Electronic Prescribing and Other Forms of Technology to Reduce Inappropriate Medication Use and Polypharmacy in Older People: A Review of Current Evidence

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- Polypharmacy • Inappropriate prescribing • Medication use
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- Older people

The medication use process includes the following stages: prescribing, dispensing, administering, and monitoring of medications. The prescribing stage is a key target for improving medication-related safety, as prescribing errors are a major source of medication-related problems, such as adverse drug events.[1] Older people are particularly vulnerable to prescribing errors such as inappropriate prescribing, polypharmacy, and adverse drug events.[2] Older people tend to have multiple conditions, with 65% having 2 or more chronic conditions such as diabetes and heart failure,[3] requiring multiple drug treatments. Older people also experience increased sensitivity to medications because of age-related changes in physiology and body composition, which affect pharmacokinetic and pharmacodynamic processes,[4,5] making prescribing

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Box 1
Key definitions

Medication errors: any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of health professional, patient, or consumer.[6]

Inappropriate Prescribing: The use of medicines that introduce a greater risk of adverse drug-related events where a safer, as-effective, alternative therapy is available to treat the same condition. It also includes the use of medicines at a higher frequency and for longer than clinically indicated, the use of medicines that have recognized drug-drug interactions, and the underuse of other clinically relevant medications.[2]

Polypharmacy: The use of 5 or more medicines.[7]

Adverse drug events (ADEs): Any response to a drug that is noxious and unintended.[6]

medications for older people a complex and challenging process. The aim of this review is to provide an overview of the current evidence in relation to the use of technologies to reduce inappropriate medication use in older people, focusing on the prescribing stage (**Box 1**).

BACKGROUND

Inappropriate Prescribing in Older People

Medicines in older people are considered appropriate when they have a clear evidence-based indication, are well tolerated in the majority, and are cost effective. In contrast, medicines that are potentially inappropriate have no clear evidence-based indication, carry a substantially higher risk of adverse side effects, and are not cost effective.[8] Inappropriate prescribing encompasses the use of medicines at a higher frequency and for longer than clinically indicated, the use of medicines that have recognized drug–drug interactions, and the underuse of other clinically relevant medications.[2] Appropriateness in prescribing is generally assessed using either process or outcome measures that are explicit or implicit.[9] Explicit process measures are criterion based and are developed from published reviews, expert opinion, or consensus techniques and usually consist of drugs to be avoided in older people, for example, the Beers criteria[10] and the European Screening Tool of Older Persons' Potentially Inappropriate Prescriptions (STOPP).[11] Implicit approaches are judgment based, compiling patient information and research evidence to assess appropriateness using instruments such as the Medicine Appropriateness Index (MAI).[12] Inappropriate prescribing in older patients is high, with estimates (depending on the criteria used and the cohort under study) ranging from 18% to 48.7% in ambulatory care,[13–15] 25% to 54% in hospitalized patients,[16,17] and 37% to 67% in nursing home residents.[18,19] Inappropriate prescribing in older people can result in increased morbidity, adverse drug events, hospitalizations, and mortality.[9,20,21]

Polypharmacy

Polypharmacy is common in older people. The prevalence of polypharmacy in older people in the United States, defined as the use of 5 or more medicines, was estimated at 7%.[7] Individuals over 65, who account for less than 15% of the US population, consumed 33% of prescription medicines and 40% of over-the-counter medicines.[22] Polypharmacy in older patients has been related to demographic factors, health status, and access to health care,[23] including factors such as white race and education,[24] poorer health, number of health care visits,[25] and multiple providers of health care.[26] Polypharmacy may describe prescribing of many drugs (appropriately) or too many drugs (inappropriately).[27] Despite this, polypharmacy has been associated with negative health outcomes, including adverse drug reactions, poor adherence, inappropriate prescribing, and geriatric syndromes such as urinary incontinence, cognitive impairment, and impaired balance leading to falls.[23] There is a 13% risk of an adverse drug event with the use of 2 medications, but with 5 medications, it increases to 58%[28] and with 7 or more medications, it further increases to 82%.[29]

Health Information Technology and Prescribing in Older People

Many technological applications are currently available in health care, and these can be categorized into 3 broad functional areas: (1) those that enable data storage, management, and retrieval; (2) those that facilitate care from a distance; and (3) those that support clinical decision making.[30] The first 2 categories have more indirect effects on medication use and prescribing and are briefly summarized here. The third category includes the use of electronic prescribing (or e-prescribing) and computerized decision support system (CDSS) technologies and is the main focus of this review.

