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Review Article

Incidence, type and causes of dispensing errors: a review of the literature

K. Lynette James[a], Dave Barlow[a], Rowena McArtney[b], Sarah Hiom[c], Dave Roberts[b] and Cate Whittlesea[a]

[a]Pharmacy Department, King's College London, London; [b]University Hospital of Wales, Cardiff and Vale NHS Trust and [c]St Mary's Pharmaceutical Unit, Cardiff and Vale NHS Trust, Cardiff, Wales, UK

Abstract

Objectives To identify, review and evaluate the published literature on the incidence, type and causes of dispensing errors in community and hospital pharmacy.

Method Electronic databases were searched from 1966 to February 2008. This was supplemented by hand-searching the bibliographies of retrieved articles. Analysis of the findings explored the research methods, operational definitions, incidence, type and causes of dispensing errors.

Key findings Sixty papers were identified investigating dispensing errors in the UK, US, Australia, Spain and Brazil. In general, the incidence of dispensing errors varied depending on the study setting, dispensing system, research method and operational definitions. The most common dispensing errors identified by community and hospital pharmacies were dispensing the wrong drug, strength, form or quantity, or labelling medication with the incorrect directions. Factors subjectively reported as contributing to dispensing errors were look-alike, sound-alike drugs, low staffing and computer software. High workload, interruptions, distractions and inadequate lighting were objectively shown to increase the occurrence of dispensing errors.

Conclusions Comparison of the reviewed studies was confounded by differences in study setting, research method and operational definitions for dispensing errors, error rate and classification of error types. The World Health Organization is currently developing global patient safety taxonomy. Such a standardized taxonomy for dispensing errors would facilitate consistent data collection and assist the development of error-reduction strategies.

Keywords causes; dispensing errors; hospital; risk management; safety

Introduction

Dispensing medication is the core function of pharmaceutical care and approximately 900 million medicines are dispensed each year by community and hospital pharmacies across England and Wales.[1] Dispensing is a complex process (Figure 1)[1,2] unequivocally under the supervision of the pharmacist.[1,2] Traditionally, dispensing has involved pharmacy staff manually selecting medication from shelves, transferring the correct number of medication dose units to a container and/or labelling the assembled product.[3] However, in recent years the use of automated dispensing systems has been widely advocated to improve efficiency, maximize storage capacity and minimize dispensing errors.[4,5] Consequently, automated dispensing systems are becoming increasingly commonplace in hospital and community pharmacies across the world.[4–8] Table 1 summarizes the different types of automated dispensing systems.

Errors can arise at any stage during the dispensing process. It is estimated that each year 134 341 dispensing errors occur in community pharmacies in England and Wales.[1] The majority (85%) of these errors are detected by pharmacists before the medication is supplied to the patient.[1] However, some errors are undetected and may cause serious patient harm and occasionally death.[9–12] Thus it is imperative that pharmacists review data on dispensing errors so that risk-reduction strategies are developed to safeguard the quality and safety of patient care.[11]

In recent years there has been a growing body of research on dispensing errors. However, a comprehensive review of the literature has not previously been undertaken. This paper reports the findings of a literature review that focuses on dispensing errors in community and

Correspondence: Dr Cate Whittlesea, Pharmacy Department, King's College London, 150 Stamford Street, London SE1 9NH, UK.
E-mail: cate.whittlesea@kcl.ac.uk

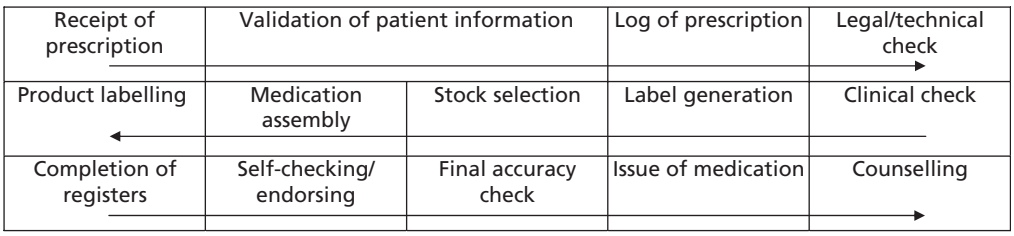

Figure 1 Dispensing process in community and hospital pharmacies[1,2]. In the European community and outpatient hospital pharmacies patients are supplied manufacturers' original packs of medication without a dispensing label detailing directions for use.

