criteria with high likelihood of readmission.

after discharge varied from within 7 days in 31 studies,[28,39–45,52,54–58,63,64,67,68,70–74,78,79,81,83–86,88] within 14 days in 12,[35,46,48,50,51,59,66,75,77,80,82,89] within 30 days in 7,[24,36,49,61,62,76,87] and 7 studies did not provide time to follow-up information.[37,38,47,53,60,65,69] Earlier post-discharge follow-up by a clinical pharmacist did not seem to impact the rate of achieving a statistically significant improvement in at least one patient clinical outcome (15,[28,39–45,52,54–58,63] 7,[35,46,48,50,51,59,75] 4,[24,36,49,61] 6,[37,38,47,53,60,65] respectively).

3.3.4. Clinical Pharmacist activity

The clinical pharmacist activities in the control or comparator groups were either not specified or defined, or described as 'no pharmacist support (or services)' or 'did not attend' in 46/57 studies (Table 1a).[24,28,35–38,40–42,44,46,47,49–53,55,56,58,59,61–71,73,74,77–81,83–85,87–90] The clinical pharmacist activities in the intervention groups for the post-discharge pharmacist follow-up were not clearly defined in 9/57 studies, all of which were a combined inpatient clinical pharmacist service with post-discharge clinic pharmacist follow-up intervention.[38,42,45,49,57,63,72,78,88] The studies which implemented a post-discharge clinic pharmacist review only or collaborative clinic type provided more detail of the post-discharge clinical pharmacist activities.

3.4. Patient clinical outcomes

The most commonly reported outcome (primary or secondary) was 30-day hospital readmissions and/or representations (n = 45/57).[24,28,35,37–51,54–56,58–60,63,66,68–76,78–84,86,88,89] A summary of readmission and representation measures is provided in Table 2.

The remaining 12/57 studies that did not report 30-day readmission and/or representation rates reported the following patient outcomes: readmission rate for a specific disease state (n = 4),[36,65,85,87] 60-day readmission rate (n = 1),[52] 90-day readmission rate (n = 1),[64] 180-day readmission rate (n = 1),[61] 730-day readmission rate (n = 1),[61] asthma-related hospitalisation count (n = 1),[53] preventable 30-day medication-related readmissions and/or representations (n = 1),[57] major adverse cardiac events (n = 2),[61,67] ADEs (n = 2),[62] or disease state metrics (n = 3).[36,62,77]

3.4.1. Hospital readmissions and/or representations

Of the 40 studies that measured 30-day readmission rate, 15 reported a significant reduction in this outcome.[24,37,38,40–43,45,46,49,50,59,60,63,75] An additional 3 studies that didn't achieve a significant reduction in 30-day readmissions, reported significant changes with secondary subgroup,[47] or covariate analysis,[56,58] and two studies had significant results in a sub-group analysis for 30-day readmission rate for heart disease or same disease state.[39,48]

A measure of composite 30-day hospital readmission and representation was significantly reduced in 7/12 studies reporting this outcome,[28,40,42–44,46,54] and a significant reduction in 30-day representation rate was seen in 3/9 studies.[42,43,55]

One study showed a significant reduction in preventable 30-day medication-related readmissions and/or representations.[57] While another study achieved a significant reduction in readmissions at 30-days and 180-days post-discharge for the 'extended intervention' arm which included a discharge and post-discharge component, compared to the 'basic intervention' arm which was medication reconciliation at admission only.[63]

Four studies reported on 60-day readmissions,[24,52,60,76] two of which were significant[24,52]; and 8 studies reported on 90-day readmissions,[35,38,40,50,51,60,64,78] 2 of which were significant.[35] Of the 4 studies that reported hospital readmissions up to 180-days,[49,51,61,63] three demonstrated a significant reduction.[51,61,63] Two studies extended the readmission follow-up to 365 days, of which neither achieved a significant result for this outcome.[35,51] Finally, a pre-post study by Pett *et al* demonstrated a significant reduction in asthma-related hospitalisation count over 12 months.[53]

3.4.2. Adverse events (AEs) and adverse drug events (ADEs)

The AEs reported in studies included mortality at 30-days,[35,39,48,55,85] 90-days,[35,48,64] 180-days, [63] and 365-days.[35] A significant reduction in mortality was only seen in one study measured at 90-days post-discharge.[48] One study reported a combined measure of mortality and any ADE at 30-days and 60-days which was non-significant.[89]

Two studies which examined a patient population who underwent stenting for myocardial infarction reported a reduction in re-stenting at 30-days (non-significant),[70] and at 180-days or 730-days (significant).[61] Major adverse cardiac events which included recurrent angina, re-stenting and nonfatal myocardial infarction were reported in 2 studies, with a significant reduction demonstrated at 180-days and 730-days post discharge,[61] and a non-significant reduction demonstrated at 180-days and 365-days in the second study.[67]

Five studies reported all ADEs as a patient clinical outcome, none of which resulted in a significant decrease in ADEs.[54,57,62,72,89] Two of these studies also measured preventable ADEs,[57,72] with 1 study reporting a significant reduction in preventable ADEs.[57] Other measures reported included potentially prevented AEs,[47] 3-day representations (non-significant),[85,88] and unplanned Primary Care Physician (PCP) visits over 365-days post-discharge (significant).[51]

3.4.3. Disease state metrics

Six studies reported improved disease state metrics which included blood pressure, cholesterol levels, blood sugar level or glycated haemoglobin (HbA1c) and attainment of treatment goals.[28,36,60–62,77] Significant results were achieved for reduction in diastolic blood pressure at 30-days,[28] attainment of treatment goals at 180-days,[62] and improvement in all measures for risk of coronary heart disease (specifically: smoking, blood sugar levels or HbA1c, blood pressure and cholesterol) at 730-days post-discharge.[61]

3.5. Clinical pharmacist activities and outcome effects

The clinical pharmacist activities are described in Table 3 for the 45

Table 1b
Study outcomes of included studies categorised by clinic type (n = 57).

Author, Year	Primary Outcomes ↓ = decreased ↑ = increased ↔ = no change N/A = not applicable	Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes ↓ = decreased ↑ = increased ↔ = no change N/A = not applicable	Results (Intervention vs Usual Care)	Statistical significance
Clinic Type: Post-discharge Clinic Pharmacist Review Only (n = 21)						
Andres *et al* 2019[36]	Composite readmission rate for stroke/TIA, MI or new/incidental PAD ↓	24 (9/3%) vs 34 (17.2%)	P = 0.013	Improved disease state metrics: ▪ Average SBP/DPB decrease ↑ ▪ Achieved BP goal <140/90mmHg ↑ ▪ Average LDL decrease ↑ ▪ Achieved LDL goal <10mg/dL ↑ ▪ Average HbA1c decrease ↑ ▪ Achieved HbA1c goal <7% ↑	 21/12mmHg vs 20/9mmHg 97 vs 59 23mg/dL vs 9mg/dL 36 vs 10 0.6% vs 0.1% 12 vs 0	
Budlong *et al* 2018[24]	30-day readmission rate ↓ 60-day readmission rate ↓	4.2% lower 2% lower	P < 0.001 P = 0.0528	30-day readmission rate per risk category: ▪ Low ↓ ▪ Average ↓ ▪ Elevated ↓ ▪ High ↓ ▪ Very High ↓ ▪ Extreme ↓		 Not sig P < 0.05 P < 0.001 P < 0.001 Not sig P < 0.01
Cole *et al* 2019[71]	30-day readmission rate ↓ Number/types of MRPs N/A ▪ Non-adherence or med access ▪ Suboptimal dosing ▪ Suboptimal drug ▪ Undertreatment ▪ Monitoring needed ▪ ADE present	15.8% vs 25% N = 108 N = 59 (55%) N = 16 (15%) N = 13 (12%) N = 8 (7%) N = 7 (6%) N = 5 (5%)	P = 0.529	Number MRPs resolved (directly by pharmacist) N/A Number MRPs resolved (with PCP) N/A Number recommendations accepted by PCP N/A	N = 49/61 (80%) N = 31/47 (66%) N = 47	
Fisher et al 2020[73]	30-day readmission rate for index diagnosis (COPD) ↓	0% vs 3.51%	P = 0.35	30-day all-cause readmission rate ↓	8.70% vs 11.46%	P = 0.62
	30-day readmission rate for index diagnosis (HF) ↓	3.22% vs 10.34%	P = 0.23	% patients with pharmacological interventions N/A % patients with non-pharmacological interventions N/A	21/46 (45.7%) 45/46 (97.8%)	
Haag *et al* 2016[74]	Quality of medication prescribing (STOPP/START) ↔		Not sig	Medication utilisation (modified MAI) ↔ 30-day readmission rate, 30-day ED representations, composite of both ↔ Medication adherence (MMAS) ↔	 	Not sig Not sig Not sig
Hahn *et al* 2019[75]	30-day readmission rate ▪ High Intensity ↓ ▪ Low Intensity ↓	 8.6% vs 25.7% 7.1% vs 25.7%	P = 0.046 P = 0.057	30-day HF readmission rate ↓ 30-day ED representations ↑ Time to readmission ▪ High Intensity ↓ ▪ Low Intensity ↔ Adherence to F/U appointments N/A ▪ High Intensity ▪ Low Intensity Time to first pharmacist F/U N/A ▪ High Intensity ▪ Low Intensity	2.9% (HI) vs 7.1% (LI) vs 17.1% 5 (HI) vs 6 (LI) vs 0 26.7±2.1 vs 14.1±8.8 12.5±7.8 vs 14.1±8.8 17/25 (68%) 14/28 (50%) 11±5 11±6	P = 0.11 P = 0.28 P < 0.01 P = 0.82
Hawes *et al* 2014[43]	30-day readmission rate and ED representations ↓	0% vs 40.5%	P < 0.001	30-day readmission rate ↓ 30-day ED representations ↓ Med discrepancies resolved (in intervention group) by the conclusion of the posthospitalisation PCP visit ↑	0% vs 32.4% 0% vs 29.7% 50% vs 9.5%	P = 0.002 P = 0.004 P = 0.15