Data storage, management, and retrieval systems

The use of electronic medical records (EMRs) is core to data storage, management, and retrieval systems. The EMR adoption rate in the United States had increased to 48.3% in ambulatory care by the end of 2009[31] and routine use of EMRs is reported in 7 European countries.[32] EMRs can be used for the digital input, storage, display, retrieval, printing, and sharing of information contained in a patient's health record.[30] A recent study in a hospital setting found EMRs to assist with ascertaining accurate medication history and in reducing medication errors, however, the quality of the data contained in the EMR may be poor.[33] Older people use many health care services and consequently have multiple care providers at the same time. By allowing multiple care providers (usually within an organization) to access a patient's information, EMRs offer the potential to enable providers at the point of care to utilize patient health history to provide better care,[34] and potentially reduce medication errors. However, the capacity to successfully integrate numerous records across health care settings relating to the same older person has not been adequately developed.[35]

Facilitating care from a distance

Telehealth technologies are key applications used in providing care from a distance. Telehealth can be defined as the use of videoconferencing or other telecommunication technologies to enable communication between patients and health care providers separated by geographical distance.[36] It was previously known as telemedicine, and these terms continue to be used interchangeably in the literature.[37] Most European countries report use of telehealth technology; however, this tends to be on a small and experimental level.[32] Telehealth applications are very diverse, ranging from home care for chronic diseases to remote primary care.[37] In particular, these technologies can play a role in the monitoring stage of the medication use process, supporting medication adherence in older people through the use of monitoring and reminders and offering a patient management approach that empowers patients, influences their attitudes and behaviors, and potentially improves their medical conditions.[36,38] It may enhance patient access to health care professionals and is most effective when used to monitor and respond to ongoing patient symptomatology and facilitate information exchange across interdisciplinary teams.

However, the sustainability of telemedicine interventions for the broad spectrum of older patients' issues presents ongoing challenges to telemedicine-delivered care.[39]

Supporting clinical decision making— E-prescribing and CDSS

Electronic prescribing (e-prescribing) is the direct computer-to-computer transmission of prescription information from physician offices to pharmacies. By using a computer or handheld device with e-prescribing software, prescribers access patient prescription benefit information and patient medication history and electronically direct prescriptions to a patient's pharmacy of choice.[40] By the end of 2010, about 34% of office-based practices in the United States were using some variant of this technology.[41] In the United States, federal initiatives have stimulated increases in e-prescribing.[42] In the United States, a key feature of e-prescribing is the bidirectional flow of information from physician office to pharmacy and back. The technology provides physicians with a system to track patient refill histories, streamline the administration of patient records, check for drug conflicts, and facilitate better communication between pharmacies and physician offices.[43] E-prescribing is expected to assist in both increasing efficiency and reducing medication errors.[44–46]

Adoption in Europe has been slower, however, with a full e-prescribing process used routinely in just 4 countries, namely, Denmark, Estonia, Iceland, and Sweden.[32] It should be remembered that the obstacles to the successful implementation of e-prescribing software in physician office practices are non-trivial and real and include the financial costs and opportunity costs (personnel and time) of implementation, lack of standardized software, and lack of systematic evidence of effectiveness.[47] Despite the challenges, e-prescribing will take on a greater role in patient management in general.[42] Although time-in-motion studies point to increased time to actually write e-prescriptions,[48] recent studies show that physicians and staff identify efficiencies gained by minimizing calls from pharmacy relating to prescription choices not being on formulary, reduced time spent on prior authorizations, reduced time spent processing refills, and overall better workflow because of decreased time spent performing refill requests.[49,50]

Medication errors may be reduced by the use of CDSS in e-prescribing systems.[51] CDSSs are information systems designed to improve clinical decision making. Characteristics of individual patients are matched to a computerized knowledge base, and software algorithms generate patient-specific recommendations that can be delivered to the clinician through the EMR, by pager, or through printouts placed in a patient's paper chart.[52] E-prescribing systems can also integrate/interface with EMRs or be an element of a broader computerized provider/physician order entry (CPOE) system.[30] CPOE systems are computer applications that allow direct, electronic entry of orders for medications, laboratory, radiology, referral, and procedures.[53] The use of e-prescribing within, or in conjunction with, these systems provides the ability to check automatically for dose errors and drug–drug/drug–disease interactions as well as provide warnings and information to enable the prescriber to make changes at the time of prescribing[54]; it has shown the potential for changing professional practice, particularly with regard to drug ordering.[52,55–58] E-prescribing has shown promise in tackling many of the problems associated with the use of medications in older people.[5] However, much of the literature in the area has focused on general populations or in just 1 setting (eg, in-patient care), and there has been less focus on the effectiveness of these technologies in older people. We undertook a comprehensive literature search as described in **Box 2** to identify studies pertaining to the use of the technologies described above, specifically in older people.

Box 2
Search strategy

PubMed, EMBASE, and the Cochrane Database of Systematic Reviews databases were searched to identify articles on e-prescribing and other technology to improve inappropriate medication use and polypharmacy using a combination of the following MeSH terms and key words: inappropriate prescribing; polypharmacy; drug therapy; electronic prescribing; medication errors; decision support systems, clinical; medical order entry systems; alerts; health informatics; aged; elderly; intervention studies; Controlled Clinical Trials as Topic.

