Evidence scan:

Reducing prescribing errors

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Identify Innovate Demonstrate Encourage

Contents

Key messages

Medicines can do a lot of good but they also have the potential to cause harm. Medication errors are one of the most common causes of patient harm and prescribing accounts for a large proportion of medication errors. This evidence scan examines strategies to reduce prescribing errors.

Prescribing errors include mistakes or inaccuracies when choosing and ordering treatments, such as wrong doses or illegible prescriptions.

Eight databases were searched and 123 studies were included about strategies for reducing prescribing errors, predominantly from North America. Studies about errors of omission, such as not prescribing a drug that might be helpful, were excluded because it is difficult to be objective about what medications should be prescribed in any individual instance. The scan does not cover other medication errors such as those related to dispensing or administration.

Most studies about reducing prescribing errors have been undertaken in hospital. The three most commonly researched approaches are, in order of frequency: computerised tools, training to improve prescribing and expanding professional roles to identify errors.

Computerised tools

Electronic prescribing and computerised decision support have been studied extensively but there are mixed findings. Most studies suggest computerised tools can reduce prescribing errors but some suggest unintended negative consequences. Emerging evidence suggests that to be successful, human factors such as workflow features, tool design and context need to be considered.

Educational strategies

Educational initiatives tend to focus on stopping errors before they occur. Strategies include:

– group training sessions

– individual education visits

– letters and printed materials

– audit and error reporting systems

– improvement projects and collaboratives.

All of these initiatives have had some success, but there is not enough evidence to say which strategies work best.

Professional roles

Studies of expanding professional roles tend to focus on how pharmacists can identify any errors before patients are harmed, including:

– checking for errors as prescriptions are received at the pharmacy or on wards

– medicine reconciliation or reviews

– individual or group education sessions.

Most research suggests that engaging pharmacists in these ways can be beneficial, but few studies have explored the best ways to integrate pharmacists into teams and the interprofessional factors to be considered. Combining education, enhanced professional roles and computerised tools may help to reduce prescribing errors most effectively.

1. Scope

Health professionals and managers are always looking for ways to improve the quality and safety of healthcare. Medicines are a key component of healthcare and errors relating to medication may impact on patient safety. This evidence scan explores what is being done to reduce prescribing errors.

1.1 Purpose

Thousands of people in the UK take medicines every day to help manage ongoing conditions or to help them through an emergency or crisis. Most receive and take their prescriptions without incident in hospital or in the community, but in a small number of cases an error occurs, whether or not it is evident to patients.

A medication error is a failure in the treatment process that leads to, or has the potential to lead to, harm to the patient.[1]

This evidence scan explores steps that have been explored to minimise prescribing errors. It does not cover the frequency or cause of prescribing errors. It focuses solely on approaches that have been used to minimise such errors.

The scan addresses the questions:

– What approaches have been used to reduce prescribing errors?

– Have any approaches related to human factors been researched?

The scan provides a rapid collation of **empirical research** about initiatives to reduce prescribing errors. All of the evidence has been sourced and compiled systematically, but the scan is not a systematic review and does not seek to summarise every study on this topic.

This section defines prescribing errors and human factors approaches and describes the methods used to identify relevant research. The following sections outline the three broad approaches that have been used to reduce prescribing errors: training to avoid prescribing errors before they happen, expanding professional roles to identify and rectify errors, and using tools to improve processes.

1.2 Definitions

Prescribing errors

Prescribing is the process whereby a doctor, nurse or other registered professional authorises use of medications or treatments for a patient and provides instructions about how and when those treatments should be used. Although the term commonly refers to orders for medicines, the concept can equally encompass laboratory tests, medical imaging, psychological treatments, eye glasses, eating and exercise regimes or other instructions to help optimise health and wellbeing.[2,3]

Prescriptions are handwritten or computerised documents containing the patient's name and address, the date, the specific treatments prescribed and an authorising signature. They are a way for prescribers to communicate with pharmacists or others who in turn fill the prescription. Prescribers include doctors of various types and, in some countries, nurse practitioners, physicians assistants, dentists, podiatrists, optometrists, clinical psychologists and clinical pharmacists also write prescriptions.[4–6]

Prescriptions can help people stay healthy or manage long-term conditions or emergency situations. However, as with other components of healthcare, prescriptions are also subject to error and can lead to unintended harm. Medication errors are one of the most common patient safety issues and prescribing errors are one of the most common types of medication errors.[7–12]

Prescribing errors can take many forms, but commonly involve incorrect doses, illegible details or ordering inappropriate medications or drugs that may react with other medications already being taken.

A study to develop a definition of prescribing errors in the UK concluded that transcription errors, failure to communicate essential information and the use of drugs or doses inappropriate for the individual patient were prescribing errors, but omissions and deviations from policies or guidelines were not.[13] Even so, some also define prescribing omissions as errors, for example if a doctor fails to prescribe an antihypertensive drug for someone who could benefit from it.

In this evidence scan, **the focus is on active errors, whereby the prescription contains a potentially harmful drug, combination or dosage rather than solely errors of omission**. Studies focused only on errors of omission were excluded unless they explicitly defined such errors as 'prescribing errors' and investigated definite strategies to reduce those errors. In this way, the scan uses the definition of 'prescribing errors' as outlined in individual studies in the review. This means that studies that sought to 'improve prescribing' in terms of adherence to guidelines or increasing or decreasing the rates of prescribing some types of medicines were not included unless the authors specifically defined these as prescribing errors. The scan focuses on research about reducing prescribing errors rather than research about 'improving prescribing' more generally.

Human factors

All approaches to reduce prescribing errors were of interest but there was a special focus on human factors approaches.

'Human factors' is a multidisciplinary field incorporating contributions from psychology, engineering, design, ergonomics, operations research, aviation, continuous quality improvement and other disciplines.

In general terms, a 'human factor' is a physical, mental, emotional or social aspect that is specific to humans and may influence how people interact with the environment and people around them. Human factors approaches thus study all aspects of the way humans relate to the world around them, their capabilities and limitations and how these can be used to improve performance and safety.

Human factors approaches address the interactions between people, the work environment and organisational systems. This discipline seeks to understand people's psychological and physiological limitations, the demands imposed upon people at work and how the mismatch between the two leads to errors.

In the field of healthcare, human factors approaches aim to enhance clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities and to apply that knowledge in clinical settings.

Human factors approaches may involve diagnosing issues in the interaction between people and systems, identifying workload and task interruptions and redesigning the workplace environment and team factors through standardisation and prioritisation.

Human factors approaches tend to focus on personnel, training and operating parameters.[14–21] More specifically, human factors solutions may include five broad approaches:[22,23]

– **training individuals** to better prepare them for the work and conditions

– **selecting individuals** who possess the best characteristics for the job and avoiding fatigue, stress and burnout

– **environmental design** such as improved lighting, temperature control and reduced noise

– **equipment design** including tools and automation

– **task design** to change what staff do rather than just the devices they use. This may involve assigning some or all of tasks to other workers or to automated processes

Interventions to reduce prescribing errors all fit broadly into these human factors categories. There is potential overlap in these categories but interventions to reduce prescribing errors have focused largely on training individuals, selecting individuals (pharmacist roles) and equipment and task design (including electronic systems). The following chapters describe research about each of these three areas in turn.

1.3 Methods

The scan focused on research articles published in journals in the UK and internationally and was completed over a two-week period.

To identify relevant research, one reviewer searched eight bibliographic databases for studies of any design in any language published between 1990 and early January 2012. The databases comprised Medline, Embase, the Cochrane Library and Controlled Trials Register, PsychLit, Google Scholar, Web of Science, ScienceDirect, and the Health Management Information Consortium.

