A literature review of the individual and systems factors that contribute to medication errors in nursing practice

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Aim This paper reports a review of the empirical literature on factors that contribute to medication errors.

Background Medication errors are a significant cause of morbidity and mortality in hospitalized patients. This creates an imperative to reduce medication errors to deliver safe and ethical care to patients.

Method The databases CINAHL, PubMed, Science Direct and Synergy were searched from 1988 to 2007 using the keywords medication errors, medication management, medication reconciliation, medication knowledge and mathematical skills, and reporting medication errors.

Results Contributory factors to nursing medication errors are manifold, and include both individual and systems issues. These include medication reconciliation, the types of drug distribution system, the quality of prescriptions, and deviation from procedures including distractions during administration, excessive workloads, and nurse's knowledge of medications.

Implications for nursing management It is imperative that managers implement strategies to reduce medication errors including the establishment of reporting mechanisms at international and national levels to include the evaluation and audit of practice at a local level. Systematic approaches to medication reconciliation can also reduce medication error significantly. Promoting consistency between health care professionals as to what constitutes medication error will contribute to increased accuracy and compliance in reporting of medication errors, thereby informing health care policies aimed at reducing the occurrence of medication errors. Acquisition and maintenance of mathematical competency for nurses in practice is an important issue in the prevention of medication error. The health care industry can benefit from learning from other high-risk industries such as aviation in the prevention and management of systems errors.

Keywords: medication errors, medication knowledge, mathematical skills, medication management, medication reconciliation, reporting medication errors

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Introduction

Medication errors have been identified as the most common type of error affecting the safety of patients and the most common single preventable cause of adverse events (National Medicines Information Centre 2001). Barker *et al.* (2002) found that medication errors occur in approximately one out of every five doses in a typical hospital, with Scott (2002) reporting a 500% rise in drug errors over the previous decade. This led to approximately 1200 deaths in England and Wales in 2001 occurring as a result of drug errors alone. Drug errors have been found to occur in 49% of drug administration procedures (Taxis & Barber 2003a). Drug administration is predominately a nursing responsibility. However, administration is only one part of the medication management process, and such errors may occur as a consequence of errors in other aspects of the medication process such as selection, procurement, storage, prescribing, ordering and transcribing (Fijn *et al.* 2002, The Joint Commission 2007). Alternatively they may occur as a consequence of or be influenced by individual or systems issues including the type of drug administration system (Kelly 2004), the quality of the prescription (Kelly 2004, Kazaoka *et al.* 2007), deviations from procedures (Han *et al.* 2005), workload staffing and shift patterns (Kelly 2004, Tang *et al.* 2007) and knowledge and mathematical skills of nurses (Polifroni *et al.* 2003, Eisenhauer *et al.* 2007). It is also evident in the literature that medication errors are widely underreported (Gladstone 1995, Antonow *et al.* 2000, Barker *et al.* 2002).

Medication errors

Medication administration is a complex process involving a myriad of individuals in an increasingly fast-paced and fragmented health care environment. Attempts to document the nature of medication errors are evident in the literature (O'Shea 1999, Armitage & Knapman 2003, Lasseter & Warnick 2003, McBride-Henry & Foureur 2006, Fry & Dacey 2007a,b). There is uncertainty and differences in interpretations among staff as to what constitutes a drug error, which obscures the evaluation of causes (Gladstone 1995, Baker 1997, Mayo & Duncan 2004). A medication error has been described as a 'deviation from a physician order' (Mayo & Duncan 2004, p. 209). An alternative definition is 'a preventable mistake in prescribing or delivering medication to patients' (Lasseter & Warnick 2003, p. 177). National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) (2007, p. 1) definition is.

> A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labelling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.

The review

Aim

The aim of the review was to explore the empirical literature on medication errors, to identify what factors within the medication management process contribute to medication errors and the implications for nursing practice.

Search methods

The review was conducted using the following electronic databases: CINAHL, PubMed, Science Direct and Synergy. Search terms including 'medication errors', 'medication knowledge and mathematical skill', 'medication management', 'medication reconciliation', 'reporting medication errors' were used, as well as a combination of terms. Key ideas were identified by reading papers and engaging in discussion on the subject to clarify pertinent issues. The search was confined to peer-reviewed research articles in English. The inclusion criteria were studies that focused on factors that contribute to medication errors that have direct relevance for nursing practice. The literature search generated 93 papers that were retrieved for more detailed evaluation. These papers were appraised for relevance, methodological rigour, trustworthiness, and only those with significant findings were included. Twenty-six qualitative and quantitative representative studies were specifically selected to illuminate the complexity of factors that influence medication errors around the following key themes: knowledge and skills, deviation from procedure, workload, reconciliation, drug distribution systems and barriers to reporting (see Table 1).

Results

Theoretical perspectives

The factors that contribute to medical errors are complex and multifaceted, but can generally be divided into

two sub-groups; those caused by systems errors and those caused by individual health care professional issues (McBride-Henry & Foureur 2006). In health care, responsibility for errors is commonly attributed to the individual and the 'five rights' in drug administration is commonly used as the benchmark against which the performance of the individual is judged. This is overly prescriptive and fails to evaluate the contributory systems issues (Dennison 2007). There are two theoretical approaches which underpin an explanation of this human error problem, the person and the system approach (Reason 2000). The person approach seeks to attribute causes to the individual whereas the system approach proposes that human error is to be expected. Reason proposes the 'Swiss Cheese Model' to illustrate the multiple contributing factors that all can line up simultaneously to enable error to happen, in the event the systems defences, barriers and safeguards are not effective. In other high-risk industries, such as aviation, using a systems analysis approach to safety is well established. An open policy in relation to reporting medical errors enables organizations to gather vital information about the factors that contribute to the medication errors (Johnson 2000). System errors can occur at any juncture of the medication management process (Institute for Safe Medical Practice 2000) from selection, procurement and storage through to administration and therapeutic monitoring (Fijn *et al.* 2002, The Joint Commission 2006).