Articles in English that measured changes in inappropriate prescribing and/or polypharmacy in older people (aged 65 years of age and older) using e-prescribing or other technology were included. Articles were excluded where it was clear from title/abstract review that they did not relate to older people, changes in inappropriate prescribing, and/or polypharmacy or e-prescribing or other technology. Articles were not excluded on the basis of methodology (eg, not a randomized, controlled trial). Articles were categorized into ambulatory care, hospital/in-patient care, and long-term care and categorized according to a generally accepted hierarchy of evidence, with experimental studies at the highest level of evidence. Outcomes were assessed in terms of process (medication-related) measures and patient outcomes, such as morbidity.

OVERVIEW OF CURRENT EVIDENCE FOR E-PRESCRIBING AND OTHER FORMS OF TECHNOLOGY TO REDUCE INAPPROPRIATE MEDICATION USE AND POLYPHARMACY IN OLDER PEOPLE

Ambulatory Care

E-prescribing and CDSS style interventions have the potential to improve outcomes in ambulatory care.[59,60] From our literature search we identified 6 studies conducted in ambulatory care that examined the use of e-prescribing and CDSS to reduce polypharmacy and inappropriate prescribing in older people. A summary of the studies can be seen in **Table 1**.

A cluster randomized, controlled trial (RCT) assessed a CDSS intervention that involved providing access to a complete drug profile (of all current and past prescriptions) through a dedicated computer link between the electronic patient chart and a drug-insurance program.[61] When a prescribing problem was identified by the CDSS software, the physician received an alert that identified the nature of the problem, possible consequences, and alternative therapy. The study found that the intervention reduced prescriptions for new inappropriate drugs in the intervention group, but had no significant impact on the discontinuation of pre-existing inappropriate prescriptions. The effectiveness of the intervention may have been influenced by unforeseen factors, including an increase in co-payments for prescription drugs during the study period and frequent hardware/software failure during early stages of the trial.

Delivering prescribing alerts at the pharmacy level was found to be effective in another RCT.[62] The pharmacist was notified via a medication alert generated from the pharmacy information management system when patients in the intervention group received a new inappropriate prescription. Prescription labels failed to print until the pharmacist had intervened. Alternative therapy options were discussed with the prescriber via telephone. The primary outcome in this study was the number of inappropriate medications dispensed. This was estimated at 1.8% for the intervention group compared with 2.2% in the usual care group. The authors highlight the modest difference in numbers of dispensing between groups as evidence of the challenging nature of modifying prescriber behavior, even in the context of an intervention that has widespread institutional and prescriber support.

Table 1
Characteristics of studies in ambulatory care

Reference (Country)	Study Design (N)	Intervention(s)	Outcomes
Tamblyn, et al,[61] 2003 (Canada)	Cluster RCT (12,560)	Computerized age-specific pop-up alerts (≥66 years of age) for 159 prescribing problems inc. Drug-disease interactions, drug-drug interactions, drug-age interactions and drug duplication. Alert identifies nature of the problem, possible consequences and alternative therapy	**P:** Number of new PIP per 1000 visits was significantly lower (18%) in the CDS group than in the control group (RR, 0.82; 95% CI, 0.69–0.98), but differences between the groups in the rate of discontinuation of PIP were significant only for therapeutic duplication by the study physician and another physician (RR, 1.66; 95% CI, 0.99–2.79) and drug interactions caused by prescriptions written by the study physician (RR, 2.15; 95% CI, 0.98–4.70).
Raebel et al,[62] 2007 (US)	RCT (59,680)	Age-specific alerts for pharmacists when a patient age 65 and older was newly prescribed 1 of 11 potentially inappropriate medications. Pharmacist contacts prescriber, suggesting alternative	**P:** 1.8% intervention group patients were newly dispensed prescriptions for targeted medications versus 2.2% in usual care group patients ($P = .002$). Significant decrease in dispensing of amitriptyline and diazepam.
Weber et al,[63] 2007 (US)	RCT (620)	Pharmacist reviewed patient charts, message was sent to prescriber via EMR alerting them that the patient was at risk for falls and made patient recommendations re: specific medications or dosing	**P:** The intervention did not reduce the total number of medications. There was a significant negative relationship between the intervention and the total number of medications started during the intervention period ($P<.01$) and the total number of psychoactive medications ($P<.05$). **PT:** The impact on falls was mixed; with intervention group 0.38 times as likely to have had 1 or more fall-related diagnosis ($P<.01$) over study period.
Smith et al,[64] 2006 (US)	Interrupted time series (450,000)	Computerized drug-specific alerts with suggested alternative medication for certain long-acting benzodiazepines and TCAs	**P:** Reduction in nonpreferred drugs of 5.1 prescriptions per 10,000, $P = .004$, a 22% relative decrease from before alert implementation.