Table 1 Summary of automated dispensing systems

Type of automated dispensing system	Description
Repackaging systems	In these systems, medication is removed from the manufacturer's original packs then repackaged into unit dose packs or blister cards. Some repackaging systems can produce patient compliance packs containing each dose of medication to be administered at a particular time of day. These unit dose systems are widely used in US and European pharmacies, whereas the compliance pack systems are used by specialist units in the UK, e.g. psychiatric hospitals.
Ward-based automated dispensers	These systems do not perform any of the characteristic stages of the dispensing process (label generation, stock selection, medication assembly or product labelling) and would be more accurately described as electronic storage devices. The system consists of an electronic drug cabinet and/or trolley comprising computer-controlled drawers. Medication is stored in patient- or product-specific drawers within the cabinet. When a patient's details are entered into the system's computer, the appropriate drawer opens, enabling administration of the medication. These systems are widely used in US hospitals.
Pharmacy-based original-pack dispensers	Medication is stored and retrieved from the system based on recognition of the European Article Number (EAN) barcode by the interlinked automated system, stock database and pharmacy labelling computer software. Medication is stored on specially designed shelves within the automated dispensing system. During label generation, the pharmacy labelling software sends a signal to the automated dispensing system software, initiating stock selection. The requested product is selected by picking devices in the automated system and transferred to the delivery station by conveyor belt or chute. Some automated systems have labelling devices which affix the corresponding dispensing label to the medication prior to transferring the product to the delivery station. These systems are widely used in US hospitals.

hospital pharmacy. This review of internationally published literature aims to summarize: research methods employed to investigate dispensing errors in community and hospital pharmacy, operational definitions for dispensing errors, classification of error types and incidence, reported incidence of dispensing errors in community and hospital pharmacy, reported types of errors in community and hospital pharmacy, and reported causes of dispensing errors.

Method

Literature search

A comprehensive search of electronic bibliographic databases was undertaken: Medline (1966–2008), Embase (1980–2008), CINAHL (1982–2008), Pharm-line (1982–2008), International Pharmaceutical Abstracts (1970–2008), Ovid (1966–2008), Sciencedirect (1997–2008) and Web of Science (1966–2008). The search included all publication types but excluded veterinary citations. Search terms used as both keywords and free-text searches included the following: dispensing, dispens*, errors, incident, inciden*, near-miss, near-miss*, medication, medicines, med*, prescription, prescri*, drug, pharmacy, pharm*. Where possible, the search terms were matched to those included in the database's thesaurus. In addition, the bibliographies of retrieved articles were searched by hand.

Inclusion/exclusion criteria

Publications were included in this review if they fulfilled the inclusion criteria (Table 2) and any relevant information was extracted from papers the scope of which exceeded pharmacy dispensing errors. In some instances, the same research study was published twice as both a conference abstract and research paper. However, only the full research paper was included in this review. Unpublished research on dispensing errors was excluded from the review due to difficulty in accessing the literature.

Data abstraction

The literature search was conducted by two reviewers (KLJ and RMcA) who independently examined the identified titles and abstracts to determine whether the research paper should be retrieved. The inclusion criteria were applied and the quality of retrieved papers was determined by KLJ using the framework established by Allan and Barker.[13] Data from the included papers were abstracted by KLJ using the following data fields: reference, study brief, pharmacy setting, dispensing system,

Table 2 Inclusion/exclusion criteria

Inclusion criteria

International, primary quantitative and/or qualitative research (including research published in a language other than English) investigating the
- incidence
- type
- causes of medication dispensing errors

Dispensing errors: errors arising during the process of dispensing medication
- detected before medication has left the pharmacy
- detected after medication has left the pharmacy

Research undertaken in community pharmacy
- Pharmacy type
  - Independent
  - Chain/multiple
  - Supermarket
  - Mass merchant
  - Mail-service
- Prescription type
  - Individually dispensed items for patients
  - Original prescriptions
  - Repeat prescriptions
- Dispensing system
  - Manual dispensing (unit dose, original pack or compliance pack)
  - Automated dispensing systems (unit dose, original pack or compliance pack)

Research undertaken in hospital pharmacies
- Hospital type
  - State
  - Private
  - Health-systems
  - Veterans Affair
- Pharmacy type
  - Centralized
  - Decentralized/satellite
  - Outpatient
  - Ambulatory care
- Dispensing system
  - Manual dispensing (unit dose, original pack or compliance pack)
  - Automated dispensing systems (unit dose, original pack or compliance pack)
- Prescription type
  - Inpatient
  - Discharge
  - Outpatient
  - Accident and emergency
  - Individually dispensed ward stock requiring a dispensing label

Exclusion criteria

Extemporaneous and aseptic dispensing errors

Ward stock-distribution errors where supplied medication is not labelled

Errors associated with ward-based automated dispensers/electronic storage devices

research method, definitions, incidence (numerator and denominator), error types and causes/contributory factors. Application of inclusion, quality criteria and data abstraction was verified by CW and any differences resolved.