System errors that contribute to medication errors transcend all professional disciplines and advance beyond professional or departmental boundaries (Cohen 1998). Rooney *et al.* (2002) advocate root cause analysis to explain comprehensively the performance shaping factors that affect a person's tasks performance. This is classified as internal and external stressors, both of which will be influenced by the presence of physiological and psychological stressors. The internal factors include the knowledge, skills and attitudes of the individual worker and external stressors including the situational, task and procedural characteristics that influence a worker when undertaking a task. Rooney *et al.* (2002) contend that a mismatch between internal and external stressors will negatively impact on performance. Therefore a system-orientated approach is advocated to instigate procedures and put in place 'checks and balances' to reduce or prevent medication errors, using standardization, simplification and use of technology (The Massachusetts Coalition for the Prevention of Medical Errors 1997). A third dimension to the notion of responsibility and medication error is 'practice responsibility' described as the 'socially embedded knowledge, notions of good and skill' within groups of practitioners (Benner *et al.* 2002, p. 509). The impact of the professional socialization on medication errors should not be underestimated. Dennison (2007) implemented a safety education programme which resulted in significant improvement in knowledge without any desirable impact on the number of errors, leading researchers to conclude that the socialization and readiness to change of staff has a significant impact on the success of such patient safety initiatives. Therefore medication errors are caused by a mix of systems, individual and practice contributory factors (Benner *et al.* 2002).

Reconciliation

Medication reconciliation is 'the systematic validation and verification of medical history and orders' (Sullivan *et al.* 2005, p. 95). It involves comparing a patient's current drug prescription with all medications that they are taking and should be undertaken at every transition in care i.e. changes in healthcare setting, service, provider or level of care (The Joint Commission 2006). Causes of reconciliation errors include performance deficit, transcription errors, documentation, communication and workflow disruption (The Joint Commission 2006). A retrospective case–control study undertaken in the Netherlands emphasized the importance of reconciliation when patients are hospitalized (Fijn *et al.* 2002). This study, which assessed predictors of prescribing errors (n = 1913), found that some specialties were associated with greater prescription errors probably as a result of being unused to prescribing outside their area. Dutton *et al.* (2003) sought to quantify preadmission prescribing errors and to evaluate the impact of a scheme to involve the clinical pharmacist in the assessment and monitoring of drug prescriptions of all new admissions. A baseline review of GP letters and hospital notes found inaccuracies to be commonplace with a reported incidence of medication errors at 34.6%. This error rate rose to 77.7% when a clinical pharmacist was actively involved in taking medication history and drug administration in addition to a review of notes. In fact it was estimated that over 70% of drug errors could not be detected from the medical notes alone. Incomplete or inaccurate patient history information used as a basis for treatment will predispose to medication error (Sullivan *et al.* 2005). A study of rate and type of medication error by Lizer and Brackbill (2007) located an average of 2.9 discrepancies per patient (n = 57). This caused 158 errors, including omitted or incorrect medication (48%), omitted or

Table 1
Summary of medication error studies

Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Theory and knowledge							
Grandell-Niemi *et al.* (2003) Finland	Quantitative evaluative	Medication calculation skills test (MCQ test) questionnaire to determine basic and higher level pharmacological, mathematical skills	Convenience *n* = 364 registered nurses and *n* = 282 graduating nursing students from a total of seven hospitals and five polytechnics	Descriptive statistics	Cronbach alpha (nurses 0.70–0.71, students 0.69–0.72) Content validity of instrument research literature and pharmacology text books	Participants did not find pharmacology easy and considered their own skills insufficient. Nurses performed better than students on the MCQ test with the results showing inadequate levels of knowledge in the student group. The maximum MCQ test score was 24. The mean score for nurses was 18.6 and 16.3 for students	Nurses answered without supervision-possible that cooperation may have overestimated proficiency
Kapborg (1995) Sweden	Quantitative	Mathematical test consisting of 65 items administered to evaluate and compare different educational back rounds in nursing students in relation to ability to add, subtract, multiply, divide whole numbers, fractions, decimals percentages, ratios, proportions and problem solving	Convenience *n* = 997 students enrolled in the two year nursing programme. Group 1 *n* = 494 had no mathematic in school Group 2 *n* = 239 studied mathematics in school Group 3 *n* = 242 (25 years of age and >4 years work experience)	Descriptive statistics	Reliability reported as previously established	Educational background was associated with performance. Students in group 2 had better results than other groups. Correct results Group 1: 57 Group 2: 64 Group 3: 63 An analysis of the variance between groups showed a significant difference ($F(2.974) = 23.77$; $P < 0.01$)	The groups are not of equitable sized
Latter *et al.* (2001) UK	Mixed method	Postal questionnaire survey targeting all higher education institutions delivering pre and post registration nurse education programmes in England to evaluate the nature of pharmacology content in nursing programmes	Convenience *n* = 60 educational institutions accessed through the ENB	Descriptive analysis Open ended questions analysed using a process of content analysis		Pre-registration: pharmacology content is integrated within other modules-evenly split between integration within biological science and nursing modules. In post registration pharmacology is integrated within other modules, mainly specialist practice modules. Dissatisfaction as to the amount of taught pharmacology. Lack of clarity in relation to learning outcomes related to pharmacology	Self report survey

