Impact of pharmacist interventions provided in the emergency department on quality use of medicines: a systematic review and meta-analysis

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ABSTRACT

Background Pharmacists have an increasing role as part of the emergency department (ED) team. However, the impact of ED-based pharmacy interventions on the quality use of medicines has not been well characterised.

Objective This systematic review aimed to synthesise evidence from studies examining the impact of interventions provided by pharmacists on the quality use of medicines in adults presenting to ED.

Methods A systematic literature search was conducted in MEDLINE, EMBASE and CINAHL. Two independent reviewers screened titles/abstracts and reviewed full texts. Studies that compared the impact of interventions provided by pharmacists with usual care in ED and reported medication-related primary outcomes were included. Cochrane Risk of Bias-2 and Newcastle-Ottawa tools were used to assess the risk of bias. Summary estimates were pooled using random-effects meta-analysis, along with sensitivity and sub-group analyses.

Results Thirty-one studies involving 13 242 participants were included. Pharmacists were predominantly involved in comprehensive medication review, advanced pharmacotherapy assessment, staff and patient education, identification of medication discrepancies and drug-related problems, medication prescribing and co-prescribing, and medication preparation and administration. The activities reduced the number of medication errors by a mean of 0.33 per patient (95% CI −0.42 to −0.23, I^2=51%) and the proportion of patients with at least one error by 73% (risk ratio (RR)=0.27, 95% CI 0.19 to 0.40, I^2=85.3%). The interventions were also associated with more complete and accurate medication histories, increased appropriateness of prescribed medications by 58% (RR=1.58, 95% CI 1.21 to 2.06, I^2=95%) and quicker initiation of time-critical medications.

Conclusion The evidence indicates improved quality use of medicines when pharmacists are included in ED care teams.

PROSPERO registration number CRD42020165234.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Quality use of medicines is vital in the ED, where the management and timing of patient care are critical and urgent.

⇒ The impact of interventions provided by pharmacists in the ED on the quality use of medicines is uncertain.

WHAT THIS STUDY ADDS

⇒ This systematic review of 31 studies showed that pharmacist interventions were associated with a reduction in the number of medication errors per patient by 0.33, on average, and the proportion of patients with at least one error by 73%.

⇒ The interventions also were associated with improved medication history taking and medication appropriateness.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The evidence from this systematic review highlights the association of ED-based pharmacy interventions with improved quality use of medicines. This may be an important finding to enhance patient safety in an overcrowded, fast-paced ED environment.

⇒ Using a rigorous approach, future investigations should focus on the clinical benefits and cost-effectiveness of the interventions.

BACKGROUND

Ensuring quality use of medicines (QUM), defined as "choosing suitable medicines if a medicine is considered necessary, and using medicines safely and effectively",[1] remains a challenge in acute care settings with heavy workloads, such as the hospital emergency department (ED).[2 3] Pharmacists are playing an increasingly important role in providing clinical services in ED.[4] However, the impact of ED-based pharmacy interventions on QUM is uncertain.

While there have been reviews of pharmacist interventions, there are only a few in ED. A narrative review focusing on strategies for decreasing medication errors in EDs was published in 2014.[5] However, it reviewed studies with mixed types of pharmacist and non-pharmacist interventions. An older systematic review (2009) determined the extent of clinical pharmacists' involvement in ED,[6] but the included studies were mostly observational. Another review was conducted in 2018, which exclusively focused on the effect of pharmacy medication reconciliation in ED.[7] It included interventions provided by pharmacists, pharmacy technicians and students.