Definitions

To facilitate the review of the identified research papers the following approach, based on the National Patient Safety Agency (NPSA) patient safety taxonomy,[1] has been adopted for the dispensing error terminology. *Dispensing error(s)* refers to all errors occurring during the process of dispensing medication as included in the identified research papers, which are detected within the pharmacy (prevented dispensing incidents) and after the medication has left the pharmacy (unprevented dispensing incidents). *Prevented dispensing incident(s)* are all errors occurring during the process of dispensing medication as included by the identified research papers that are detected within the pharmacy before the medication has been issued to the patient. This term replaces internal error, dispensing incident and filling error. *Unprevented dispensing incident(s)* are all errors occurring during the process of dispensing medication as included by the identified research papers that are detected after the medication has been issued to the patient and left the pharmacy. This term replaces external error and incident.

Results

Overview of identified research papers

The literature search identified 60 research papers which fulfilled the inclusion criteria (Figure 2). Forty-one research papers focused on dispensing errors in inpatient and/or outpatient hospital pharmacies and 19 papers investigated dispensing errors in community pharmacy (retail, independent, chain-store, mail-service and supermarket pharmacies). The majority of dispensing-error research was conducted in the US (48%, $n = 29$) and UK (40%, $n = 24$). However, research papers have investigated hospital dispensing errors in Australia ($n = 3$), Spain ($n = 1$) and Brazil ($n = 1$); and community pharmacy dispensing errors in Australia ($n = 1$) and Denmark ($n = 1$).

Research methods

Various research methods were used to investigate dispensing errors, including self-completed standardized incident forms, observation, postal surveys, simulation, interviews, case-note review and focus groups.[3,14–72] In some research papers mixed methods were used to determine the incidence and causes of dispensing errors.[15,30,43,65] Table 3[3,14–35,37–62,64–71] summarizes the research methods employed by the identified research papers.

This review has identified that the majority (88%, $n = 21$) of UK research papers employed incident report forms to investigate dispensing errors. In contrast, observation was most frequently (66%, $n = 19$) employed by US researchers. In a comparative study of observation and incident reports, observation detected more dispensing errors (16 errors among 3337 prescription orders) than incident reports (0 errors among 3337 prescriptions).[30] However, this study was small scale, involving data collection at a single mail-service pharmacy over 5 days and little is known about the accessibility of incident forms to the pharmacy clients.[30] Thus the study findings may not be generalizable to other community and hospital pharmacy settings.

Operational definitions

Dispensing errors

This review identified a myriad of terms ($n = 8$) and definitions ($n = 21$) used to describe dispensing errors with terminology

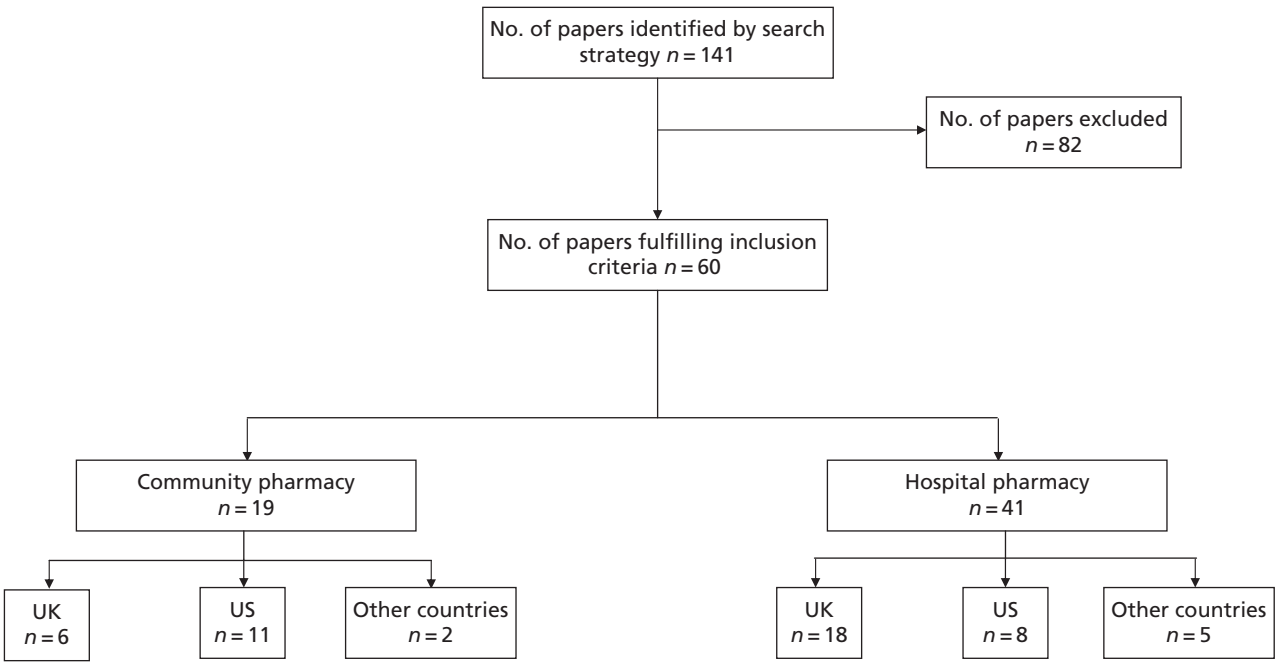

Figure 2 Summary of the literature search.

