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Prescribing errors in hospital practice

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Prescribing errors that occur in hospitals have been a source of concern for decades. This narrative review describes some of the recent work in this field. There is considerable heterogeneity in definitions and methods used in research on prescribing errors. There are three definitions that are used most frequently (one for prescribing errors specifically and two for the broader arena of medication errors), although many others have also been used. Research methods used focus primarily on investigating either the prescribing process (such as errors in the dose prescribed) or the outcomes for the patient (such as preventable adverse drug events). This complicates attempts to calculate the overall prevalence or incidence of errors. Errors have been reported in handwritten descriptions of almost 15% and with electronic prescribing of up to 8% of orders. Errors are more likely to be identified on admission to hospital than at any other time (usually failure to continue ongoing medication) and errors of dose occur most commonly throughout the patients' stay. Although there is evidence that electronic prescribing reduces the number of errors, new types of errors also occur. The literature on causes of error shows some commonality with both handwritten and electronic prescribing but there are also causes that are unique to each. A greater understanding of the prevalence of the complex causal pathways found and the differences between the pathways of minor and severe errors is necessary. Such an understanding would underpin theoretically-based interventions to reduce the occurrence of prescribing errors.

Introduction

Prescribing errors that occur in hospitals have been a source of concern for a long time. Fifty years ago, researchers were highlighting the number of errors and designing systems to try to reduce the problem [1, 2]. Despite the intervening decades, and considerable change to the delivery of care, we are *still* concerned with measuring the prevalence, understanding the causes and implementing potential solutions to the problem of prescribing errors in hospitals.

This narrative review of recent literature in this area describes some of the published work on definitions, research methods, prevalence and causes of errors that occur in either general or specialist hospitals. The databases MEDLINE and EMBASE were searched from 2008 using the search terms 'prescribing errors' and 'hospitals'. No attempt was made to conduct a systematic review of the literature. Instead, articles were chosen to give a broad description of the field. Although prescribing by health care professionals other than doctors occurs in hospitals internationally, almost all research on prescribing errors has been conducted on prescribing by doctors, so that is the focus of this review also.

There is considerable heterogeneity in the definitions and research methods used in research on prescribing errors. This is potentially confusing to new researchers in the field. Therefore, this paper will begin with an overview of these two areas, to ensure that readers are up-to-date with the latest findings in those areas. Prescribing in hospitals is still most commonly done via handwriting the prescription although the way in which that is done varies considerably between countries. In the UK, for example, doctors write the prescription directly onto a 'drug chart', which is also used to record the administration of the medicines to the patient by the nursing staff. In the USA, on the other hand, prescriptions are written in the medical record and transcribed by the nursing staff onto an administration sheet.

In less than 20% of hospitals in the USA [3] and even fewer in the UK, the process is conducted electronically, with the prescriber (or in some cases, another healthcare professional) entering the order into a computerized prescribing system, which may or may not be part of a wider electronic medical record. One of the reasons for the implementation of electronic prescribing is to reduce the prescribing error rate. This is particularly the case when the electronic prescribing system is integrated with the electronic medical record of the patient and coupled with clinical decision support. Errors are not eliminated, however, so their prevalence, nature and causes are also described below.

Definitions

Researchers use a variety of definitions as to what they mean by a prescribing error [4]. Some researchers have described the types of problems that they included (such as the prescription of interacting or contraindicated drugs) but did not actually define the term itself [5–7]. Others have given neither definition nor description of what they mean by prescribing errors in their study [8]. One of the most commonly used definitions of prescribing errors used in Europe is the definition developed by Dean [9], which has mostly been used in studies conducted in the UK, but has also been used more widely [10–19].

A significant number of researchers situate and define prescribing errors as being part of the broader arena of 'medication' errors, which include errors in the medication process from prescribing through to administration. Unfortunately, 'medication errors' also lacks consensus about its definition, with 26 different definitions identified in one systematic review [20]. Commonly used medication error definitions used when defining prescribing errors include those from The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) [21] and the American Society of Health-system Pharmacists (ASHP) [22]. The NCC MERP definition has been used internationally [23–27], whereas the ASHP definition has mainly been used in the USA [28–30].

It is not clear why researchers have chosen to develop and use multiple definitions of prescribing and medication errors. Even in recent studies [31], researchers choose to create their own definition without explanation, rather than, for example, use one of the three described above that have been already developed and widely used [9, 28–30]. It has been suggested that the rationale for conducting the research has an influence on the definitions used – some studies focus on identifying causality via a systems approach and others focus on measuring prevalence using an epidemiological approach [20]. If this is the case, researchers should justify their choice of definition explicitly in their publications.