Search terms included combinations of prescribing error, prescription error, medication error, dosing error, dose error, human factors, task identification, task redesign, workplace environment, situational awareness, team roles, standardisation, prioritisation, workload interruptions, pharmacist, pharmacy, computerised order entry, computerised physician order entry, computerised pharmacist order entry, e-prescribing and similes.

General search terms such as 'prescribing error' were used first to identify the largest range of studies. When research about specific interventions was identified, such as e-prescribing, these interventions were then added as search terms to ensure completeness. In this way the search strategy was initially general, to identify research about a wide variety of interventions, and then became more detailed, to gain in-depth information about the specific interventions identified.

To be eligible for inclusion, studies had to be readily available empirical research or systematic literature reviews which examined some type of outcome relating to reducing prescribing errors. This may include, for example, strategies used to reduce errors, the benefits or costs of doing so, or increases in reporting rates. Studies about the number and type of prescribing errors were not included. Studies that described potential approaches to reducing prescribing errors but did not contain empirical data were also excluded.

While the focus is on prescribing errors, rather than medication errors more generally, the review screened studies related to 'medication errors' because often studies use this terminology rather than the term 'prescribing'. Studies using this broader terminology were included if they contained specific data about prescribing errors.

More than 10,000 articles were scanned and **123 studies met the inclusion criteria.**

Although prescribing of all types was eligible for inclusion, only research about reducing errors in medication prescribing was identified in the search. The report therefore focuses on reducing errors in medication prescribing.

Findings were extracted from all publications using a structured template and studies were grouped according to key themes to provide a narrative summary of trends.

2. Education and development

Training personnel to better prepare them for tasks and work conditions is a human factors approach. This section describes 24 studies about training and educational initiatives to reduce prescribing errors.

Research has focused on using training and development initiatives to reduce prescribing errors in two distinct ways.

– The first relates to reducing errors **during** the prescribing process itself. Here, research has examined one-to-one and group education and improvement projects to stop errors happening in the first place.

– Second, research has examined training and development initiatives to identify and rectify any errors that do occur, to minimise the chance of them harming patients. Here, the focus tends to be on error monitoring and reporting systems.

Research about training and development initiatives is divided into these two subsections below.

2.1 Reducing errors during prescribing

One-to-one education

Individualised education can take many forms, including 'academic detailing' whereby a professional is visited in their workplace for a one-to-one education session. A Cochrane Review examined face-to-face outreach visits by a trained person to a health professional. 18 randomised trials were included, 13 of which targeted prescribing. All outreach interventions included several components such as written materials or conferences. Reminders or audit and feedback were sometimes used. All studies found improved behaviours. However, few studies examined patient outcomes or costs.[24]

Another review of interventions to improve prescribing included 29 studies. Educational outreach visits and audit and feedback were most commonly studied and were found to be effective for improving prescribing practice.[25]

Researchers in Australia tested the value of academic detailing to reduce simple errors when prescribing drugs that can be addictive in hospital. One hospital acted as a control and another received academic detailing, where junior doctors received an educational visit and a bookmark reminder containing the requirements for selected drugs. Prescription error rates decreased from 41% to 24% at the hospital receiving academic detailing and the confidence of junior doctors in writing prescriptions increased. There was no change in error rates at the control hospital.[26]

Elsewhere in Australia, a hospital used a decision support tool to help with drug dosing for people with kidney problems. The system was introduced to prescribers using academic detailing. There were improvements in dosing for various drugs. The evaluators concluded that one-to-one education helped to introduce tools for reducing prescribing errors.[27]

Group education for trainees

Most studies of group education sessions to reduce prescribing errors focus on training for medical or pharmacy students or registrars.

A prescribing skills course for interns was tested in the US. A pharmacy faculty gave two lectures, attended hospital rounds and took part in clinics. Interns then undertook a written exam and clinical assessment. All interns made at least one

prescribing error on the exam, but all passed on the second attempt and gained prescribing privileges after six months. The researchers concluded that the prescribing curriculum was practical and feasible.[28] However, studies like these tend not to follow up on results to examine the impact on reducing prescribing errors in practice.

An Objective Structured Clinical Examination (OSCE) is an assessment tool that uses lay people trained to respond to questions in a standardised manner. Students' performance is observed and scored. An OSCE station related to the communication and management of prescription errors was tested with third-year students at one US medical school. In total, 77% of students said that the OSCE station improved their awareness of medication errors and 71% thought that they were more comfortable communicating prescription errors to patients. Feedback about root cause analysis, collaboration with the pharmacist for error analysis, interpersonal and communication skills feedback from faculty, use of a standardised patient and use of an actual prescription that led to a medication error were thought to be helpful.[29]

But not all types of training for students are successful. A hospital in Canada tested a 30-minute tutorial for all fellows and residents starting in the accident and emergency (A&E) department at the beginning of the academic year. The tutorial was followed by a written test. Prescribing errors were reviewed on 18 randomly selected days. There was no difference in prescribing error rates between those who attended and those who did not attend the tutorial.[30]

Group education for qualified professionals

Education to reduce prescribing errors has also targeted fully qualified professionals. A neonatal intensive care unit in Spain evaluated the effect of educational sessions for health professionals on the number and type of prescription errors. The prescription error rate reduced from 21% to 3%.[31]

Another hospital in Spain tested ways to improve handwritten prescriptions in neonatal units. Staff took part in training about good prescribing practice and used a pocket PC automatic dosage calculation system. Incorrect prescriptions reduced from 40% to 12%.[32]

Other studies have examined combined training for both fully qualified professionals and trainees. Researchers in England examined whether prescriber education in tutorials, ward-based teaching and feedback with each new group of trainee medical staff could reduce prescribing errors in intensive care. Prescribing audits before training, immediately after training and six weeks after training were fed back to prescribers with their individual prescribing and error rates and anonymised information about other prescribers' error rates. Prescription errors decreased.[33]

Improvement programmes

A small number of studies have tested how collaborative improvement projects and networks of professionals may impact on prescribing errors.

Thirteen hospitals in one US state took part in a collaborative project to improve medication safety. Teams were encouraged to make changes to their medication processes based on evaluating their medication systems and ergonomic principles and research. Before and after data from eight of the hospitals suggested a 27% decrease in medication errors, a 13% increase in error detection and prevention and a 24% increase in formal written reporting of errors that reached the patient.[34]

A hospital in Argentina implemented strategies to change the safety culture and reduce medication errors in children and babies. Interventions focused on promoting positive safety culture without punitive management of errors and specific prescribing and drug administration recommendations. The medication error rate decreased from 11% to 7% over a two-year period. Prescribing errors were not analysed separately but were specifically targeted.[35]

2.2 Reducing errors after prescribing

One-to-one education

Various types of individualised education have also been studied for reducing the impact of errors or identifying errors before they harm patients. In Australia, direct feedback to clinicians was tested to reduce errors from polypharmacy or drug interactions in older people. GPs were sent information about the at-risk patient, relevant clinical guidelines and a personalised covering letter. There was a reduction in the average number of medications prescribed for each person following the prescriber feedback.[36]

Similarly, researchers in Canada examined whether follow-up letters from pharmacists to doctors following inappropriate prescriptions would improve prescribing for people in long-term care. The educational letters briefly described potentially inappropriate prescriptions and suggested alternatives. 38% of potentially inappropriate prescriptions were changed by the doctor following a letter.[37]

Researchers in the US tested whether a computerised drug review database linked to a telepharmacy intervention reduced inappropriate medication use in 23,269 people aged 65 years or older. Computer alerts triggered telephone calls to doctors from pharmacists with training in older people's medicine who could discuss substitution options. As a result, 24% changed to a more appropriate drug.[38]

Education may also be informal and result from interactions between staff members. Researchers in the US assessed the views of pharmacy directors, medical centre executives and pharmacists about the value of pharmacist residency training programmes. Participants believed that residency programmes had many benefits and that these outweighed costs. They thought that pharmacy residents helped to reduce medication errors by educating prescribers and checking prescribing.[39]

Patients have been targeted for education in a small number of instances. In one study, 913 US outpatients with potential prescribing errors were identified and randomly assigned to provider feedback or usual care. However, after one year there was no difference in adverse drug events.[40]

Group education for trainees

Researchers in Canada evaluated a computer training module to improve third-year pharmacy students' ability to identify and correct prescribing errors. The module helped increase the identification of errors.[41]

In the US, first-year pharmacy students took part in laboratory simulations to help identify and prevent medication errors, including prescribing errors. Following simulations and role plays, students' knowledge and awareness of medication errors improved as did their confidence in recognising and preventing errors and communicating about them.[42]

However, studies like these tend not to follow up to examine the impact on reducing prescribing errors in practice.