being used interchangeably (Table 4).[3,15,17,19,21,25,27–33,37–41,43,44,46–48,50,59,61,65,66,71,72] Nineteen different definitions for the term dispensing error were identified. These nineteen definitions were all embracing, encompassing descriptions of the action involved in the error (e.g. 'a discrepancy between the prescriber's written interpretable written order and the filled prescription…'[25]) and/or type of dispensing errors (e.g. '… wrong drug or dose strength; incorrectly labelled directions or drug dispensed to wrong patient'[31]). The remaining three definitions related to error detection. Dispensing errors detected after the medication had been issued and left the pharmacy were described as dispensing errors, external errors, incidents and/or unprevented dispensing incidents. In contrast, dispensing errors detected within the pharmacy before issue of medication to patients were termed near-miss, internal errors, dispensing incidents and/or prevented dispensing incidents. A filling error was also used to describe a dispensing error detected by pharmacists during accuracy checking/verification of dispensed medicines. The multiplicity and interchanging of terminology and definitions for dispensing errors confounds the comparison of identified research papers.

Franklin and O'Grady[19] were the only researchers to describe the development of a definition for a dispensing error. In their study, they employed the Delphi technique to explore an expert panel's (n = 20) views of a proposed definition for a dispensing error.[43] Based on the responses of 16 experts to two rounds of Delphi surveys, consensus was achieved and a dispensing error was defined as the following. 'Any unintended deviation from an interpretable written prescription or medication order. Both content and labelling errors are included. Any unintentional deviation from professional or regulatory references or guidelines affecting dispensing procedures.'[19]

Classification of error types

Various categories were employed by the identified research papers (66%, n = 39) to classify the different types of dispensing errors occurring in community (Table 5)[15,17,19,21,24,25,27–32] and hospital pharmacy (Table 6).[3,33–37,39,41–44,47–50,52,54,56–61,63,64,70,71] The most common error categories identified in the research papers were dispensing the wrong drug (100%, n = 39), strength (95%, n = 37), dosage form (77%, n = 30) and quantity (69%, n = 27), and labelling drugs with the wrong directions (77%, n = 30). Errors arising during the screening of prescriptions for legal validity and clinical safety,[49,50,54] completing controlled drug documentation[43,50,54,61] and reconstituting and preparing extemporaneous medicines[63,65] were included in a few research papers despite being typically subject to separate risk-management procedures.[39]

Dispensing error rate

Forty-five reviewed papers reported the dispensing error rate in community and/or hospital pharmacy (Tables 7 and 8).[14,15,17,19,21,24–28,30,32], [3,33–35,38,39,43–47,49–57,59–72] However, only 18% (n = 8) of these papers clearly defined the calculation of dispensing-error rate.[15,28,30,52,56,59,61,62] In the remaining 37 papers, the dispensing-error rate calculation (numerator and denominator) was elucidated from the data presented in the papers.

Overall a range of different numerators and denominators were employed by the reviewed papers to determine the dispensing error rate (Tables 7 and 8). The numerator was defined as the number of prescriptions or error reports containing one or more different error types (18%, n = 8), the total number of each mutually exclusive error type (16%, n = 7), number of doses with errors (5%, n = 2) and number of errors discovered by auditors/undetected by pharmacy staff (5%, n = 2). However, in

Table 3 Description, strengths and limitations of dispensing-error research methods employed by identified research papers