Data collection methods

As with definitions, there are multiple methods used in prescribing error research. Errors may be investigated either from the perspective of their outcome i.e. errors that cause actual harm to the patient, or from the perspective of the process i.e. errors in decision making or prescription writing. Some studies have investigated both [32, 33]. Studies that investigate process-based errors are more commonplace – they were used in 87% of studies in our systematic review [34]. The latter methods result in the recording of a greater number of minor errors, i.e. those unlikely to cause patient harm. Interventions and corrections are frequently made to prescriptions with errors before they are administered to patients [34], although a mean of 0.9 doses had been given in one study before the errors were corrected [10]. Knowledge about the potential for harm, or 'near-misses', can be used to improve health care systems in the same way as can knowledge about the causes of actual harm.

Prevalence and incidence

Most research studies into the prevalence and incidence of prescribing errors, from the perspective of either patient outcome or the prescribing process, use health care professionals to collect data prospectively [4, 34]. Data may be collected alongside routine work, often by clinical pharmacists (for example, the studies of Dean *et al*. [13] and Tully & Buchan [19]), or may be collected by supernumerary clinically trained researchers (for example, the studies of Bates *et al*. [35] and Vaidya *et al*. [36]). Both methods have their advantages and disadvantages [11]. They are both labour intensive, requiring the data collectors to visit the ward, then gain access to and record data from the patient's prescription chart and/or medical record. Using pharmacists who work on the ward, and who are familiar with the patients, allows tacit knowledge of the context to inform data collection. The latter, however, can be burdensome alongside routine work. Using supernumerary, clinically trained researchers allows a greater amount of time to be devoted to data collection despite the lack of the above contextual knowledge. Comparison of both methods applied to the same set of medical records has shown very little overlap in the errors identified, with pharmacists identifying 36% and record review identifying 69% of all prescribing errors identified by both [11]. This suggests that researchers should consider using multiple methods in future work for greater accuracy and that existing estimates published in the literature should be treated cautiously as underestimates.

Studies investigating the impact of electronic prescribing have understandably had to use methods that can collect data both from the control (paper-based) system and the intervention (electronic) system. Therefore, it is commonplace to use the methods described above, i.e. pharmacist prescription review [14, 16, 18, 27, 37] or medical record review [31, 36, 38–40], for both the 'before' and 'after' phases.

When the research question does not require the examination of handwritten prescriptions or records, methods that harness the secondary use of electronic data can be used. Such methods vary from using specific drugs (such as antidotes) that can act as proxies for adverse events and potential errors [41] to the extraction of all prescribing data over a defined period of time and its examination for indicators of error, such as a prescription being discontinued quickly by other healthcare professionals [42, 43]. The advantages of having large and comprehensive datasets mean that new questions can be asked about prescribing errors, which were hitherto not possible to answer. One recently investigated question was whether making numerous minor errors predisposes an individual doctor to also make serious errors. No relationship was found between the frequency of overriding low level compared with high level alerts (automatically recorded by the software), which were used as proxies for error prone behaviour [44].

Causes

Considering how much has been written about the prevalence of prescribing errors, it is surprising how little empirical work has been done to investigate the causes. Only seven studies reporting empirical data on the cause of error were identified in our systematic review [45]. There have been no empirical studies that have investigated the epidemiology of all causes of a large sample of errors. Leape *et al*. only reported a single error-provoking condition for each error [46], although they recognized that causation is usually multifactorial. Winterstein *et al*. used the professional opinion of the researchers to approximate the cause, rather than empirically collected data [30].

The person who knows most about the potential cause of a specific prescribing error is the prescriber him/herself. Other health care workers, perhaps intimately involved in addressing that error, may be aware of some of what had happened, but generally only the prescriber is aware of how decisions were made. For example, they can tell whether it was a lack of knowledge or a distraction causing a slip in attention that resulted in an error in dosage being made. Many studies have used the professional opinion of the researchers to categorize the assumed cause. Although some errors could be caused by the suggested reasons, there is no guarantee that those *particular* errors were caused by them. An individual error type (such as the wrong dose) can be caused by any of several active failures [46]. Thus, the most effective methods to identify the causes of errors use semi-structured [8, 10, 47–49] or structured interviews [6, 26, 46] and occasionally observation of prescribing [50, 51]. Similarly, interviews [52, 53] and observations [54] have been used to investigate the causes of errors with electronic prescribing.

The most common theoretical approach that has taken to investigating the causes of prescribing errors is using the taxonomy of James Reason [55]. This model of accident causation considered an error to be 'a failure to achieve the intended outcome of a planned series of actions, when the failure is not due to chance'. Skill-based slips and memory lapses occur when the intended and correct action did not go as planned; mistakes occur when the intended action was incorrect but did go as planned.