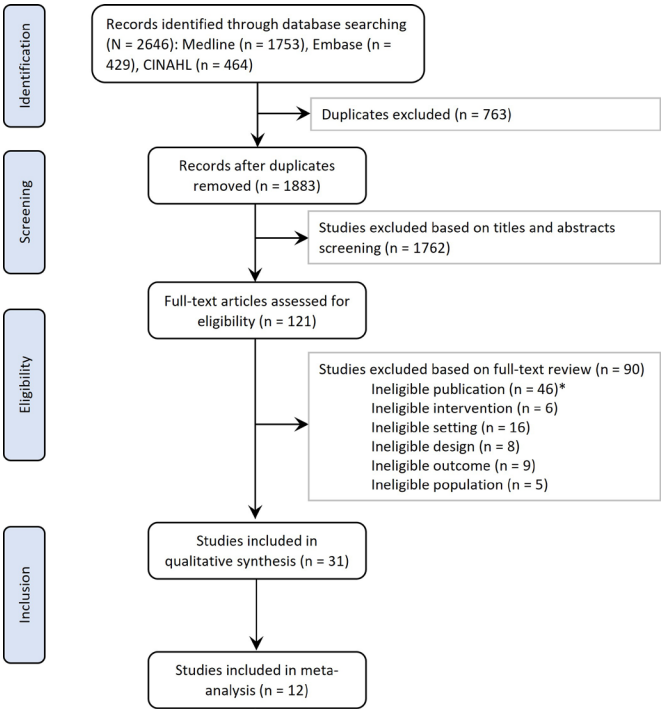

Figure 1 PRISMA flow diagram of the selection process.*Conference abstracts, articles published in a language other than English and media articles.

There has been an ongoing debate on how and when to involve ED pharmacists in patient care and over the need to allocate resources for the service.[8] Therefore, we conducted a systematic review to investigate whether the delivery of interventions by pharmacists leads to improved QUM for adult ED patients.

METHODS

Literature search

A systematic literature search was conducted in Ovid MEDLINE, Ovid EMBASE and EBSCOhost CINAHL from inception to 12 February 2021. A combination of search terms was identified and adapted to each database with the assistance of a research librarian (online supplemental table 1). In addition, citation analysis was performed in Google Scholar and Web of Science to identify potentially relevant articles. Reference lists of the included studies were also manually checked.

The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42020165234). The review was conducted as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[9]

Study screening and selection

Screening and selection of imported studies were conducted in Covidence.[10] Two reviewers (TMA and BCW/GMP/LRB/MSS) independently screened the titles/abstracts and reviewed the full texts of potential articles. The first reviewer (TMA) reviewed all the articles and each of the second reviewers reviewed 25% of the articles. Any disagreements between the first and the second reviewer were discussed and resolved at research team meetings.

Inclusion and exclusion criteria

Original studies published in peer-reviewed journals in English that met the PICOS framework[11] were included. Studies that included adults (≥18 years old) presenting to ED, employed pharmacist interventions in the ED and compared the interventions with usual care, defined and reported QUM, and had control groups or pre–post designs were included. The interventions must have been provided by pharmacists. 'Usual care' was defined as standard care that did not include ED-based pharmacy interventions.

Interventions conducted in non-ED settings (eg, short-stay acute medical units) and interventions involving pharmacy technicians or students were excluded. Reviews, letters, editorials, commentaries, abstracts and theses were also excluded.

Data extraction

Relevant data were independently extracted by one reviewer (TMA) and cross-checked by a second reviewer (BCW/GMP/LRB/MSS). When necessary, we contacted authors to obtain additional information and for clarification of research methods. Intervention activities were grouped based on the reported interventions.

Risk of bias assessment

Two reviewers (TMA and BCW/GMP/LRB/MSS) independently assessed the risk of bias of the included studies using the Cochrane Risk of Bias-2 Tool[12] for randomised controlled trials (RCTs) and the Newcastle-Ottawa scale[13] for non-RCTs. Any discrepancies between the reviewers were resolved through discussion in the research group.

Outcomes

Impact of the interventions was determined as changes in rates or proportions of the primary medication-related outcomes, such as adverse drug events, medication errors, appropriateness of prescribed medications and time to drug initiation. An adverse drug event was defined as "an injury resulting from a medical intervention related to a drug".[14] The term 'medication error' referred to "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer".[15] Different studies used various terms, such as medication discrepancy or prescribing error, with similar meanings for medication error.

Medication errors were reported as the mean number of errors per patient and the proportion of patients having at least one error. Error severity and error types were also analysed. Medication errors that reached or potentially reached the patients, if specified, were also reported. Secondary outcomes included length of hospital stay, length of ED stay, ED revisits, hospital readmissions and mortality.

Data analysis

Outcomes were recalculated to common denominators to account for differences in reporting outcomes. For instance, the total number of medication errors in the intervention group and the control group were divided by the number of patients in each group to determine the mean number of errors per patient. Summary estimates were pooled using the random-effects model to account for study heterogeneity. We were unable to pool results from some studies due to missing data.