Research method	Description of method	Reference for identified papers employing research method						Strengths	Limitations
		Community pharmacy			Hospital pharmacy				
		UK	US	Other countries	UK	US	Other countries		
Incident forms	Details of errors reported by staff on standardized forms.	[14–18]	[30]	[32]	[3,33–35, 37–39, 41–48,72]	[64–66]	[67–70]	Used to investigate incidence, type and causes of errors. Anonymity can eliminate fear of disciplinary action.	Identity of person completing form is ambiguous. Under-reporting due to fear of disciplinary action or lack of awareness of error. Underestimates incidence of error.
Observation	Researcher observes dispensing process or performs independent accuracy check of dispensed medicines. Any errors detected are recorded.	[19]	[24–28,30]			[49–57, 59,61, 65,66]	[71]	Used to investigate incidence, types and causes of errors. Highly sensitive. Does not rely on awareness or willingness of staff to report.	Presence of observer may influence staff performance (Hawthorne effect). Observer may fail to detect error. Overestimates incidence of unprevented dispensing incidents (errors detected after medication has left the pharmacy).
Covert patients	Covert patients present legally valid prescription for dispensing at pharmacy. Medicines dispensed to covert patient checked for accuracy by researcher.		[21]					Used to investigate incidence and types of errors. Accurate estimate of incidence of errors. Does not rely on awareness or willingness of staff to report.	Expensive. Time-consuming. Selection of drugs prescribed on covert patients' prescriptions may influence generalizability of study findings.
Case-note review	Trained reviewers screen patients' case notes to identify errors.					[58,63]		Used to investigates incidence and types of errors. Large amount of information on error.	Relies on documentation of error in patients' case notes. Time-consuming. Expensive. Dependent on reviewers' experience and ability to conduct adequate review.
Simulation	Dispensed medicines with artificially introduced errors checked by study participants and any errors detected on a form. Researchers double-checked the dispensed products and data-collection form to determine the accuracy of the study participants at detecting dispensing errors.					[60,62]		Used in research and training to evaluate accuracy of pharmacy and nursing staff at detecting errors.	Artificial errors may not be representative of range of dispensing errors encountered in real-life practice. Working and environmental conditions imposed on study participants may not be consistent with real-life working conditions.
Surveys	Postal surveys sent to pharmacy staff to elucidate opinions on causes of dispensing errors.		[20,22, 23, 29]	[31]				Used to identify factors contributing to errors. Effectively collects data from large sample of pharmacy staff in short-time.	Low response rates. No follow-up of non-respondents. Responses highly subjective.
Interviews	Semi-structured interviews with pharmacy staff involved in error 24–48 hours after error occurred.				[40,43]			Used to explore causes and circumstances surrounding error.	Relies on recall. Highly subjective. Staff may not fully divulge details of error.
Focus groups	Group discussions with pharmacy staff.	[15]						Used to explore causes of errors and risk reduction strategies.	Does not address individual errors or trends.

Table 4 Definitions describing dispensing errors

Term	Definition	Identified research papers	
		Community pharmacy	Hospital pharmacy
Dispensing error	An error detected and reported after the medication has left the pharmacy.	[15,17]	[3,37,41]
	Any unintended deviation from an interpretable written prescription or medication order. Both content and labelling errors are included. Any unintentional deviation from professional or regulatory references or guidelines affecting dispensing procedures.	[19]	
	Any deviation from the physician's written prescription.	[21]	
	A discrepancy between the prescriber's interpretable written order and the filled prescription including written modifications made by the pharmacist pursuant to contact with the prescriber or in compliance with pharmacy policy.	[25]	
	Errors that occur when distributing or selling prescription to patient's or patient's agents.	[27]	
	Discrepancy between the prescriber's written order and the filled prescription.	[28]	
	Any inconsistencies or deviations from the prescription order such as dispensing the incorrect drug, dose, dosage form, wrong quantity; inappropriate, incorrect or inadequate labelling; confusing or inadequate directions for medication use; incorrect or inappropriate preparation, packaging or storage of medication prior to opening.	[29]	
	A deviation from the prescriber's orders, as received by fax or electronically and made by staff in the pharmacy, prior to releasing (dispatching) the dispensed prescription to the carrier for delivery to a specific cost centre.	[30]	
	Errors in the dispensing process (e.g. wrong drug or dose strength; incorrectly labelled directions or drug dispensed to wrong patient) that are not detected and corrected prior to the patient leaving the pharmacy, and which may lead to sub-optimal outcomes of treatment for the patient.	[31]	
	An error in connection with dispensing the prescriptions at the community pharmacy. These will have reached the patients. Prescribed medicines were included.	[32]	
	Any variation from a perfect presentation including such minor errors as typographical mistakes.	[33]	
	An error arising during the dispensing process, ignoring errors involving the pharmacist's clinical check. First, an error is dispensing the wrong medication; that is the wrong drug, wrong form, the wrong strength or wrong dose. Second, a dispensing error involves incomplete or improper labelling. Other dispensing errors do occur.		[39]
	A deviation from an interpretable written prescription or medication order, including written modifications made by a pharmacist following contact with the prescriber or in compliance with pharmacy policy. Any deviation from professional or regulatory references, or guidelines affecting dispensing procedures.		[43,46]
	Categorized by the origins of the error; these included pharmacist's error in labelling (labelling error), pharmacist's error in filling medication bottles (content errors) or pharmacist's errors in completing the prescription form (administrative error).		[50]
	One or more deviations from a physician's written medication order.		[59]
	Any event involving one or more deviations from an interpretable physician order, including written modifications made by the pharmacist pursuant to contact with the prescriber or in compliance with pharmacy policy.		[61]
	Any discrepancy between dispensed medications and physician orders or replenishment reports. Any deviation from standard pharmacy policies.		[65]
	Error caught by a pharmacist observer after verification by the pharmacist.		[66]
	Discrepancy between the written instruction found on the prescription order form and the accomplishment of this instruction by the pharmacy when the drug was dispensed to the wards or hospital services.		[71]
Near-miss	Any error that was detected up to and including the point at which the medication was handed over to the patient or patient's representative.	[17]	
External errors	Errors detected and reported after issue of medication.		[33,38]
Internal errors	Errors detected within pharmacy before the dispensed item is issued.		[33,38,40]
Dispensing incidents	An error which is detected prior to the item leaving the pharmacy and after the person dispensing the item has completed their part of the process.		[3]
Incidents	Errors detected outside the pharmacy department.		[34]
Unprevented dispensing incidents	Unprevented patient safety incident detected after the medication has left the pharmacy, which could have or did lead to patient harm.		[44,47,72]
Prevented dispensing incidents	Errors identified before the medication has left the pharmacy department.		[48,72]
Filling error	Error caught by a pharmacist during the verification step.		[66]