Improvement programmes

A hospital in Switzerland tested various approaches for reducing the impact of adverse drug incidents. Non punitive incident monitoring was set up in a neonatal-paediatric intensive care unit. Systems changes included double checking for potentially harmful drugs, using a standardised prescription form and contacting the national drug control agency about misleading drug labels. Most of the system changes were based on minor critical incidents which were only detected after a long period of time. They resulted in some potential errors being caught, including prescribing errors.[43]

Another popular educational and improvement method is audit and feedback. Changes are monitored over time and prescribers and pharmacists are given written feedback about their own performance in comparison to others. A Cochrane Review about audit and feedback included 37 randomised trials, including some about prescribing. Effects were varied. The reviewers concluded that audit and feedback can sometimes be effective in improving the practice of health professionals, in particular prescribing and diagnostic test ordering, but effects tend to be small.[44]

Error monitoring and reporting

Monitoring and reporting on errors may in itself serve to raise awareness and support improvement. A neonatal intensive care unit in Spain tested whether prescribing errors would decrease merely as a result of observation and recording of errors. The prescription error rate reduced from 33% to 19%. Rates of incorrect dosing and lack of dose specification in prescriptions reduced significantly but there was no change in transcription errors.[45]

A hospital in New Zealand conducted audits over a 10-year period to improve the quality of written prescriptions. Initially there was a high rate of insufficient documentation and illegible prescriptions. Interventions designed to address deficiencies included feeding back audit results, education sessions for doctors and nurses on prescribing and medication errors and changes to systems, such as modifying medication charts, developing hospital-wide prescribing standards and an alert notification system. Over time, legibility and documentation improved.[46]

A system was set up to report on medication errors at one hospital in France. 60% of medication errors related to prescribing. The system was found to be feasible and resulted in steps being taken to reduce errors. Success factors included a blame-free approach and ensuring that the system was confidential.[47]

3. Expanding professional roles

Selecting appropriate personnel is an important human factors approach. This section describes 19 studies about initiatives relating to roles and personnel to reduce prescribing errors.

As with studies about education and development, research has focused on using varying professional roles and skill mix to reduce prescribing errors in two distinct ways.

– The first relates to roles during the prescribing process to reduce the likelihood of errors happening in the first place. Here, research is very limited, and has examined prescribing by nurses versus doctors.

– Second, research has examined the use of healthcare professionals to identify and rectify any errors that do occur, to minimise the chance of them harming patients. Here, the focus tends to be on expanding the role of pharmacists to perform checks and identify errors.

Research about roles is divided into these two subsections below.

3.1 Reducing errors during prescribing

Few studies have examined how professional roles can be expanded to reduce prescribing errors. One exception is a study of engaging nurses in roles usually performed by doctors. A hospital in Iran tested whether a collaborative prescription order entry method consisting of nurse order entry followed by doctor verification and countersignature is as effective as a strictly physician order entry method in reducing prescribing errors in the neonatal ward. In both systems a warning and suggested change appeared when the dose or frequency of the prescribed medication was incorrect. The rate of medication errors was 40% lower for nurse order entry compared to doctor order entry. Prescription

errors decreased from 10% to 5% and the number of warnings that doctors complied with increased from 44% to 68%.[48]

3.2 Reducing errors after prescribing

Pharmacist roles
Most studies about reducing errors after prescriptions have been written have been undertaken in hospital, particularly in the US. The most common interventions related to specific roles focusing on pharmacists.

Pharmacist roles to identify prescribing errors and to stop them reaching patients include:

– checking for errors as prescriptions are received at the pharmacy and contacting prescribers for clarification or amendment before filling prescriptions

– visiting wards to review charts and provide advice to prescribers about individual patients

– reconciling the medicines patients usually take with what they are prescribed in hospital

– providing medication reviews upon discharge.

Each of these initiatives is explored in turn.

Pharmacists have also run one-to-one or group education sessions for prescribers but these interventions tend to focus on prevention rather than error identification. Studies of this nature were covered in the previous section.

Checking medication orders

A number of studies have examined the value of asking pharmacists to specifically check and review medication orders. For instance, pharmacists at a US hospital used an electronic system to review all prescriptions. This alerted the prescriber and pharmacist to dosage errors and allergies and reduced prescription errors.[49]

Another US hospital examined how paediatric clinical pharmacists intercept prescription errors. In total, 78% of potentially harmful prescribing errors were intercepted by pharmacists.[50]

A hospital in England examined the impact of pharmacists on preventing prescribing errors at discharge. Routinely collected data showed that 8% of all medication orders had an intervention by a pharmacist. Pharmacists intercepted 83% of erroneous orders without referring to doctors. Omission, drug selection and dosage errors were the most common.[51]

Researchers in the Netherlands analysed the costs and benefits of hospital pharmacy staff detecting prescribing errors. Over a five-day period, 10% of 3,540 medication orders in two Dutch hospitals contained an error. Estimated benefits amounted to 9,867 Euro compared to 285 Euro in staff time costs.[52]

But interventions involving checks by pharmacists are not always successful. Researchers in France examined how pharmacy validation can be used as a secondary filter for eliminating errors from a computerised order entry system. All prescriptions over a five-day period were analysed at one hospital. Pharmacy validation produced only a moderate short-term impact on potential prescribing errors.[53]

Pharmacists on wards

Another strategy is to engage pharmacists to check prescribing on hospital wards. In the Netherlands, a clinical pharmacist reviewed medication orders for patients admitted to the intensive care unit and discussed recommendations during patient review meetings with attending doctors. Over an eight and a half month period, the rate of prescribing errors was lower than before the intervention and preventable adverse drug events were reduced. The intervention cost 3 Euro per monitored day but potentially saved 26 to 40 Euro per monitored day by preventing adverse drug events.[54]

Similarly, pharmacists reviewed prescriptions on the surgical wards at one hospital in Canada and provided group educational sessions for doctors. Doctors accepted 90% of pharmacist recommendations. There was a 9% decrease in drug costs.[55]

Medicine reconciliation

Medication reconciliation, whereby a pharmacist checks usual medicines against planned prescribing, can take place in hospital or in primary care. A systematic review of four studies examined medication reconciliation interventions in both settings. One randomised trial and one before and after study evaluated pharmacist medication review at hospital discharge. Neither found a benefit. Two before and after studies examining systematic medication reconciliation at each primary care visit had conflicting findings.[56]

In the UK, a pharmacist independent prescriber completed systematic medicine reconciliation in A&E and initiated an inpatient prescription chart. Medicine reconciliation completed within 24 hours of admission increased from 50% to 100% and prescription chart initiation in A&E increased from 6% to 80%. The prescribing error rate was reduced from 3.3 errors to 0.04 errors per patient.[57]

Elsewhere in the UK, a cost analysis of five different strategies for preventing medication errors at hospital admission used models and previous studies. Pharmacist reconciliation of medicines was found to be cost effective.[58]