Simon et al,[65] 2006 (US)	Interrupted time series (239 physicians, 50,924 patients)	Follow-up study in which computerized age-specific alerts (≥65 years of age) replaced drug-specific alerts, occurring at the time of prescribing for targeted potentially inappropriate medication (eg, TCAs, long-acting benzodiazepines) with suggested alternative medication and academic detailing	**P:** Age-specific alerts resulted in a continuation of the effects of the drug-specific alerts without measurable additional effect (P = .75 for level change), but the age-specific alerts led to fewer false-positive alerts for clinicians. Group academic detailing did not enhance the effect of the alerts.
Monane,[66] 1998 (US)	Cohort study (23,269)	Online computerized drug utilization review database alerts pharmacists to inappropriate drug use, pharmacist contacts prescriber to discuss principles of geriatric pharmacology and alternatives	**P:** A total of 24,266 recommendations were made. Rate of change to a more appropriate therapeutic agent was 24% but ranged from 40% for long half-life benzodiazepines to 2% to 7% for drugs that theoretically were contraindicated by patients' self-reported history.

Abbreviations: P, process (medication-related outcomes); PIP, potentially inappropriate prescribing; PT, patient-related outcomes.

An EMR-based intervention to reduce overall medication use, psychoactive medication use, and the occurrence of falls failed to yield positive results.[63] A standardized medication review was conducted by a pharmacist, and a message was sent to the prescriber via the EMR, alerting them that the patient was at risk of falls and making recommendations with regard to specific medications or dosing. The intervention did not reduce the total number of medications, but there was a significant negative relationship between the intervention and the total number of medications started during the intervention period and the total number of psychoactive medications. Despite this, the findings were limited by the small sample size.

A study by Smith and coworkers[64] integrated drug-specific alerts into an existing CPOE system, alerting clinicians to preferred alternative medications when they ordered certain long-acting benzodiazepines and tertiary amine tricyclic antidepressants (TCAs). A 22% relative decrease in the use of non-preferred medications after the intervention implementation, when compared with the month before alert implementation, was reported. A follow-up interrupted time series study in the same population found no additional significant effects after changing the drug-specific alerts to age-specific alerts (≥65 years of age). However, there was a decrease in the number of false-positive alerts (ie, alerts received when prescribing a medication that was not contraindicated for their age for those aged <65).[65] These 2 studies may have limited generalizability, as they were conducted in a Health Maintenance Organization with several years' experience in the use of CPOE and CDSS; therefore, participants may have been more receptive to these alerts than clinicians elsewhere.

A computerized drug utilization review was found to improve prescribing in a study by Monane and colleagues[66] As part of the intervention, pharmacists were instructed how to use the drug utilization review program. When a potentially inappropriate medication was ordered, the computer sent a message to the pharmacist who subsequently called the physician to discuss the medication and possible therapeutic alternatives. The study findings showed improved prescribing patterns, with a 24% rate of change to a more appropriate therapeutic agent. The reasons physicians gave for not changing included not seeing the intervention as applicable to the patient, disagreeing with intervention, or seeing the intervention as inconvenient for the patient and patient preference. The authors noted that this study may have underestimated the extent of the problem and overestimated the potential benefit of the intervention, as it was based on mail-service prescriptions and did not include retail pharmacies.

Hospital/In-Patient Care

E-prescribing and CPOE systems can have a positive impact on care in the hospital setting.[67] We identified 4 studies in our literature search that looked at the use of e-prescribing and CDSS to reduce polypharmacy and inappropriate prescribing in older people in a hospital setting. A summary of the studies can be seen in **Table 2**.

Terrell and colleagues[68] integrated CDSS into the existing CPOE system in an emergency department. Alerts appeared when the physician tried to order one of the targeted medications and offered alternatives. There was a significant decrease in the proportion of all prescribed medications that were inappropriate from 5.4% to 3.4% postintervention. However, the study targeted a small sample of academic physicians and residents; thus, findings may not be generalizable to other providers or health care settings.

Peterson and coworkers[69] aimed to improve psychotropic drug selection among hospitalized older people by integrating CDSS into the existing CPOE system in the form of geriatric specific default dosages for targeted medications and suggested

Table 2
Characteristics of studies in hospital care

Reference	Study Design (N)	Intervention(s)	Outcomes
Terrell et al,[68] 2009 (US)	RCT (63)	Age-specific alerts occurring at the time of prescribing in ED for 1 of 9 potentially inappropriate medications with recommended alternatives	**P**: Intervention physicians prescribed 1 or more inappropriate medications during 2.6% of ED visits by seniors, compared with 3.9% of visits managed by control physicians (P = .02; OR = 0.55; 95% CI, 0.34–0.89). The proportion of all prescribed medications that were inappropriate significantly decreased from 5.4% to 3.4%.
Peterson et al,[69] 2005 (US)	Interrupted time series (3718)	Age-specific dosing suggestions and alternatives when physician ordered 1 of 12 psychotropic medications known to be poorly tolerated/higher risk in older people	**P**: The intervention increased the prescription of the recommended daily dose (29% vs 19%; P<.001), reduced the incidence of 10-fold dosing (2.8% vs 5.0%; P<.001), and reduced the prescription of nonrecommended drugs (10.8% vs 7.6% of total orders; P<.001). **PT:** Patients in the intervention cohort had a lower in-hospital fall rate (0.28 vs 0.64 falls per 100 patient-days; P = .001). No effect on hospital length of stay or days of altered mental status was found.
Agostini et al,[70] 2007 (US)	Before/after (24,509)	Computer-based reminder directing clinicians to prescribe a nonpharmacologic sleep protocol, to minimize the potential for harm with diphenhydramine and diazepam use by choosing an alternative medication (trazodone or lorazepam), or both	**P**: Prescribing of sedative-hypnotics decreased from 18% in patients preintervention to 15% postintervention (OR, 0.82; 95% CI, 0.76–0.87), an 18% risk reduction. Ninety-five percent of patients were successfully directed to a safer sedative-hypnotic drug or a nonpharmacologic sleep protocol.
Mattison et al,[71] 2010 (US)	Before/after	Drug-specific warning system within CPOE system that alerted ordering prescriber when ordering one of the targeted medicines and advised alternative medication or dose reduction.	**P**: The mean rate of ordering medications that were not recommended decreased from 11.56 (SE = 0.36) to 9.94 (SE = 0.12) orders per day after the implementation of a CPOE warning system (difference, 1.62 [0.33]; P-value .001), with no evidence that the effect waned over time.