Mean difference was pooled for continuous outcomes using Comprehensive Meta-Analysis (V.3.0, Englewood, New Jersey, USA). Pooled risk ratios (RRs) were determined for dichotomous outcomes using Review Manager (V.5.4. The Cochrane Collaboration, 2020). The number of studies that reported p values

Table 1 Qualitative summary of the included studies (N=31)

Author, year	Country, setting	Study population	Study design	Sample (n)	Female sex (%)	Mean age (year)
Carter *et al*, 2006[43]	USA, tertiary hospital	Patients to be admitted to hospital through ED	Pre–post interventional study with no comparative design	C: 252* I: 252*	Not reported	C: 51.8 I: 51.8
DeClifford *et al*, 2007[45]	Australia, teaching hospital	Patients admitted for less than 24 hours through ED	Prospective controlled sequential study	C: 56 I: 55	C: 51.8 I: 49.1	C: 67.6 I: 68.7
Hayes *et al*, 2007[19]	USA, teaching hospital	Adult patients admitted to hospital through ED	Pre–post pilot study	C: 78 I: 60	Not reported	C: 63.3 I: 55.6
Vasileff *et al*, 2009[46]	Australia, teaching hospital	ED patients ≥60 years at risk of medication misadventure	Sequential study with two phases of pre–post design	C: 45 I: 29	C: 51.1 I: 53.3	C: 77.6 I: 75.3
De Winter *et al*, 2010[17]	Belgium, tertiary hospital	Adult patients planned to be hospitalised through ED	Prospective study	C: 3594 I: 3594	C: 50.0 I: 50.0	C: 59 I: 59
Mills *et al*, 2010[20]	The UK, general hospital	Adult unscheduled patients admitted via ED	Pre–post interventional study	C: 66 I: 50	C: 44.0 I: 30.0	C: 71.8† I: 77.6†
Mortimer *et al*, 2011[41]	Australia, public hospital	ED patients ≥65 years with chronic conditions, or ≥70 years without chronic conditions, and ATC of ≥2	Prospective study	C: 66 I: 73	C: 52.0 I: 55.0	C: 77.6 I: 77
Ernst *et al*, 2012[29]	USA, academic level I trauma centre	Adult patients with major trauma and resuscitation presenting to ED	Cross-sectional cohort study	C: 452 I: 242	C: 44.0 I: 47.0	C: 48 I: 45
Becerra-Camargo *et al*, 2013[38]	Colombia, three teaching hospitals	Consecutive adult patients admitted through ED	Multicentre, double-blind, RCT study	C: 125 I: 117	C: 56.0 I: 59.8	C: 58 I: 59
Brancaccio *et al*, 2014[21]	USA, academic community hospital	Adult patients receiving a phenytoin loading dose in ED‡	Pre–post study	C: 50 I: 71‡	C: 26.0 I: 42.9	C: 40.4 I: 45.9
Baena Parejo *et al*, 2015[47]	Spain, 11 general hospitals	Consecutive adult patients admitted to ED	Multicentre cross-sectional comparative study	C: 387 I: 387	C: 50.1 I: 50.1	C: 67.2† I: 67.2†
Becerra-Camargo *et al*, 2015[39]	Colombia, three teaching hospitals	Consecutive adult patients admitted through ED	Multicentre, double-blind, RCT study	C: 125 I: 117	C: 56.0 I: 59.8	C: 58 I: 59
Lawrence *et al*, 2015[22]	Australia, public hospital	Consecutive adult patients admitted through ED	Prospective pre-interventional and post-interventional study	C: 66 I: 52	Not reported	Not reported
DeWitt *et al*, 2016[30]	USA, academic level I trauma centre	Adult patients taking cefazolin, cefepime, ciprofloxacin, piperacillin–tazobactam or vancomycin in ED	Retrospective cohort study	C: 105 I: 105	C: 45.0 I: 31.0	C: 54.0 I: 54.0