Table 1
Continued

Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Greenfield (2007) USA	Quasi-experimental study	Personal assistant technology usage by degree nursing students (experimental) was compared with a control group who only used textbooks to facilitate learning about medication process during a semester. Evaluated by medication calculation	Convenience $n = 87$	Descriptive statistics and *t*-tests		Mean accuracy scores 4.1 for the experimental group and 3.5 for the control ($P = 0.037$) Mean time scores 13.2 mins for experimental and control was 17.2 min ($P = 002$)	Small and self selected sample so results can not be generalised
Wright (2007) England	Quasi-experimental pre and post test design	30 question drug calculation test to evaluate a number of strategies to enhance mathematical ability. Online maths sessions; 2 hour lecture; workbook; practical sessions; private study. Retested after 7 months	Convenience sample $n = 44$ 2nd year nursing students for pre and post test	Statistical analysis of test results	Kappa coefficients of 0.74, 0.90 and 0.83 were reported between the raters	Scores ranged from 7 to 29 mean 16.5. Mean increased to 21.5. Noticeable improvement in scores ($P = .005$; $\chi^2 = 22.4$; d.f. = 6). Strategies that focus on developing mathematical and conceptual skills are effective in improving the calculation skills of nursing students	Small sample size so results cannot be generalised. Improvement in scores cannot be attributed to the strategies alone
Polifroni *et al.* (2003) USA	Quantitative	28 item questionnaire assessing practices, policies, procedures relating to validation of mathematical competence for medication administration	Random proportional sampling $n = 594$ (of 1219) schools preparing individuals for nurse licensure Diploma 9%, Associate 51%, Baccalaureate degree 40%	Descriptive statistics	Face validity and content 10 RNs and five experts	Nursing students and new graduates have difficulty with basic Maths (the study did not examine the specific areas of difficulty). The required passing score of tests varied ranging from requiring 100% accuracy to 70% accuracy. There are also variations in policies relating to the consequence of not achieving the required score	
Deviation from procedure							
Bruce and Wong (2001) UK	Direct disguised observational study	Observation and recording of errors that occurred during the preparation and administration of parental medications over a 4 week period	Convenience $n = 107$ opportunities for error	Descriptive statistics and content analysis		Rate of observed errors = 27 (25.2%) (95% CI 17.0–33.5%). Excluding wrong time errors reduced to 10.3% (95% CI 3.8–14.9%) Wrong base solution = 3 Incompatibility error = 1 Wrong preparation technique = 5 Incorrect labelling = 1	Presence of observer may positively or negatively influence drug administration process Single site Small sample

Table 1
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Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Taxis and Barber (2003a) England	Prospective ethno-graphic study design	Observer accompanied participants recording preparation and administration of intravenous drug. Data was collected on 6–10 consecutive days on each ward. Validated scale was used to assess clinical importance of intravenous drug errors	Purposive sampling strategy. University teaching and non-teaching general hospital 113 nurses and 1 doctor observed over 76 days *n* = 1042 doses of intravenous drugs/35 different drugs/106 patients	Data was coded using human error theory as a basis to explain the chain of event in errors made	Test submitted to an expert panel and piloted to ensure content validity	Error rate 212 out of 430 IV doses = 49% (95% CI 45–54) Errors were potentially harmful in about a third of cases. The most common errors was in giving bolus doses too quickly (95%) and mistakes in preparing drugs that required multiple steps (14%)	The effect of the observer on the participant has been discussed as a possible limitation in ethnographic observation methods
Tissot *et al.* (2003) France	Prospective observation based study	Medication administration errors were identified and classified. Injection administration, absence of standardised protocol for administration, quality of prescriptions and workload were evaluated as potential risks	Convenience sample. Study carried out in two units, a 25 bed Geriatric unit and 11 bed Cardiovascular Thoracic Surgery Unit over a period of 20 days. 523 opportunities for medication error and *n* = 78 medication administration errors that occurred during the study	Statistical analysis, univariate and multivariate logistic regression analyses		The medication errors rate was 14.9%.The most frequent errors were dose errors (41%), followed by wrong time (26%) and wrong rate (19%) errors. Incomplete or illegible prescriptions and nurse workload were the two significant risk factors in medication administration errors. Lack of knowledge of medication, lack of knowledge of the patient, rule violations or slips and memory lapses were reported as causes of medication errors	The potential effect of the observer on the nurse behaviour is a concern for the validity of the study. Prescribing and dispensing errors were excluded. The hospital and medication use process may not be representative for European hospitals. The analysis of risk factors of MAE was limited to four variables, when the rate of errors was multi-factorial
Han *et al.* (2005) Australia	Prospective observa-tional study	A direct observational approach was used to document rate of medication errors and contributing variables during administration of continuous Intravenous (IV) infusions over a 4 week period	Study carried out on three surgical wards *n* = 687 observations	Descriptive analysis regression analysis	Trained observer	A least one medication error in 124 observations (18%) Wrong administration rate = 100 (79.3%) Dose omission 15 (11.9%) Variables more associated with error Peripheral lines (Odds ration 3.48, 95% CI 1.87–6.50) Duration of infusion (Odds ratio 0.90 95% CI 0.86–0.93) Variables more associated with no error Intravenous infusion device (odds ratio (0.12 95% CI 0.06–0.25)	May be some under representation

Table 1
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Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Mrayyan *et al.* (2007) Jordan	Descriptive exploratory study	Used the 'Gladstone scale' to investigate the rates of reported error, causes and views about reporting among nurses	Convenience sampling *n* = 799 (57% response rate) nurses from 24 hospitals	Descriptive and inferential statistics	Psychometric properties previously established. Pilot for appropriate ness for use in Jordan	Mean no. recalled errors = 2.2 per nurse Reported error rate-only 42.1% Highest perceived causes: Poor quality/damaged medication labelling or packaging (mean = 5.42 SD 2.91); confusion over infusion devices (mean = 5.61 SD 2.87 and work distractions mean = 5.42 SD 2.91). highest ranked views on reporting : Fear of disciplinary action (mean 1.59 SD 0.491); not thinking error was serious enough (1.58 SD 0.492)	Convenience sampling so findings may not be generalisable
Cousins *et al.* (2005) UK Germany and France	Prospective Observation study	Direct observation by a single observer of the preparation and administration of intravenous drugs to compare the systems and rate of errors in three countries	Convenience Study centres UK: med-surg wards in four hospitals Germany three wards in one hospital France: one ward *n* = 824 prepared doses *n* = 798 doses administered	Descriptive statistics	UK audit form based on 'manual of clinical nursing procedures' piloted and tested and adapted for use in Germany and France	Wrong label in 43% (UK); 99% (Germany); (France) 20% of all observed cases. Wrong dilutent 1% (UK); 49% (Germany); 18% (France). Wrong rate 49% (UK); 21% (Germany); 5% (France). Deviation from aseptic technique100% (UK); 58% (Germany); 19% (France). Intravenous therapy is drug administration activity that is at particular high risk for error	Self selected sites. Different observer in each country
Reconciliation							
Pronovost *et al.* (2003) USA	Mixed method evaluation of medical reconcilia-tion process	Medical records reviewed, allergies and medications verified with client/family and compared with outcome measure: Primary: medication errors detected through a random audit of medical record each week Secondary: number of times patient orders were changed as a result of discharge survey and level of staff compliance with the reconciliation process	Random sampling of 10% (*n* = approximately 10 per week) of discharges from a 14 bed surgical ICU 2 weeks before for baseline and for 19 weeks post routine implementation	Descriptive statistics	Grading system developed by research team	Prior to implementation 94% (31 of 33 patients) reviewed has orders changed. This reduced to an average of 10 per week following implementation. Subsequently the survey was electronically developed and included in the electronic medical record	A change to the medical record may be an unreliable definition of medication error

