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Emergency Department Programs to Support Medication Safety in Older Adults
A Systematic Review and Meta-Analysis

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Abstract

IMPORTANCE Given that older adults are at high risk for adverse drug events (ADEs), many geriatric medication programs have aimed to optimize safe ordering, prescribing, and deprescribing practices.

OBJECTIVE To identify emergency department (ED)–based geriatric medication programs that are associated with reductions in potentially inappropriate medications (PIMs) and ADEs.

DATA SOURCES A systematic search of Scopus, Embase, PubMed, PsycInfo, ProQuest Central, CINAHL, AgeLine, and Cochrane Library was conducted on February 14, 2024, with no date limits applied.

STUDY SELECTION Randomized clinical trials or observational studies focused on ED-based geriatric (aged ≥65 years) medication programs that provide ED clinician support to avoid PIMs and reduce ADEs.

DATA EXTRACTION AND SYNTHESIS Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for abstracting data and the Cochrane risk-of-bias tool were used to assess data quality and validity. Abstract screening and full-text review were independently conducted by 2 reviewers, with a third reviewer acting as an adjudicator.

MAIN OUTCOMES AND MEASURES Process (ordering, prescribing, and deprescribing PIM rates) and clinical (ADE, health care utilization, and falls) outcomes.

RESULTS The search strategy identified 3665 unique studies, 98 were assessed for eligibility in full-text review, and 25 studies, with 44 640 participants, were included: 9 clinical pharmacist reviews (with 28 360 participants), 1 geriatrician teleconsultation (with 50 participants), 8 clinician educational interventions (with 5888 participants), 4 computerized clinical decision support systems (CDSS; with 9462 participants), and 3 fall risk–increasing drug (FRID) reviews (with 880 participants). Clinical pharmacist review was not associated with decreased hospital admission or length of stay, but 2 studies showed a 32% reduction in PIMs from deprescribing (odds ratio [OR], 0.68 [95% CI, 0.50-0.92]; $P = .01$). One study also found that ED geriatrician teleconsultation was associated with enhanced deprescribing of PIMs. Three clinician educational intervention studies showed a 19% reduction in PIM prescribing (OR, 0.81 [95% CI, 0.68-0.96]; $P = .02$). Two computerized CDSS studies showed a 40% reduction in PIM ordering (OR, 0.60 [95% CI, 0.48-0.74]; $P < .001$). FRID reviews were not associated with reduced time to first fall or fall recurrence at 12 months.

(continued)

Key Points

Question Are geriatric medication programs based in the emergency department (ED) associated with reduced potentially inappropriate medications (PIMs) and adverse events for adults aged 65 years or older?

Findings This systematic review and meta-analysis of 25 eligible studies with 44 640 participants found that multidisciplinary approaches, including clinical pharmacists and geriatricians, were associated with improved PIM deprescribing among older adults but not with hospital outcomes, while computerized clinical decision support systems, with or without ED clinician education, were associated with enhanced geriatric ordering and prescribing practices by reducing PIMs. However, medication reviews targeting fall risk–increasing drugs were not associated with reduced falls in older adults.

Meaning These findings will inform the implementation of ED-based geriatric medication safety programs in updating the Geriatric ED Guidelines version 2.0.

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Abstract (continued)

CONCLUSIONS AND RELEVANCE In this systematic review and meta-analysis of ED-based geriatric medication safety programs, a multidisciplinary team, including clinical pharmacists and/or geriatricians, was associated with improved PIM deprescribing. Furthermore, computerized CDSS, alone or in combination with ED clinician education, was associated with enhanced geriatric ordering and prescribing practices. These findings will inform the Geriatric ED Guidelines version 2.0 update.

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Introduction

Adults aged 65 years and older account for 26.8 million (20.4%) annual emergency department (ED) visits.[1] Older adults are susceptible to high-risk medications in the ED setting due to geriatric syndromes requiring complex medical decision-making.[2,3] Due to polypharmacy (concomitant use of ≥5 medications), comorbidities, and physiologic changes of aging, older adults are predisposed to adverse drug events (ADEs), which are associated with ED revisits, hospitalization, and mortality.[4-9] Concerningly, rates of inappropriate prescription drug use and polypharmacy are rising among older adults.[10,11] Almost half of older patients are discharged from the ED with at least one new prescription medication, and more than 85% of adults aged 60 years and older report using prescription drugs in the past 30 days.[12-14] Concerns over safe medication use has led to explicit criteria for potentially inappropriate medications (PIMs) in older adults, such as the American Geriatrics Society (AGS) Beers Criteria and Screening Tool of Older Person's Prescriptions/Screening Tool to Alert Doctors to Right Treatment (STOPP/START) criteria.[15-18] In recent meta-analyses, older adults were 91%, 60%, and 26% more likely to have ADE-related hospitalization, functional decline, and ADE, respectively, when prescribed a PIM, and this risk increased with increasing number of PIMs.[6,7]

Safer medication use and management has been a research priority for high-quality geriatric emergency care for nearly 20 years.[19-21] More recently, the Centers for Medicare & Medicaid Services identified responsible medication management monitoring PIM use in older adults as a core domain of age-friendly hospitals.[22] In 2014, American College of Emergency Physicians (ACEP), Emergency Nurses Association, Society for Academic Emergency Medicine, and AGS-endorsed geriatric ED guidelines outlining policies and protocols for medication management, including screening for polypharmacy and high-risk medication use with established medication reconciliation tools and engaging a multidisciplinary team, including pharmacists and geriatric specialists.[23] Santangelo et al[24] reported that 69% of level I and II accredited geriatric EDs, which meet certain quality-of-care criteria by ACEP's geriatric ED accreditation program, had care processes to minimize the use of PIMs and 60% had medication reconciliation protocols leveraging pharmacists.[24] Although several studies have evaluated the impact of geriatric medication program interventions to optimize safe medication practices for older adults being treated in the ED, it is unknown how EDs can best facilitate responsible medication management to reduce PIMs and associated ADEs in older adults.[25,26] The Geriatric ED Guidelines 2.0 is a multidisciplinary initiative to update the 2014 iteration. As part of this effort, we systematically reviewed the published literature to identify which ED-based geriatric medication programs were associated with reduced PIMs and ADEs.

Methods

This systematic review and meta-analysis is reported in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) reporting guidelines.[27] It was not registered; a protocol was not published.

Search Strategy

We conducted literature searches using strategies created by a medical librarian (E.M.) to identify studies that analyzed the impact of ED-based geriatric medication programs providing support for ED clinicians to avoid PIMs. The search strategies (eMethods in Supplement 1) were established using a combination of keywords.

Inclusion and Exclusion Criteria

We included studies of ED medication programs targeting patients aged 65 years and older. We defined geriatric medication programs broadly as clinical pharmacist review, clinician educational interventions, geriatrician teleconsultations, computerized clinical decision support systems (CDSS), or high-risk medication reviews that aid ED clinicians when ordering, prescribing, and/or deprescribing medications during the ED stay or at ED discharge.