Gosser *et al*, 2016[42]	USA, stroke centre	Adult patients receiving i.v. rtPA for acute ischaemic stroke in ED	Retrospective study	C: 38 I: 67	Not reported	C: 73† I: 72†
Robey-Gavin *et al*, 2016[31]	USA, teaching hospital	Adult patients eligible for rapid sequence intubation and receiving sedative and paralytic agents in ED	Retrospective cohort study	C: 41 I: 41	C: 44.0 I: 34.0	C: 66 59
De Lorenzo-Pinto *et al*, 2018[32]	Spain, tertiary hospital	Adult patients hospitalised through ED with at least one pharmacotherapy recommendations	Prospective cohort study with pre–post design	C: 51 I: 51	C: 43.1 I: 45.1	C: 70.9 I: 72.5
Mekonnen *et al*, 2018[44]	Ethiopia, tertiary hospital	Adult patients (≥18 years) with ≥2 regular drugs on admission and hospitalised for at least 24 hours	Prospective, pre–post study	C: 49 I: 74	C: 53.1 I: 45.9	C: 48.6 I: 42.7
Mogaka *et al*, 2018[33]	USA, academic medical centre	Adult patients admitted to ED, then to medical floors for continuing care	Prospective cohort study	C: 172 I: 172	Not reported	Not reported
Pevnick *et al*, 2018[40]	USA, university hospital	Patients taking ≥10 active chronic prescription medications in ED	RCT	C: 95 I: 94‖	C: 48.0 I: 52.0	C: 71 I: 72
James *et al*, 2019[34]	USA, teaching hospital	Inappropriately treated asymptomatic patients with suspected bacteriuria in ED	Retrospective cohort study	C: 134 I: 134	C: 82.8 I: 78.4	C: 46.1 I: 54.4
Koehl *et al*, 2019[35]	USA, tertiary hospital	Adult patients with home medication at admission in ED	Prospective pre–post cohort study	C: 181 I: 138	Not reported	Not reported
Kulwicki *et al*, 2019[36]	USA, teaching hospital	Adult patients presenting to ED with CAP and IAIs	Retrospective cohort study	C: 135 I: 185	C: 48.0 I: 52.	C: 59.2 I: 60.5
Liu *et al*, 2019[23]	Taiwan, tertiary medical centre	Patients aged ≥65 years awaiting hospitalisation through ED	Pre–post interventional study	C: 243 I: 668	C: 51.9 I: 49.6	C: 78.2 I: 78.1
Masic *et al*, 2019[37]	USA, university hospital	Adult patients presenting to ED with oral anticoagulants necessitating rapid reversal	Retrospective cohort study	C: 66 I: 50	C: 44.0 I: 30.0	C: 71.8† I: 77.6†
Mostafa *et al*, 2019[25]	Egypt, university hospital	Patients admitted to hospital via ED	Prospective pre-/post-interventional study	C: 1025 I: 1024	C:41.5 I: 42.6	C: 41.0** I: 40.9**
Taylor *et al*, 2019[18]	Australia, referral hospital	Patients presenting to ED during working hours	Retrospective study	C: 17 I: 17	C: 56.0 I: 59.0	C: 73 I: 78
Kozlow *et al*, 2020[27]	USA, academic medical centre	Adult ED patients receiving 4F-PCC for acute anticoagulation reversal	Retrospective study with pre–post design	C: 33 I: 67	C: 51.5 I: 37.3	C: 75.5 I: 75.8
Loborec *et al*, 2020[24]	USA, academic medical centre	Adult patients discharged from ED with subsequent positive microbiologic tests	Retrospective pre–post study	C: 92 I: 86	Not reported	Not reported
Stoll *et al*, 2020[26]	USA, community hospital	Adult patients on prescribed outpatient antibiotics by ED providers	Prospective, pre–post interventional study	C: 325 I: 353	C: 66.8 I: 68.8	C: 41† I: 44†