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
Jack *et al* 2009[44]	Composite 30-day readmission rate and ED representations	↓	0.314 vs 0.451 (visits per person per month)	P = 0.009	Improved patient self-preparedness for D/C	↑		Not stated
	Most effective if hospital utilisation greater in 6 months before index hospitalisation	↓		P = 0.014	Increase PCP follow-up	↑	62% vs 44%	P < 0.001
Kilcup *et al* 2013[79]	7-day readmission rate	↓		Not stated	Financial savings	↓		Not stated
	14-day readmission rate	↓		Not stated	Rates of med discrepancies	↓		Not stated
	30-day readmission rate	↓		Not stated				
Layman *et al* 2020[80]	30-day readmission rate	N/A	7.8%		30-day HF readmission rate	↓	13% vs 17%	
					30-day COPD readmission rate	↓	10% vs 24%	
					30-day readmission rate (propensity matched)	↓	3.1% vs 15.6%	P = 0.196
Liu *et al* 2019[46]	Composite 30-day readmission rate and ED representations	↓	22.2% vs 32.5%	P = 0.03	30-day readmission rate	↓	6.4% vs 14.7%	P = 0.02
					Time to next hospital use	↔	60.1 days vs 71.3 days	P = 0.24
Miller *et al* 2016[84]	30-day readmission rate	↓		Not sig	Identified and intervened on MRPs and medication discrepancies	N/A	212 MRPs (189 faxed, 23 phone contacts (urgent))	
Nguyen *et al* 2018[64]	Med adherence (MMAS-8 ≥6) at 30 days	↑	90.0% vs 76.5%, OR = 2.77, 95% CI = 1.01-7.62	P = 0.043	Med adherence (MMAS-8 ≥6) at 90 days	↑	90.2% vs 77.0%, OR = 2.74, 95% CI = 0.91-8.23,	P = 0.065
					90-day readmission rate (all-cause)	↔	12.1% vs 8.8%	P = 0.551
					90-day mortality (all-cause)	↔	0% vs 1.5%	P = 1.000
					Change in QoL at 90 days	↔	0.234 (0.000; 0.379) vs 0.000 (0.000; 0.275)	P = 0.081
Odeh *et al* 2019[50]	30-day readmission rate	↓	18.0% vs 28%	P < 0.001	Time to readmission	↑	70.9 vs 60.1 days; log rank = 11.3	P = 0.001
	90-day readmission rate	↓	33.6% vs 48.8%	P = 0.21	LOS on first readmission	↓	8.3 vs 6.7 days	P < 0.0001
Odeh *et al* 2020[51]	30-day readmission rate	↓	6.5% vs 16.1% (ITT)	P = 0.42	Readmission rate (ITT vs UC)			
					▪ 7-days	↓	0% vs 6.5%	P = 0.49
					▪ 14-days	↓	0% vs 12.9%	P = 0.11
					▪ 90-days	↓	19.4% vs 25.8%	P = 0.75
					▪ 180-days	↓	22.6% vs 41.9%	P = 0.10
					▪ 365-days	↓	41.9% vs 58.1%	P = 0.9
					Multiple readmissions (ITT vs UC)			
					▪ 90-days	↓	3.2% vs 19.4%	P = 0.104
					▪ 180-days	↓	3.2% vs 32.3%	P = 0.003
					▪ 365-days	↓	12.9% vs 35.5%	P = 0.038
					Average days to readmission (ITT vs UC)	↑	276.3 vs 226.3	P = 0.19
					LOS of first readmission	↔	5 days (all groups)	P > 0.05
					ED representation rate (total visits) (ITT vs UC)	↓	31 vs 51	P = 0.59
					Unplanned PCP visits (total visits) (ITT vs UC)	↓	17 vs 34	P = 0.07
					Health related QoL (ED-5D-3L) index at:			
					▪ Baseline	↔	0.56 vs 0.63	P = 0.16
					▪ 30-day	↑	0.76 vs 0.39	P < 0.001
					▪ 90-day	↑	0.78 vs 0.44	P < 0.001
					▪ 180-day	↑	0.64 vs 0.45	P < 0.036
					▪ 365 days	↔	0.66 vs 0.53	P = 0.15
Paquin *et al* 2015[52]	60-day readmission rate	↓	OR = 0.75	95% CI = 0.60-0.694	60-day readmission rate (Adjusted for age, no. of meds and no. of discrepancies)	↓	OR = 0.72	95% CI = 0.57-0.91
Pett *et al* 2016[53]	Asthma-related hospitalisations	↓	2 vs 11	P = 0.02	Decreased oral steroid script refills	↔		P = 0.085
	Asthma-related ED representations	↓	25 vs 43	P = 0.02	ICS Rx refills	↑		P = 0.01
Rebello *et al* 2017[55]	30-day ED representations or urgent care visits	↓	7 vs 20, OR = 0.30	95% CI = 0.12-0.75	60-day ED representations or urgent care visits	↔	16 vs 26, OR = 0.54	95% CI = 0.27-1.09, Not sig

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
					30-day readmission rate	↔		Not sig
					30-day and 60-day Mortality	↔		Not sig
Shaya *et al* 2015[87]	30-day readmission as related to the disease diagnosis at the index admission	↔	0% (both groups)	Not sig	All-cause hospitalisation count rate at 30, 60, 90, 120 and 180 days	↔		Not sig
					Reduced hospital readmissions and cumulative health services utilisation over 180 days post-D/C	↔		Not sig
Westberg *et al* 2014[89]	30-day readmission rate and any ED representation at 30-days, 60-days and 180 days	↔		Not sig	30-day and 60-day post-D/C events (e.g. death, any ADE)	↔		Not sig
Yang *et al* 2017[66]	30-day readmission rate	↔	11.3% vs 9.0	P = 0.376	Identification of post-D/C MRPs and interventions (impact assessed using NPSA risk matrix).	N/A	An effective method to solve or avoid critical MRPs	
Clinic type: Inpatient Clinical Pharmacist Service with Post-discharge Clinic Pharmacist Follow-up (n = 23)								
Bae-Shaw *et al* 2020[38]	30-day readmission rate	↓	OR = 0.654	P = 0.035	LOS during index hospitalisation	↔	-0.15 days	P = 0.662
	90-day readmission rate	↓	OR = 0.752	P = 0.070				
Bonetti *et al* 2018[39]	30-day mortality rate	↓	0 (0%) vs 3 (5.7%)	P = 0.243	Med adherence ▪ "MedTake" ▪ Beliefs about Medicines Questionnaire (BMQ) ▪ Adherence to Refills and Medications Scale (ARMS)	 ↑ ↑ ↓		 P < 0.001 P = 0.028 P = 0.001
	30-day readmission rate (total)	↓	4 (7.8%) vs 7 (13.2%)	P = 0.374				
	30-day readmission rate (non-heart disease)	↑	4 (7.8%) vs 1 (1.9%)	P = 0.156				
	30-day readmission rate (heart disease)	↓	0 (0%) vs 6 (11.3%)	P = 0.027				
	30-day ED representations (non-heart disease)	↑	3 (5.9%) vs 1 (1.9%)	P = 0.289				
	30-day ED representations (heart disease	↓	0 (0%) vs 4 (7.5%)	P = 0.118				
	30-day readmission rate	↓	5% vs 13%	P = 0.18	MedAL (baseline vs 30-days post-D/C, intervention group only)	↑	4.5 -> 8	P = 0.0005
Budiman *et al* 2016[70]					Re-stenting (readmitted patients)	↓	0% vs 25%	Not stated
Farris *et al* 2014[72]	Medication use outcomes (MAI, ADE's or post-D/C healthcare utilisation)	↔		Not sig	ADEs post-D/C, preventable ADEs (across all study groups)	↔		Not sig
	The average MAI per medication at 90 days	↑	0.53 to 0.75	Not sig (across all study groups)	ADEs identified during hospitalisation	↑	6.1% (both groups) vs 4.5%	Not sig
					Composite 30-day readmission rate, 30-day ED representations or urgent care visits (across all study groups)	↔		Not sig
					30-day readmission (across all study groups)	↔		Not sig
Fera *et al* 2014[42]	Composite 30-day readmission rate and ED representations	↓	22% vs 42%	P = 0.01	30-day readmission rate	↔	14% vs 23%	P = 0.16
					30-day ED representations	↓	8% vs 19%	P = 0.02
					Increase in HCAHPS scores (in med-related and D/C domain questions)	↑		Not assessed
Ho *et al* 2014[77]	Med adherence	↑	89.3% vs 73.9%	P = 0.003	PDC for statins	↑	93.2% vs 71.3%	P < 0.001
	Mean PDC >0.8 for all 4 meds	↑	0.94 vs 0.87	P < 0.001	PDC for ACEI/ARB	↑	93.1% vs 81.7%	P = 0.03
					PDC for clopidogrel	↑	86.8% vs 70.7%	P = 0.03
					PDC for beta-blockers	↔	88.1% vs 84.8%	P = 0.59
					Target BP	↔		P = 0.23
					Target LDL-cholesterol	↔		P = 0.14
Jones *et al* 2018[78]	30-day readmission rate	↓	18% vs 24%	P = 0.547	Case manager or social worker note	↑	88% vs 59%	P = 0.006
	90-day readmission rate	↓	27% vs 39%	P = 0.296	PCP F/U scheduled	↑	85% vs 74%	P = 0.230
	Composite 30-day readmission rate and ED representations	↓	24% vs 30%	P = 0.580	PCP F/U ≤7 days of D/C	↑	76% vs 64%	P = 0.341
	Composite 90-day readmission rate and ED representations	↓	36% vs 49%	P = 0.319	Pharmacist phone F/U completed	N/A	27/34 (79%)	