We excluded studies that were not randomized clinical trials (RCTs), nonrandomized interventional studies, or observational cohort studies, including case series and reports, systematic and scoping reviews, abstracts, and dissertations and theses. We excluded studies if the intervention was not initiated in the ED, did not provide ED clinician support to avoid PIMs, or lacked a comparison group. The initial search was run August 8, 2022, and updated February 14, 2024, with no date limits applied. We used Scopus, Embase, PubMed, PsycInfo, ProQuest Central, CINAHL, AgeLine, and Cochrane Library.

Study Selection

Duplicate studies were first automatically identified by the citation manager EndNote version X8 (Clarivate) by comparing title, author, and year for exact matches. After the first pass of exclusions, all remaining studies were then reviewed by the librarian (E.M.) for similarities in title, author, and year, then by abstract, to identify and remove any duplicates not found by EndNote due to differences in formatting. Unique citations were then exported to Covidence, a systematic review software, which also checked for duplicates upon import in the title, year, author, and volume fields. Two team members (of B.D.H., K.S., S.L., K.T., P.T., J.M.H., C.T., M.F.C., R.M.S., and S.W.L.) independently screened reference titles and abstracts and reviewed the full texts of studies to determine final inclusion. Any disagreements were adjudicated by a third reviewer (another of the authors listed previously).

Data Extraction and Quality Assessment

Qualifying studies not published in English were translated. Four team members independently extracted data from included studies (B.D.H., K.T., S.W.L., and R.M.S.). Outcomes included ordering, prescribing, and/or deprescribing rates, comparison of preintervention and postintervention PIM rates, and adverse event rates. Adverse events included but were not limited to ADEs, hospitalization, length of stay (LOS), mortality, ED revisit, delirium, and falls (eFigure 3 in Supplement 1).

The risk of bias (ROB) of each study was assessed using the Revised Cochrane Risk of Bias Tool for Randomized Trials (RoB 2.0) for RCTs and the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) for observational studies.[28,29] Four team members (J.M.H., S.L., K.S., and P.T.) participated in ROB analyses. For both data extraction and ROB assessment, each study was analyzed independently by 2 team members and disagreements were resolved by discussion.

Statistical Analysis

For each study, odds ratios (ORs) and hazard ratios (HRs) with 95% CIs were extracted. If necessary, ORs were calculated based on sample numbers reported in the study results. For studies reporting hospital LOS as median and IQR, the mean and SD were estimated using a previously reported method.[30]

A random-effects meta-analysis model was utilized to better account for heterogeneity between studies.[31] Heterogeneity between studies was assessed using Cochran *Q*.[32] Weighting by sample size was used to avoid excessive influence of smaller studies. Funnel plots and Fail-Safe N were used to assess presence of study bias and robustness of results (eFigure 1 in Supplement 1).[33,34] All analyses were conducted using the metafor package[35] in R Studio version 2024.12.0+467 (R Project for Statistical Computing). Statistical significance was set at α = .05, and all tests were 2-tailed.

Results

Included Studies and ROB

The literature search identified 5196 abstracts. After deduplication, 3665 unique abstracts remained. Of these, 3567 were excluded based on title and abstract review. We assessed the full text of 98 studies for eligibility. Ultimately, we included 25 studies (**Figure 1**)[5,36-59] with 44 640 participants, published between 2009 and 2024. Included studies evaluated the following interventions: 9 clinical pharmacist review (with 28 360 participants),[36-44] 1 geriatrician teleconsultation (with 50 participants),[45] 8 clinician educational interventions (with 5888 participants),[46-52] 4 computerized CDSS studies (with 9462 participants),[53-56] and 3 fall risk–increasing drug (FRID) reviews (with 880 participants)[57-59] (**Table** and eTable in Supplement 1). We determined that 1 study[40] (4%) had low ROB, 15 studies[5,37-39,43-45,47,49,50,52,53,55-57] (60%) had moderate or some concerns of ROB, and 9 studies[36,41,42,46,48,51,54,58,59] (36%) had serious or high ROB (**Figures 2** and **3**).[60]