Continued

Table 1 Continued

Author, year	Country, setting	Study population	Study design	Sample (n)	Female sex (%)	Mean age (year)
Parro Martín *et al*, 2021[28]	Spain, university hospital	Elderly patients admitted to a trauma unit in ED and traumatology service	Pre–post prospective intervention study	C: 423 I: 463	††	††

*Number of medication histories. †Median. ‡Postimplementation groups included both prescriber-dosing and pharmacist-dosing groups. ‖Only pharmacists' arm was included.
**Of those patients with errors only. ††The mean age of patients who had experienced medication errors was 79.5±14 years and 60.4% of them were women.
ATC, Australasian Triage Category; C, control groups; CAP, community-acquired pneumonia; ED, emergency department; F-PCC, four-factor prothrombin complex concentrate; I, intervention group; IAIs, intra-abdominal infections; i.v. rtPA, intravenous recombinant tissue plasminogen activator; RCT, randomised controlled trial study.

were higher than the number of studies that reported SD for the continuous outcomes. We, therefore, used comprehensive meta-analysis to maximise the number of studies included because summary effects could be estimated using p values. We also combined RCTs and non-RCTs to increase the power to estimate the pooled effects.

Statistical heterogeneities of the pooled estimates were assessed using I^2, Q value and p value. Only studies that were considered to have 'good' methodological qualities (ie, RCTs with a low risk of bias[12] and non-RCTs of 'good quality'[13]) were included in a sensitivity analysis. Subgroup analyses based on study design (RCTs vs non-RCTs), participants' age (adults vs elderly, ie, aged 65 years and above), sample size (<100 vs ≥100 in each of the study groups) and the number of intervention components (one/two vs three/four) were also undertaken to explore the possible causes of heterogeneity. Publication bias was evaluated by inspecting funnel plots and through statistical Egger's test. p value <0.05 was considered statistically significant in all analyses. Data were analysed per the Cochrane handbook.[16]

RESULTS

Study selection

The search identified 2646 records from the three databases. Out of 1883 screened articles based on title and abstract, 121 studies were eligible for full-text review. Ninety were then excluded as they failed to meet the inclusion criteria (online supplemental table 2). Thirty-one studies were finally included in the systematic review (figure 1).

Study characteristics

Qualitative summaries of the included studies are given in table 1. These studies included 13 242 participants in total, with sample sizes varying considerably between 34 and 3594 participants.[17 18] Ten studies were controlled pre–post interventional studies,[19–28] nine were cohort studies,[29–37] three were RCTs,[38–40] three were controlled concurrent studies,[18 41 42] three were pre–post interventional studies without controls,[17 43 44] two were controlled sequential studies[45 46] and one was a multicentre cross-sectional study.[47] Seven of the studies exclusively limited the participants to older adults, aged 65 years and above.[18 23 28 40 41 45 46]

Quality of the evidence

The outcome assessors were not blinded to the intervention status and the concealment of the allocation sequence was unclear in one RCT study, raising 'some concerns' about the study's overall risk of bias as per the definition of the Cochrane Risk of Bias-2 Tool.[40] Two other RCT studies were judged to be at low risk of bias (online supplemental figure 1).[38 39] Except for one study[17] with 'fair quality', the methodological quality of 27 non-RCT studies was assessed to be 'good' (online supplemental table 3). The risk of bias assessment for non-RCTs is detailed in online supplemental result.

Characteristics of pharmacist interventions

Types of interventions were clustered around eight activities (table 2 and online supplemental table 4). Pharmacists were predominantly involved in comprehensive medication reviews and order verification,[19 20 22 23 28–33 37–42 44 45] identification of drug-related problems,[19 32 40 41 43 46 47] structured patient and/or caregiver interviews,[19 20 28 33 37–41 43–47] or medication prescribing/co-prescribing.[18 20 21 23 29 35 36 46]

The pharmacists also participated in specialised activities such as phenytoin loading dose and clinical pharmacokinetics services,[21] resuscitation services,[43] renal and weight dosing adjustments of antibiotics,[30] ischaemic stroke care,[42] educational initiatives on antibiotic management,[26 34] microbiological reviews,[24] administration of four-factor prothrombin complex concentrate,[27] and initiation of postintubation analgesia.[31]

Sixteen studies reported that the interventions were provided to patients in ED either before being seen by doctors,[38 39 45–47] before the creation of medication orders,[18 33 35 40 44] or during the initiation of medication orders.[21 27 30 31 34 37]

Impact of pharmacist interventions

Medication errors

Eighteen studies reported the interventions' impact on medication errors[17–20 22 25 28 29 33 35 38 40 41 43–47] and one study on adverse drug events (online supplemental table 4).[39] The errors in the intervention groups[17 19 20 22 25 28 29 33 35 38 40 41 43–47] and control groups[17 20 25 28 35 38 40 41 43–47] were prospectively identified in the majority of the studies. The errors were retrospectively identified from the medical records in one study for the intervention group[18] and in five studies for the control groups.[2 18 19 22 29 33] Nine studies reported that the errors were communicated to the treating physicians,[17 19 29 32 35 40 44–46] and the errors had been rectified in three of them.[19 29 45]