Pharmacist discharge services

One hospital in the Netherlands examined the effect of a clinical pharmacist discharge service on medication discrepancies and prescription errors in people with heart failure. One group received usual care by doctors and nurses. The other received a review of discharge medication by pharmacists

who alerted specialists to prescribing errors, gave patients information, prepared a written overview of discharge medication and communicated with community pharmacists and GPs. The pharmacist discharge service was associated with fewer medication discrepancies and prescription errors at one-month follow up (39% versus 68% of people in the control group).[59]

Multifaceted hospital interventions

Sometimes a range of interventions involving pharmacists are implemented simultaneously. One paediatric intensive care unit in Egypt introduced a structured medication order chart, doctor education by pharmacists, provision of dosing assists and performance feedback to doctors. Prescribing error rates reduced from 78% to 35%. Potentially severe errors reduced from 30% to 7%.[60]

A systematic review examined the frequency of medication and prescribing errors in neonatal intensive care units. In 11 studies, the highest reported rate was 5.5 medication errors per 100 prescriptions, but rates varied widely between studies partly due to differences in definitions and methods. Dose errors were the most common. Computerised physician order entry, participation of pharmacists in ward rounds and pharmacist review of prescriptions prior to dispensing were suggested to improve medication safety, but there were few high-quality evaluation data available.[61]

Pharmacists in primary care

Studies are also available about the role of pharmacists in reducing prescribing errors in primary care. However, most of the research in this area is relatively small scale and descriptive and observational. It tends to describe interventions undertaken in a small number of sites, and little detailed or long-term data about outcomes are available.

For instance, a US study examined the pharmacist's role in improving medication safety in primary care using focus groups with pharmacists and patients. Patients were likely to see multiple doctors but only one pharmacist. They were more likely to report

medication errors to the pharmacist than to their doctor. Pharmacists acted as the final interceptors, detecting errors in prescriptions before they reached patients.[62]

Pharmacists may contact primary care doctors to clarify prescriptions or suggest changes. In the US, call backs from pharmacies to 22 primary care practices were logged over a two-week period. Keeping records of the number and type of queries from pharmacists helped practices develop specific interventions to reduce errors.[63]

Some proactive approaches to pharmacist review have also been tested. In Switzerland six quality circles were set up whereby six community pharmacists reviewed the prescribing of 24 GPs. Key elements included the review of specific prescriptions, continuous quality improvement and education, local networking and feedback of comparative data about costs and drug choices. Analysis of nine years' worth of data found improved quality and safety of prescribing and a 42% decrease in drug costs compared to a control group, representing savings of US$225,000 per GP per year.[64]

Nursing homes

A review of 18 randomised trials of interventions to improve prescribing in nursing homes found that seven studies described educational approaches such as outreach visits, five studies described clinical pharmacist activities such as medication reviews and two studies described computerised decision support. Two studies described multidisciplinary approaches and two described multifaceted approaches. Improvements in prescribing were found in 83% of studies. In some cases, this included reductions in prescribing errors, but most of the interventions focused on improving suboptimal prescribing which was outside the scope of this evidence scan.[65]

3.3 Other human factors issues

Other human factors issues such as fatigue, concentration levels and stress may all have an impact on prescribing behaviour. It has also been suggested that temporary staff are more likely to be associated with medication errors.[66]

While descriptive articles are available about these human factors concepts and their potential impact on safety issues, no empirical research was identified about interventions targeting these factors specifically to reduce prescribing errors.

4. Tools

Redesigning equipment and tasks can reduce prescribing errors. This section describes 80 studies about tools that have been used to reduce prescribing errors.

Human factors approaches are concerned with the interface between tools and systems and the personnel responsible for them. The majority of studies about re-designing equipment and tasks to reduce prescribing errors focus on electronic prescribing systems (e-prescribing) and computerised decision support systems. These studies tend to describe implementation of specific systems and their outcomes, but do not usually examine the interlinkages with workflow, interruptions and other human factors.

Studies about computerised tools are described in this section because the majority of research about reducing prescribing errors has focused on such tools. However, it is acknowledged that the research tends to focus on the technology rather than the interface between technology and personnel.

Almost all of the studies focus on how tools can be used to reduce errors during the prescribing process itself, but some of the tools can also be used as a way of identifying errors after they have occurred.

When interpreting the findings in this section it is important to remember that there are **differences in prescribing and in the roles of pharmacists in various countries**. For example, electronic systems have been set up to reduce transcription errors but transcription errors do not apply in the same way in the UK as in the US. In the UK, doctors write directly onto a drug chart or into an electronic prescribing system rather than onto a piece of paper which is then transcribed by someone else. Studies that focus on reducing transcription errors of this nature are therefore of limited relevance to the UK.

Similarly, electronic prescribing is already standard in primary care in the UK, whereas in the US this is just beginning to get established. A great deal of research has been undertaken in the US about e-prescribing systems, but the findings perhaps merely serve to reinforce what is already standard practice in the UK.

4.1 E-prescribing

Hospital care

E-prescribing is also known by the terms computerised physician order entry (CPOE), computerised provider order entry or computerised pharmacist order entry (in the US where pharmacists may transcribe prescribers' handwritten orders into a computer system). This is an electronic process for entering instructions about patient treatment. Orders for medication, equipment or other treatments are communicated over a computer network to various medical staff and departments such as pharmacy, laboratory or radiology who are, in turn, responsible for filling those orders.

Before e-prescribing systems were available, in the US doctors traditionally wrote out or verbally stated their instructions for patient care, which were then transcribed by nurses or ancillary staff before being actioned. It was thought that such handwritten notes may result in more errors and delays[67] and, as a result, the US Institute of Medicine recommended e-prescribing be implemented as standard.[68]

E-prescribing systems aim to reduce delay in accessing medication or treatment, reduce errors related to handwriting or transcription, allow orders to be made at the point of care or off-site and simplify inventory and charging processes.

The systems often have decision support tools built in whereby the system automatically checks for duplicate or incorrect doses or tests, provides alerts to let the prescriber know that a dose is too high or may interact with other medications, or highlights clinical guidelines or other ways to improve evidence-based treatment. This section includes studies about e-prescribing systems with and without inbuilt decision support tools (often the distinction is not made clear in the studies). The next subsection examines research about the impacts of decision support tools themselves.

A large number of studies have found benefits from e-prescribing, and it is commonly suggested that such tools can reduce prescribing errors by around a half.[69,70]

For instance, a systematic review found that 23 out of 25 studies about e-prescribing which reported on the medication error rate found improvements. Six out of nine studies that analysed the effects on potential adverse events found reduced risks. Four out of seven studies that analysed the effect on actual adverse drug events found reduced risks. Studies of locally developed systems, those comparing e-prescribing to handwritten prescriptions and studies using manual chart review to detect errors, found greater improvements.[71]

Another review of 12 studies compared handwritten versus computerised prescription orders. 80% of studies about e-prescribing reported fewer prescribing errors compared with handwritten orders. The use of e-prescribing was associated with a 66% reduction in prescribing errors in adults, but not children.[72]

Studies from many parts of the world with diverse health systems have found that e-prescribing systems can reduce prescribing errors. For example, researchers in England assessed e-prescribing

in a nephrology outpatient clinic at a paediatric hospital. The overall prescribing error rate was 77% for handwritten items and 5% with e-prescribing. Before e-prescribing, 73% of items were missing essential information and 12% were judged illegible. After e-prescribing was introduced, 1% of items were missing essential information and there were no illegibility errors. The number of error-free patient visits increased from 21% to 90%.[73]

Researchers in Canada examined the impact of e-prescribing on medication errors and adverse drug events in hospitalised children over a six-year period. Compared to wards using handwritten orders, the computerised system was associated with a 40% lower medication error rate. However, there was no impact on adverse drug events.[74]