Abbreviations: ED, emergency department; P, Process (medication-related outcomes); PT, patient-related outcomes.

alternatives. The study findings showed that the intervention increased the prescription of recommended doses (29% vs 19%), reduced the prescription of nonrecommended drugs (10.8% vs 7.6% of total orders), and was associated with fewer inpatient falls (0.28 vs 0.64 falls per 100 patient-days). No effect on hospital length of stay or days of altered mental status was found. The lack of randomization in this study was a limitation.

Agostini and colleagues[70] aimed to improve the prescribing of 4 sedative-hypnotic medications via integrating CDSS into an existing CPOE system. When a physician ordered any of the targeted medications, reminder screens appeared on the computer system to check the indication and offer educational reminders about the potential adverse effects, recommendations for appropriate nonpharmacologic and sedative-hypnotic medication, and dosing advice. The study findings were positive, with an 18% risk reduction for prescribing of sedative-hypnotics postintervention. The study hospital had a restricted formulary including only 4 sedative-hypnotic medications; therefore, the findings of this study may not be directly applicable to hospitals with different formularies.

Drug-specific alerts with alternative medications or dose reductions were implemented into an existing CPOE system.[71] The alert was activated when one of the targeted medications was ordered by the physician and alternatives were offered. The study findings showed that CPOE with CDSS did reduce orders for nonrecommended medications from a mean (standard error, SE) of 11.56 (0.36) to 9.94 (0.12) orders per day after the implementation of a CPOE warning system (difference, 1.62 [0.33]; $P=.001$), with no evidence that the effect waned over time. The study could not determine whether ADEs were prevented by the use of the CDSS.

Nursing Home Care

Nursing homes have been slow to integrate CDSS and CPOE systems into their normal work flow[72] even though some studies have found them to be acceptable and feasible.[73–76] Four studies related to the use of CDSS and CPOE in the nursing home setting were identified, and a summary of these is presented in **Table 3**.

A study by Gurwitz and coworkers[77] assessed the effect of CPOE with CDSS on adverse drug events in 2 large long-term care facilities. The CDSS was implemented into the existing CPOE system in the facilities. Possible drug-related incidents were presented to 2 physicians who determined if an ADE was present, the severity of the event, and if the event was preventable. The study findings showed that CPOE with CDSS did not reduce the adverse drug event rate or preventable adverse drug event rate in the long-term care setting. The adjusted odds ratio for all adverse drug events in intervention units versus control units was 1.06 (95% confidence interval [CI], 0.92–1.23). The authors identified various limiting factors that may have contributed to the null results such as alert burden (>50% of the alerts were deemed unnecessary, and this may have been related to the fact that the CPOE system was unable to calculate total daily dose), limited scope of the alerts (41 alerts, which targeted a minority of ADEs identified in the study), and the need to more fully integrate clinical and laboratory information.

A similar RCT investigated the use of CPOE with CDSS and its effect on the appropriateness of prescribing for residents with renal insufficiency in a single long-term care facility. CDSS alerts for adjusting the dose and frequency of medication orders for residents were displayed to prescribers in the intervention units and hidden but tracked in control units. The proportion of appropriate final drug orders was significantly higher in the intervention units compared with control units. This study was limited by the possibility of contamination, as the physicians operating in