Twelve studies reported statistically significant reductions in the number of errors per patient, compared with usual care (online supplemental table 5).[19 20 22 25 28 29 35 38 40 44–46] Pooling results from these studies indicated that pharmacist interventions were associated with an average error rate decrease of 0.33 per patient (95% CI −0.42 to −0.23, p<0.001) with relatively moderate heterogeneity (I^2=51%, Q=22.5, p<0.001) (figure 2). A sensitivity analysis from 11 studies of good methodological quality yielded a similar result (mean difference: 0.31, 95% CI −0.41 to −0.21, p<0.001).[19 20 22 25 28 29 35 38 44–46] There was moderate heterogeneity (I^2=49.2%, Q=19.7, p=0.033) (online supplemental figure 2).

A meta-analysis using 10 studies[19 24 25 28 29 35 38 41 44 46] showed that pharmacist interventions were associated with a decrease in the proportion of patients having at least one error by 73% (RR=0.27, 95% CI 0.19 to 0.40, p<0.001) compared with usual care (figure 3). However, considerable heterogeneity was observed (I^2=89%, Q=85.3, p<0.001).

Table 2 Summary of the interventions

Pharmacists' role	Number of studies	References
Undertaking comprehensive medication review/reconciliation, medication order verification, and/or identification and resolution of discrepancies and DRPs	22	17 19 20 22 23 28–33 37–47
Undertaking a structured clinical interview	14	19 20 28 33 37–41 43–47
Involvement in specialised (ie, task-specific) interventions	9	21 24 26 27 30 31 34 42 43
Involvement in medication order prescribing or co-prescribing	8	18 20 21 23 29 35 36 46
Involvement in medication preparation and/or administration	7	25 27 31 36 37 42 43
Involvement in staff and/or patient education	7	21 25 26 31 34 36 41
Involvement in advanced pharmacotherapy assessment	4	28 31 32 42
Participation in rounds, bedside assistance and/or consultations	3	29 31 36

DRP, drug-related problem.

In subgroup analyses (online supplemental figure 3), the impact of the intervention on the mean number of errors per patient was not associated with the participants' age or the number of intervention components. However, a relatively higher reduction in the mean number of errors per patient was observed in studies with RCTs and a sample size of <100 in each group. No differences in the proportion of patients with at least one error were observed in the subgroup analysis based on the participants' age, the sample size or the number of intervention components except for the study design, in which a more pronounced effect was observed in the RCTs than in the non-RCTs.

The interventions were associated with reductions in the risk of errors causing insignificant/minor harm by between 33.5% and 96.6%,[39 46] moderate/significant harm by 51.5% and 100%,[18 29 39 45 46] and serious/catastrophic harm by 38.3% and 100%[39 45 46] (online supplemental table 6). An omitted drug, wrong drug or wrong dose were the most common error types reported from seven studies.[20 29 32 33 38 45 46] Except for the study conducted by DeLorenzo-Pinto *et al*,[32] the absolute risk reduction of 'drug omission error' was in favour of the interventions—ranging from 70.4%[32] to 100%[20 33] (online supplemental table 7). The pharmacist interventions were also associated with more complete and accurate medication[17 20 43 47] and immunisation histories.[43]

Appropriateness of medications

Except for two studies,[21 42] pharmacist interventions were significantly associated with improved appropriateness of prescribed medications in five studies.[23 26 30 34 36] Statistically significant increases in the rates of appropriately adjusted antibiotics,[30] appropriately treated asymptomatic bacteriuria,[34] guideline-concordant empiric antibiotics prescribing[26 36] and potentially appropriate medications[23] were reported. According to a summary estimate pooled from seven studies, the interventions were associated with increased appropriateness of prescribed medications by 58% (RR=1.58, 95% CI 1.21 to 2.06, p<0.001) with high heterogeneity (I^2=95%, Q=119.4, p<0.001) (figure 4).[21 23 26 30 34 36 42]

Time to drug initiation

Involving pharmacists in the ED was associated with shortened time from ED presentation to initiation of recombinant tissue plasminogen activator,[42] four-factor prothrombin complex concentrate[27 37] and postintubation analgesia.[24 31]