Table 5 Classification of dispensing error types in community pharmacy research

	Reference	[15]	[17]	[19]	[21]	[24]	[25]	[27]	[28]	[29]	[30]	[31]	[32]
	Country	UK	UK	UK	US	US	US	US	US	US	US	Australia	Denmark
	Unprevented (U)/prevented (P) dispensing incident	U & P	U & P	U	U	U & P	U	U	U	U	U & P	U	U
Drug/content error	Wrong drug dispensed	X	X	X	X	X	X	X	X	X	X	X	X
	Wrong strength dispensed	X	X	X	X	X	X	X	X	X	X	X	X
	Wrong form dispensed	X	X	X	X	X	X	X	X	X	X		X
	Wrong quantity dispensed	X	X	X	X	X	X	X		X			X
	Expired/deteriorated drug			X		X	X	X	X				
	Failure to supply drug	X	X	X		X	X						
Labelling error	Wrong drug name on label		X	X	X	X	X				X		
	Wrong strength on label		X	X	X	X	X				X		
	Wrong dosage form on label		X	X							X		
	Wrong directions/warnings on label	X	X	X	X	X	X	X	X	X	X	X	X
	Wrong patient name on label	X	X	X	X	X	X						
	Wrong quantity on label		X	X		X	X				X		
	Wrong ward/cost centre/prescriber				X	X	X						
	Completely wrong label on bottle	X	X										X
Issue error	Issued to wrong patient							X				X	X
	Incorrectly bagged	X											
Other errors			X	X	X	X	X		X	X			X

X denotes inclusion in reviewed research paper. Error types categorized as 'other' include wrong name on bag, wrong patient address on bag, extra item in bag, incorrect date on label, incorrect pharmacy address on label, incorrect pharmacy name on label, incorrect prescription number on label, incorrect manufacturer, incorrect expiry date on label, drug dispensed in blister at wrong time, incorrect/inappropriate packaging/storage and incorrect delivery of medicines.

the majority (39%) of papers it was unclear whether the numerator referred to the number of error reports or the total number of mutually exclusive errors. The denominators were most commonly defined as the number of items dispensed (37%, $n = 17$), prescriptions (25%, $n = 11$) and doses (9%, $n = 4$). Other denominators employed by research papers were number of observations (2%, $n = 1$), artificial errors (2%, $n = 1$), clinic orders (2%, $n = 1$), medication lines (2%, $n = 1$) and unintentional therapeutic exposures (2%, $n = 1$).

Dispensing errors in community pharmacy

Incidence in the UK

Four reviewed papers investigated the incidence of dispensing errors in UK community pharmacies.[14,15,17,19] All four of these papers reported the incidence of unprevented dispensing incidents but only two papers[15,17] reported the incidence of prevented dispensing incidents. The incidences of prevented and unprevented dispensing incidents are summarized in Table 7. Prevented dispensing incidents occurred at a rate of 0.22–0.48%. In contrast, the rate of unprevented dispensing incidents varied considerably from 0.04 to 3.32%. This wide variation in the rate of unprevented dispensing incidents can be attributed to differences in operational definitions (error definition, classification of error types and error rate) and research methods employed by the different papers (Tables 3–5 and 7). An observational study, conducted by Franklin and O'Grady,[19] reported a considerably higher unprevented dispensing incident rate (3.32%) than the other studies employing incident forms (0.04–0.99%).[14,15,17] However, the data-collection procedure employed by Franklin and O'Grady[19] was inconsistent. In this study, previously dispensed items awaiting collection were double-checked by the observer at 11 pharmacies over 2 working days separated by a week. This was supplemented by real-time observation of the dispensing process (number of items observed ranged from 0 to 98) at seven pharmacies to ensure sufficient data were collected.[19] This real-time observation may have influenced the behaviour of pharmacy staff. In addition, the paper does not specify whether any strategies were implemented to prevent the observer from double-checking items included in the previous data-collection period. Consequently, the validity, reliability and reproducibility of study findings are compromised.