studies that reported 30-day readmissions and/or representations as an outcome. One study by Rebello *et al*, is represented twice as it reported a significant reduction in representations (primary outcome), but a non-significant reduction in readmissions (secondary outcome).[55]

Clinical pharmacist activities described in studies were classified into the following: no pharmacist support, best possible medication history, medication reconciliation (inpatient or post-discharge), best possible medication discharge list, patient education, discharge medication supply, medication order review, ward rounds, interventions directed to inpatient physician, interventions directed to the primary care provider (PCP), post-discharge MTM, post-discharge comprehensive medication management (CMM) or clinical pharmacist practitioner (CPP). Studies that did not define any clinical pharmacist activity were classified as 'not specified or defined'.

Studies that did not achieve a significant reduction in hospital readmissions and/or representations provided little detail regarding clinical pharmacist activities in the usual care arm (Table 3). With a total of 21/27 studies providing no information or 'no pharmacist support' as the clinical pharmacist activity description,[35,51,55,58,63,66,68–71,74,76,78–84,88,89] compared to 13/19 of studies which achieved a significant result.[24,28,37,38,40,41,44,46,49,50,55,56,59]

In the 19 studies reporting a statistically significant improvement in 30-day readmissions and/or representations, 6/19 provided a full post-discharge MTM or CMM/CPP service, which is equivalent to six clinical

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
	30-day ED representations	↑	15% vs 6%	P = 0.230				
	90-day ED representations	↔	24% vs 21%	P = 0.769				
Kirkham *et al* 2014[45]	30-day readmission rate	↓	5.0% vs 9.5%; OR = 1.90	95% CI = 1.35-2.67	Factors associated with readmission: ▪ black race ▪ longer LOS ▪ Medicaid as primary insurer ▪ month of D/C ▪ higher count of condition categories	N/A	 Adj OR = 1.24 Adj OR = 1.01 Adj OR = 1.38 Adj OR = 1.02 Adj OR = 1.12	95% CI: 1.12-1.36 1.01-1.02 1.22-1.56 1.01-1.03 1.10-1.13
	30-day readmission rate (patients 65+ years)	↓	OR = 6.05	95% CI = 1.92-19.00				
Lisenby *et al* 2015[81]	30-day readmission rate	↓	27.9% vs 40.0%	Not sig	Most common risk factors for readmission	N/A	▪ 5+ meds ▪ COPD	
					Reasons for readmission	N/A	▪ Treatment failure (Pneumonia) ▪ Exacerbation COPD/CCF	
March *et al* 2020[47]	HCAHPS score – "communication about medicines"	↑	52.6% (pre) vs 67.3% (post)	P = 0.0001	30-day readmission rate	↓	13.3% vs 16.4%	P = 0.133
					30-day readmission rate (sub-group D/C phone call + D/C education)	↓	12.4% vs 17.3%	P = 0.007
					Number of patients with a potential safety event prevented	N/A	N = 143	
McFarland *et al* 2020[48]	Composite 30-day readmission rate and ED representations	↔	26.9% vs 28.9%	P = 0.6852	Composite 30-day readmission rate and ED representations (same disease state)	↓	4.1% vs 16.9%	P = 0.0001
					Composite 90-day readmission rate and ED representations	↓	62.4% vs 74.4%	P = 0.0062
					Composite 90-day readmission rate and ED representations (same disease state)	↓	16.1% vs 37.6%	P = 0.0001
					Mortality within 30-days (all-cause)	↔	2 (0.8%) vs 2 (0.8%)	No difference
					Mortality within 90-days (all-cause)	↓	8 (3.3%) vs 18 (7.4%)	P < 0.05
Miller *et al* 2020[83]	Phase 2: 30-day readmission rate	↓	ARR = 13.69% RRR = 64%					
	Phase 3: 30-day readmission rate (1 service: either D/C med reconciliation or post-D/C phone F/U)	↔	O/E ratio = 1.01					
	Phase 3: 30-day readmission rate (both services: D/C med reconciliation and post-D/C phone F/U)	↓	O/E ratio = 0.77					
Ni *et al* 2017[49]	30-day readmission rate	↓	28%, OR = 0.720	95% CI, 0.526-0.985	Number of readmissions within 30 days	↓	6 per 100 patients	
	180-day readmission rate	↓	31.9%, OR = 0.681	95% CI, 0.507-0.914	Number of readmissions within 180 days	↓	19 per 100 patients	
O'Reilly *et al* 2020[86]	30-day readmission rate	↓	0 (0%) vs 73 (12.3%)	Not sig	30-day ED representations	↓	0 (0%) vs 107 (18.6%)	Not sig
					Completed pharmacist phone F/U	N/A	N = 15 (65.2%)	Not sig
					Completed pharmacist clinic F/U	N/A	N = 12 (52.2%)	Not sig
					Average number of MRPs identified at pharmacist clinic F/U	N/A	N = 1.2 per patient (N = 6 (40%) adherence related)	Not sig
Phatak *et al* 2016[54]	ADEs or ME's at 30 days	↓	11.8% vs 12.8%	P = 0.22	Composite 30-day readmission rate or ED representations	↓	24.8% vs 39%	P = 0.001
					Hospital Consumer Assessment of Healthcare Providers (HCAHPS) scores	↑	9%	P > 0.05

pharmacist activities (Tables 3 and 4).[24,28,40,41,60,75] For the remaining studies, 11/19 of the studies that were not MTM or CMM/CPP the number of clinical pharmacist activities ranged from 6 (n = 1) to 1 (n = 1),[37,38,43,44,46,49,50,54–56,59] of which 4/11 provided four or more clinical pharmacist activities,[37,43,46,56] and 2/19 of the studies did not specify the components of pharmacist post-discharge follow-up (Tables 3 and 4).[42,45]

In the 27 studies reporting no significant difference in 30-day readmissions and/or representations, 8/27 of the studies provided MTM or CMM/CPP services (Tables 3 and 4).[48,71,73,74,76,80,83,89] The remaining 17/27 of the studies reported clinical pharmacist activities ranging from six (n = 1) to one (n = 2),[35,39,47,51,55,58,63,66,68–70,78,79,81–83,86] with 4/17 providing four or more clinical pharmacist activities,[51,58,68,82] and 2/27 of the studies did not specify the components of clinical pharmacist activities.[72,88]

The frequency of post-discharge clinical pharmacist activities reported in the intervention arm in studies achieving a significant improvement in 30-day hospital readmissions and/or representations compared to those that were not significant are summarised in Table 4. Studies that reported the intervention as MTM, CMM or CPP were assumed to have included best possible medication history, medication reconciliation (post-discharge), patient education, medication order review, pharmaceutical review and interventions directed to the PCP as clinical pharmacist activities as per the American College of Clinical