Figure 1. Flowchart of Included Studies

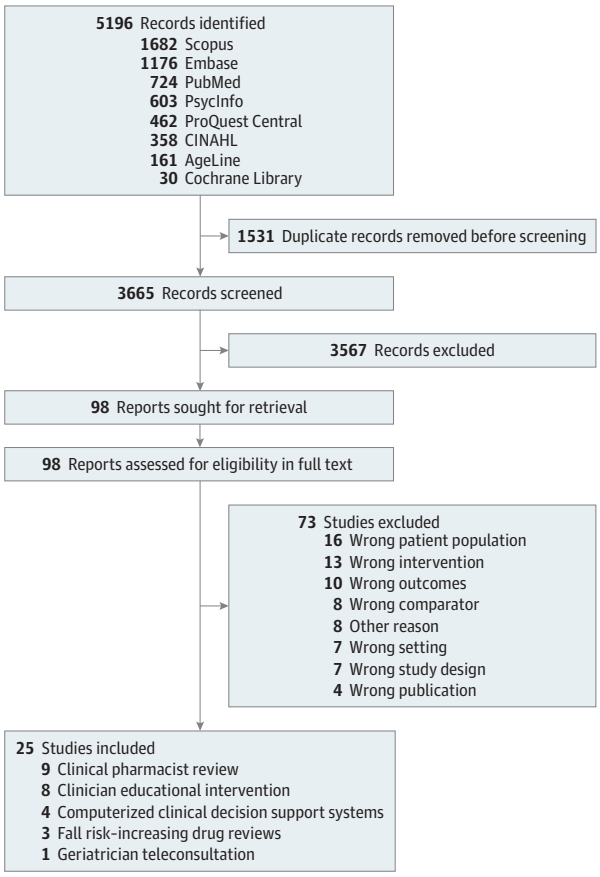

Table. Characteristics of Included Studies

Source (location)	Time frame	Patients, No.	Age, y	% Male	Study design	Intervention	Control	Primary outcome	Secondary outcomes
Clinical pharmacist review studies									
Atey et al,[44] 2023 (Australia)	June 2020 to May 2021	321	PPMC arm: median, 82.3 y; early BPMH arm: 80.1 y; usual care arm: 75.4 y	47%	Pragmatic concurrent controlled study	PPMC arm, redesigned process; early BPMH arm, modified process	Usual care arm, traditional standard of care	Fewer patients in the PPMC group (41%) were prescribed ≥1 PIM, despite being prescribed more drugs, than those in the early BPMH group (48%) and the usual care group (51%) upon ED departure (P = .04). The risk of using ≥1 PIM on ED departure decreased by 14.6% (95% CI, 12.4% to 17.8%) and 19.6% (95% CI, 16.8% to 23.7%) with PPMC when compared with the early BPMH group and the usual care group, respectively.	On ED departure, the median number of PIMs per patient (P = .05) and the median number of PIMs per medication (P = .04) were both significantly lower for the PPMC group than for the comparison groups. Neither the median number of PIM per patient nor the median number of PIM per prescribed medication changed significantly within the comparison group on hospital discharge vs at baseline.
Briggs et al,[36] 2015 (Australia)	October 2011 to June 2012	1021	Mean, 81 y	Not reported	Stratified RCT	Medication review by clinical pharmacist	Usual care	Odds of admission was lower in intervention group (OR, 0.68 [95% CI, 0.53 to 0.87]; P = .002). No evidence that intervention affected hospital LOS for admitted patients (difference in days, 0.09 [95% CI, 0.08 to 0.25]; P = .31), rate of re-presentation (difference, 0.08% [95% CI, 0.12% to 0.28%]; P = .44), or admission to an aged care facility. GPs adopted 49% of pharmacists' recommendations.	Admission rate was 9 pp lower in the intervention group compared with the control group (53% vs 62%; P = .003).
Clementz et al,[42] 2019 (France)	February to October 2018	252	≥75 y	Not reported	Longitudinal and comparative study	Early in-hospital clinical pharmacist-led medication review and reconciliation (clinical pharmacy services)	Patients admitted to OAEM unit during the same period but outside the operating hours of the clinical pharmacist	Rate of unplanned rehospitalizations within 90 d were lower in intervention group than control group (OR, 0.45 [95% CI, 0.26 to 0.79]; P = .005).	Unplanned rehospitalization rate within 30 d: aOR, 0.45 (95% CI, 0.26 to 0.95); P = .04; unplanned rehospitalization rate within 72 h: aOR, 0.24 (95% CI, 0.06 to 0.94); P = .04.
Hohl et al,[38] 2017 (Canada)	September 2011 to February 2012	10 807	Mean, 70 y	44%	Quasi-randomized design	Early in-hospital pharmacist-led medication review (obtaining medication history, discussing goals of therapy with the patient or caregiver, and reviewing medications to identify and resolve medication-related problems)	Usual care (nurse or physician-led medication reconciliation using electronic forms prepopulated with outpatient medication dispensing record)	Median hospital days was numerically lower (−0.48 days [95% CI, −0.96 to 0.00 days]; P = .06) in medication review group compared with usual care.	No significant association with ED revisits, admissions, readmissions, or mortality.
Jovevski et al,[41] 2023 (Indiana, United States)	October 2019 to February 2022	298	Mean, 82.4 y	98%	Retrospective before-and-after intervention pilot study	EHR-automated protocol for pharmacists to perform a medication reconciliation	Preintervention	The case rate of PIM deprescribing in the preintervention group was 11.1% compared with the case rate of PIM deprescribing in the postintervention group of 57.1% (P < .001).	Preintervention, 91% of PIMs remained unchanged at 60 days compared with only 49% postintervention (P < .05). Regardless of PIM identification, the 30-d primary care follow-up number increased postintervention: 31.5% vs 55.7% (P < .001). There was no change in 7- or 30-day subsequent ED visit or hospitalization rates. Mortality remained unchanged at 60 days.

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Table. Characteristics of Included Studies (continued)

Source (location)	Time frame	Patients, No.	Age, y	% Male	Study design	Intervention	Control	Primary outcome	Secondary outcomes
Kitchen et al,[39] 2020 (Canada)	November 2011 to January 2013	10 783	Median, 70 y	44%	Population-based evaluation of a continuous QI project	Pharmacists completed a medication review	Physicians or nurses completed medication reconciliation	ED-based pharmacist-led medication review did not result in a significant change in total outpatient health services utilization. At 12 months, there was no change in the level or trend of total physician visits per 1000 patients between groups (P = .46 and P = .89, respectively).	No differences in the secondary outcomes of PCP visits or ED visits relative to standard of care in the 12 months after intervention.
Marks et al,[37] 2021 (United States)	NA	110	Median, 83 y	33%	Prospective RCT	Pharmacist-led motivational interviewing-based intervention (GAPcare): 20 min medication management session performed by pharmacists	Usual care: brochures on home safety	Total pharmacist recommendations, 219; partial or full uptake of recommendations: advisory, 47 (81% [95% CI: 67% to 91%]); increased precaution, 22 (82% [95% CI: 60% to 95%]); specific actions, 83 (64% [95% CI, 53% to 74%]); decrease dose, 9 (44% [95% CI, 14% to 79%]); stop medication, 14 (64% [95% CI, 35% to 87%]);and use safer alternative, 23 (78% [95% CI, 47% to 83%]).	GAPcare: lower repeat fall-related ED visits (aIRR, 0.34 [95% CI, 0.15 to 0.76]) and all-cause ED visits (aIRR, 0.47 [95% CI, 0.29 to 0.74]).
Santolaya-Perrín et al,[40] 2019 (Spain)	October 2014 to June 2015	665	Mean, 78 y	47%	Multicenter RCT	Pharmacist reviewed chronic medications and identified PIMs based on the STOPP/ START criteria	Usual care: chronic medication recorded, but identification of PIMs based on the STOPP/ START criteria was not performed	ARR of emergency visits and hospital admissions was 0.81 (95% CI, 0.62 to 1.06) at 3 months, 0.89 (95% CI, 0.70 to 1.13) at 6 months, and 0.95 (95% CI, 0.77 to 1.18) at 12 months.	NA
Shaw et al,[43] 2016 (Colorado, United States)	November 2012 to May 2013	4103	Mean, 77 y	42%	Retrospective cohort	CPS in the ED for seniors (EMBRACE)	Non-EMBRACE ED	CPS EMBRACE group (adjusted percentage, 19.6%) more likely to have 30-day ED return visit than control (adjusted percentage, 18.6%) (adjusted difference, 1.0 pp [95% CI, 3.2 to 5.9 pp]; aOR, 1.34 [95% CI, 1.02 to 1.76]).	Of the CPS EMBRACE group, 154 (45.0%) had at least 1 medication-related problem. No differences across groups in 90-day ED return visits, 90-day mortality, or 90-day health care expenditures.
Geriatrician teleconsultation study									
Matz et al,[45] 2021 (Germany)	November 2017 to February 2018	50	Mean, 82 y	60%	Prospective pilot study	Drug recommendations by telemedical consultation with geriatrician	Drug recommendations by ED physicians	Higher frequency of recommendations regarding changes to preexisting medications via geriatric telemedicine vs standard ED treatment (P < .001). Geriatricians intervened more often than ED physicians: discontinuation of a drug (P < .001); start of a new drug (P = .004); dose change of a drug (P = .001). Recommendations for immediate drug therapy were made more frequently by ED physicians (P = .04). Amount of medication taken by the patient was reduced compared with standard ED treatment (ED assessment t_{49} = 0.622 vs geriatrician's assessment t_{49} = 4.165; P < .001). Geriatricians changed 53.9% of drugs (35/65) whereas ED physicians changed 12.3% (8/65).	The number of PIMs was lower compared with standard medical treatment (P < .001).
Clinician educational intervention studies									
Biese et al,[46] 2011 (North Carolina, United States)	2008 to 2010	No. depends on outcome	Mean, ≥65 y	Not reported	Prospective cohort pre-post intervention	Geriatric curriculum for EM residents	Before curriculum implementation	No change in percentage of older patients receiving chemical sedation before and after curriculum (5.4% vs 4.5%; P = .47).	Before and after curriculum total urinary Foley catheter use, 7.4% vs 5.9%, P = .30. Total inappropriate urinary Foley catheter use: 16.3% vs 2.1%, P = .03.