Incidence in the US

Seven reviewed papers investigated the incidence of dispensing errors in US community pharmacies.[21,24–28,30] Each of these papers reported the incidence of unprevented dispensing incidents but only one paper[24] investigated the incidence of prevented dispensing incidents. The incidences of prevented and unprevented dispensing incidents are summarized in Table 7. The rate of prevented dispensing incidents was 1.28% but the rate of unprevented dispensing incidents ranged from 0.08 to 24%. Similar to research in UK community pharmacies, differences in operational definitions may have contributed to the wide-ranging rate of unprevented dispensing incidents.

A highly automated mail-service pharmacy was associated with the lowest rate of unprevented dispensing incidents (0.08%).[26] Flynn and Barker[28] demonstrated that automation reduced the incidence of unprevented dispensing incidents at two community pharmacies (site 1: pre-automation = 2.7%,

Table 6 Classification of dispensing error types in hospital pharmacy research

	Reference	[3]	[33]	[34]	[35]	[37]	[39]	[41]	[42]	[43]	[44]	[47]	[48]	[49]	[50]	[52]	[54]	[56]	[57]	[58]	[59]	[60]	[61]	[63]	[64]	[65]	[70]	[71]
	Country	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	US	US	US	US	US	US	US	US	US	US	US	US	Spain	Brazil
	Unprevented (U)/ prevented (P) incidents	U & P	U & P	P	P	U	U	U	P	U & P	U	U	P	U	U	U	U	U	U	U	U	U	U	U	U	U & P	U	U
Drug/content error	Wrong drug dispensed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Wrong strength dispensed	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X
	Wrong dosage form dispensed	X	X	X			X		X	X	X	X	X		X	X	X	X			X	X	X			X	X	X
	Wrong quantity dispensed		X	X	X	X	X	X	X	X	X	X	X	X					X		X	X	X			X		X
	Expired/deteriorated drug	X					X		X	X	X	X	X	X					X							X		
	Failure to supply prescribed drug								X		X	X	X	X			X	X		X						X	X	X
Labelling error	Wrong drug name on label	X		X						X	X	X	X		X	X	X				X		X	X				
	Wrong strength on label	X		X						X	X	X	X		X	X	X				X		X					
	Wrong dosage form on label	X		X						X	X	X	X		X	X	X							X				
	Wrong directions/warnings on label	X		X	X	X	X	X	X	X	X	X	X		X	X	X			X	X		X	X				
	Wrong patient name on label	X		X			X			X	X	X	X		X	X	X				X		X		X			
	Wrong quantity on label			X						X	X	X	X		X	X	X				X		X					
	Wrong ward/cost centre/ prescriber	X		X							X	X	X		X	X					X		X		X			
	Completely wrong label on bottle	X									X	X	X															
Issue error	Issued to wrong patient										X	X		X													X	
	Incorrect bag label										X	X																
	Incorrectly bagged										X	X					X											
Other error		X	X	X			X		X	X	X	X	X	X	X		X	X			X		X	X		X		X

X denotes inclusion in reviewed research paper. Errors categorized as 'other' include typographical error, container error, incorrect date on label, pharmacy address missing/incorrect, documentation errors, absent/incorrect controlled drug documentation, wrong/missing expiry date on label, issued to wrong ward, failure to relabel patient's own drug, oral syringe marked incorrectly, wrong calculation, extra medicine dispensed, drug continued past automatic stop, absent/incorrect prescription number, absent patient name, absent drug strength, absent drug quantity, directions changed inappropriately, neglect to clarify order, absent directions, no controlled drug stamp, no child-resistant closure, no pharmacist initials, absent refill instructions, wrong dosage form in directions, patient name missing, charge code/lot number missing, patient address not recorded for controlled drug, request for non-child-resistant closure not signed, drug supplied not ordered, wrong manufacturer/distributor, incorrect liquid dilution, incorrect capsule preparation, overdosage/underdosage, wrong signature, wrong order entry, reconstitution error, medicine prescribed without administration schedule, quantity, concentration and/or form dispensed.