Table 1
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Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Dutton *et al.* (2003) UK	Mixed method evaluation	Phase 1: standard prescription monitoring to quantify the prescription errors relating to pre-admission medication. Errors classified according to severity Phase 2 implementation of 3 month medication management system including bedside dispersion of own drugs supplies, enhanced assessment in relation to patient own drugs and greater involvement of the clinical pharmacist in medication management on the ward. Survey of physicians	Phase 1: n = 526 patients Phase 2: n = 506 patients	Chi-square test for statistical significance. Descriptive statistics	Standardised checklist developed by research team	Phase 1: mean number errors per day 3.3 (95% CI 2.5–4.11) (total 182). Phase 2: Mean number of errors per day 7.1 (96% CI 6.18–8.11) (total 393). The largest number of errors were due to omissions (80 in phase 1. 177 in phase 2, $P > 0.001$). Only 69/13.1% (95% CI 10.2–16.0%) in phase 1 and 99/19.6% (95% CI 16.1–23.1%) of errors were detected by prescription review. Other sources for detection of errors were PODs, patient carer, personal knowledge, GP and notes	In phase 2 greater detection of errors was probably enabled by the ward being visited twice daily rather than once in the 1st phase
Lizer and Brackbill (2007) USA	Mixed method evaluation	A pharmacy initiated medication reconciliation process was implemented using history taking, patient interviews and chart review. Initial medication histories were taken by nursing staff. Assessment of staff satisfaction with the process	Convenience sample n = 54 patients	Descriptive statistics *t*-tests	Detail not given	Mean number of medication discrepancies identified per patient was 2.9 SD ± 2.5 (range 0–10) (total number 158). Physician notification was needed for 43 (80%) of patients. 80% were to omission or incorrect medication. Increased effectiveness in reconciliation demonstrated through pharmacist participation	Pilot study with a small sample size confined to one site
Vira *et al.* (2006) Canada	Prospective mixed method evaluation	A medication reconciliation process was undertaken by pharmacist from admission until after discharge to detect, determine severity and explain unintended variances.	Randomly selected n = 60 patients admitted to a community hospital	Descriptive statistics	Content validity of research instrument previously established. Test–retest reliability coefficient reported (0.78)	Mean number of variances were 2.3 per patient. At least one unintended variance was found in 60% of study participants (95% CI 48–72). 18% (11 patients) had one clinically significant variance (95% CI 9–28). Study confirms the importance of reconciliation at times of transition.	Single reviewer. Only included prescription medications Small sample from one community hospital

Table 1
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Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Midlöv *et al.* (2005) Sweden	Quantitative evaluation	All patient notes and medication records were examined o detect the nature and frequency of error on transfer in and out of hospital	Convenience *n* = 69 patients >65 years. 34 on admission 35 on discharge	Descriptive statistics Logistical regression	All patient information was reviewed by 2 evaluators independently with a third consultation PRN	142 errors detected out of 758 transfers. 29 patients had at least one error on admission (85% CI 69–95). 19 patients had at least one error on discharge (54% CI 37–71. Medication added in error total = 52 (0.8 per patient). Medication withdrawn in error total = 59 (0.9 per patient). Change in dosage total = 31 (0.4 per patient). The transfer of information accurately is contingent on systems issues	Small sample in one community care area
Gleeson *et al.* (2004) USA	Mixed method evaluation	Review of notes, medication record and interview of patients to identify the type, frequency, and severity of medication discrepancies and evaluate the process of reconciliation carried out by pharmacist reduced the number of errors	Convenience *n* = 2046 admissions over 11 month period. *n* = 204	Descriptive and inferential statistics	Agreed taxonomy of discrepancies used. Discrepancies were clarified by reconfirming with the patient and using additional records and follow-up with other professional	Medication discrepancies per patient = Mean 1.2 ± SD1.5 (total 241). 97 interventions required involving 55 patients. Omission 41/97 (42.3%) Different dosage/route 34/97 (35.1%) In the absence of intervention 22% of discrepancies would have resulted in patient harm during hospitalisation and 59% would have resulted in harm after discharge	Convenience sample may not be representative
Nursing workload							
Pape *et al.* (2005) USA	Quantitative study	Observation of nurses by clinical educators using a standardised protocol to evaluate the effects of standard protocols and visible signage to reduce distractions during medication administration includes those by physician, other nurses, other personnel, missing doses, uniform, conversation, visitor, computer problems or external noises	Convenience *n* = 78 nurses from five units in one hospital	Descriptive and inferential statistics	Inter-rater reliability 0.90	Mean number of interruptions = 42 SD ± 10.4 range 26–56. Mean after intervention = 31 SD ± 8 range 16–45. (Interruptions by other nurses reduced from mean of 5.6 (SD 2.98) to 2.9 (SD 1.7) following intervention. Other personnel reduced from 6.00 (SD 2.2) to 4.3 (SD 1.7). External conversation interruptions reduced from 6.2 (SD 2.7) to 3.9 (SD 2.1). Interruptions from physicians unchanged. *t*-test found statistically significant reduction after signage ($t = -14.33$ d.f. > 19 $P = 0.000$)	One site survey