Hospital length of stay

Nine studies reported the association of the interventions with the length of hospital stay (online supplemental table 8 and online supplemental figure 4).[27 31 32 36 37 40 41 45 46] Only two of these studies reported a statistically significant result.[27 37] The pooled estimate for the average length of stay from six studies[27 32 36 37 40 45] did not show an association (mean difference=0.28 days, 95% CI −0.88 to 1.45, p=0.64) with high heterogeneity (I^2=63.5%, Q=13.7, p=0.018). A sensitivity analysis using five studies with good methodological quality[27 32 36 37 45] did not change the pooled effect (mean difference=0.03 days, 95% CI −1.41 to 1.46, p=0.92). There were contrasting findings reported with respect to the length of ED stay; savings of 2.6 hours favouring the control group[41] and 2 hours favouring the intervention group.[31]

Based on a small number of studies, the pooled estimates showed a 30% reduced risk of re-presenting to ED (RR=0.70, 95% CI 0.52 to 0.94, p=0.02)[26 32] and a 38% reduced risk of being readmitted to hospital (RR=0.62, 95% CI 0.38 to 0.99, p=0.05)[32 40] in the intervention groups compared with the control groups. The pooled risk ratio from four studies[27 32 36 37] for in-hospital mortality was 1.15 (95% CI 0.69 to 1.93, p=0.60), an inconclusive finding with low heterogeneity (I^2=0%, Q=1.86, p=0.60).

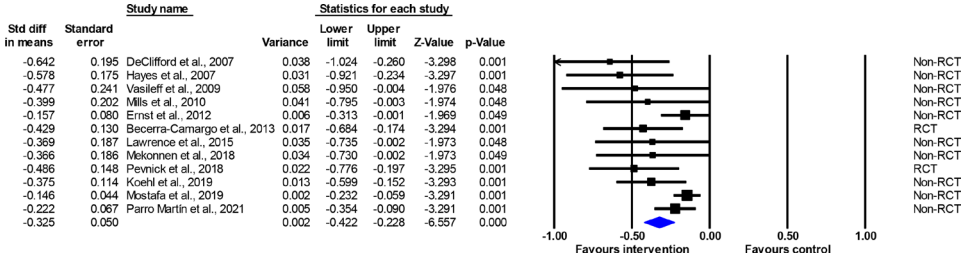

Figure 2 Forest plot illustrating the impact of pharmacist interventions on the number of medication errors per patient. RCT, randomised controlled trial.

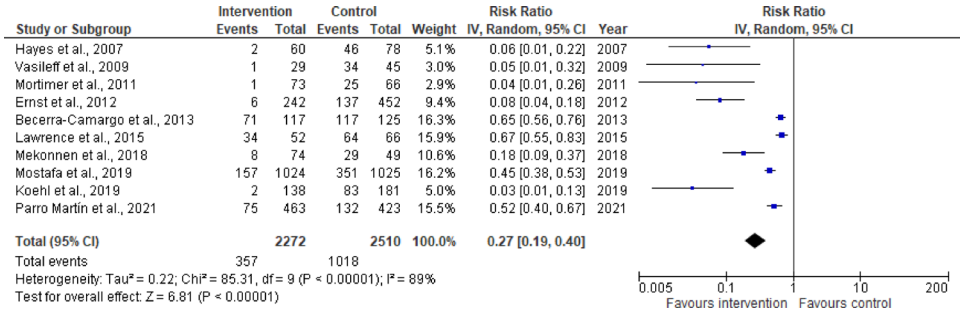

Figure 3 Forest plot illustrating the impact of pharmacist interventions on the proportion of patients with at least one medication error.

Publication bias

Statistical Egger's tests and funnel plots (online supplemental figure 5) revealed no significant evidence of publication bias for the appropriateness of medications (p=0.07), length of hospital stay (p=0.73) and mortality (p=0.14). However, there was some evidence of publication bias for the number of errors per patient (p<0.001) and the proportion of patients with one or more errors (p<0.001).

DISCUSSION

This review revealed that deploying pharmacists in ED was associated with a significantly reduced mean number of medication errors per patient by 0.33 and the proportion of patients having at least one error by 73%. Pharmacists' interventions were also significantly associated with improved appropriateness of prescribed medications by 58% and shortened time from ED presentation to the initiation of time-critical medications. The studies also revealed more complete and accurate medication histories when pharmacists provided interventions in the ED.