Over a four-year period, a US hospital introduced an e-prescribing system and incorporated decision support features. The medication error rate (excluding missed doses) fell by 81%. Serious medication errors that were not intercepted fell by 86%. Dose errors, frequency errors, route errors, substitution errors and allergies all reduced.[75]

Another US hospital implemented e-prescribing with features designed to improve medication safety such as required fields, use of pick lists, enhanced workflow features, alerts and reminders and access to online reference information. The system was associated with a reduced error rate.[76]

A US A&E department found that before e-prescribing there were 222 prescribing errors per 100 orders compared to 21 per 100 orders afterwards.[77]

Another study tested e-prescribing in a US children's critical care unit. Before implementation, there were about 2 potential adverse drug events per 100 orders compared to 1 per 100 orders afterwards. There was a 96% reduction in errors.[78]

A before and after study in a public hospital in Pakistan found that prescribing errors for inpatients were 23% during paper-based prescribing and 8% after the introduction of e-prescribing. The error rate for patients upon discharge was 17% for paper-based prescribing and 4% after introducing e-prescribing.[79]

In Spain, a hospital unit using handwritten prescriptions was compared with another using e-prescriptions. Handwritten prescriptions were associated with a 20% error rate compared to 9% in electronically assisted prescriptions. Omission errors were also lower with e-prescriptions.[80]

Intensive care units at one hospital in Belgium tested whether a computerised system could reduce the incidence and severity of prescription errors. One unit used a paper-based system and another used e-prescribing. There were fewer prescription errors with the computerised system (3% versus 27%) and fewer adverse drug events.[81]

A hospital in France compared two prescribing and medication distribution systems on a paediatric nephrology ward: a handwritten prescription plus ward stock distribution system versus computerised prescription plus unit dose drug dispensing system. Over an eight-week period, the computerised prescription error rate was 11% and the handwritten prescription error rate was 88%.[82]

A hospital in the Netherlands tested decision support and computerised order entry. The proportion of prescriptions containing one or more errors reduced from 55% to 17%.[83]

Some hospitals have modified or developed specialised e-prescribing systems to target people with particular conditions or to address specific types of errors. A systematic review of e-prescribing in hospital paediatric care and neonatal, paediatric or adult intensive care settings included 12 observational studies. Meta analysis found a decreased risk of prescription errors. There was no reduction in adverse drug events or mortality rates.[84]

Dose calculation errors are the most common type of medication error in children and babies. A systematic review examined interventions to reduce the risk of this type of error. 28 studies were included, mostly about e-prescribing. Most studies of e-prescribing found some reduction in errors. However, one study found increased mortality after the implementation of e-prescribing.[85]

Most research focuses on the potential of e-prescribing to avoid errors during the initial prescribing process, but these tools can also be used to identify errors after the prescription has been entered. A US hospital aimed to reduce oral chemotherapy related prescribing errors intercepted by clinical pharmacists prior to reaching the patient. A multidisciplinary team identified key elements of the oral chemotherapy process using healthcare failure modes and effects analysis (HFMEA) then implemented e-prescribing which reduced the risk of prescribing error by 69%.[86] Pharmacists used the system to check and amend prescriptions.

E-prescribing systems have also been used to try to reduce errors indirectly. For example, researchers in England tested whether data routinely produced by an e-prescribing system could be used to identify doctors at higher risk of making a serious prescribing error, with the aim of intervening with these doctors. 848,678 prescriptions by 381 junior doctors at one hospital over a year long period were analysed. Doctors varied greatly in the extent to which they triggered and responded to alerts of different types. It was not possible to use data about the number and type of alerts to identify doctors at high risk of making serious errors.[87]

Not all studies of e-prescribing have found favourable results. Researchers in Canada evaluated commercially available prescribing software in hospital outpatient clinics. Data from 22 weeks when the system was not available were compared with 44 weeks when the system was available. During intervention weeks, about 8% of prescriptions were electronic and the rest were handwritten. There was no difference in prescription error rates[88] but this may be due to the very low uptake rate of the system.

A hospital in Portugal examined an e-prescribing system with a dose distribution tool. The tool helped to reduce medication errors related to transcribing and patient identification, but prescription and monitoring errors remained.[89]

E-prescribing systems have sometimes been associated with negative or unexpected outcomes too, including an increase in some types of errors.[90] For instance, a systematic review of 12 studies published between 1998 and 2007 examined e-prescribing in hospital. Nine studies found reduced prescribing error rates for all or some drug types, usually regarding minor errors. But several studies reported increases in the rate of duplicate orders and failures to discontinue drugs. This was attributed to inappropriate selection from a dropdown menu or not being able to view all active medication orders concurrently. The reviewers concluded that evidence for e-prescribing systems is not compelling and is limited by small sample sizes and poor study designs.[91]

Researchers in the US examined hospital staffs' interaction with an e-prescribing system at one hospital over a two-year period. In total, 261 staff were surveyed, 32 were interviewed and there were five focus groups. The system led to 22 types of risks of medication errors such as not allowing a coherent view of patients' medications, mistaking pharmacy inventory displays for dosage guidelines, placing alerts on paper charts rather than in the system, separating functions that facilitate double dosing and incompatible orders and generating incorrect orders due to inflexible ordering formats. These risks occurred frequently.[92]

Another US hospital implemented a commercially available e-prescribing system to help reduce mortality among children transported for specialised care. Before and after analysis found that the tool was associated with increased rates of mortality, not reductions.[93]

It may take some time for the benefits of e-prescribing systems to become apparent and there may be difficulties in the transition or implementation period. An analysis of US data found that changing from using older e-prescribing to newer systems was associated with a reduction in prescribing errors from 36% to 12%. Improvements were mainly a result of reducing inappropriate

abbreviation errors. However, errors not associated with abbreviations increased during the transition period.[94]

A hospital in Italy compared manual prescription versus a computerised system. When the computerised system was first introduced the number of errors increased due to incomplete dose and incomplete prescriptions. However, after the system was modified the overall rate of errors decreased.[95]

Some suggest that e-prescribing may take longer than handwritten prescriptions. Researchers in England assessed a combined e-prescribing, automated dispensing, barcode patient identification and electronic medication administration record system in a hospital surgical ward. Prescribing errors reduced from about 4% to 2% of orders. However, medical staff required 15 seconds to prescribe a regular inpatient drug before and 39 seconds after introducing the system.[96]

Primary care

Research about e-prescribing outside hospital is less frequent and sometimes less positive, though this is standard in UK primary care.

A review of e-prescribing in outpatient settings included 30 studies. Only one study found reduced prescribing errors. There were no impacts on adverse drug events. Three studies found reduced medication costs but five others did not.[97]

Another study examined the impact of e-prescribing in four US primary care practices. There was no difference between those who used basic computerised prescribing and those using handwritten prescriptions.[98]

However some benefits have been observed. An analysis of 10,172 prescriptions in primary care found that a basic e-prescribing system was associated with reduced medication errors.[99]

Compared to when using handwritten orders, the proportion of errors reduced from 18% to 8% in community-based US primary care. The largest improvements were in illegibility, inappropriate abbreviations and missing information.[100]

But when three primary care clinics in the US implemented e-prescribing, a time motion study found that it took longer than handwritten prescriptions.[101]

4.2 Decision support

Decision support tools provide prompts to help prescribers avoid errors when writing or entering prescriptions. This subsection focuses on decision support tools or alert systems that are standalone systems (not part of e-prescribing) or where alert systems are embedded in e-prescribing tools but their effects have been analysed separately.

Hospital care

Evidence about the benefits of decision support tools, such as alerts and prompts for prescribers, is mixed.