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
Ravn-Nielsen *et al* 2018[63]	30-day readmission rate				30-day med-related readmission rate			
	▪ Basic	↓	19.9% vs 22.3%	Not sig	▪ Basic	↓	6.9% vs 7.6%	Not sig
	▪ Extended	↓	14.3% vs 22.3%	HR = 0.62; 95% CI = 0.46-0.84	▪ Extended	↓	5.0% vs 7.6%	Not sig
	180-day readmission rate				180-day med-related readmission rate			
	▪ Basic	↓	47.3% vs 48.8%	Not sig	▪ Basic	↓	19.3% vs 19.3%	Not sig
	▪ Extended	↓	39.7% vs 48.8%	HR = 0.75; 95% CI = 0.62-0.90	▪ Extended	↓	15.8% vs 19.3%	Not sig
	Composite 180-day readmission rate or ED representations				Mortality within 180-days (all-cause)			
	▪ Basic	↓	47.3% vs 48.8%	Not sig	▪ Basic	↔	8.5% vs 10.0%	Not sig
	▪ Extended	↓	40.5% vs 48.8%	HR = 0.77; 95% CI = 0.64-0.93	▪ Extended	↔	11.3% vs 10.0%	Not sig
					Mortality within 180-days (med-related)			
					▪ Basic	↓	0.6% vs 1.2%	Not sig
					▪ Extended	↓	1.1% vs 1.2%	Not sig
Rottman-Sagebiel *et al* 2018[56]	30-day readmission rate	↓	15.6% vs 21.9%	P = 0.06	30-day readmission rate (covariate adjusted)	↓	OR = 0.54	P = 0.02
	30-day readmission rate (unadjusted)	↓	OR = 0.74	P = 0.06	≥1 recommended change in treatment (inpatient admission)	N/A	35%	
					≥1 recommended change in treatment (follow-up)	N/A	39%	
Schnipper *et al* 2006[57]	Preventable ADEs at 30 days post-D/C	↓	1% vs 11%	P = 0.01	30-day preventable, med-related readmission rate and ED representations	↓	1% vs 8%	P = 0.03
					All ADEs	↔	No difference	
					Frequency of MRPs at D/C (Interventiion group only):	N/A		
					▪ 1+ discrepancy		49%	
					▪ Med issues prior to admission		16%	
					Frequency of MRPs at follow-up (Intervention group only):	N/A		
					▪ 1+ discrepancy		29%	
					▪ Side effects		37%	
					▪ Non-adherence		23%	
					▪ Difficulty obtaining supply		18%	
					▪ Affordability		11%	
					Med adherence	↔	No difference	
					Med discrepancies	↔	No difference	
Snyder *et al* 2020[58]	30-day readmission rate	↓	9% vs 15%	P = 0.08	Multivariable modelling of 30-day readmission risk (control group)	↑	OR = 1.82 95% CI, 1.15-2.89	P = 0.0108
					PCP visits ≤14 days	↔	No difference	
					TOC pharmacist activities:			
					▪ Identified MRPs	N/A	N = 960	
					▪ Resolved MRPs	N/A	N = 823 (85.7%)	
Walker *et al* 2009[88]	30-day readmission rate	↔	22.1% vs 18.0%	P = 0.17	Med discrepancies identified at D/C	↑	33.5% vs 59.6%	
	14-day readmission rate	↔	12.6% vs 11.5%	P = 0.65	Med discrepancies resolved prior D/C (Intervention group only)	↑		P < 0.001
	3-day (72 hour) ED representations	↔	2.8% vs 2.2%	P = 0.60				
	14-day ED representations	↔	6.2% vs 7.4%	P = 0.51				
	30-day ED representations	↔	9.5% vs 12.3%	P = 0.23				
	Composite 30-day readmission rate and ED representations	↔	27.4% vs 25.7%	P = 0.61				

Pharmacy (ACCP) guidelines.[91,93,94]

In the 18 inpatient clinical pharmacist service with post-discharge clinic pharmacist follow-up studies, 15 provided three or less clinical pharmacist activities in the post-discharge setting.[38,39,42,45,47,49,54,63,70,72,78,81,83,86,88] Thirteen of these studies provided pharmaceutical review,[38,47–49,54,56,58,63,70,78,81,83,86] and 3 provided post-discharge medication reconciliation with the pharmaceutical review.[48,58,86] This compared to the 16 post-discharge clinic pharmacist review only and 11 collaborative clinic studies which provided three or less clinical pharmacist activities in the post-discharge setting in 5,[44,50,55,66,79] and 3 of the studies respectively.[35,59,69] However, all studies in these two groups provided pharmaceutical review as part of their study intervention,[24,28,35,37,40,41,43,44,46,50,51,55,59,60,66,68,69,71,73–76,79,80,82,84,89] and 14 of the post-discharge clinic studies,[24,43,46,51,55,66,71,73–75,79,80,84,89] and 10 of the collaborative clinic studies,[28,35,37,40,41,60,68,69,76,82] provided medication reconciliation with the pharmaceutical review.

3.6. Risk of bias

Of the 14 RCTs,[39,43,44,51,54,57,61–64,67,72,74,77] 6 studies scored low in all six risk of bias domains.[44,51,63,67,72,74] Six studies exhibited 'some concerns' overall due to randomisation,[61,62] selection bias with regard to concealment,[39,61,63,64,67] adherence to the intervention,[54,57,77] missing outcome data,[39,63] detection bias,[39,61,67] and reporting bias.[61,64] And 'high risk of bias' was found in 2 studies due to selection bias with regard to adherence to intervention and reporting bias,[43] as well as detection bias and randomisation.[62]

Of the 43 non-randomised studies only 1 study by Westberg *et al* scored low risk of bias in all seven domains.[89] Nineteen studies exhibited moderate risk of bias,[24,35,38,41,45,48–50,55,57–59,75,76,80–82,84,85] 16 studies were scored as serious risk of bias,[36,40,42,52,53,60,68–71,73,78,79,86–88] and critical risk of bias was found for 7 studies.[28,37,46,47,65,66,83]

A complete summary of the risk of bias assessment outcomes utilising the RoB 2.0 tool for RCTs,[33] and the ROBINS-I tool for non-randomised

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
Xu N *et al* 2019[61]	180-day readmission rate	↓	9.2% vs 20.0%	P = 0.041	Patient understanding (at 180-days and 730-days respectively)			
					▪ Disease severity	↑		P = 0.022, 0.002
					▪ Therapeutic goal	↑		P < 0.001, < 0.001
					▪ Med awareness	↑		P < 0.001, < 0.001
					▪ Emotion management	↑		P < 0.001, < 0.001
					▪ Treatment satisfaction	↑		P = 0.026, < 0.001
	180-day MACE				Med adherence			
	▪ Recurrent angina	↓	11.2% vs 15.8%	P = 0.053	▪ 180-days	↑		P = 0.065
	▪ Revascularisation	↓	2.0% 10.5%	P = 0.015	▪ 730-days	↑		P < 0.001
	▪ Nonfatal MI	↓	0% vs 1.1%	P = 0.309				
	730-day readmission rate	↓	48.0% vs 72.6%	P = 0.001	Risk factor control at 730-days			
	730-day MACE				▪ Smoker	↓	12.6% vs 3.1%	P = 0.012
	▪ Recurrent angina	↓	39.8% vs 67.4%	P < 0.001	▪ Normal BGL	↑	62.1% vs 79.6%	P = 0.007
	▪ Revascularisation	↓	13.3% vs 35.8%	P < 0.001	▪ HbA1c	↓	6.5±0.43 vs 5.8±0.24	P < 0.001
	▪ Nonfatal MI	↓	1.0% vs 7.4%	P = 0.027	▪ Normal BP	↑	53.7% vs 74.5%	P = 0.003
					▪ Normal blood lipid	↑	57.9% vs 84.7%	P < 0.001
Xu H *et al* 2019[67]	180-day MACE	↓	3.3% vs 7.5%	P = 0.154	180-day readmission rate	↓		P = 0.071
	365-day MACE	↓	10.8% vs 11.7%	P = 0.838	Self-reported med adherence to CHD meds (all 4-classes)			
					▪ 180 days	↔	48.3% vs 45.8%	P = 0.691
					▪ 365 days	↔	47.9% vs 46.6%	P = 0.836
Zhao *et al* 2015[62]	Improved self-care ability, QoL, drug therapy compliance,	↑		Not stated	Adherence (med, diet, lifestyle changes) at 180 days	↑	93.39% +/- 6.56% vs 79.36% +/- 15.46% (t = 5.469)	P = 0.00
	treatment success in CHD (over 6 months)				Goals of treatment attained at 180 days[a]	↑	77.8% vs 48.9%	P = 0.004
					ADEs	↔	7% vs 4.8%	P = 1
Clinic Type: Post-discharge Collaborative Clinic; Clinic Pharmacist with Other Health Care Professionals (n = 13)								
Al-Bawardy *et al* 2019[35]	30-day readmission rate	↓	9.2% vs 20.0%	P = 0.063	Readmissions between 90-days and 1 year	↔	59.6% vs 55.6%	P = 0.641
	90-day readmission rate	↓	24.8% vs 48.9%	P = 0.003	30-day mortality rate	↔	0.0% vs 0.0%	P = N/A
					90-day mortality rate	↔	0.0% vs 6.7%	P = N/A
					1 year mortality rate	↓	5.2% vs 11.1%	P = 0.290
Arnold *et al* 2015[37]	30-day readmission rate	↓	9.2% vs 19.5%	P = 0.023	Mean time to hospital readmission (days)	↑	18.3 vs 12.8	P = 0.042
					MRPs identified by pharmacist:			
					▪ Inappropriate dose	N/A	N = 18	
					▪ Therapeutic duplication	N/A	N = 11	
					▪ Additional therapy required	N/A	N = 45	
					Recommendations by pharmacist:			
					▪ Drug interactions	N/A	N = 3	
					▪ Appropriate drug product (dose form)	N/A	N = 10	
					▪ Inappropriate monitoring	N/A	N = 13	
					▪ Appropriateness of drug therapy	N/A	N = 94	
					▪ Suboptimal drug therapy	N/A	N = 41	
Bingham *et al* 2019[68]	30-day readmission rate	↓	13% vs 17%; OR = 0.56, 95% CI, 0.24-1.30	Not sig	Clinical interventions (total)	N/A	N = 1242	
					Clinical interventions (improve patient care)	N/A	N = 190	
					Clinical interventions (med safety)	N/A	N = 657	
					Clinical interventions (adherence)	N/A	N = 22	

studies,[34] is provided in Tables 5a and 5b respectively.