(continued)

Table. Characteristics of Included Studies (continued)

Source (location)	Time frame	Patients, No.	Age, y	% Male	Study design	Intervention	Control	Primary outcome	Secondary outcomes
Goldberg et al,[47] 2022 (Rhode Island, United States)	July 2018 to January 2021	No. not reported	Mean, ≥65 y	Not reported	Quasi-experimental interrupted time series	EQUIPPED medication safety program implementation	Preimplementation of EQUIPPED	PIMs at the preimplementation compared with postimplementation time periods had a rate 1.11 times greater (95% CI, 1.03 to 1.21; $P < .01$). In the preimplementation period, average monthly rate of PIM prescribing was 9.30% (95% CI, 8.82% to 9.78%). In the postimplementation period, PIM prescribing rate decreased to 8.62% (95% CI, 8.14% to 9.10%) ($P < .01$). During preimplementation, 1325 of 14 193 prescribed medications were PIMs, while only 1108 of 13 213 prescribed medications in postimplementation were PIMs.	Change of PIM rate by drug: antihistamines, 3.36% to 3.01% (difference, −0.35 pp [95% CI, −0.42 to −0.28 pp]); skeletal muscle relaxants, 3.08% to 2.36% (difference, −0.72 pp [95% CI, −0.82 to −0.62 pp]); benzodiazepines, 1.91% to 1.30% (difference, −0.61 pp; [95% CI, −0.70 to −0.62 pp]); antispasmodic, 0.32% to 0.25% (difference, −0.07 pp [95% CI, −0.10 to −0.04 pp]); nonsteroidal anti-inflammatory drug, 0.32% to 0.26% (difference, −0.06 pp [95% CI, −0.09 to −0.03 pp]).
Moss et al,[48] 2019 (North Carolina, United States)	February 2013 to December 2014	5662	Mean, ≥65 y	Not reported	Prospective cohort pre-post intervention	Academic detailing (AGS 2012 Beers Criteria)	Untrained resident cohort	Resident cohort who received educational intervention was less likely to prescribe a PIM compared with untrained resident cohort (RR, 0.73 [95% CI, 0.62 to 0.85]; $P < .001$).	PIM by residents: cyclobenzaprine: RR, 0.41 (95% CI, 0.30 to 0.57); $P < .001$; naproxen: RR, 0.23 ([95% CI, 0.14 to 0.38); $P < .001$; ibuprofen: RR, 0.23 (95% CI, 0.14 to 0.39); $P < .001$; hydroxyzine: RR, 0.75 (95% CI, 0.38 to 1.40); $P = .38$; diphenhydramine: RR, 0.56 (95% CI, 0.28 to 1.15); $P = .11$; methocarbamol: RR, 0.59 (95% CI, 0.29 to 1.2); $P = .14$.
O'Connor et al,[50] 2021 (United Kingdom)	September 2017 to October 2018	226	Mean, ≥65 y	43%	Prospective pre-post intervention	Plan-Do-Study-Act: spreading awareness via 3 presentations, 5 posters, and 1 email	Prescribing patterns before intervention	Reduction in the number of patients with ≥1 prescribing error (37% to 26%; $P = .04$). Proportion of patients with ≥1 STOPP error reduced from 17.5% to 9.0% ($P = .03$). Reduction in proportion of patients with ≥1 START error was not significant (24.6% to 20.7%; $P = .24$).	NA
Stevens et al,[5] 2017 (United States, multisite)	NA	Not reported	Mean, ≥65 y	Not reported	Prospective pre-post intervention comparison	EQUIPPED implementation: multicomponent QI initiative combining education, electronic clinical decision support, and individual clinician feedback	At least 6 mo prior to EQUIPPED implementation	Change in mean (SD) PIM pre-post intervention by site: site 1, 11.9 (1.8) vs 5.1 (1.4); $P < .001$; site 2, 8.2 (0.8) vs 4.5 (1.0); $P < .001$; site 3, 8.9 (1.9) vs 6.1 (1.7); $P = .007$; site 4, 7.4 (1.7) vs 5.7 (0.8); $P = .04$.	NA
Vandenberg et al,[51] 2024 (United States, multisite)	July 2018 to July 2021	Not reported	Mean, ≥65 y	Not reported	Prospective pre- and post-intervention comparison	EQUIPPED: initial group education on geriatric prescribing principles and training in how to access order sets, a 1:1 training session with a site champion, and monthly audit and feedback with peer benchmarking for 12 months	Pre-implementation	The proportion of PIMs at all 4 sites decreased significantly from pre- to post-EQUIPPED: at traditional site 1 from 8.9% (95% CI, 8.1% to 9.6%) to 3.6% (95% CI, 3.6% to 9.6%) ($P < .001$); at spread site 1 from 12.2% (95% CI, 11.2% to 13.2%) to 7.1% (95% CI, 6.1% to 8.1%) ($P < .001$); at spread site 2 from 11.3% (95% CI, 10.1% to 12.6%) to 7.9% (95% CI, 6.4% to 8.8%) ($P = .045$); and at spread site 3 from 16.2% (95% CI, 14.9% to 17.4%) to 11.7% (10.3% to 13.0%) ($P < .001$).	Time to implement was equivalent at all sites across both models. Interview data, reflecting a wide scope of responsibilities for the champion at the traditional site and a narrow scope at the spread sites, indicated disproportionate barriers to engagement at the spoke sites.

(continued)

Table. Characteristics of Included Studies (continued)