Table 1
Continued

Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Tang *et al.* (2007) Taiwan	Mixed method	Focus groups and survey to establish the factors that contribute to medication error	Snowball sampling method *n* = 72	Descriptive analysis Narrative statements analysed by two researchers		Medical wards & ICU -most common location for medication errors. Older patient combined with complex prescription may result in a higher error rate. Main factors involved in each medication error were believed to be personal neglect (*n* = 62 86.1%), heavy workload (*n* = 27, 37.5%) and new staff *n* = 27 37.5%). Wrong dose or wrong drug - two leading drug error types. Errors do not result from one single human factor	The relatively small sample size and the sampling procedure made have caused a sampling bias
Antonow *et al.* (2000) USA	Descriptive quantitative survey	Study investigated the four stages of the medication process at which errors occur: Prescription, transcription, dispensing and administration	Convenience *n* = 72 nurses who completed mandatory skill training in one 232 paediatric hospital	Multi-variate logistic regression analysis	Pre-tested and pre-validated in a previous study	177 errors were reported by participants. 15.3% had never observed a medication error 62.1% of observed errors never reached the patient 30.5% of observed errors had formal incident report completed : the likelihood increased in the latter stages of the medication process Administration errors accounted for 51% of written incident reports	Potential for recall bias too influence under and over estimation of errors
Drug distribution systems							
Taxis *et al.* (1992) Germany and UK	Mixed methods	Comparison of medication error rates using three different drug distribution systems-observation of the preparation and administration of regularly scheduled solid oral medication	Convenience UK: Ward pharmacy system/850 bed hospital (*n* = 843 doses) Germany: traditional drug distribution system/600 bed hospital (*n* = 973 doses) and Unit dose system/880 bed hospital (*n* = 1318 doses)	Percentage error rates calculated for each site	No detail given	Ward pharmacy system: Medication error rate 8.0% (95% CI 6.2–9.8%). Traditional drug distribution system: Medication error rate 5.1% (95% CI 4.4–5.8%). Unit dose system medication error rate 2.4% (95% CI 2.0–2.8%)	Study confined to solid oral medication- IV, PRN, inhalation, liquid administration or controlled drugs error rates not known. Potential for observer effect. Differences in staffing, occupancy, workload, ward characteristics are differing factors between sites which limit generalisability

Table 1
Continued

Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Bennett *et al.* (2006) Canada	Mixed method non-experimental descriptive design	Comparison between the effectiveness and efficiency of centralised unit dose distribution system and decentralised individual bedside distribution system using tracking sheets devised by the research team and focus groups with nursing and pharmacy staff involved	Convenience Two 24 bed general medical ward. Nursing and pharmacy staff participated over 4 (12 hour) day and night shifts *n* = 43 staff	Descriptive statistics Content analysis	Face validity of the tracking sheets established by the research team	On average each nurse saved an average of 23 minutes per 12 hour shift with decentralised medication systems. Decentralisation resulted in 64% reduction in the number of interruptions nurses experienced while administering medications	Study confined to one hospital
Jarman *et al.* (2002) Austalia	Descriptive mixed method design	Nurses completed a self report questionnaire in relation to single-person checking. Comparison single and double person approaches specifically in relation to the medication incident report forms over a 7 month period	Convenience sample of nurses from inpatient units *n* = 129 (44% response rate)	Descriptive statistics Content analysis		High satisfaction (scale range up to 100) 80.74 mm (SD 16.61) with single person checking. High confidence in their ability for single person checking 83.84 (SD 15.11) Error rate during study = 4 Error rate compared with double person checking same period previous year = 5	Study confined to one hospital
Barriers to reporting medication errors							
Mayo and Duncan (2004) USA	Descriptive correlation study	A self-report survey used to examine the perceptions of nurses about what is a medical error, causes, what is appropriate to report and the barriers	Random sample of 5000 nurses surveyed with 20% response (*n* = 983)	Descriptive statistics		Inconsistency between nurses as to what constitutes a drug error. Top ranked causes were illegible handwriting, distractions and tiredness. Fear of manager reaction (76.9%); fear of co-workers reaction (61.4%) and believing error not be sufficiently serious (52.9%) were the most significant barrier. The large majority did not believe fear of job loss to be a significant barrier (80.4%)	Sample drawn from a union so may not be representative. Ranking of causes means some errors may causes may not be identified

Table 1
Continued

Author year & country	*Study type*	*Methods*	*Characteristics of samples*	*Data analysis*	*Rigor*	*Main findings*	*Limitations*
Gladstone (1995) UK	Mixed method descriptive study	Survey and interviews with trained nurses and managers to understand perceptions and attitudes in relation to causes, reporting and response to drug errors Review of drug error incident forms over 12 month period	Convenience $n = 79$ incident reports $n = 81$ (79% response rate) staff nurses $n = 12$ (71% response rate) nurse managers $n = 14$ nurses who had made drug error		Questionnaire to staff nurses piloted with 5 registered nurses. Questionnaire to managers piloted with three senior nurses	Dose-related errors accounted for 50% This included Incorrect infusion rate 14 (17.7%) Unprescribed extra dose 13 (16.5%) Deviation from procedure, illegible prescription, miscalculations and distractions were all reasons ranked highly as contributing to medication error. Considerable disagreement between staff as to what constitutes a drug error and when to report	Small sample
Baker (1997) Australia	Ethnographic study	Participant observation, documentary analysis, interviews used over the 18 weeks of the study to help understand how nurses define medication error	Purposive sample	Qualitative analysis		Nurses use logical management practices to overcome complexities that arise in practice. Particular criteria are applied by nurses in practice to redefine 'real error' to be reported. Highlights issues of validity in errors rates and ways medication error id defined	

incorrect dose (31%), omitted or incorrect frequency (13%) and miscellaneous (8%). An evaluation of the reconciliation process by Gleeson *et al.* (2004) found discrepancies between the patient history and drug prescriptions in more than half of the patients. Resultant errors included omission (42%) or change in dosage, route or frequency (35%). Midlöv *et al.* (2005) analysed the transfer of 65 patients in Sweden between the hospital and community and found that on average there were two errors per patient on each transfer. The main outcome again of such discrepancies in documentation and transferring data was inadvertent withdrawal of medication. Pronovost *et al.* (2003) demonstrated a significant reduction in medication errors through a systematic medication reconciliation process used in American critical care settings.