4. Discussion

This systematic review identified 57 studies that evaluated at least one patient clinical outcome using an intervention-control design from the addition of a hospital-based post-discharge clinical pharmacist medication review. Three key clinic types were identified and the most frequently reported outcome was 30-day hospital readmissions and/or representations. There was a mix of clinical pharmacist activities described across the studies in both the usual care and intervention groups. These activities were not always clearly defined by the study investigators and terms such as 'medication reconciliation' or 'medication review' may have also included undertaking a 'best possible medication history' or 'identification and resolution of MRPs' without explicitly stating so.

4.1. Patient clinical outcomes

This systematic review included primary and secondary outcomes in the inclusion criteria to thoroughly assess all patient clinical outcomes measured. The three main outcome metrics, hospital readmissions and/or representations, AEs and ADEs as well as disease state metrics were reported as a mixture of primary and secondary outcomes.

Author, Year	Primary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes (↓ = decreased, ↑ = increased, ↔ = no change, N/A = not applicable)		Results (Intervention vs Usual Care)	Statistical significance
Borhanjoo et al 2019[69]	30-day readmission rate	↓	7.58% vs 9.27%	P = 0.49	Patient co-morbidities effect on 30-day readmission rate (26% increase for each additional co-morbidity)	↑	Adjusted OR = 1.26 95% CI 1.07-1.47	P = 0.005
Cavanaugh *et al* 2014[40]	30-day readmission rate	↓	9% vs 26%	P = 0.023	30-day ED representations	↓	11% vs 22%	P = 0.121
	90-day readmission rate	↓	19% vs 44%	P = 0.004	90-day ED representations	↓	20% vs 31%	P = 0.188
					30-day readmission rate or ED representations	↓	19% vs 44%	P = 0.004
					90-day readmission rate or ED representations	↓	33% vs 59%	P = 0.007
					Days to first Internal Medicines Clinic F/U (median)	↓	7 (IQR 6, 11) vs 12 (IQR 7.5, 25.5)	P < 0.001
					Days to first UNC clinic F/U (median)	↓	6.5 (IQR 5, 10) vs 10.5 (IQR 7, 17)	P < 0.001
					Hospital F/U within 30-days	↓	100% vs 85%	P = 0.003
Cavanaugh *et al* 2015[41]	30-day readmission rate (at UNC hospitals)	↓	14.3% vs 34.3%	P = 0.010	Med dose adjustments	↔	37.9% vs 33.8%	P = 0.719
					Recommendation of a lower cost alternative	↔	0% vs 2.9%	P = 0.497
					Addressed non-adherence	↑	98.5% vs 86.8%	P = 0.017
					Initiation of new med	↑	60.9% vs 37.7%	P = 0.010
					Discontinuation of a med	↑	31.4% vs 15.7%	P = 0.046
					30-day readmission rate	↓	ARR 16.7% (overall reduction) or 1 in 7 patients seen	
Hawes *et al* 2018[76]	MRPs (Intervention group only)	N/A	Mean of 4.36+/- 2.65 (range 0-11) per patient		30-day readmission rate	↓	8.1% vs 12.8%	P = 0.162
					30-day ED representations	↔	18.6% in both groups	
					60-day readmission rate	↓	14.0% vs 18.6%	P = 0.171
					60-day ED representations	↔	22.1% in both groups	
Khatib *et al* 2018[65]	Medicines optimisation (receiving a recommended dose at 6mth post-D/C vs baseline):				Patient concerns ("MYMEDS") (1mth post-clinic vs baseline):			
	▪ ACEI/ARB	↑	73.9% vs 16.3%	P < 0.001	▪ Understands reasons for meds	↑	99% vs 73%	P < 0.001
	▪ β-blocker	↑	46.1% vs 6.2%	P < 0.001	▪ Concern cardiac meds do more harm than good	↓	3.2% vs 33.2%	P < 0.001
	▪ Statin	↑	20.8%		▪ Non-adherence	↓	3.5% vs 20.2%,	P < 0.001
					Self-reported non-adherence (3-6mths post-clinic vs baseline):			
					▪ Aspirin	↔	7.8% vs 13.6%	P = 0.112
					▪ Secondary prevention meds	↑	4.2-7.7% vs 13.6-21.5%	P < 0.05
					Mean prescription persistence scores at 11-12mths post-MI (Medicines Optimisation Clinic vs Cardiologist alone, n = 50)	↑	83.1% vs 76.5%	P = 0.002
					Follow-up clinic waiting times (days)	↓	44% (49 vs 88)	
					Seen by pharmacist only		>95%	
					30-day readmission rate for ACS	↓	4% vs 7%	Not stated
					60-day readmission rate for ACS	↓	5% vs 10%	Not stated
					90-day readmission rate for ACS	↓	5% vs 11%	Not stated
Mayzel *et al* 2020[82]	Proportion of patients ≥1 MRP identified	↑	72% vs 18%	P < 0.001	Number MRPs identified	↑	56 vs 11	
					30-day readmission rate	↓	9 vs 11	P = 0.065
Murphy *et al* 2019[85]	30-day readmission rate				72-hour ED visit rate			
	▪ HF	↑	24% vs 18.2%	P = 0.238	▪ HF	↑	4% vs 1.9%	P = 0.267
	▪ MI	↑	17.2% vs 11.4%	P = 0.252	▪ MI	↔	4.3% vs 4.3%	P = 1.000
					30-day mortality rate			
					▪ HF	↓	0% vs 1.52%	P = 0.579
					▪ MI	↓	1.1% vs 2.5%	P = 0.656

4.1.1. *Hospital readmissions and/or representations*

Hospital readmissions were the most commonly reported outcome and likely reflects that this is considered a key indicator for the quality of healthcare internationally,[17,95,96] and affects how health systems are funded. Measurement of medication-related hospital readmissions is not commonly reported in studies, most likely due to the difficulty in assessing this outcome. An Australian study of patients aged 50 years and older reported 34% of patients experienced a MRP within 4 months of discharge from hospital, and 9% reported being readmitted to hospital due to a MRP.[97] Only 1 study included in this systematic review assessed preventable medication-related readmissions, demonstrating a significant reduction in this outcome with pharmacist intervention.[57]

Health professional collaboration appears a good indicator of success with studies utilising a collaborative post-discharge clinic model of care more likely to report a significant reduction in 30-day readmissions and representations. These findings are similar to previous studies that have shown that pharmacists working with other health professionals or in multidisciplinary teams were more likely to achieve positive patient outcomes.[18,98] Perhaps the pharmacist taking responsibility for the implementation of peer-agreed recommendations to optimise medicines in a collaborative environment to enhance a patient's pharmaceutical care is a key approach to influencing patient outcomes.