Source (location)	Time frame	Patients, No.	Age, y	% Male	Study design	Intervention	Control	Primary outcome	Secondary outcomes
Vaughan et al,[49] 2021 (Georgia, United States)	NA	Not reported	Mean, ≥65 y	Not reported	Prospective pre-post intervention comparison	EQUIPPED implementation: multicomponent QI initiative combining education, electronic clinical decision support, and individual clinician feedback	6-month Period before EQUIPPED implementation	Pre-post monthly PIM proportion by site: site 1: 5.6% (95% CI, 5.0 to 6.3) vs 5.1% (95% CI, 4.7 to 5.5); *P* = .02; site 2: 5.8% (95% CI, 5.0 to 6.6) vs 5.4% (95% CI, 4.8 to 6.0), *P* = .62; site 3: 7.3% (95% CI, 6.4 to 9.2) vs 7.5% (95% CI, 6.6 to 8.4); *P* = .64.	In exploratory analyses, the proportion of benzodiazepine prescriptions decreased across all sites from approximately 17% of PIMs at baseline to 9.5% to 12% after implementation, although not all reached statistical significance.
Vaughan et al,[52] 2023 (United States, multisite)	October 2019 to September 2021	Not reported	Mean, ≥65 y	Not reported	Prospective parallel cluster RCT	Dashboard-based clinician feedback	Traditional personnel-intensive clinician feedback involving academic detailing delivered 1:1 by an EQUIPPED champion	During a 6-month baseline period, the academic detailing and dashboard sites had similar PIM prescribing rates of 8.01% for academic detailing vs 8.04% for dashboard (*P* = .90). Comparing 12 months of prescribing data after EQUIPPED implementation, the academic detailing group significantly improved PIM prescribing (7.07%) compared with the dashboard group (8.10%) (OR, 1.14 [95% CI, 1.08 to 1.22]; *P* < .001).	Within the groups, 2 of 4 academic detailing sites demonstrated statistically significant reductions in PIM prescribing; 1 of 4 dashboard sites achieved nearly 50% relative reduction in PIM prescribing.
Computerized CDSS studies									
Griffey et al,[53] 2012 (Massachusetts, United States)	July 2006 to January 2007	1407	Mean, 75 y	39%	Prospective controlled trial	Computerized CDSS: ED order entry system	On vs off period	Majority of recommendations for alternate medications were declined (49/53 [92.5%]). More orders were consistent with dosing recommendations during on periods (403/1283 [31%]) than off periods (256/1115 [23%]) (*P* < .001). Overall agreement with recommendations was low for on vs off periods: 403/1283 (31% [95% CI, 29% to 34%]) vs 256/1115 (23% [95% CI, 21% to 26%]).	The rate of ADEs was lower during on (8/237 [3.4%]) compared with off (31/436 [7.1%]) periods (*P* = .02). Remaining secondary outcomes showed no difference. Acceptance rate of computer recommended appropriate dose for individual medications, on vs off: benzodiazepines, 29% vs 24%; *P* = .29; nonsteroidal anti-inflammatory drugs, 19% vs 11%; *P* = .04; opiates, 36% vs 26%; *P* < .001; sedatives-hypnotics, 15% vs 12%; *P* = .64; and adverse events, 8 (3% [95% CI, 1% to 6%]) vs 31 (7% [95% CI, 5% to 9%]); *P* = .02.
Kim et al,[54] 2017 (Washington, United States)	May 2015 to April 2016	1946	Mean, 73 y	25%	Prospective before-and-after intervention study	CPOE adjustment based on established pharmacy guidelines and expert consensus: default geriatric dosing	Before vs after CPOE template modification	Significant improvement in the rate of recommended dose administration of all medications of interest before vs after CPOE template modification (27.3% vs 32.5%; *P* < .001).	Medications of interest: opioids, 29.0% vs 35.2%; *P* < .001; benzodiazepines, 20.1% vs 25.5%; *P* = .08; and nonsteroidal anti-inflammatory drugs, 18.4% vs 17.0%; *P* = .76.
Liu et al,[55] 2019 (Taiwan)	December 2017 to October 2018	911	78 y	49.8%	Prospective, observational pre-post	Automatic screening by the computer-based medication reconciliation and integration system	Preintervention group (historical control)	Number of medications was reduced from a mean (SD) of 12.5 (2.7) to 6.9 (3.0) in postintervention period in patients with major polypharmacy (*P* < .001).	Proportions of major polypharmacy and PIM were lower in the postintervention than in the preintervention period (−79.4% vs −65.3%; *P* < .001, and −67.5% vs −49.1%; *P* < .001, respectively).
Terrell et al,[56] 2009 (Indiana, United States)	January 2005 to July 2007	5162 Visits	Mean, 74 y	35%	Prospective RCT	Computer-assisted decision support that advised against use of 9 PIMs and recommended safer substitute therapies	Control: did not receive the decision support, but the computer system tracked their prescribing	Decision support provided 114 times to intervention physicians, who accepted 49 of the recommendations (43%). Intervention physicians prescribed ≥1 inappropriate medications during 2.6% of ED visits, compared with 3.9% visits managed by control physicians (OR, 0.55 [95% CI, 0.34 to 0.89]; *P* = .02; aRR, 1.3% [95% CI, 0.4% to 2.3%]).	Proportion of all prescribed medications that were potentially inappropriate decreased from 103 (5.4%) to 69 (3.4%) (OR, 0.59 [95% CI, 0.41 to 0.85]; *P* = .006; ARR, 2.0% [95% CI, 0.7% to 3.3%]).

(continued)

Table. Characteristics of Included Studies (continued)

Source (location)	Time frame	Patients, No.	Age, y	% Male	Study design	Intervention	Control	Primary outcome	Secondary outcomes
FRID review studies									
Boyé et al,[57] 2017 (the Netherlands)	NA	612	Mean, 76 y	38%	Prospective multicenter RCT	Withdrawal of FRIDs by research physician via fall-related assessment, including medical history and medication use (IMPROVeFALL)	Usual care	Intervention did not have a significant association time to first fall HR, 1.17 (95% CI, 0.89 to 1.54).	Time to second fall: HR, 1.19, (95% CI, 0.78 to 1.82); time to first fall-related GP consultation: HR, 0.66 (95% CI, 0.42 to 1.06); time to first fall-related ED visit: HR, 0.85 (95% CI, 0.43 to 1.68).
Polinder et al,[58] 2016 (the Netherlands)	October 2008 to October 2011	612	Mean, 76 y	38%	Prospective multicenter RCT	Systematic FRIDs assessment by research assistant combined with FRIDs withdrawal or modification in consultation with geriatrician or prescribing physician (IMPROVeFALL)	Care as usual for fall injuries and structured medication assessment	Total fall-related health care costs did not differ significantly between the intervention group and the control group (€2204 vs €2285). The withdrawal of FRIDs reduced medication costs a mean of €38 per participant. The control group had a greater decline in EuroQol-5D utility score during the 12-mo follow-up than the intervention group (P = .02).	NA
Tan et al,[59] 2018 (Malaysia)	2012 to February 2016	268	Mean, 75 y	33%	Pragmatic RCT	Individually tailored multifactorial interventions, including modified Otago exercise program, visual intervention, HOMEFAST home environmental modification, cardiovascular intervention, medication review, and falls education	Control group received conventional treatment	Fall recurrence did not differ between intervention and control groups at 12 months (70.5% vs 70.1%; RR, 1.04 [95% CI, 0.61 to 1.75]; P = .89).	Rate of fall: RR, 1.16 (95% CI, 0.85 to 1.58); time to first fall: HR, 0.95 (95% CI, 0.78 to 1.52); mortality rate: RR, 0.90 (95% CI, 0.34 to 2.40).

Abbreviations: ADE, adverse drug event; AGS, American Geriatrics Society; aIRR, adjusted incidence rate ratio; aOR, adjusted odds ratio; ARR, adjusted rate ratio; BPMH, best-possible medication history; CDSS, clinical decision support system; CPOE, computerized physician order entry; CPS, clinical pharmacy specialist; ED, emergency department; EHR, electronic health record; EM, emergency medicine; EQUIPPED, Enhancing Quality of Prescribing Practices for Older Adults Discharged From the Emergency Department; FRID, fall risk–increasing drug; GPs, general practitioners; HR, hazard ratio; LOS, length of stay; NA, not applicable; OAEM, older adult emergency medicine; OR, odds ratio; PCP, primary care physician; PIM, potentially inappropriate medication; pp, percentage point; PPMC, partnered pharmacist medication charting; QI, quality improvement; RCT, randomized clinical trial; RR, rate ratio; STOPP/START, Screening Tool of Older Person's Prescriptions/Screening Tool to Alert Doctors to Right Treatment.