Drug distribution systems

'Root cause analysis' to fully investigate and understand all of the elements in the medication process can uncover system deficiencies that will increase potential for error (Greenall & Wichman 2006). A number of systems issues are highlighted by Kelly (2004) as contributing factors in medication errors, including information overload, lack of clinical decision supports with general inadequacy in the 'checks and balances' inherent in any drug administration process. Medication error is also more likely with inappropriate reliance on manual documentation or information systems that do not communicate with one another (William 2004). The process of receiving medication from the pharmacy can contribute to errors; issues such as late deliveries, loss of orders and inadequate 24-hour cover can all contribute to errors. The absence of pharmacy staff 'out of hours' can limit the availability of drugs which may increase omission errors (Madegowda *et al.* 2007). Omission errors are also caused by the availability of non-stock drugs and through difficulty in locating stock drugs prescribed generically but supplied in brand name packaging (Taxis *et al.* 1992). Incorrect or delayed transcriptions are also a cause of medication error (Taxis *et al.* 1992).

The drug distribution system can potentially determine vulnerable points at which medication error can occur. The standardization that is anticipated in a well-designed drug distribution system is impacted by numerous sub-systems that exist in any organization (Hronek & Bleich 2002). Multiple medication systems may exist within the one system, 'Mon to Fri' standard system, 'out of hours system', 'between service system' and even the 'stashed drug system' (Hronek & Bleich

2002, p. 18). Different drug administration systems are associated with higher rates of medication error. Unit dose systems have been found to have lower error rates (Taxis *et al.* 1992). Bennett *et al.* (2006) compared the unit dose medication system with the wall-mounted medication cupboard. The decentralization system for the distribution of medicine was found to result in significant time conservation with fewer interruptions in the medication process (Bennett *et al.* 2006). Increased awareness during drug administration was felt by nurses when they moved from double-person to single-person checking (Jarman *et al.* 2002). Greenall and Wichman (2006) highlight the potential for error caused by similar packaging. Similar packaging and labelling can have deadly consequences (William 2004). A Jordanian study by Mrayyan *et al.* (2007) found that the highest perceived causes of medication errors were poor quality/damaged medication labelling or packaging; confusion over infusion devices and work distractions. Some blame has been attached to difficulties and confusion in using different infusion types (Mayo & Duncan 2004). Technology can also be a contributory or preventative factor in medication error. Computer-order entry systems, decision support systems automated dispensing cabinets, robots for filling prescriptions, computerized medical record and bar-coded enabled systems are all technological innovations designed to make the medication management process safer (Bates 2000, Grissinger & Globus 2004). While all of these technologies can contribute to a safer medication administration system, they still require substantial human guidance and supervision (Bates 2000). All of these interventions necessitate considerable capital investment and organization commitment and need to be evaluated in terms of the potential cost savings to medication error reduction or prevention.

Deviation from procedures

Failure to follow procedures and the presence of distraction has been demonstrated to contribute to medication errors (Pape *et al.* 2005). In an increasingly frenetic work environment, interruption, distraction and difficulty in retaining focus are key issues in the administration of drugs (Pape 2001, Mayo & Duncan 2004, Fu-In *et al.* 2007). Gladstone (1995) used mixed methods to investigate the risk factors and conditions in which medication errors can occur. A critical factor identified was deviation from accepted protocol for safe administration. Delays in administering intravenous (i.v.) drugs have been found to be caused by lack of indwelling i.v. cannulae (Bruce & Wong 2001) leading these researchers to speculate that problems in coordination of care adversely affected the timely administration of drugs. Medication error producing conditions also included design of technology, communication, workload, and patient-related factors (Bruce & Wong 2001). There can be pressure on staff to deviate from official procedures, for example, administering i.v. boluses faster than recommended, because it is common practice in the practice environment (Taxis & Barber 2003b). Han *et al.* (2005) found that one-fifth of all continuous infusions have some kind of error, the most prevalent of which was deviation from the prescribed administration rate, with a lack of understanding of the potential implications of administering too slowly or too quickly.

Good people can unintentionally make mistakes as a result of inadequate training or knowledge, staff shortages and overwork and fatigue (William 2004). Tang *et al.* (2007) used mixed methods to investigate contributory factors to medication errors in Taiwan (n = 72, 80% response rate). The three most common categories that caused medication errors were personal neglect (n = 62, 86.1%), workload (n = 27, 37.5%) and new staff (n = 27, 37.5%). A lack of familiarity with the drug or patients was also a significant factor. The conditions that led to personal neglect were multi-tasking while administering a drug and carrying out drug preparations in advance. These are time-saving activities commonly employed by nursing staff to manage their workload. Multiple interruptions are a feature of health care work. Conversations with other staff and performance of multiple tasks during medication preparation and administration can predispose to error (Gladstone 1995, Fu-In *et al.* 2007).

Tissot *et al.* (2003) described workload as the number of patients per nurse and demonstrated that the higher the workload the higher the risk for error. A study to examine the relationship between adverse patient outcomes and staffing, reported that increased registered nurse staffing was associated with a lower incidence of all adverse patient outcomes including medication errors (Blegen *et al.* 1998). Medication errors were found to be associated with increased stress in nurses (Duggan *et al.* 1996). In a national study of the work hours and errors and near misses, working more than 12 hours, overtime or more than 40 hours per week were associated with higher rates of error (Rogers *et al.* 2004). Blegen and Vaughn (1998) examined the relationship between staffing and medication errors among other outcome variables in 39 hospitals.

A higher proportion of registered nurses were found to be associated with lower medication error generally. However, as units reached a total registered nursing staff, adverse medication errors increased. Researchers speculated that this may be because of higher vigilance for reporting by an all registered nursing staff or may be as a result of the higher patient acuity associated with all registered nurse staffed units such as intensive care units. Madegowda *et al.* (2007) used a retrospective, non-experimental study design to determine the relationship between three nursing shifts and the number of reported medical errors (n = 120) over a 12-month period. They found the rate of errors to be higher in winter, which may be attributed to higher census during those months. They found an association between the 2nd shift and rate of error, which may be a result of lower staffing levels. This was a relatively small study but did uncover that the majority of errors were as a result of omissions.