4.1.2. *Adverse events (AEs) and adverse drug events (ADEs)*

Pharmacist interventions have been shown to reduce medication discrepancies,[23,99,100] or improve the quality of medication

Author, Year	Primary Outcomes ↓ = decreased ↑ = increased ↔ = no change N/A = not applicable	Results (Intervention vs Usual Care)	Statistical significance	Secondary Outcomes ↓ = decreased ↑ = increased ↔ = no change N/A = not applicable	Results (Intervention vs Usual Care)	Statistical significance
				Pharmacist phone F/U completion rate ▪ HF N/A ▪ MI N/A	 73/100 (73%) 54/93 (58%)	
				Pharmacist MTM clinic completion rate ▪ HF N/A ▪ MI N/A	 18/100 (18%) 5/93 (5%)	
Thurston *et al* 2019[59]	30-day readmission rate ↓	21.3% vs 33.7% (RRR = 0.696, CI 0.4888-0.994); NNT = 13	P = 0.046	Medication adherence (MMAS-8) rating: ▪ High ↑ ▪ Medium ↔ ▪ Low ↓	 49% vs 32% No difference 6% vs 32%,	 P < 0.001 P = 0.276 P < 0.05
Trang *et al* 2015[28]	30-day readmission rate or ED representations ↓	23% vs 41.4%	P = 0.013	MRPs identified by the pharmacist (Intervention group only) N/A	Total of 49; approximately 2 MRPs per patient	
				MRPs requiring follow-up and intervention (Intervention group only) N/A	85.7% (n = 42)	
				Clinic quality indicators, average reduction: ▪ Fasting BGL ↓ ▪ SBP ↓ ▪ DBP ↓		 P = 0.32 P = 0.14 P = 0.003
Wiegmann *et al* 2020[60]	90-day readmission rate ↓	14% vs 22%	P = 0.244	60-day readmission rate ↓	10% vs 22%	P = 0.089
				30-day readmission rate ↓	2% vs 16%	P = 0.015
				Time to readmission ↑	52 vs 17 days	P = 0.026
				Average reduction in HbA1c at 90 days (n = 40) ↓	-0.9% vs -0.2%	P = 0.86
				Average reduction in BP at 90 days (n = 42) ▪ SBP ↔ ▪ DBP ↔	 	 P = 0.74 P = 0.68

Legend: ACEI = Angiotensin Converting Enzyme Inhibitor; ACS = Acute Coronary Syndrome; ADE = Adverse Drug Event (or Averse Drug Reaction); ARB = Angiotensin Receptor Blocker; BGL = blood glucose level; BP = blood pressure; CHD = Coronary Heart Disease; CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; DBP = diastolic blood pressure; D/C = Discharge; ED = Emergency Department; F/U = follow-up; HbA1c = Glycated Haemoglobin; HCAHPS = Hospital Consumer Assessment of Healthcare Providers and Systems; HF = Heart Failure; ICS = Inhaled Corticosteroid; ITT = Intention to Treat; LDL = Low-density Lipoprotein; LOS = Length of Stay; MACE = Major Adverse Cardiac Events; MAI = Medication Appropriateness Index; ME = Medication Error; med = medication; MedAL = Medication Adherence and Literacy; MI = Myocardial Infarction; MMAS = Morisky Medication Adherence Scale; MRP = Medication Related Problem (or Drug Therapy Problem or Drug Related Problem); NNT = Number Needed to Treat; Not sig = Not Significant; NPSA = National Patient Safety Agency; OR = Odds Ratio; PAD = Peripheral Artery Disease; PCP = Primary Care Provider; PDC = Proportion of Days Covered; QoL = Quality of Life; RRR = Relative Risk Reduction; SBP = Systolic Blood Pressure; START = Screening Tool to Alert Doctors to the Right Treatment; STOPP = Screening Tool of Older Persons Prescriptions; TIA = Transient Ischaemic Attack; TOC = Transitions of Care; UNC = University of North Carolina.
[a] Goals of treatment at 6 months: blood pressure, rates of diabetes, dyslipidaemia, average heart rate, body mass index.

Table 2
Summary of readmission and representation outcomes (n = 45).

Outcome measured	Number of studies
30-day readmission rate only[37,39,41,45,47,56,58,59,66,68–71,73,80–84,88]	20
Composite 30-day readmission rate and 30-day representation rate[28,44,48,54,89]	5
30-day readmission rate and 30-day representation rate and composite of both[40,42,43,74,78]	5
30-day readmission rate and 30-day representation rate[55,75,86]	3
30-day readmission rate and composite of both 30-day readmission rate and 30-day representation rate[46,72]	2
30-day and 60-day readmission rate[24,76]	2
30-day, 60-day and 90-day readmission rate[60]	1
30-day and 90-day readmission rate[35,37,50]	3
30-day and 180-day readmission rate[49,63]	2
7-day, 14-day and 30-day readmission rate[79]	1
7-day, 14-day, 30-day, 90-day, 180-day and 365-day readmission rate[51]	1

prescribing.[26,101,102] A survey of patients recently discharged from hospital revealed 9% of patients were readmitted due to a MRP.[97] This is within the range of medication-related readmissions of 3-64% reported in a systematic review by El Morabet *et al*, of which between 5-87% were deemed potentially preventable.[15] It is proposed that pharmacists are the key health professional likely to influence the prevention of MRPs,[98,101] and thus any on-flow of adverse effects. However, this has not necessarily translated into a reduction in clinical outcomes such as preventing ADEs,[99,102] or reducing hospital admissions or ED visits.[102] These two reviews both focussed on pharmacist activities in primary or community care on preventing ADEs,[99,102] which is quite different to this systematic review of hospital-based post-discharge clinical pharmacist care.

The study by Schnipper *et al* assessed preventable ADEs at 30-days post-discharge in an RCT design, and demonstrated a significant reduction in preventable ADEs as well as preventable medication-related readmissions and representations.[57] The study design included the implementation of pharmacist-led medication reconciliation, medication review, patient education and phone follow-up after discharge compared to routine review of inpatient medication orders only.[57] The observed decrease in ADEs at 30-days suggests that pharmacist input throughout transitions of care is needed to impact on medication-related patient outcomes. However, the authors reported that the measurement of these specific medication related outcomes is more labour intensive than using standard patient outcomes such as all-cause 30-day hospital readmissions, and hence, is not as commonly reported in the literature.

4.1.3. *Disease state metrics*

This study did not find a link between improved readmission rates

Table 3
Clinical pharmacist activities associated with 30-day hospital readmissions and representations (unless specified), categorised by clinic type.

	Study Interventions																				
	Clinic type	Method of post-D/C follow-up	Number of post-D/C contacts	Time to first post-D/C follow-up (days)	Outcome: Hospital readmission and/or representation	Not specified or defined	No Pharmacist support	Best possible med history	Med reconciliation (inpatient)	Med reconciliation (post-D/C)	Best Possible Med D/C List	Patient education	D/C med supply	Med order review	Pharmaceutical (or med) review	Ward rounds	Interventions directed to inpatient Physician	Interventions directed to PCP	Post-D/C MTM [e]	Post-D/C CMM [b] or CPP [f]
Statistically significant outcome (n = 19)																					
Budlong *et al* 2018[24]	PDC	P or F or V	2	<30	H	●		○		○		○			○			○	● [e]	[f]
Hahn *et al* 2019[75]	PDC	P or F	1+	10	H					○		●○		○	○		○		● [e]	● HI
Hawes *et al* 2014[43]	PDC	F	1	3	H / ED			●		●	●●	●			●●	●	●	●		
Jack *et al* 2009[44]	PDC	P	1	2-4	H + ED	●						●			●			●		
Liu *et al* 2019[46]	PDC	P	1	2-14	H		●			●		●		●	●			●		
Odeh *et al* 2019[50]	PDC	P	3	<10	H	●								●	●			●		
Rebello *et al* 2017[55] [a]	PDC	P	1+	7	H / ED[a]	●				●					●			●		
Bae-Shaw *et al* 2020[38]	IPC+PDC	P	1	NS	H	●			●			●	●		●●		●●			
Fera *et al* 2014[42]	IPC+PDC	P	1	3	H + ED	●						●●		●	●		●●			
Kirkham *et al* 2014[45]	IPC+PDC	P	1	2-3	H	●						●	●	●●						
Ni *et al* 2017[49]	IPC+PDC	P + F	1+	<30	H		●		●			●	●		●●					
Phatak *et al* 2016[54]	IPC+PDC	P	3	3	H + ED				●●			●●			●●		●			
Ravn-Nielsen *et al* 2018[63]	IPC+PDC	P	2	7	H		●		●		●	●●			●●		●	●		
Arnold *et al* 2015[37]	CC	F	1	NS	H		●			●				●	●			●		
Cavanaugh *et al* 2014[40]	CC	F	1	5	H / ED		●					●								● [g]
Cavanaugh *et al* 2015[41]	CC	F	1	<7	H		●	○		○		○			○			○		● [g]
Thurston *et al* 2019[59]	CC	P	2	14	H		●	●			●		●		●					
Trang *et al* 2015[28]	CC	P + F	2	2	H + ED		●	○		●		●			●			●		● [f]
Weigmann *et al* 2020[60]	CC	F	3	<14	H				●	●		●					●			● [f]
Non-significant outcome (n = 27)																					
Cole *et al* 2019[71]	PDC	P	2	<2	H		●			●		○			○			○		● [f, g]
Fisher *et al* 2020[73]	PDC	P or V	2	<7	H				●	●		●●								● [f]
Haag *et al* 2016[74]	PDC	P	1	3-7	H + ED		●	○		○		○			○			○	● [e]	
Kilcup *et al* 2013[79]	PDC	P	1	3-7	H		●			●					●			●		
Layman *et al* 2020[80]	PDC	F	1	<14	H		●			○		○			○					● [g]
Miller *et al* 2016[84]	PDC	P	2	3	H	●		○		●	●	○			●			●		● [f]
Odeh *et al* 2020[51]	PDC	F + P	2	<14	H		●			●	●	●			●		●	●		
Rebello *et al* 2017[55] [a]	PDC	P	1+	7	H[a] / ED	●				●					●			●		
Westberg *et al* 2014[89]	PDC	F	1	14	H / ED		●	○		○		○			○			●		● [f]
Yang 2017[66]	PDC	P	2	2-7	H	●				●		●			●					
Bonetti *et al* 2018[39] [b]	IPC+PDC	P	2	3, 15	H[b]						●	●●		●●	●●		●●			
Budiman *et al* 2016 [70]	IPC+PDC	P	2	2-3	H		●	●	●		●	●	●		●					
Farris *et al* 2014[72]	IPC+PDC	P	1	3-5	H / ED	●		●	●●		●	●					●			
Jones *et al* 2018[78]	IPC+PDC	P	1	≤3	H / ED	●		●	●		●	●		●●	●					
Lisenby *et al* 2015[81]	IPC+PDC	P	1	2-4	H		●		●			●●			●●		●			
March *et al* 2020[47] [c]	IPC+PDC	P	1	≤3	H[c]		○		●		●	●○			○●		●			
McFarland *et al* 2020[48] [b,d]	IPC+PDC	F	1+	≤10	H[b,d] + ED				●			●○			○	●	●●			● [f]
Miller *et al* 2020[83] [c]	IPC+PDC	P	2	7	H[c]		●		●			●			●		●			
O'Reilly *et al* 2020[86]	IPC+PDC	P + F	2	≤3	H / ED				●	●	●	●●			●	●				
Rottman-Sagabiel *et al* 2018[56] [c]	IPC+PDC	P	1	2-3	H[c]	●			●	●		●●			●		●	●		
Snyder *et al* 2020[58] [c]	IPC+PDC	P	1	≤2	H[c]	●				●			●	●	●			●		
Walker *et al* 2009[88]	IPC+PDC	P	2	3	H	●	●	●	●			●			●	●	●			
Al-Bawardy *et al* 2019[35] [d]	CC	F	1	7-10	H		●			●		●			●					
Bingham *et al* 2019[68]	CC	P	2	≤7	H		●			●		●		●	●					
Borhanjoo *et al* 2019[69]	CC	F	1	NS	H		●			●		●			●					
Hawes *et al* 2018[76]	CC	F	1	<30	H / ED		●	○		●		●			○			●		● [g]
Mayzel *et al* 2020[82]	CC	F	1	7-14	H		●			●		●			●			●		