Clinical Pharmacist Reviews

Overview

Nine studies,[36-44] enrolling 28 360 participants, evaluated a pharmacist-led medication review within the ED to identify PIMs and provide recommendations. The mean or median age in the studies was 70 years and older, and the sample sizes ranged from 110 to 10 807 participants.

Medication Recommendations

Briggs et al[36] reported that clinicians adopted 49% of pharmacists' recommendations. Marks et al[37] examined patient adoption of pharmacists' recommendations after a motivational interviewing–based intervention. They found patients were able to partially or fully uptake 81% (95% CI, 67%-91%) of advisory recommendations, such as "discuss further with prescriber," and 64% (95% CI, 53%-74%) of recommendations with specific actions, such as "decrease dose."[37]

Hospital Admission and LOS

Rates of hospital admission and hospital LOS were calculated in 2 studies. Briggs et al[36] found odds of admission were lower among patients receiving clinical pharmacist review (OR, 0.68 [95% CI, 0.53-0.87]; *P* = .002). However, Hohl et al[38] found in-hospital pharmacist-led medication review was not associated with admissions.[38] Neither found a significant association between the program and hospital LOS.[36,38]

Subsequent Health Care Utilization

In 5 studies,[36,38-41] pharmacist-based medication review was not associated with reduced ED revisits, readmissions, or primary care visits. In Clementz et al,[42] pharmacist-led medication review was associated with significantly lower rates of unplanned rehospitalizations (within 72 hours: OR, 0.24 [95% CI, 0.06-0.94]; within 30 days: OR, 0.45 [95% CI, 0.26-0.95]; within 90 days: OR, 0.45 [95% CI, 0.26-0.79]). However, this study was judged to have serious ROB. Marks et al[37] similarly found pharmacist-led motivational interviewing was associated with reduced repeat all-cause ED visits (adjusted incidence rate ratio [aIRR], 0.47 [95% CI, 0.29-0.74]).[37] Conversely, Shaw et al[43] found patients receiving pharmacist medication reconciliation and review were more likely to have a 30-day return visit (adjusted OR, 1.34 [95% CI, 1.02-1.76]).[43]

PIM Deprescribing

Two studies[41,44] found pharmacist-performed medication review and reconciliation were associated with significantly reduced PIM use at ED discharge. Atey et al[44] found use of at least 1 PIM on ED

Figure 2. Revised Cochrane Risk of Bias Tool for Randomized Trials for Randomized Clinical Trials

Risk of bias domains						
Source	D1	D2	D3	D4	D5	Overall
Briggs et al,[36] 2015	+	–	–	–	+	X
Boyé et al,[57] 2017	–	–	+	–	–	–
Marks et al,[37] 2021	+	+	–	+	+	–
Polinder et al,[58] 2016	+	X	+	+	+	X
Santolaya-Perrín et al,[40] 2019	+	+	+	+	+	+
Tan et al,[59] 2018	+	–	–	–	+	X
Terrell et al,[56] 2009	+	–	+	+	+	–

Figure was created using robvis,[60] a web app designed for visualizing risk-of-bias assessments performed as part of a systematic review. Domain (D) 1 indicates bias arising from the randomization process; D2, bias due to deviations from intended intervention; D3, bias due to missing outcome data; D4, bias in measurement of the outcome; and D5, bias in selection of the reported result.

departure was significantly lower for the intervention group than comparison groups (P = .04). Similarly, Jovevski et al[41] found that case rate of PIM deprescribing in a preintervention group was 11.1% vs 57.1% in a postintervention (pharmacist-led medication reconciliation) group (P < .001).

Geriatrician Teleconsultation

Matz et al[45] evaluated geriatrician teleconsultation and pharmacological recommendations among 50 ED patients aged 70 years and older with an Identification of Seniors at Risk Score of 2 or greater.[45] There was a higher frequency of recommendations, including drug discontinuation (P < .001), drug initiation (P = .004), or dose adjustment (P = .001), via geriatric telemedicine compared with standard ED treatment. Total medications per patient and number of PIMs were lower with geriatrician teleconsultation (P < .001). ED physicians more frequently made recommendations for immediate drug therapy than geriatricians (P = .04).

Clinician Educational Interventions

Geriatric Training

Eight studies evaluated clinician educational interventions and prescribing PIMs to older adults in the ED.[5,46-52] Two[46,48] evaluated the association of geriatric training and academic detailing with resident physician prescribing patterns. Biese et al[46] found a geriatric curriculum was not associated with a change the number of older ED patients receiving sedation, while Moss et al[48] found resident

Figure 3. Risk of Bias in Nonrandomized Studies of Interventions or Observational Studies.

	Risk of bias domains							
Source	D1	D2	D3	D4	D5	D6	D7	Overall
Atey et al,[44] 2023	-	-	-	?	+	+	-	-
Biese et al,[46] 2011	-	+	+	+	-	X	+	X
Clementz et al,[42] 2019	X	+	+	?	-	+	-	X
Goldberg et al,[47] 2022	-	+	+	+	+	+	-	-
Griffey et al,[53] 2012	+	+	+	-	+	+	+	-
Hohl et al,[38] 2017	-	-	-	-	+	-	-	-
Jovevski et al,[41] 2023	X	+	+	?	+	+	-	X
Kim et al,[54] 2017	-	+	+	+	+	+	X	X
Kitchen et al,[39] 2020	-	+	-	+	+	-	-	-
Liu et al,[55] 2019	-	-	+	+	-	-	+	-
Matz et al,[45] 2021	+	-	+	+	+	+	+	-
Moss et al,[48] 2019	-	-	+	-	X	-	X	X
O'Connor et al,[50] 2021	-	+	+	+	+	+	+	-
Shaw et al,[43] 2016	+	+	-	+	+	-	-	-
Stevens et al,[5] 2017	-	+	+	+	+	+	+	-
Vandenberg et al,[51] 2024	X	+	+	?	+	+	-	X
Vaughan et al,[49] 2021	-	+	+	+	+	+	-	-
Vaughan et al,[53] 2023	+	+	+	?	+	+	-	-

Figure was created using robvis,[60] a web app designed for visualizing risk-of-bias assessments performed as part of a systematic review. Domain (D) 1 indicates bias due to confounding; D2, bias due to selection of participants; D3, bias in classification of interventions; D4, bias due to deviations from intended interventions; D5, bias due to missing data; D6, bias in measurement of outcomes; and D7, bias in selection of the reported result.

physicians were less likely to prescribe a PIM to older ED patients after academic detailing (rate ratio, 0.73 [95% CI, 0.62-0.85]). Both were deemed to have serious ROB, limiting interpretability.