Quality of prescriptions

Ineffective written and verbal communication in relation to prescriptions contribute to medication errors, particularly between nurses and physicians (Fiesta 1998, Kazaoka *et al.* 2007). Nurses and doctors have a duty not only to communicate significant changes in relation to the prescriptions and administration of medications but also to listen carefully to all information (Fiesta 1998). Dose omission is commonly as a result of failure to communicate prescriber changes after medical and surgical consults (Han *et al.* 2005). Incomplete or illegible prescriptions were associated with medication errors by both nurses and managers (Gladstone 1995). In a survey of registered nurses (RNs) (n = 983) to determine American nurse perceptions of drug errors, participants reported that nurses believed that poor physician handwriting, tiredness and distractions were the top three causes of medication errors (Mayo & Duncan 2004). Similarities between drug names, miscalculations, prescriptions errors and failure to follow procedure were also significant factors. Kelly (2004) describes hand-written prescriptions as archaic and graphically illustrates the potential for error caused in particular by poor handwriting. Drugs with similar sounding names are a particular issue in negotiating verbal drug orders (William 2004). Tolerance and overuse of abbreviations can also contribute to a high mix of error and misinterpretations of prescriptions (The Joint Commission 2007). Abbreviations and ambiguous, incomplete or unclear orders are contributory and avoidable factors that cause medication errors and therefore organizations should seek to reduce the inappropriate use of abbreviations (Cohen 2001, Abushaiqa *et al.* 2007).

Knowledge and medication errors

The medication management process involves intellectual activity in addition to the physical act of medication preparation or administration. Constant vigilance is required as nurses engage with professional judgement and critical thinking to observe patients, communicate with all stake holders, interpret relevant data and apply knowledge and experiences to specific patient situations (Eisenhauer *et al.* 2007). Through the process of medication administration, 'nurses are multitasking, in action and thought' and the fast-paced health care environment can offer immense distraction and interruptions (Eisenhauer *et al.* 2007, p. 86).

Results from many studies indicate that nurses lack adequate pharmacological skills for practice (Latter *et al.* 2000, Manias & Bullock 2002, Morrison-Griffiths *et al.* 2002). Researchers observed nurses (n = 113) on 10 wards in two UK hospitals during 483 i.v. preparations and 447 i.v. administration (Taxis & Barber 2003b). During the study, 265 drug errors were detected ranging from minor slips, mistakes and violations. Lack of knowledge and experiences with drugs or equipment were the cause of 79% of all errors (Taxis & Barber 2003b). In this study, the need for training was highlighted as staff commonly confused drug names or made inappropriate selections. Confusion over drug names is well documented as contributory to medication error (Hoffman & Proulx 2003). Miscalculations on the behalf of nurses was also reported to be a high ranking cause of errors and 18.5% of nurse respondents in a study by Gladstone (1995) on the causes of medical error did not have any form of mathematical qualification. Wright (2007) investigating the impact of strategies to improve conceptual and mathematical skills of nurses (n = 71) in order to improve accuracy in drug calculations found considerable deficit in the ability of nurses to accurately calculate dosages in practice. Errors are also caused by inadequate safety knowledge in relation to particular drugs for e.g. compatibility (Bruce & Wong 2001). The use of personal digital technology (pharmacy drug calculation software) can reduce medical errors (Greenfield 2007). Researchers were able to demonstrate the high accuracy in drug calculation and decision-making in relation to drug administration. However, many participants still made errors, highlighting the importance of improving the drug knowledge of nurses.

Mathematical skills

The literature generally indicates that two skills are necessary in order to perform accurate drug calculations, basic mathematical skills to calculate mathematical problems and the ability to conceptualize the clinical information presented and extract the relevant information in order to formulate a Maths calculation to be solved (Wright 2007). Mathematical skill and proficiency is a prerequisite to the performance of medication calculations. Medication errors resulting from poor calculation skills are an international problem (Bayne & Bindler 1988, Kapborg 1995, Polifroni *et al.* 2003, Wright 2007). One of the most frequent mathematical errors identified in the literature is misplacement of decimal points (Kapborg 1995). Oldridge *et al.* (2004), Preston (2004), Haigh (2002), and Segatore *et al.* (1994) concur that the inability to accurately calculate medication dosages significantly contributes to the likelihood of making a medication error. This is of particular significance in all settings but particularly in settings whereby drug doses are determined by body weight, e.g. paediatric and neonatal settings, which can lead to an increased opportunity for medication error.

Reporting medication errors

A number of barriers to nurses and doctors reporting errors have been identified. These include fear of disciplinary action, not being able to report anonymously, constraints on time and also thinking that it was unnecessary to report the errors because they had no negative outcomes (Uribe *et al.* 2002). Mayo and Duncan (2004) also found that 50% of nurses did not report medication errors because they feared negative repercussions. Berntsen (2004) advocates finding a non-punitive, safe and confidential way to share root case analysis and error preventions strategies amongst institutions, but it is widely acknowledged that creating a no-blame culture that encourages the reporting required to achieve this at an institutional and systems level is a slow process. Ross *et al.* (2000) found that errors were more likely to be reported when the outcome would be incident analysis, another measure to prevent further errors, rather than punishment. Reporting medication errors for health care facilities can also be problematic as such errors may increase the potential for litigation. This creates difficulties in sharing data and learning from medication errors.

Electronic error reporting systems have been identified as one means of facilitating hospital employees to report adverse events. In some instances this has been accompanied by changes in legislation to afford legal protection. Milch *et al.* (2006) in their study of reporting of adverse events found that nurses reported 47% of errors, of which 33% were medication or transfusion events. Many errors relating to drug administration were identified, including omitted drugs, wrong drugs, wrong route, time and frequency and wrong patient. In this study, the reporting rate by physicians was 2%. The researchers suggested that the different reporting rates amongst nurses and doctors might pertain to the training that nurses receive in reporting adverse events. They also suggest that such a type of reporting system had greater potential to uncover the root causes of near misses, whereas retrospective chart analysis would not uncover these events.

Informal reporting is sometimes utilized by nurses and collectively such mechanisms had the potential to militate against organizational learning as all errors are not reported (Espin *et al.* 2007). Nurse's interpretation of errors has also been identified as an antecedent of their decision to report medication errors. Baker (1997, pp. 156–157) identified that nurses categorize medication errors in six different ways which include:

(1) If it's not my fault then it is not an error;
(2) If everybody knows then it is not an error;
(3) If you can put it right then it is not an error;
(4) If a patient has needs that are more urgent than the accurate administration of medication, then it is not an error;
(5) If it is a clerical error, then it is not an error; and
(6) If an irregularity is carried out to prevent something worse then is it not an error.