A systematic review of computerised drug alerts and prompts found that 23 out of 27 studies suggested improved prescribing behaviour or reduced error rates. The impact varied based on the type of decision support. Five out of 27 studies reported benefits for clinical and health service management outcomes.[102]

Another systematic review reported that four out of seven studies about standalone clinical decision support systems found improvements in medication errors and three did not. Most studies were not powered to detect differences in adverse drug events and evaluated small 'home grown' systems rather than commercial systems.[103]

A review of 87 trials of medication management information technology found that most trials:

– focused on clinical decision support and e-prescribing systems

– took place in US hospitals

– focused on doctors

– studied process changes related to prescribing and monitoring medication.

Processes of care improved for prescribing and monitoring in hospitals. There were few studies measuring clinical outcomes and these tended to show limited improvements.[104]

It may be that decision support is more useful at some stages of the prescribing process than others. A systematic review of 56 studies found that during treatment initiation, decision support systems were more effective after drug selection, rather than before. Decision support systems were more effective in hospital than ambulatory settings and when decision support was initiated automatically by the system as opposed to the user. Combining decision support with other strategies such as education was no more effective than decision support alone.[105]

A Cochrane Review of 23 studies examined whether computerised advice about drug dosage improved processes or outcomes. Computerised advice improved doses, reduced time to therapeutic stabilisation and reduced the length of hospital stay. It had no effect on adverse reactions. There was no evidence that integration into an e-prescribing system optimised effects. Interventions usually targeted doctors, but a few attempted to influence prescribing by pharmacists and nurses.[106]

Often, decision support is an adjunct to e-prescribing. A paediatric intensive care unit in Israel tested e-prescribing with or without clinical decision support. The rate of prescription errors was 2.5% without any tools and 2.4% once e-prescribing was introduced. There was a significant reduction to less than 1% when decision support was added. E-prescribing decreased prescription errors only to a small extent, but adding a decision support system had more impact.[107]

A US trial tested the effectiveness of computer-assisted decision support in reducing potentially inappropriate prescribing for older adults in A&E. 63 doctors using e-prescribing were randomly assigned to receive, or not to receive, decision support that advised against use of nine potentially inappropriate medications and recommended safer substitutes. The decision support group prescribed one or more inappropriate medications during 3% of A&E visits by older people compared with 4% of visits managed by those not receiving decision support. This was a statistically significant difference.[108]

Prescribing excessive doses is a common prescription error and can lead to adverse drug reactions. In Germany, a clinical decision support system was tested that provided alerts about upper dose limits personalised to individual patient characteristics. Before the system was introduced 5% of prescriptions exceeded upper dose limits. Afterwards, the rate of excessive doses reduced to 4%, with 20% less excessive doses compared with baseline.[109]

A hospital in the US used decision support tools to meet the unique prescribing needs of children. An advanced dosing model was designed to interact with an e-prescribing system to provide decision support for complex dose calculations for children. The system was flexible and could be altered over time. It was well used and found to be feasible.[110]

Other researchers in the US examined decision support alerts for helping avoid errors when putting medication orders into an e-prescribing system. Data for all patients at five community hospitals over a six-month period were analysed. The alert system changed doctor's behaviour and patient therapy 42% of the time and reduced medication errors.[111]

As with more generic e-prescribing systems, decision support tools have also been used to identify potential errors after prescribing has occurred. A hospital in Japan tested an alert system for evaluating kidney function and checking doses of medication according to the patient's renal function. Discontinuation of inappropriate medication for those with poor renal function rose from 24% to 54% after the alert system was implemented.[112]

Alerts targeting pharmacists have also been tested. These focus on identifying errors once prescriptions have been entered. In the US a computerised tool alerted pharmacists when people aged 65 and older were newly prescribed potentially inappropriate medications. In total, 59,680 older people were randomised to intervention or usual care groups. Alerts helped to reduce inappropriate prescriptions for two drugs.[113]

Similarly, researchers in the US tested whether a computerised alert system would reduce the rate of errors in drug selection or dosing for people with renal insufficiency. A total of 32,917 people were randomly assigned to usual care or the intervention group, where a computerised tool was used to alert pharmacists at the time of dispensing to possible errors in target drug selection and dosing. Of these, 6,125 people were prescribed one or more of the target drugs over a 15-month period. Alerts helped to reduce medication errors. 33% of the intervention group and 49% of the usual care group had medication errors at follow up.[114]

While alerts can work well to reduce prescribing errors during the prescribing process or after prescribing, ensuring that prescribers or pharmacists see alerts may be an issue. Researchers in Australia tested whether decision support within a hospital e-prescribing system influenced medication ordering on ward rounds. 46 doctors were shadowed during ward rounds and 16 were interviewed. Senior doctors influenced prescribing decisions during ward rounds but rarely used the e-prescribing and alerts system. Junior doctors entered most medication orders into the system, often ignored computerised alerts and never raised their occurrence with other doctors on ward rounds. Doctors did not think that most features of the decision support system were useful.[115]

Alerts are not the only type of decision support system. Decision support tools may also include access to clinical information and guidelines. Researchers in France tested whether making guidelines about antibiotics more accessible to doctors would increase adherence to guidelines. In this instance, a lack of adherence was specifically defined as a prescribing error. One hospital changed from having guidelines available in booklet format on wards to embedding these guidelines into an e-prescribing system. Assessment of 471 consecutive antibiotic orders for pneumonia before and after the change found improvements in the daily dose and the planned duration of treatment.[116]

In the US, a computerised guideline increased use of appropriate medication and decreased errors in drug doses.[117]

Other researchers in the US examined three personal digital assistant (PDA)-based drug information sources for reducing potential medication errors. All three PDA tools were found to be feasible and one was found to be more effective than the others.[118]

Primary care

Little has been written about standalone decision support or alert systems for reducing errors in primary care. The evidence that does exist tends to be mixed.

The US Food and Drug Administration (FDA) issues black box warnings about medications with serious risks. Doctor adherence to these warnings is low. A system was tested for inserting black box warning alerts about drug-drug, drug-disease and drug-laboratory interactions into an outpatient electronic health record with clinical decision support. The alerts did not increase adherence to the black box warnings.[119]

On the other hand, following implementation of alerts cautioning against prescribing certain drugs to elderly people in some US outpatient clinics, there was a 22% reduction in exposure of elderly patients to these drugs.[120]

A review of computer decision support for improving prescribing in older adults in primary care or hospital included 10 studies. Eight of these studies found some improvement in prescribing including minimising drugs to avoid, optimising drug dosage or improving prescribing choices. Few studies reported clinical outcomes.[121]

4.3 Human factors issues

Few studies have examined how health professionals interact with e-prescribing and decision support systems and the human factors issues that may be influential. But there is some evidence of scope for further work in this area.