PIM Prescribing

Five studies[5,47,49,51,52] across 22 US sites evaluated the Enhancing Quality of Prescribing Practices for Older Veterans Discharged From the ED (EQUIPPED) program, including ED clinician education through academic detailing, computerized CDSS (medication order sets), and feedback on prescribing practices. Compared with the preimplementation period, there were significantly lower rates of PIM prescribing among older adults discharged from the ED in the majority of sites (15 of 22 [68%]), ranging from a 0.5% to 6.8% reduction overall, calculated in Stevens et al[5] as an absolute reduction of more than 50 PIMs monthly.[5] Goldberg et al[47] found lower PIM rates for benzodiazepines (change, −0.61% [95% CI, −0.70% to −0.62%]), skeletal muscle relaxants (change, −0.72%, [95% CI, −0.82% to −0.62%]), and antihistamines (change, −0.35% [95% CI, −0.42% to −0.28%]).[47]

Prescribing Errors

A Plan-Do-Study-Act cycle study examined whether presentations, posters, and emails were associated with reduced prescribing errors based on STOPP/START.[50] O'Connor et al[50] found a reduction in the number of patients with at least 1 prescribing error (37% to 26%; $P = .04$) and proportion of patients with at least 1 STOPP error (17.5% to 9.0%; $P = .03$).[50]

Computerized CDSS

Overview

Four studies evaluated a computerized CDSS for medication and dosing appropriateness.[53-56] These included a total of 9426 patients (mean ages, 73-78 years), with sample sizes ranging from 911 to 5162.

PIM Deprescribing

Liu et al[55] utilized a computer-based, pharmacist-assisted medication reconciliation and integration system that was associated with a reduction in major polypharmacy (≥10 medications; −79.4% vs −65.3%; $P < .001$). It was also associated with a reduction in PIMs (−67.5% vs −49.1%; $P < .001$).[55]

PIM Ordering and Prescribing

In 3 of 4 studies that evaluated PIM ordering and prescribing as an outcome, computerized CDSS was significantly associated with a reduced proportion of PIM usage.[53,54,56] Terrell et al[56] found computerized CDSS for computerized physician order entry (CPOE) was associated with a lower proportion of PIM prescriptions, changing from 5.4% to 3.4% (OR, 0.59 [95% CI, 0.41-0.85]; $P = .006$).[56] Griffey et al[53] and Kim et al[54] found computerized CDSS was associated with improved CPOE adherence to recommended geriatric dose administration rate for opioids (Griffey et al[53]: 36% vs 26% [control], $P < .001$; Kim et al[54]: 29.0% [control] vs 35.2%, $P < .001$) but differed in outcomes for appropriate dosing of benzodiazepines and nonsteroidal anti-inflammatory medications.[53,54]

ADEs

Griffey et al[53] reported the rate of ADEs was lower with use of computerized CDSS compared with usual care. For computerized CDSS, the rate was 3.4%, while the usual care rate was 7.1% ($P = .02$).

FRID Reviews

Overview

Three RCTs[57-59] focused on reducing FRIDs with medication review as part of multifactorial fall prevention programs among older patients presenting to the ED after falls. These studies included a total of 880 patients (mean ages, 75-76 years), with sample sizes from 268 to 612.

Fall Rates

Boye et al[57] and Tan et al[59] reported no difference in time to first fall or rates of falls and fall recurrence at 12 months between the intervention and control group. However, Marks et al[37] found a pharmacist-led motivational interviewing–based intervention was associated with reduced repeat fall-related ED visits (aIRR, 0.34 [95% CI, 0.15-0.76]). Furthermore, Polinder et al[58] evaluated health-related quality of life measured with the EuroQol Quality of Life scale and found the control group had a greater decline after 12 months (P = .02) compared with intervention.[58]

Meta-Analysis

After reviewing the consistency of intervention, outcome, and effect, we conducted 7 meta-analyses. Given fewer than 3 included studies, we were unable to assess publication bias.[61]

Clinical Pharmacist Review and Hospital LOS

Average difference in hospital LOS for the 2 included studies[36,38] ranged from −0.05 to 0.00 days. Random-effects meta-analysis showed the combined average difference in LOS across studies was −0.03 days (95% CI, −4.19 to 4.12 days; P = .99) (eFigure 2A in Supplement 1). The funnel plot showed very minimal heterogeneity (Cochran Q = 0.0001; df = 1; P = .99; I^2 = 0.00%) (eFigure 1A in Supplement 1).

Clinical Pharmacist Review and Hospital Admission

The ORs for hospital admission rates for the 2 included studies[36,38] ranged from 0.68 to 1.05. Random-effects meta-analysis showed the combined OR was 0.86 (95% CI, 0.56-1.31; P = .48) (eFigure 2B in Supplement 1). The funnel plot showed substantial heterogeneity (Cochran Q = 10.603; df = 1; P = .001; I^2 = 90.57%) (eFigure 1B in Supplement 1).

Clinical Pharmacist Review and PIM Deprescribing

The OR for PIM deprescribing for 2 studies[41,44] ranged from 0.33 to 0.52. Random-effects meta-analysis showed the combined OR was 0.68 (95% CI, 0.50-0.92; P = .01), implying a 32% reduction of PIMs with clinical pharmacist review (**Figure 4**A). The funnel plot showed very minimal heterogeneity (Cochran Q = 1.808; df = 2; P = .41; I^2 = 0.00%) (eFigure 1C in Supplement 1).

Clinician Educational Interventions and PIM Prescribing

The ORs for PIM prescribing for the 3 included studies[47,48,52] ranged from 0.66 to 0.89. Random-effects meta-analysis showed the combined OR was 0.81 (95% CI, 0.68-0.96; P = .02), implying a 19% reduction of PIMs with educational interventions (Figure 4B). The funnel plot showed substantial heterogeneity (Cochran Q = 13.057; df = 2; P = .002; I^2 = 90.69%) (eFigure 1D in Supplement 1).

Computerized CDSS and PIM Ordering

The OR for PIM ordering for the 2 included studies[55,56] ranged from 0.54 to 0.65. Random-effects meta-analysis showed the combined OR was 0.60 (95% CI, 0.48-0.74; P < .001), implying a 40% reduction of PIM ordering with computerized CDSS (Figure 4C). The funnel plot showed minimal heterogeneity (Cochran Q = 0.667; df = 1; P = .41; I^2 = 0.00%) (eFigure 1E in Supplement 1).

FRID Review and Fall Recurrence at 12 Months

The ORs for fall recurrence at 12 months for the 2 included studies[57,59] ranged from 1.04 to 1.14. Random-effects meta-analysis showed the combined OR was 1.11 (95% CI, 0.83-1.48; P = .48) (eFigure 2C in Supplement 1). The funnel plot showed minimal heterogeneity (Cochran Q = 0.081; df = 1; P = .78; I^2 = 0.00%) (eFigure 1F in Supplement 1).