Legend: D/C: discharge; med: medication; NS: Not stated; PCP: primary care physician; Clinic type: PDC: Post-discharge clinic; IPC+PDC: Inpatient clinical pharmacy service; CC: Collaborative post-discharge clinic. Method of follow-up: P: Phone; F: Clinic (face to face); V: Virtual. Outcome: H: 30-day hospital readmission; ED: 30-day representation; H + ED composite 30-day readmissions/representations only; Green = primary outcome, Orange = secondary outcome.
Intervention delivered: ● Usual care; ○ Usual care (single intervention component only); ● Inpatient clinical pharmacy service; ● Post-discharge follow-up; ○ Incorporated into MTM/CMM/CPP.
[a]Statistically significant for ED/urgent care visit, not significant for 30-day readmission.

[b]Not statistically significant for 30-day readmission rate (all-cause), statistically significant for 30-day readmission rate (heart disease or same disease state).
[c]Not statistically significant for 30-day readmission rate (all-cause), statistically significant for 30-day readmission rate (sub-group analysis).
[d]Not statistically significant for 30-day readmission rate (all-cause), statistically significant for 90-day readmission rate.
[e]MTM: MTM services include the performing of a comprehensive pharmaceutical care review by ensuring all medication therapies, over the counter and herbal products are safe and effective, providing patient or carer education to optimise medication use, as well as liaising with a patients' PCP or other health care providers to optimise medication therapy.[91,92]
[f]CMM: is an expansion on MTM and ensures that patients' medications are appropriate, effective, safe and provides ongoing monitoring and review. CMM incorporates the development of a patient-centred care plan that assesses a patients' clinical state and requires collaboration among members of the health care team and is continually updated as needed.[93]
[g]CPP: Clinical Pharmacist Practitioner is a licensed pharmacist advanced practice provider, who may prescribe medication therapy and order appropriate monitoring tests in accordance with an agreed protocol under the supervision of a physician.[94]
[HI]High Intensity.

Table 4
Summary of clinical pharmacist activities provided by the post-discharge clinical pharmacist in studies reporting 30-day hospital readmission and/or representations (n = 45).

Clinical pharmacist activity	Significant (n = 19)[a]		Not significant (n = 27)[a]	
	Frequency	%	Frequency	%
Best possible medication history	7	37	8	30
Medication reconciliation (post-discharge)	10	53	18	67
Best possible medication discharge list[b]	1	5	2	7
Patient education[b]	10	53	19	70
Discharge medication supply	0	0	1	4
Medication order review	8	42	9	33
Pharmaceutical (or medication) review	16	84	24	89
Interventions directed to inpatient physician	2	11	1	4
Interventions directed to primary care provider	12	63	13	48

[a] Rebello *et al* is represented as a study with both a significant (ED/urgent care visit) and not significant (30-day readmissions) outcome.
[b] Provided as part of the post-discharge clinic pharmacist follow-up.

and significant improvements in disease state metrics, [28,36,60] or improved adherence and improved disease state metrics.[61,62,77] The two studies that reported significant improvements in reported disease state metrics by Zhao *et al* and Xu *et al,* describe a personalised monthly interaction with patients for 6 or 24 months.[61,62] This suggests that ongoing education that may impact on health-related behaviours such as smoking cessation, diet and exercise, compared to improved medication taking behaviour alone may be responsible for these improved patient outcomes.

4.2. Clinical pharmacist activities

There have been several systematic reviews with or without meta-analysis, exploring the effect of pharmacist-led medication reconciliation at transitions of care both in hospital and in the community post-discharge on preventing medication errors or improving patient outcomes with predominantly favourable effects supporting pharmacist-led care.[18,20,23,100] In this systematic review, the results suggest that the detail in reporting of clinical pharmacist activities varied considerably between studies. This made it difficult to draw any conclusions on the most effective clinical pharmacist activity or combination of activities required to improve patient outcomes. Other reviews highlight the high heterogeneity between studies makes it difficult to assess the impact of a single clinical pharmacist activity on patient clinical outcomes, such as medication reconciliation, or medication review.[18,20,23,98,100,101,103] This is mainly due to the variability in use of different terms and lack of definition of these activities in the study methods.

Reviews in the literature have proposed several components for an optimal transition of care process, of which clinical pharmacists would ideally play a key role throughout a patient's hospital stay as well as in the post-discharge period.[19,98,104] The components include post-discharge pharmacist follow-up, and comprehensive post-discharge clinical pharmacist medication review combined with in-hospital clinical pharmacist interventions.[19,98] Our results suggest that a comprehensive inpatient clinical pharmacy service, incorporating pharmacist-led medication reconciliation, medication review and patient education, with additional post-discharge clinical pharmacist follow-up, ideally in a multidisciplinary or collaborative care environment is needed to impact patient clinical outcomes.

However, recent systematic reviews to determine the most effective pharmacy intervention to influence patient outcomes,[105] and evaluate hospital readmissions,[18] could not identify a preferred pharmacist-led intervention that was most effective at improving patient outcomes. Like these studies, this review was unable to determine if a post-discharge medication review by a clinical pharmacist in a hospital-based clinic could be solely attributable to improving patient outcomes, as these studies often included some form of inpatient clinical pharmacist activity either as part of their usual care or the overall intervention studied. It may be that an individualised patient approach is required to influence patient outcomes.[105]

Improved reporting of interventions using standardised methods such as the Template for Intervention Description and Replication (TIDieR) checklist may enhance the ability to compare outcome measures of services and interventions between studies,[106] and future research should ideally use this methodology. Providing post-discharge medication review by a clinical pharmacist in a hospital-based clinic to

Table 5a
Risk of bias of randomised controlled trials (n = 14).

Randomised Controlled Trials (RoB 2.0)							
Study	Randomisation process	Selection bias (concealment)	Selection bias (adherence to intervention)	Missing outcome data	Detection bias (measurement of outcome)	Reporting bias	Overall risk of bias
Bonetti, 2018[40]	🟢	🟡	🟢	🟡	🟡	🟢	🟡
Farris, 2014[74]	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Haag, 2016[76]	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Hawes, 2014[45]	🟢	🟢	🔴	🟢	🟢	🟡	🔴
Ho, 2014[78]	🟢	🟢	🟡	🟢	🟢	🟢	🟡
Jack, 2009[46]	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Nguyen, 2018[66]	🟢	🟡	🟢	🟢	🟢	🟡	🟡
Odeh, 2020[53]	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Phatak, 2016[56]	🟢	🟢	🟡	🟢	🟢	🟢	🟡
Ravn-Nielsen, 2018[65]	🟢	🟡	🟢	🟡	🟢	🟢	🟢
Schnipper, 2006[59]	🟢	🟢	🟡	🟢	🟢	🟢	🟡
Xu H, 2019[69]	🟢	🟡	🟢	🟢	🟡	🟢	🟢
Xu N, 2019[63]	🟡	🟡	🟢	🟢	🟡	🟡	🟡
Zhao, 2015[64]	🟡	🟢	🟢	🟢	🔴	🟢	🔴

🟢 Low risk of bias, 🟡 Some concerns, 🔴 High risk of bias.

improve patient outcomes requires further exploration. And studies should provide a clear description and evaluation of the clinical pharmacist activities provided.