Implementation factors

E-prescribing systems are common in the UK. This contrasts with the US, where the use of e-prescribing systems has been strongly advised nationally, but rates of adoption remain relatively low. Eight focus groups in US primary care found that e-prescribing was thought to improve the availability of clinical information, prescribing efficiencies, coordinated care and documentation, and result in safer care. Factors supporting adoption included human factors features such as organisational support, adequate time, a shift in staff workload, equipment stability, education about changes in patient interactions and positive attitudes.[122]

In another part of the US, a community based integrated health system implemented a computerised order entry system. Strategies for successful adoption included senior buy-in, ongoing communication, a team-oriented culture, iterative implementation, ongoing readily accessible training, gaining buy-in from clinicians and workflow redesign.[123]

Workflow redesign is gaining more attention, but knowledge in this area remains limited. Researchers in the Netherlands tested the effects of an e-prescribing system on inter-professional workflow. In total, 23 doctors, nurses and pharmacists at one hospital were interviewed and documents were reviewed. The system reorganised existing work procedures and impacted on workflow in positive and negative ways. It reassigned tasks and areas of expertise and fragmented patients' medication-related information, while providing limited support for professional groups to coordinate their tasks.[124]

Three sites in the US implementing e-prescribing identified barriers, including those relating to human factors. Implementation barriers included previous negative experiences with technology, initial and long-term cost, lost productivity, competing priorities, change management issues, functional limitations, IT requirements, waiting for an 'all in one' solution and confusion about competing systems.[125] Another study identified 15 barriers to using medication alerts at five primary care clinics in the US.[126]

Design features

Human factors approaches are concerned with how technologies are designed to be most useful and user friendly. A systematic review of 19 studies examined the impact of design aspects of e-prescribing systems on usability, workflow and prescriptions. 16 studies were qualitative and three used mixed qualitative and quantitative methods. Design aspects were found to be important for increasing use of the systems and reducing prescribing errors. Such design aspects were categorised into seven groups: documentation and data entry components, alerts, visual clues and icons, dropdown lists and menus, safeguards, screen displays and auxiliary functions.[127]

Another review of 41 randomised trials examined whether design features of prescribing decision support systems predict successful implementation and usage. 37 studies reported successful implementation, 25 reported changing professionals' behaviour and five found improvements in patient outcomes. No design feature was more prevalent in successful trials.[128]

Cognitive fit between the user interface and clinical task may impact on whether doctors use e-prescribing systems. Cognitive task analysis of clinical alerts for antibiotic prescribing in a US neonatal intensive care unit found that responses to alerts may be context specific and that a lack of screen cues increases the cognitive effort required to use a system.[129]

Types of alerts

The effectiveness of e-prescribing systems and decision support may sometimes be modest because clinicians often override electronic alerts. Two US teaching hospitals tested an alert that did or did not allow the information for a certain drug combination to be entered on the system. Of those in the intervention group, 57% did not reorder the alert-triggering drug within 10 minutes of receiving an alert compared to 14% in the control group. In other words, prohibiting input of some drug combinations reduced errors of this type. However, unintended consequences included serious delays in treatment.[130]

The impact of active versus passive alerts, alerts that pop up versus those that are just inserted into the online record and alerts that require the prescriber to acknowledge reading them have all been tested. In the US, alerts were built into an e-prescribing system to help doctors take account of changing kidney function when prescribing medications. When treating 1,598 hospital patients with acute kidney injury, doctors received passive non-interactive warnings from the e-prescribing system and on printed ward round reports. An interruptive alert was provided for contraindicated or high toxicity medications that should be avoided or adjusted. This alert asked prescribers to modify or discontinue the orders, mark the dosing as correct or defer the alert to reappear next time. The active alerts were associated with more modifications or discontinuations and more prompt action. Passive alerts had limited response.[131]

Decision support tools may generate large numbers of insignificant on-screen alerts presented as pop-up boxes. This may interrupt clinicians and limit the effectiveness of these systems. A randomised trial in England compared the impact of pop-up and non-pop-up alerts on prescribing error rates. 24 junior doctors, each performing 30 simulated prescribing tasks in random order, were shown pop-up alerts, non-pop-up alerts or no alerts. Doctors receiving pop-up alerts were about 12 times less likely to make a prescribing error than those not shown an alert. Doctors shown a non-pop-up alert were about three times less likely to make a prescribing error than those not shown an alert.[132]

Similarly, researchers in the US aimed to improve clinician acceptance of drug alerts in 31 primary care practices by prioritising alerts in order to reduce workflow disruptions. Over a six-month period, 71% of alerts were non-interruptive and 29% were interruptive. Two thirds of the interruptive alerts were accepted.[133]

The majority of prescribing alerts may be ignored because they are not seen as clinically relevant. Being able to customise when alerts are seen may increase their usefulness. A Canadian study tested two approaches to medication alert customisation: on-demand versus computer-triggered decision support. Doctors randomised to on-demand alerts activated the drug review when they considered it clinically relevant. Doctors randomised to computer-triggered decision support viewed all alerts for electronic prescriptions in accordance with the severity level they selected. Customisation of computer-triggered alert systems was more useful in detecting prescribing problems than on-demand review. There was no difference between groups in prescribing errors. The majority of alerts were ignored because the benefit was judged greater than the risk.[134]

Researchers in the US tested alerts that required a response from doctors to prevent concurrent orders of warfarin and non-steroidal anti-inflammatory drugs. In total, 1,963 doctors were assigned to receive passive alerts or active alerts which required a response. Active alerts had no benefits over passive alerts.[135]

Workforce

A hospital in England tested computerised prescribing with alerts over a three-month period. Senior doctors and those more experienced using the system were more likely to ignore a warning message.[136]

4.4 Standardised medication charts

Other tools to support the interface between health professionals and the systems and environments in which they work have been researched in less depth, but some studies are available.

Computerised medication charts have been tested. In a system very different to that used in the UK, a hospital in the Netherlands compared a medication distribution system where the transcription of handwritten into printed medication orders takes three to five days versus a computerised medication chart which was updated daily by pharmacy assistants on the ward. The prescription error rate was higher with computerised charts (50% versus 20%) but this was due to more administrative errors, such as omitting the prescriber's name and the date. The rate of errors with potential clinical significance was lower because duplicate therapy was eliminated.[137]

In Australia, a standard medication chart was developed for recording prescribing and administration of medication in hospital. Before and after audits in five sites found the prescribing error rate decreased from 20% of orders per patient to 16%.[138]

After preliminary testing, the standardised medication chart was rolled out to 22 Australian hospitals. Prescribers were educated and baseline audit findings were presented when the chart was introduced. Prescribing errors decreased by almost one third.[139]

4.5 Other tools

A number of computerised and other tools have been tested to reduce prescribing errors, often in conjunction with electronic prescribing. These interventions are a mix of tools to reduce errors during prescribing and tools to identify and mitigate errors before they reach the patient.

One study examined the effect of regular and expected printed educational materials on prescribing. In Canada, 499 doctors were

randomised to receive 12 evidence-based drug therapy letters immediately or after 3–8 months (control group). The aim was not merely to improve evidence-based prescribing, but also to reduce dosage and drug choice errors. The series of letters influenced which drugs were prescribed to newly treated patients. Each letter alone did not make a significant impact, but when combined they made a difference.[140]

A hospital in the US introduced a voluntary interactive computerised worksheet for use when prescribing parenteral nutrition in the neonatal intensive care unit. The worksheet reduced the prescribing error rate from 14% to 7%.[141]

Another US hospital tested a standardised chemotherapy order form to reduce prescribing errors and the cost of medication to reduce vomiting and nausea. The form was associated with fewer prescribing errors and a reduction in the average cost.[142]

Another US hospital examined the impact of adding a medication list targeting the most common medications to an e-prescribing system in a paediatric A&E department. The medication list decreased errors from 24 to 13 per 100 visits.[143]

Elsewhere in the US, a hospital tested a system for reconciling medications that patients take at home with what they receive in hospital. The unintended discrepancy rate between a patient's home medications and admission medication orders was reduced from 20% to 1% using the electronic reconciliation system.[144]

A hospital in Sweden tested providing a medication report for older people discharged into the community. 32% had one or more medication errors compared to 66% of a retrospective comparison group who did not receive a medication report. Prescribing errors were not identified separately.[145]

In China and Japan, patients may 'shop around' for doctors or hospitals, visiting a number of doctors for the same condition. In Taiwan, a national insurance health smart card was adopted, which carries information about the medications a patient receives from different hospitals nationwide. This system was used to address the problem of duplicate medications for outpatients visiting multiple hospitals. At one hospital an e-prescribing system was enhanced with the ability to access smart cards and alert doctors about potential duplicate medications at the time of prescribing. Over a three-month period, 2% of all smart cards read contained medications that would potentially have been duplicated without this system. Around one-third of these prescriptions were revised due to the alerts.[146]