Hand-written prescriptions

The heterogeneity of the methods used to collect data and define prescribing errors has meant that it is challenging to calculate the prevalence or incidence of errors [56]. Our systematic review of errors with handwritten prescriptions, including studies published from 1985 to 2008 that used a variety of data collection methods, found an overall median prescribing error rate of 7% (interquartile range (IQR) 2–14) per medication order, 52% (IQR 8–227) of admissions and 24 (IQR 6–216) per 1000 patient days. More recently published studies have reported comparable error rates of 10.7–14.7% [10, 11, 29, 57] and the largest study conducted in the UK (in 19 hospitals) found an error rate of 8.9% [58].

The methods used for data collection have an impact on the findings [56]. Studies where *all* medication orders were screened by pharmacists prior to administration (common in the USA) found a median error rate of 2.7% (IQR 0.3–20.3%). Alternatively, where pharmacists screen prescriptions on the wards, and where they would not see all prescriptions written (as in the UK), studies using this method found a higher median error rate of 9.9% (7.7–14.6%).

In studies conducted in the UK, errors are 41–70% more likely to be identified on admission to hospital than at any other time, after controlling for confounders [19, 58]. This may be the result of the national requirements to conduct medicines reconciliation within 24 h of patient admission, which enables errors at that time to be identified quickly [59]. Work conducted elsewhere has found that the median number of days to a prescribing error was 2 days (95% CI 1.11, 2.90) [7].

Throughout the patients' stay, the types of errors that occur most commonly are both under and overdoses. Such errors are not necessarily doses with order of magnitude errors (i.e. prescribing milligrams instead of micrograms) or doses outside of the recommended range for the drug, but also doses that are within that range but too high or too low for the individual patient. The medications most commonly reported as being associated with prescribing errors are antimicrobials, with a median error rate of 32% of orders, especially for children. Other common medications include drugs acting on the cardiovascular, central nervous and gastrointestinal systems [34].

A median of nine errors per 1000 patient days has been reported to cause actual patient harm [34]. In one study, 42% of life-threatening or severe adverse drug events were due to prescribing errors [35]. Elsewhere, the hospital or ward the patient was in, and whether they were prescribed antimicrobials, were determinants of patient harm due to either prescribing or transcribing errors [60]. There is no consistent relationship between the frequency of major harm to no-harm incidents [61].

Where studies have conducted an in-depth analysis of the causes of particular errors, multiple error-provoking conditions have been found for each error [6, 8, 58]. Prescribers have reported that errors occurred because they did not know enough about either the medication (particularly the dose) [26, 46, 47, 49] or the patient (including comorbidity) [26, 46, 51]. This was particularly the case when junior doctors were starting their first rotation, moving to a new rotation or when they were on call [58]. For other errors, slips and lapses were the reported causes, such as where interruptions prevented self-checking and hence error recognition, or where pressure of other work resulted in forgetfulness [46–48, 50, 51].

Ten studies were included in our systematic review that investigated the factors associated with prescribing errors [45]. These factors could be considered to be error-provoking conditions, part of Reason's model of accident causation i.e. they were risk factors because errors were more likely to occur with them present [55]. Lack of training and practical experience in prescribing is often suggested as an error provoking condition [62], with junior doctors found to be more error prone than senior doctors [46–48]. Not all studies, however, have taken prescribing rates into consideration. In our multivariate analysis of prescribing errors in 19 hospitals, which did consider such confounders, we found both first and second year doctors to be twice as likely to make errors than were consultants [58]. Elsewhere, reduced physical and mental health of doctors, such as being tired, hungry, unwell or having an excessive workload, were all reported as being present at the time of making an error [45, 58]. Other error-provoking conditions have included poor communication and documentation within teams, lack of access to information [8, 45] and the variety of drug charts used in different hospitals [10, 58].

Characteristics of the patient have also been investigated as error-provoking conditions, although the results are equivocal. Fijn *et al.* found no patient characteristics to be predictive of error on multivariate analysis [5], whereas others have found age [63, 64] and ward (as a proxy for type and severity of illness) [65, 66] to be predictors. Supporting this, more recently morbidity and length of hospital stay have been found to be associated with prescribing errors in elderly patients [7].