4.3. Strengths and limitations of the study

This study utilised broad search criteria with the aim to identify as many studies as possible that assessed patient clinical outcomes associated with a post-discharge medication review provided by a clinical pharmacist in a hospital-based clinic. This systematic review excluded studies that provided a home assessment, and studies based in community pharmacies or primary care. This enabled the focus to be on studies in which the clinical pharmacist is located within the hospital, and therefore has access to the inpatient medical records and hospital health professionals. Potentially, patients unable to attend a hospital-based clinic appointment were excluded from these studies, which may be a group at higher risk of admission or readmission to hospital due to reasons such as socioeconomic factors. This review included studies published in English only, which may have excluded significant outcomes from published research in other languages.

This systematic review excluded studies examining surrogate markers for outcomes such as identification and resolution of medication discrepancies or MRPs, or improvement in medication adherence to focus on patient clinical outcomes likely to impact on healthcare services. This may have resulted in an included study being underpowered for the patient clinical outcome reported as it may not have been a primary outcome.

A clinic pharmacist interacts with many health professionals including inpatient pharmacists, nurses or physicians. This systematic review tried to capture all studies with a post-discharge clinical pharmacist service in a hospital-based clinic incorporating some element of medication review. However, it may have contributed to the difficulty in determining the most effective activity impacting on the patient outcomes measured.

5. Conclusion

A post-discharge clinical pharmacist medication review in a hospital-based clinic appears to improve patient clinical outcomes, in particular hospital readmissions and/or representations. The most beneficial clinical pharmacist activities in a post-discharge clinic remain unclear due to the lack of clarity around the comprehensiveness of the services provided. Evidence suggests including clinical pharmacist services in the post-discharge period, particularly utilising a collaborative approach

Table 5b
Risk of bias of non-randomised studies (n = 43).

Non-randomised Studies (ROBINS-I)								
Study	Confounding bias	Selection bias (concealment)	Bias in intervention	Selection bias (adherence to intervention)	Missing outcome data	Detection bias (measurement of outcome)	Reporting bias	Overall risk of bias
Al-Bawardy, 2019[36]	Moderate	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate
Andres, 2019[37]	Moderate	Serious	Low	Low	Moderate	Moderate	Serious	Serious
Arnold, 2015[38]	Critical	Low	Serious	Moderate	NI	Moderate	Low	Critical
Bae-Shaw, 2020[39]	Moderate	Low	Low	Low	Low	Low	Low	Moderate
Bingham, 2019[70]	Moderate	Critical	Low	Moderate	Low	Moderate	Low	Serious
Borhanjoo, 2019[71]	Moderate	Low	Low	Moderate	Low	Moderate	Serious	Serious
Budiman, 2016[72]	Serious	Low	Low	Low	NI	Moderate	Low	Serious
Budlong, 2018[25]	Low	Moderate	Moderate	Low	NI	Low	Low	Moderate
Cavanaugh, 2014[41]	Serious	Serious	Moderate	NI	Low	Moderate	Serious	Serious
Cavanaugh, 2015[42]	Moderate	Moderate	Moderate	NI	NI	Low	Low	Moderate
Cole, 2019[73]	Serious	Moderate	Moderate	Low	Low	Serious	Moderate	Serious
Fera, 2014[43]	Serious	Moderate	Moderate	Low	NI	Low	Moderate	Serious
Fisher, 2020[75]	Serious	Moderate	Low	NI	Low	Moderate	Low	Serious
Hahn, 2019[44]	Moderate	Low	Low	Moderate	Low	Moderate	Moderate	Moderate
Hawes, 2018[77]	Low	Low	Low	NI	NI	Moderate	Low	Moderate
Jones, 2018[79]	Moderate	Low	Low	Moderate	Serious	Moderate	Moderate	Serious
Khatib, 2018[67]	Critical	Critical	Low	Critical	NI	NI	Low	Critical
Kilcup, 2013[80]	Low	Moderate	Serious	NI	NI	Low	Low	Serious
Kirkham, 2014[47]	Moderate	Low	Low	Low	NI	Moderate	Moderate	Moderate
Layman, 2020[81]	Moderate	Low	Low	Moderate	Low	Moderate	Moderate	Moderate
Lisenby, 2015[82]	Moderate	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Liu, 2019[48]	Serious	Critical	Moderate	Low	Moderate	Low	Low	Critical
March, 2020[49]	Serious	Critical	Serious	Serious	NI	Moderate	Moderate	Critical
Mayzel, 2020[83]	Moderate	Low	Low	Moderate	Low	Moderate	Serious	Moderate
McFarland, 2020[50]	Moderate	Moderate	Low	NI	NI	Moderate	Low	Moderate
Miller, 2016[85]	Serious	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Miller, 2020[84]	Critical	Critical	Critical	Critical	Critical	Critical	Critical	Critical
Murphy, 2019[86]	Moderate	Low	Low	Low	Low	Moderate	Low	Moderate
Ni, 2017[51]	Moderate	Low	Low	Low	Low	Low	Low	Moderate
O'Reilly, 2020[87]	Moderate	Low	Moderate	Serious	Low	Moderate	Serious	Serious
Odeh, 2019[52]	Low	Moderate	Low	Moderate	Low	Low	Low	Moderate
Paquin, 2015[54]	Serious	Moderate	Serious	Low	NI	Low	Low	Serious
Pett, 2016[55]	Serious	Low	Low	Low	NI	Moderate	Low	Serious
Rebello, 2017[57]	Moderate	Moderate	Low	Low	Low	Low	Low	Moderate
Rottman-Sagabeil, 2018[58]	Moderate	Moderate	Low	Low	Moderate	Moderate	Moderate	Moderate
Shaya, 2015[88]	Low	Low	Low	Low	Low	Moderate	Serious	Serious
Snyder, 2020[60]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Thurston, 2019[61]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Trang, 2015[29]	Critical	Low	Low	Low	Moderate	Serious	Low	Critical
Walker, 2009[89]	Moderate	Moderate	Low	Low	Low	Moderate	Serious	Serious
Weigmann, 2020[62]	Critical	NI	Moderate	NI	Serious	Moderate	Moderate	Serious
Westberg, 2014[90]	Low	Low	Low	Low	Low	Low	Low	Low
Yang, 2017[68]	Critical	Low	Serious	NI	NI	Moderate	Critical	Critical

Low risk of bias, Moderate risk of bias, Serious risk of bias, Critical risk of bias, NI = No Information.

may best influence patient clinical outcomes.

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Declaration of Competing Interest

I declare there are no conflicts of interest to disclose for the primary author of this review.

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Appendix A. Appendices

Appendix 1
Search strategy Pubmed.

Inclusion criteria	Exclusion criteria
• Papers >1990 (pharmaceutical care concept became widely described and pharmaceutical care dramatically changed) • Pharmacist review / Intervention / Medication Review (incl Phone or Virtual) • Post-discharge / Outpatient / Ambulatory (Clinic) • Recent hospital admission with outpatient pharmacist medication review • Clinical outcome (lipids, hospitalisations)	• Conference abstracts • Paediatrics / Cancer Care / Mental health • Home Medicines Review / Non-hospital (linked) clinics • Chronic disease management without recent hospital admission / Ambulatory Clinic • Non-outcome based papers / Descriptive studies (e.g. descriptions of services etc) • Non-medication review studies • Medication reconciliation • Reviews / Systematic Reviews • Multidisciplinary interventions • Surrogate outcomes (e.g. MRPs, MAI, Adherence)

(((((((("Medication Therapy Management"[Mesh]) OR ((medicine*[Title/Abstract] OR medication*[Title/Abstract])))) AND (((review*[Title/Abstract] OR service*[Title/Abstract] OR reconcil*[Title/Abstract] OR followup[tiab] OR "follow up"[tiab] OR clinic[tiab] OR clinics[tiab])))) AND ((((pharmacist*[Title/Abstract] OR pharmacy[Title/Abstract] OR pharmaceutical[Title/Abstract])))) OR (("Pharmacists"[Mesh]) OR "Pharmacy"[Mesh]))) AND ((((outpatient[Title/Abstract] OR outpatients[Title/Abstract] OR "Patient Discharge"[Mesh] OR discharge[Title/Abstract] OR postdischarge[Title/Abstract] OR "post discharge"[Title/Abstract] OR "hospital discharge"[Title/Abstract] OR ambulatory[Title/Abstract]))) OR ("Outpatients"[Mesh] OR "Outpatient Clinics, Hospital"[Mesh] OR "Ambulatory Care"[Mesh])))).

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