Table 3
Characteristics of studies in nursing home care

Reference	Study Design (N)	Intervention(s)	Outcomes
Gurwitz et al,[77] 2008 (US)	Cluster RCT (1,118)	Thirty-nine clinical decision support criteria and 41 corresponding alerts were developed based on adverse drug events identified from previous research and a standard pharmaceutical drug interaction database and integrated into the existing CPOE system in 2 long-term care settings. The CDSS appeared in the form of a pop-up box in real time when the drug order was entered by physician.	**P**: Adverse drug events that may have resulted from medication errors (eg, errors in ordering, dispensing, administration and monitoring) or from adverse drug reactions in which there was no error. CPOE with CDSS did not reduce the adverse drug event rate or preventable adverse drug event rate in the long-term care setting. Comparing intervention and control units, the adjusted rate ratios were 1.06 (95% CI, 0.92–1.23) for all adverse drug events and 1.02 (95% CI, 0.81–1.30) for preventable adverse drug events.
Field et al,[78] 2009 (Canada)	Cluster RCT (833)	Conducted in a single long-term care facility among 833 residents over 12 months. A list of 62 drugs that may have needed dose or frequency adjustments was compiled and alerts related to the prescribing of these agents for residents with renal insufficiency were displayed to prescribers in the intervention units and hidden but tracked in control units. Four types of alerts were developed.	**P**: The proportion of final drug orders that were appropriate was significantly higher in the intervention units (RR, 1.2; 95% CI, 1.0–1.4). The proportions of dose alerts for which the final drug orders were appropriate were similar between the intervention and control units (RR, 0.95; 95% CI, 0.83, 1.1).

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Table 3
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Reference	Study Design (N)	Intervention(s)	Outcomes
Colon- Emeric et al,[72] 2009 (US)	Before/after (265)	Development and pilot testing (to examine feasibility and acceptance) of computerized order entry algorithms for geriatric problems in nursing homes among 42 Veteran's Affairs nursing home providers. Computerized order entry algorithms based on clinical practice guidelines were developed. These were presented to physicians at the time of prescribing on a single screen and provided an array of diagnostic and treatment options and means to communicate with the interdisciplinary team.	**P**: Use was infrequent and varied according to condition: falls (73.0%), fever (9.0%), pneumonia (8.0%), urinary tract infection (7.0%), and osteoporosis (3.0%). **PT:** In subjects with falls, trends for improvements in quality measures were observed for 6 of the 9 measures. Little improvement was observed in the other conditions There was no change in resource utilization.
Judge et al,[79] 2006 (US)	Study within a cluster RCT (445)	Thirty-nine clinical decision support criteria and 41 corresponding alerts were developed and integrated into the existing CPOE system in 2 long-term care settings. This study assessed prescribers' responses to alerts generated by a CDSS system.	**P**: A total of 47,997 medication orders were entered through the CPOE system and 9,414 alerts were triggered. Prescribers who received alerts were only slightly more likely to take an appropriate action (RR, 1.11; 95% CI, 1.00, 1.22).

Abbreviations: P, process (medication-related outcomes); PT, patient-related outcomes.

intervention units also worked in control units, and their prescribing practices in the intervention groups may have influenced the care given in the control units. This study found that clinical decision support provided for physicians prescribing medications for long-term care residents (with renal insufficiency) can improve care and that CDSS implemented within a commercial CPOE system was successful and had capacity for further linkage.[78]

A study by Judge et al,[79] set within the RCT described above,[77] assessed prescribers' responses to alerts generated by a CDSS system. The frequency of drug orders, associated with various alerts, was assessed. Overall prescribers who received the alerts were only slightly more likely to pursue an appropriate action. Alerts related to prescriptions for warfarin or central nervous system side effects were more likely to lead to an appropriate action. The authors concluded that the low rate of response to the alerts triggered by the CDSS suggested that further adjustments to the system were necessary.

A study investigating the development and pilot testing of computerized order entry algorithms for geriatric problems in Veterans' Affairs (VA) nursing homes found infrequent and varied use of computerized order entry algorithm. However, CPOE was used in 73% of falls cases, and some improvements were noted in quality measures related to these incidents. This study was limited by the fact that it was carried out at VA nursing homes; therefore, the findings may not be generalizable to community nursing homes. VA nursing homes have more on-site providers and an electronic order medical record system, which may not be available in community nursing homes. The authors concluded that this technology exhibited potential promise for improving clinical practice guideline use in nursing homes, but further modifications to adapt to the community nursing home system and to prompt use for chronic conditions was needed.[72]

Other studies in the nursing home sector that did not specifically focus on the prescribing stage of medication use, are complimentary to this discussion—The Geriatric Risk Assessment MedGuide (GRAM) study and the Fleetwood study are 2 such studies. GRAM[80] was an RCT that examined the extent to which the use of a clinical informatics tool that implemented prospective monitoring plans reduced the incidence of potential delirium, falls, hospitalizations caused by adverse drug events, and mortality among 25 nursing homes. The intervention involved the pharmacies generating GRAM reports to identify medications that may cause, aggravate, or contribute to common or serious geriatric problems and automated monitoring plans to prospectively detect serious geriatric problems that may have been caused by medications. Overall, this study found that newly admitted residents in intervention homes experienced a significantly lower rate of potential delirium onset than those in usual care homes. Lower rates of overall hospitalization and mortality were reported, but these findings did not reach statistical significance. The intervention had no effect on falls. The positive effects of the intervention were not seen in longer stay residents, although it had been hypothesized that because of the nature of the intervention, the effect would be stronger in new admissions.