This author found that if it could not be assigned to one of these categories then it would be categorized as an error. Antonow *et al.* (2000) also found that administration errors were more likely to be reported if they had reached the patient, but ordering errors were less likely to be reported. Anecdotally, Armitage and Knapman (2003) comment that their experience is that many health care professionals identify and troubleshoot errors in areas such as prescribing but that these are never reported, thus reducing the value of reporting and learning from near miss errors. These interpretations of what constitutes errors impacts on the reporting of medication errors to the detriment of organization learning.

Implications for practice

The literature reviewed highlights the complexity and diversity of factors that influence the occurrence of

medication errors (see Figure 1). It is crucial that nurse leaders, educators and researchers in conjunction with other members of the multidisciplinary team adopt a strategic approach in addressing this multifaceted problem. It is vital to look to and learn from other high-risk industries such as aviation and the systems that they utilize to reduce and manage risk. In the first instance, the issue of reducing medication error needs to be incorporated more fully onto the health policy agenda as an integral part of quality and risk management. The further development of reporting mechanisms, both national and international, in establishing a baseline regarding the nature and magnitude of the problem is imperative.

At an individual level, it is the responsibility of each nurse/midwife to take appropriate steps to develop and maintain competence in relation to all aspects of medication management and to ensure that their knowledge, skills and clinical practices are up to date. (UKCC 2000, An Bord Altranais 2003, 2007). Several studies concur that nursing curricula and continuing education programmes continue to have insufficient teaching input on pharmacology (Jordan *et al.* 1999, Naylor 2002, Grandell-Niemi *et al.* 2003) and tend to focus on pharmacology knowledge required for the administration of medications (Latter *et al.* 2001). A critical concern for education and practice stakeholders is the development of, attainment and maintenance of competence, in particular mathematical calculation skills through out the medication management process (Kapborg 1995, Polifroni *et al.* 2003, Greenfield 2007, Wright 2007). It is important that medication management is addressed within nurse education, both in the preparation of nursing students for practice and in the continuing education of nurses (Bullock & Manias 2002, Manias & Bullock 2002). There are a number of strategies including workbook, practice sessions and online tools which could be used in conjunction with current teaching approaches which will contribute to the development of knowledge and skills (Wright 2007).

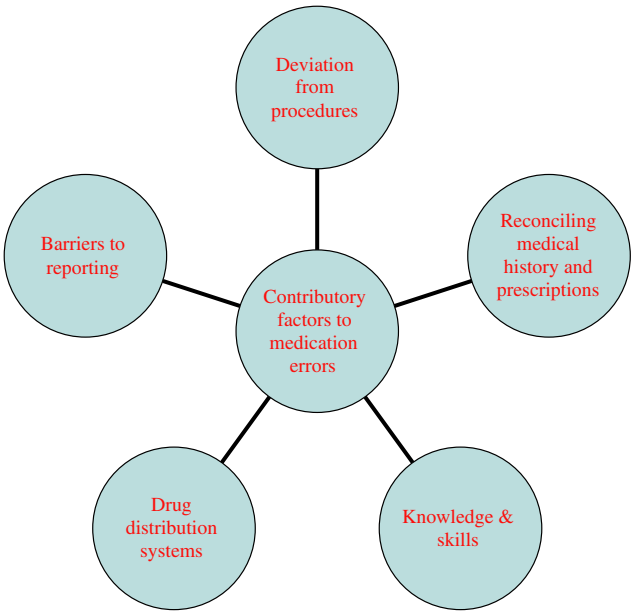

Figure 1
Contributory factors to medication errors.

The studies that highlight deviations from procedure are commonplace (Bruce & Wong 2001, Taxis & Barber 2003a, Tissot *et al.* 2003). Distractions while administering medications are commonplace and their effect may not be fully appreciated in practice (Gladstone 1995, Pape *et al.* 2005). Intravenous therapy is a medication management activity that has been found to be at particularly high risk of deviation from procedures (Bruce & Wong 2001, Taxis & Barber 2003a, Cousins *et al.* 2005, Han *et al.* 2005). Experiences from the aviation industry have demonstrated the effects of making systems error proof. Regular auditing and evaluation of all elements that contribute to the medication management process will enable system re-engineering initiatives such as simplification, standardization and check and balances that may be employed to minimize risk of error.

Reporting medication errors is pivotal in improving the medication management process, and is also both a legal and ethical obligation for every nurse. There appears to be inconsistency among nurses as to what constitutes medication error and factors that influence when errors are reported (Baker 1997). Failure to report medication errors means that both near misses and medication errors are not analysed, and do not inform the body of knowledge in this area. Therefore, it is imperative that reporting systems are such that they facilitate nurses to document all errors and potential errors as adverse events. Suggestions put forward to facilitate reporting of medication errors include monitoring programmes in all health care institutions, spontaneous reporting systems and the establishment of nationwide mandatory reporting systems. Management approaches have also been identified as a means by which reporting can be facilitated, with Khatri *et al.* (2006) highlighting that control-based management with a traditional human resource management approach has the potential to perpetuate a culture where blame must be attributed to the individual (high blame culture), wherein medical errors are not reported and the outcomes are a continuance of such errors coupled with low organizational learning.

The review does endorse the need for a structured and systematic approach to medication reconciliation (Schaubhut & Jones 2000, Dutton *et al.* 2003, Gleeson *et al.* 2004, Midlöv *et al.* 2005, Vira *et al.* 2006, Lizer & Brackbill 2007). This is a responsibility of all stakeholders in the medication management process and requires the involvement of nursing, medical and pharmacy staff at all junctures or points of transfer in the health service. Patient and family member education can also contribute to enhancement of the reconciliation process. This becomes more critical considering contemporary changes in health care delivery, which include higher acuity, greater complexity of patients and prescriptions, shorter hospitalizations and higher patient turnover, where the factors that contribute to medication errors may increase.

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