Combining more than one tool is becoming popular. A US hospital system implemented a range of clinical information technology such as e-prescribing, pharmacy and laboratory information systems, clinical decision support systems, electronic drug dispensing systems and a barcode point-of-care medication administration system. Medication errors decreased. Most prescribing errors decreased, including drug allergy detection, excessive dosing and incomplete or unclear orders.[147]

5. Summary

5.1 Key points

Most people taking medication will benefit from it, but there is always the potential for errors which may cause harm. Prescribing errors are the largest source of medication errors. A systematic review of 16 studies about errors in handwritten prescriptions in hospitals found that the most common causes of error were mistakes due to inadequate knowledge of the drug or the patient, memory lapses, lack of training or experience, fatigue, stress, high workload and inadequate communication between healthcare professionals.[148]

A number of strategies have been tested to reduce prescribing errors. The most commonly researched strategy involves redesigning equipment and tasks through the use of electronic tools such as e-prescribing and computerised decision support systems (alerts and prompts). While a great deal has been written about e-prescribing and alert tools in hospital, and to a lesser extent in primary care, evidence about the effectiveness and value of such systems is mixed. In the US e-prescribing systems have been mandated for widespread use, while in the UK such tools are very common. Some research supports this, with findings of substantial reductions in prescribing errors. In fact, it is common for the introduction of combined e-prescribing and alert systems to halve prescribing errors.

However, other studies suggest that the types of errors affected may be clinically insignificant and that there may be other costs involved. While e-prescribing systems reduce illegibility errors, such systems may take more time than handwritten prescriptions and may introduce new types of errors, particularly if the systems do not allow the prescriber to see the entire medication history or other relevant information easily.

Alerts and prompts alone have generally not been found to reduce prescribing errors, though some studies have positive results.

Although opinion pieces and narrative articles are available,[149] less empirical research has been published about 'human factors' approaches to reducing prescribing errors regarding the interface between personnel and the environment and systems in which they work.

Training staff to fulfil their roles is an important human factors component. There is some evidence that training medical students can help them feel more confident about prescribing but the longer-term impact on reducing errors remains uncertain.

Other studies have examined training for fully qualified doctors. This has taken the form of one-to-one sessions about specific medications or patients (academic detailing), group sessions and collaborative improvement projects and quality circles where groups of prescribers network, share good practice and take part in practical error reduction initiatives.

Some research is available about expanding pharmacist roles to target error reduction, particularly in hospital. Research is also emerging about pharmacist roles in primary care. Studies have examined reactive use of pharmacist roles, such as using pharmacists to review prescriptions for errors before medication orders are filled. Research is also emerging about more proactive use of pharmacist roles, such as circulating on wards to check prescriptions and providing education one to one or in groups to prescribers.

However, these studies tend to focus on the identification and mitigation of prescribing errors after they have occurred. There is very little research about using different roles to address errors during the prescribing process itself.

The scan suggests that there is a real gap in the literature about improving the safety and reliability of prescribing in patient pathways. None of the solutions previously researched have focused in-depth on patient pathways. This is a focus of the Health Foundation's Safer Clinical Systems initiative, which has the potential to make a significant contribution to the knowledge base in this area.

Summary of key themes in studies about reducing prescribing errors

Factor	Findings
Training	One-to-one educational visits can improve prescribing[150–153]
	Individualised educational letters have shown promise[154,155] as have follow-up telephone calls from pharmacists[156]
	Training sessions and simulations for students improve confidence in identifying errors, but impacts on error reduction are uncertain[157–160]
	Education sessions for professionals have reduced prescribing error rates[161–163]
	Improvement programmes and learning networks have positive outcomes but each varies considerably.[164–166] The process of monitoring and reporting errors may be a key part of this[167–169]
Roles	Pharmacists checking medication orders can identify prescribing errors[170–174] but not all findings are positive[175]
	Pharmacists circulating on wards can identify and reduce prescribing errors, especially when coupled with education[176,177]
	Medicine reconciliation by pharmacists has mixed findings[178] but there are some positive trends[179,180]
	Introducing pharmacist initiatives as part of a multifaceted intervention may work well[181,182]
Tools	E-prescribing systems have been found to reduce prescribing errors,[183–199] though not all studies are positive[200–207]
	There are mixed findings about alerts and prompts[208–210]
	Human factors issues such as the design of systems, workflow, alert type and context may be key success factors when implementing tools to reduce prescribing errors[211–222]

5.2 Caveats

When interpreting the findings of the evidence scan it is important to bear in mind several caveats.

Scope

The evidence scan is not exhaustive. It presents examples of studies but does not purport to represent every study about reducing prescribing errors. The purpose is to give a flavour of available research rather than to summarise every existing study in detail.

It is also important to note that only studies explicitly aiming to reduce prescribing errors are summarised. A number of other studies may have reduced prescribing errors as a secondary or unexpected outcome, but if the research did not have this as a key target it would not have been included.

Quantity of research

Although a reasonable amount of research is available about this topic, there are limits to the conclusions that can be drawn. There is insufficient comparative evidence to suggest that one approach is more effective than others for reducing prescribing errors. Nor is there good evidence to be able to extrapolate about key success factors or the settings or situations in which improvement approaches work most effectively. The cost effectiveness of various strategies to reduce prescribing errors is also uncertain.

Most research focuses on reducing prescribing errors in hospital. Far less is known about reducing prescribing errors in other settings such as primary care, dentistry or mental health. A lack of evidence about settings or interventions other than those covered in the scan does not mean that other options are not useful or effective, just that few research articles have been published about these topics.

Quality of research

There are also some issues with the quality of the studies included. A number of studies have been conducted at single sites or a small number of homogeneous sites and include small numbers of patients and prescribers. Before and after study designs are common in this field and these may be subject to potential bias. A number of factors could have affected prescribing error rates over time other than the specific intervention being tested. For example, studies of introducing an e-prescribing system may note a reduction in prescribing errors but it is uncertain the extent to which such reductions are a result of the tool itself versus the awareness raising, education and culture change that may have accompanied its introduction.

Making comparisons

Finally, it is difficult to make comparisons between studies because various definitions of 'prescribing errors' are used and the research methods vary in design and quality.[223,224]

Furthermore, there are differences in the healthcare context in which studies took place. Much of the research is drawn from North America, where prescribing practices, laws and the healthcare systems are very different from the UK. For example, e-prescribing is almost universal in UK primary care, but is just beginning to be rolled out in the US. Similarly, in countries such as the US and some parts of Europe, prescriptions are commonly written by doctors and then transcribed by others into prescription forms or electronic systems. In the UK, prescribers are responsible for writing or inputting their own prescriptions. These differences in systems and context have an impact on the relevance and applicability of the research to UK settings.

Even where comparable definitions are used and geographic contexts can be compared, the level of detail reported in individual studies is sometimes insufficient to provide a meaningful summary or to extract the exact impacts of interventions. While we can say that a particular study found a reduction in prescription errors, the details provided are usually not enough to be able to replicate the intervention or roll it out more broadly.

Despite these caveats, research continues into the most effective ways to reduce prescribing errors in order to enhance patient safety.

It is likely that the best strategies to reduce prescribing errors are multifaceted.

Interventions are needed at three levels to improve prescribing: (1) improve the training, and test the competence, of prescribers; (2) control the environment in which prescribers perform in order to standardise it, have greater controls on riskier drugs, and use technology to provide decision support; and (3) change organisational cultures, which do not support the belief that prescribing is a complex, technical, act, and that it is important to get it right. [225]

Human factors issues and the interactions between systems, tasks and personnel have not been explored in any depth so there is much scope for learning in this area. As prescribing errors make up a significant proportion of all errors in healthcare, further work in this field has the potential to significantly improve patient safety.

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