Studies that reported the largest reductions in the number of errors per patient tended to involve pharmacists in medication co-prescribing/co-charting in ED.[18 35 46] The absolute risk reduction in the number of errors per patient in these studies ranged from 87% to 97%. The rates of drug omission errors were also reduced by between 97.5% and 100%,[20 46] and the risk of errors causing 'moderate/significant' or 'serious/catastrophic' impacts by 93.3% and 100%.[18 46] Pharmacists collaboratively ordered medications, modified doses and/or charted medications in these interventions. Pharmacist interventions (eg, staff educational activities) that did not directly involve pharmacists in patient care through medication co-prescribing/co-charting, rounds or consultations were relatively less effective in reducing the number of errors per patient.[21 25 28] Direct participation in rounds, therapeutic dialogues, bedside assistance and patient counselling may improve implementation of pharmacists' recommendations.[48]

The interventions in this review also demonstrated positive effects on medication history taking, initiation of time-critical medications and medication appropriateness. However, there were no clear impacts on length of time spent in the ED or in hospital, and in-hospital mortality. These inconclusive findings were similar to a systematic review conducted on in-hospital pharmacist medication review.[49] There was some evidence that the interventions were associated with reduced odds of ED revisits and hospital readmissions at 30 days. However, given the substantial heterogeneity in the study designs and intervention types, and small numbers of contributing studies, the findings on health-related outcomes should be interpreted with caution.

Strengths and limitations

This review synthesised evidence from the relatively good quality of published studies. The majority of the included studies in the meta-analysis had a low risk of bias because of their rigorous study designs and comparability of the study groups.

This review has some limitations. Most studies were not RCTs and the meta-analysis showed significant statistical heterogeneities for the majority of the pooled results. The reported differences in the absolute risk reduction of errors also varied greatly, which could be explained by differences in study designs, definitions of outcome measures and sample sizes. There are subtlely different types and definitions of what constitutes medication errors and discrepancies in the literature.[50] This variation may have had some impact on generating evidence in this meta-analysis. Because different tools with different scales were also used to assess the error severity, we were unable to pool summary estimates.

While medication errors were prospectively identified in the majority of the studies, it was often difficult to ascertain if the reported errors actually or potentially reached the patients. Studies conducted in emergency short-stay or similar units, as opposed to the ED, were not included in this review.

Some relevant literature may have been missed as only articles published in English were included. We assessed health-related outcomes if they were reported additionally to medication-related outcomes as secondary outcomes. Synthesising evidence from studies evaluating the specific impact of ED pharmacists on health-related outcomes, such as length of hospital and ED

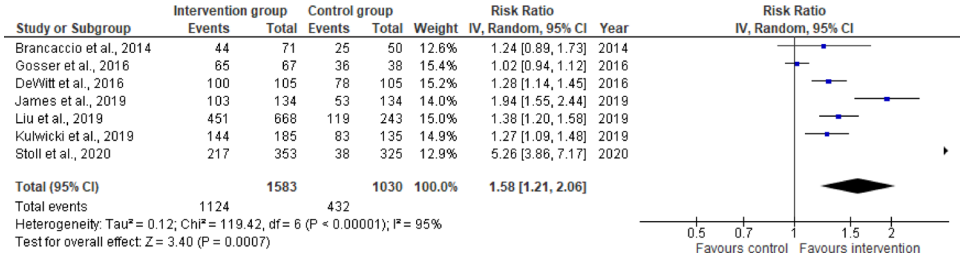

Figure 4 Forest plot illustrating the impact of pharmacist interventions on the appropriateness of prescribed medications.

stay, and cost-effectiveness necessitates a different research question, which is an important area for future reviews. Another limitation includes publication bias for the number of errors per patient and the proportion of patients with one or more errors. It is possible that studies with unsuccessful pharmacist interventions in the ED might not publish their findings.

CONCLUSION

The evidence in this systematic review demonstrated improved QUM when pharmacists were involved in ED care. The evidence is uncertain about the impact on ED/hospital stay and mortality outcomes. Future studies with rigorous designs, robust outcome measures using blinded expert panels, appropriate control groups and sufficiently large sample sizes based on power calculations should focus on the clinical benefits and cost-effectiveness of ED-based pharmacy interventions.

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