FRID Review and Time to First Fall

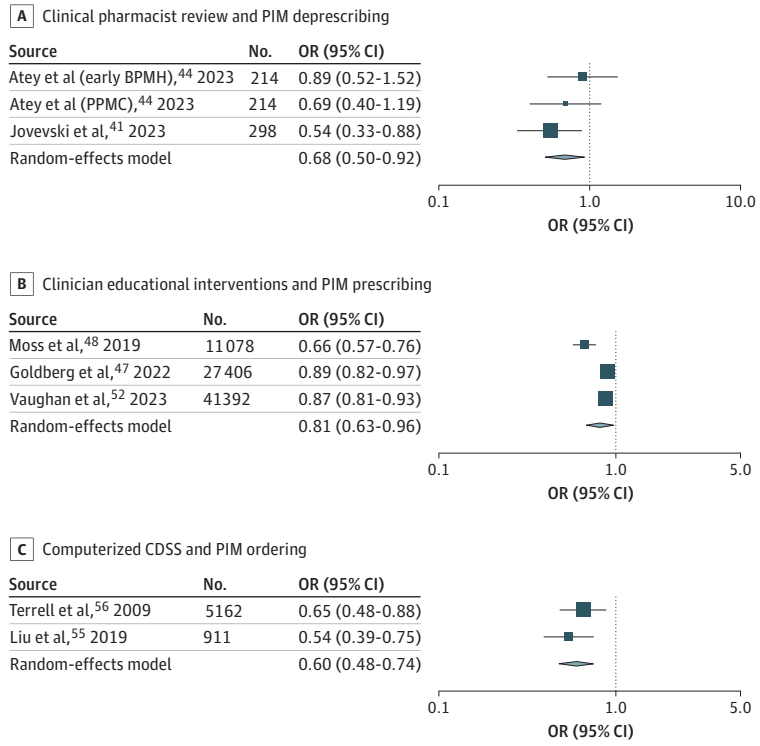
The HRs for time to first fall for the 2 included studies[57,59] ranged 0.95 to 1.17. Random-effects meta-analysis showed the combined HR was 1.03 (95% CI, 0.84-1.26; P = .78) (eFigure 2D in Supplement 1). The funnel plot showed minimal heterogeneity (Cochran Q = 1.520; df = 1; P = .22; I^2 = 34.22%) (eFigure 1G in Supplement 1).

Discussion

Overall, our systematic review and meta-analyses found certain ED-based geriatric medication programs were associated with improved PIM deprescribing and reduced PIM ordering and prescribing among older adults. Specifically, clinical pharmacist review or geriatric teleconsultation was associated with improved PIM deprescribing but was not associated with improved hospital admission rates or LOS. Furthermore, clinician educational interventions and computerized CDSS were associated with reduced PIM ordering and prescribing. Finally, FRID review as part of ED-based fall prevention programs were not associated with reduced time to first fall or fall recurrence at 12 months.

Our systematic review identified a positive impact of clinical pharmacists and geriatrician teleconsultation in ED-based geriatric medication safety programs.[36-40,42,43] There is broad support for ED clinical pharmacist services from emergency medicine, toxicology, and pharmacy organizations in the US.[62-64] Our meta-analysis demonstrated that clinical pharmacist review was not associated with decreased hospital admission or LOS, but 2 studies[41,44] showed a 32% reduction in PIMs from deprescribing. Furthermore, pharmacists were associated with improved outcomes, such as medication safety recommendations and unplanned rehospitalizations, in our included studies, but likely did not affect subsequent health care utilization.[36-42] Additionally, 1 study[45] demonstrated geriatrician teleconsultations in the ED were associated with enhanced deprescribing of PIMs compared with changes made by ED physicians. However, barriers to medication deprescribing

Figure 4. Results of Random-Effects Meta-Analysis Models



The size of the boxes (symbols) is proportional to the sample size. BPMH indicates best-possible medication history; CDSS, clinical decision support systems; OR, odds ratio; PIM, potentially inappropriate medications; PPMC, partnered pharmacist medication charting.

include patients' and physicians' unwillingness, fear of negative consequences, lack of time, and poor communication between multiple prescribers.[65,66]

Three EQUIPPED studies showed a 19% reduction of PIM prescribing through ED clinician education. Our meta-analysis supports academic detailing to enhance quality of prescribing practices for older adults in the ED.[67,68] However, academic detailing requires effort to provide individualized clinician feedback and audit prescribing rates. Furthermore, academic detailing requires buy-in from prescribers and could cause resentment around prescription patterns being tracked.[69,70] Sustainability of these interventions and long-term effects have yet to be determined.

Two computerized CDSS studies showed 40% reduction of PIM ordering, similar to other studies reporting positive impact of computerized CDSS to decrease clinician cognitive load.[71] Use of computerized CDSS in routine ED practice may be a practical option for reducing adverse events related to high-risk medications for older adults, especially given widespread use of electronic health records (EHR). While there may be up-front costs to implementing EHR-based medication safety programs, such programs could be shared across EDs and do not require additional staffing resources, such as pharmacist and geriatrician consultations or academic detailing.[5,47,49,67] Conversely, drawbacks to EHR interventions include clinician fatigue with best practice alerts.[72,73]

Finally, multifactorial fall prevention programs that included medication review for FRIDs were not associated with reduced time to first fall or fall recurrence at 12 months; however, pharmacist-led motivational interviewing–based interventions were associated with reduced repeat fall-related ED visits, and FRID review was associated with reduced functional decline at 12 months.[37,57-59] Future studies are needed to determine which interventions are effective at reducing future falls.

Our findings from this systematic review and meta-analysis will be combined with findings from another systematic review on comparative safety of sedating medications for agitation among older adults in a subsequent article. These will inform our recommendations on implementing ED-based geriatric medication safety programs in the upcoming Geriatric ED Guidelines version 2.0 following the Grading of Recommendations, Assessment, Development, and Evaluation methods.[74-76]

Limitations

There are several limitations to this systematic review and meta-analysis. We focused on ED-based interventions for older adults. There may be other interventions for geriatric patients that were excluded because they did not focus on older adults or were not based in the ED, such as a comprehensive intervention bundle using the Drug Burden Index to facilitate deprescribing.[77] As we excluded studies that were not RCTs or observational cohort studies, we may have missed other potentially effective interventions. The limited number of studies with data available for meta-analysis prevented assessment of publication bias. As only 1 study had low ROB, generalizability of study findings is limited, and results of our meta-analysis should be interpreted with caution. Although most studies assessing outcome measures did not find a clear benefit to patients, many showed significant improvement in process measures, such as PIM deprescribing, prescribing, and ordering. Outcome measures often require a longer timeframe and are influenced by multiple factors beyond the specific process being measured, making it challenging to definitively attribute changes in the outcome to the process alone. Future studies on ED-based geriatric medication safety programs should evaluate appropriate patient-centered outcomes, which will be critical for implementation.

Conclusions

In this systematic review and meta-analysis of ED-based geriatric medication safety programs, involvement of a multidisciplinary team, including clinical pharmacists and/or geriatricians, was associated with improved PIM deprescribing. Furthermore, computerized CDSS, alone or in combination with ED clinician education, was associated with enhanced geriatric ordering and prescribing practices. Although these studies demonstrated that the interventions were associated with improved process measures, future studies will be needed to determine whether they impact

patient-centered outcomes, such adverse events and health care utilization. These findings will inform the Geriatric ED Guidelines version 2.0 update.

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SUPPLEMENT 1.

eMethods. Search Criteria and Strategies
eFigure 1. Funnel Plots and Fail-Safe N Calculation Using Rosenberg Approach of Meta-Analyses
eFigure 2. Results of Random-Effects Meta-Analysis Models
eFigure 3. Extracted Data From Source
eTable. Included Studies Inclusion and Exclusion Criteria

SUPPLEMENT 2.

Nonauthor Collaborators

SUPPLEMENT 3.

Data Sharing Statement