Electronic prescriptions

Electronic prescribing is often seen as a defence against errors. Two recent systematic reviews found a significant reduction in error rates of 29–96% [67] and an overall odds ratio of 0.34 (95% CI 0.22, 0.52) for error reduction with electronic prescribing (with or without decision support) compared with handwritten prescriptions [68]. Both groups of authors, however, described the quality and generalizability of the included studies as 'limited'. Most studies on the impact of electronic prescribing on errors report an improvement in incomplete orders [67]. The use of mandatory fields and suggested doses means that certain errors, such as incomplete prescriptions or orders of magnitude errors in dosage, cannot occur with electronic prescribing.

Despite this reduction in errors when compared with handwritten prescriptions, there may still be an error rate with electronic prescribing of 2.0–7.9% [11, 16, 31]. Many of the other types of errors identified with handwritten prescriptions, however, have also occurred with electronic prescribing, especially if there is no associated decision support [12, 31, 53]. Errors such as the prescribing of a dose within the recommended range that is too high for the particular patient, or that is contra-indicated due to other concomitant diseases, can still occur. Similarly, errors of omission have been reported, such as where patients are not prescribed medicines that they were on at home [12, 53]. As with handwritten prescriptions, most prescribing errors with electronic systems occur on the day of admission [12]. On multivariate analysis, renal impairment, number of prescribed items and the day of stay (e.g. day of admission) were all found to be related to the occurrence of errors [12].

The total number of adverse events, i.e. actual patient harm, due to prescribing errors that occurred with electronic prescribing has been reported in one study as 3.9 per 1000 patient days, no different from that with handwritten prescriptions [69]. One systematic review concluded that the impact of electronic prescribing on potentially severe errors was unknown, although there was some evidence that there were fewer minor errors [67].

Many of the causes of prescribing errors by electronic prescribing are similar to those for handwritten prescribing. Slips and lapses still occur, for example, because of the pressured environment and multiple simultaneous tasks conducted [58]. Under test conditions, however, interruptions have not been shown to increase errors in electronic prescribing [70]. Electronic prescribing systems have also been reported as the direct cause of new errors, i.e. those that had not previously been reported with handwritten prescribing [71]. These were reported by 91% of 174 US hospitals in a survey about unintended consequences of such systems [72]. Ash *et al.* categorized the errors caused by electronic systems, using data on hospitals in the USA, the Netherlands and Australia [73]. These were split into errors in communication and coordination and errors in information entry and retrieval. Communication and coordination errors occur when the system fails to take into account the fact that health care work does not have a linear, clear-cut and predictable workflow. The inflexibility results in workarounds and subsequent errors. Similarly, communication was seen merely as data entry, rather than ensuring that information had been received by the relevant colleagues [73].

Information entry errors have been reported in many studies. Examples include choosing an inappropriate dosage form for the route (capsules being prescribed for intravenous administration) [67] or selecting an incorrect drug, dose, frequency or formulation from a drop down list [18, 52, 53]. Order sets (such as groups of drugs normally prescribed together) have been reported as 'hiding' drugs like non-steroidal anti-inflammatories, which were subsequently erroneously prescribed to patients with asthma [53]. Information retrieval problems, such as when different kind of prescriptions (such as regular and when required) cannot be viewed together on the same screen, can result in duplication errors [53, 74] or failure to discontinue drugs no longer required [74].

Most systems have the ability to add free text to electronic prescriptions, which is generally complementary to the information in the structured field. However, 16.1% of electronic prescriptions in one study had discrepancies between these, most of which could have led to adverse events [75]. Examples included conflicting advice that resulted in a fourfold difference between directed doses in the two places, or instructions to take medication orally in the structured field and to put it in the ear in the free text.

Conclusions

This narrative review highlights just how common prescribing errors are, regardless of the methods used for data collection or the medium used to order the medication. There is clearly a need for consistency in the use of definitions, but there is also a need to understand why so many definitions of both prescribing and medication errors are still in use, before recommendations can be made as to which are the preferred ones to use. Electronic prescribing systems that are linked to the electronic medical record and have advanced clinical decision support may well reduce many of the errors found with paper-based prescribing. It is certainly not a panacea to address the problem, however, and systems to address and ameliorate new and continuing errors need to be sought and implemented.

The literature on causes of errors is sparser than that for their epidemiology and this is clearly an area where further work needs to be done. Most errors have been found to be multifactorial in their cause, which makes a simple epidemiology of those causes less helpful. A greater understanding of the prevalence of certain complex causal pathways may be more useful. Similarly, little is known about whether there are differences between the causal pathways of potentially severe and potentially minor errors and, if so, what those differences are. Interventions that are based on a sound theoretical understanding of the causes of errors are potentially more likely to be successful. Certainly, from what we currently know, such interventions must also address human factors, in addition to offering technological solutions.

Competing Interests

There are no competing interests to declare.

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