The Fleetwood study used a before-and-after design with a non-randomized comparison group and utilized health information technology to improve communication and implement the Fleetwood Model of pharmaceutical care. This was performed by dispensing and consultant pharmacists and incorporated prospective reviews, direct communication with the prescribers, and formalized pharmaceutical care planning in patients at highest risk for medication-related problems. It was conducted in 25 nursing homes in North Carolina. Residents in the intervention had similar hospitalization rates, hospitalizations owing to potential adverse drug events, and mortality rates as residents in the usual care homes. With respect to the use of potentially inappropriate medications, the decline of use of these medications appeared earlier in the intervention homes relative to the usual care homes, but differences did not reach statistical significance (adjusted Hazard Rate=0.86; 95% CI: 0.65–1.12).[81]

DISCUSSION

Summary of Main Findings—Process Measures

This review has provided an overview of the current evidence in relation to the use of e-prescribing and CDSS technology to reduce inappropriate prescribing and polypharmacy in older people. Eleven of the 14 studies identified reported positive outcomes for the use of e-prescribing and CDSS in lowering rates of inappropriate prescribing and polypharmacy. However, the magnitude of effect sizes reported for interventions varied according to study design and setting, and some studies focused on different drug classes.

In ambulatory care, 4 studies reported positive outcomes. Both RCT designs described favorable outcomes. Tamblyn and colleagues[61] reduced the inappropriate prescription rate by 18%, whereas Raebel and coworkers[62] reported that just 1.8% of intervention group patients received a newly dispensed inappropriate prescription compared with 2.2% in usual care, a smaller magnitude of effect but relevant nonetheless. One study using an interrupted time series design found a 22% relative decrease in the exposure of older people to certain benzodiazepines and TCAs when drug-specific alerts were implemented.[64] In a follow-up to this study, Simon et al[65] found that changing drug-specific alerts to age-specific alerts produced no additional effect on the rates of inappropriate prescribing. The only cohort study (which is low on the hierarchy of research design) included in this review also showed positive outcomes, reporting a rate of change to a more appropriate therapeutic agent of 24%. An RCT by Weber and coworkers[63] was the only study conducted in the ambulatory care setting to report a negative finding. In that study, the introduction of pharmacist-initiated EMR alerts did not reduce the overall number of medications; however, this was possibly related to the small sample size.

All studies conducted in hospital or in-patient settings showed positive outcomes. However, the magnitude of the findings again varied by study design and intervention type. The only RCT[68] included found that the proportion of inappropriate prescriptions reduced from 5.4% to 3.4% overall, whereas an interrupted time series study found a reduction in the prescription of inappropriate prescriptions from 10.8% to 7.6%.[69] For sedative-hypnotic prescribing, one study reported an 18% risk reduction after intervention,[70] whereas a similar study found the mean rate of ordering of nonrecommended medications decreased from 11.56 to 9.94 orders per day after intervention.[71]

In the nursing home sector, 3 studies reported positive outcomes. Judge and colleagues[79] reported a small positive effect in 1 RCT with prescribers in the intervention group only slightly more likely to pursue an appropriate action. Similarly, a cluster RCT found appropriate drug orders were higher in intervention units than control.[78] The study by Gurwitz and colleagues[77] did not show favorable benefits of CPOE with CDSS on adverse drug events in the long-term care setting; however, it is important to recognize that adverse drug events are less common than inappropriate drug orders, so differences may be more difficult to detect. The need to increase the use of CPOE with CDSS to a broader range of drug safety issues is, therefore, apparent.

In all but one study across all 3 settings, alternative agents were offered to the prescriber to accept, whether at the point of prescribing directly or more indirectly via pharmacist review. One of the studies with negative findings, Gurwitz and coworkers[77] did not offer alternative agents for prescribers to accept, indicating that drug-specific alerts with alternative therapy advice may be important elements of successful interventions to improve inappropriate prescribing.

Summary of Main Findings—Patient Outcomes

Although some promising results were reported in this review, which suggested that e-prescribing and CDSS style interventions may be successful in improving appropriate prescribing and polypharmacy, the clinical impact of this is not known. Few studies in this review examined the effect of the interventions on patient outcomes such as hospitalizations, morbidity, and mortality, which limited the interpretation of such interventions. In a study in which a pharmacist inserted alerts into EMRs in ambulatory care, a mixed effect on the incidence of falls was reported, with the intervention group 0.38 times as likely to have had 1 or more fall-related diagnosis.[63] Peterson and coworkers[69] reported a lower in-hospital fall rate for those in the CDSS intervention group but noted no effect on hospital length of stay or days of altered mental status. Health information technology in nursing home settings has the potential to be successful if specific recommendations for ordering[78] or monitoring[80] are provided; however, to date, the impact on patient outcomes appears minimal.[81]

Challenges to Adoption of E-Prescribing and Other Technologies

Despite the vast heterogeneity in the included studies in terms of intervention types, health care settings, and study designs, the use of health information technology, including e-prescribing with CPOE and CDSS, has demonstrated some potential in improving appropriate, safe, and effective prescribing in all the care settings described. However, widespread diffusion of these interventions has not occurred, and it would appear that there are various obstacles that need to be surmounted before significant effects can be seen.

The attitudes of health care professionals can be a significant factor in the acceptance and efficiency of use of health information technology in practice[82] and, as Raebel and colleagues[62] note, changing prescriber behavior can be very difficult. While physicians and pharmacists generally report being satisfied with e-prescribing systems and see the systems as having a positive impact on the safety of their prescribing practices,[83–86] a number of obstacles to the successful implementation of such systems have been reported. These include a lack of trust in technology, the associated costs of implementation, a lack of integration of systems and standards, lack of systematic evidence of effectiveness, and the potential for new patient safety issues to arise, such as “juxtaposition error,” when an item near the one actually desired is clicked by mistake.[47,87–90]

Costs are a particularly salient concern in the nursing home setting. Although studies have found feasible and effective approaches to reducing harm owing to medication use among nursing home residents, how to stimulate adoption and who would pay for this in the US context has yet to be determined. In the years since the Institute of Medicine report calling for nursing homes to implement and use clinical information systems to support clinical practice,[91] adoption of health information technology in nursing homes has been slow.[92] Indeed, 1% or less of skilled nursing facilities have electronic health records used for clinical processes.[93] Recent research suggests that nursing homes are using technology for improving care processes[94] and indeed some tools are being designed specifically for this purpose.[95] One such nursing home chain, HCR Manor Care, has increased its use of health information technology by investing in more than 10,000 personal computers as well as expansion of facilities.[96]

Another significant barrier to the adoption and use of e-prescribing and CDSS systems centers on electronic alerts. Health care professionals recognize the positive impact that alerts can have on patient safety[43,97]; however, there is a problematic lack of acceptance of alerts in clinical systems.[98] It has been estimated that anywhere between 49% and 96% of alerts are overridden or ignored.[99] Alerts are overridden because of a range of factors, including unsuitable content of alerts, excessive frequency of alerts, and alerts causing unwarranted disruption to the prescriber's workflow, as was noted in the study by Gurwitz and colleagues.[77,100] Alerts are more likely to be well received if they are focused on highly critical information, can be trusted to provide high accuracy, and are designed to promote efficient information retrieval.[101] Other strategies recommended by physicians for the improvement of e-prescribing include the simplification of drug choice and cancellation of e-prescriptions.[86]

Patients themselves tend to be largely absent from discussions on the use of technology in prescribing, and less research has been conducted in this area. A recent study in Sweden found patients generally report a positive attitude toward e-prescriptions and electronic storing of prescriptions. A majority affirmed that such systems were safe, created benefits, and promoted faster dispensing. However, attitudes differ according to age, with younger age groups having the most positive attitudes and the older age groups having the least positive attitudes.[102] A survey of older patients in the United States found that e-prescribing technology solutions may provide opportunities for earlier and enhanced communication between geriatric patients and their clinicians about their medications, but generally, older patients may require more education to appreciate the value of e-prescribing.[103]

Comparison with Existing Literature

Previous reviews on improving prescribing in older populations have suggested (in line with our findings) that computerized decision support interventions may be effective in improving prescribing practices.[9,104–106]

Limitations

This review has a number of shortcomings. First, this review was not conducted systematically. It was a narrative review, and a meta-analysis was not conducted because of the level of heterogeneity among the studies. The studies included differed in terms of study design, the interventions delivered, the intensity and duration of interventions, and the outcomes measured, and it was difficult to tease out the exact components of the interventions that were most successful.

Future Research

Future research should continue to focus on evaluating the use of e-prescribing and other technologies to reduce inappropriate prescribing and polypharmacy in older people. It would appear that more formal rigorous investigations into these systems are required to enhance patient safety in all settings. More emphasis on the effect of interventions on patient-centered outcomes such as morbidity, mortality, and hospitalizations is needed. The barriers and obstacles to successful implementation of CDSS- and CPOE-type interventions, such as alert fatigue, need to be more fully investigated and workable solutions developed. Increasing the success of these interventions requires focused strategies to overcome the barriers to implementation.

SUMMARY

This review provided an overview of the current evidence in relation to the use of e-prescribing and other forms of technology, such as CDSS, to reduce inappropriate prescribing in older people. The evidence indicates that various types of e-prescribing and CDSS interventions have the potential to reduce inappropriate prescribing and polypharmacy in older people, but the magnitude of their effect varies according to study design and setting. There was significant heterogeneity in the studies reported in terms of study designs, intervention design, patient settings, and outcome measures with patient outcomes seldom reported. Widespread diffusion of these interventions has not occurred in any of the health care settings examined. Overall, health care providers report being satisfied with e-prescribing systems and see the systems as having a positive impact on the safety of their prescribing practices, yet the problem of overriding or ignoring alerts persists. The problem of large numbers of inaccurate and insignificant alerts and this issue, along with the other barriers that have been identified, warrant further investigation.

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