Table 7 Incidence of dispensing errors in community pharmacy

Reference	[14]	[15]	[17]	[19]	[21]	[24]	[25]	[26]	[27]	[28]	[30]	[32]
Country	UK	UK	UK	UK	US	US	US	US	US	US	US	Denmark
Research method	Incident form	Incident form	Incident form	Observation	Covert patients	Observation	Observation	Observation	Observation	Observation	Observation & incident forms	Incident forms
Setting	4 Pharmacies in Scotland	4 Pharmacies in England	35 UK pharmacies	11 Pharmacies in England	100 Pharmacies	Unclear	50 Pharmacies	1 Mail-service pharmacy	18 Pharmacies	2 Pharmacies	1 Mail-service pharmacy	40 Pharmacies
Dispensing system	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Repackaging automated dispensing system	Manual[a]	Repackaging automated dispensing system	Manual[a]	Manual[a]
Unprevented (U)/ prevented (P) dispensing incidents	U	U & P	U & P	U	U	U & P	U	U	U	U	U	U
Definition for numerator	Unspecified	Total no. of mutually exclusive error type	Total no. of errors	Unspecified	No. of prescriptions containing one or more error type	Unspecified	Total no. of errors	Total no. of errors	Total no. of errors	No. of prescriptions containing one or more error type	No. of prescriptions containing one or more error type	Total no. of errors
Numerator	50	U = 39 P = 247	U = 50 P = 280	U = 95	U = 28	U = 91 P = 74	77	16	5	Site 1: pre-automation = 92, post-automation = 58 Site 2: pre-automation = 58, post-automation = 57	16	203
Definition for denominator	No. of prescriptions	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of prescriptions	No. of prescriptions	No. of prescriptions	No. of prescriptions	No. of observations	No. of prescriptions	No. of prescriptions	No. of prescriptions
Denominator	5004	51 357	125 359	2859	100	5784	4481	21 252	950	Site 1: pre-automation = 3427, post-automation = 3241 Site 2: pre-automation = 3424, post-automation = 3028	3337	1 466 043
Incidence (%)	0.99%	U = 0.08% P = 0.48%	U = 0.04% P = 0.22%	3.32%	24%	U = 1.57% P = 1.28%	1.71%	0.08%	0.5%	Site 1: pre-automation = 2.7%, post-automation = 1.8% Site 2: pre-automation = 1.7%, post-automation = 1.9%	0.48%	0.01%

[a]Inadequate description of dispensing process or no reference to automated dispensing system in research paper, therefore the dispensing system was assumed to be manual.

Table 8 Incidence of dispensing errors in hospital pharmacy

Reference	[3]	[33]	[34]	[35]	[38]	[39]	[43]	[44]	[45]	[46]	[47]	[72]
Country	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK	UK
Research method	Forms	Forms	Forms	Forms	Forms	Forms	Forms	Forms	Forms	Observation	Forms	Forms
Setting	19 NHS hospitals (teaching, district general, psychiatric)	5 NHS hospitals (teaching, district general, psychiatric)	1 NHS district general hospital	1 NHS hospital	1 Acute NHS Trust	1 NHS teaching hospital	1 NHS teaching hospital	1 NHS teaching hospital	1 NHS teaching hospital	2 NHS hospitals	20 NHS hospitals (teaching, district general, psychiatric)	5 NHS hospitals
Dispensing system	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual and pharmacy-based original pack automated dispensing system	Pharmacy-based original pack automated dispensing system	Manual and pharmacy based original pack automated dispensing system	Manual dispensing (n = 17), pharmacy-based original pack dispensing system (n = 3)	Manual dispensing (n = 3), pharmacy-based original pack dispensing system (n = 2)
Unprevented (U)/prevented (P) dispensing incidents	U	U	P	P	U & P	U	U & P	U	P	P	U	U & P
Definition for numerator	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors reported containing one or more error types	Total no. of errors reported containing one or more error types	Total no. of errors	Total no. of errors reported containing one or more error types	Total no. of errors reported containing one or more error types
Numerator	181	21	180	352	Pre-intervention: U = 52, P = 351, post-intervention: U = 16, P = 359	Unspecified	U = 32 P = 130	Pre-automation = 42, post-automation = 32	89	Site 1: pre-automation = 245, post-automation = 93 Site 2: pre-automation 1 = 118, pre-automation 2 = 99, post-automation = 46	915	U = 35 P = 291
Definition for denominator	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of items dispensed
Denominator	1 002 095	Unknown	38 846	37 828	Pre-intervention: 332 501, post-intervention: 165 212	Unspecified	U = 194 584 P = 4849	Pre-automation = 391 467, post-automation = 429 911	3930	Site 1: pre-automation = 9161, post-automation = 9289 Site 2: pre-automation 1 = 8250, pre-automation 2 = 8033, post-automation = 7894	5 564 969	221 670
Incidence	0.02%	0.02%	0.4%	0.94%	Pre-intervention: U = 0.02%, P = 0.11%; post-intervention: U = 0.009%, P = 0.22%	0.02%	U = 0.02% P = 2.7%	Pre-automation = 0.01% Pre-automation = 0.008%	2.26%	Site 1: pre-automation = 2.7%, post-automation = 1% Site 2: pre-automation 1 = 1.4%, pre-automation 2 = 1%, post-automation = 0.6%	0.02%	U = 0.02% P = 0.13%

Table 8 (*Continued*)

Reference	[49]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[59]	[60]
Country	US	US	US	US	US	US	US	US	US	US	US
Research method	Observation	Observation	Observation	Observation	Observation	Observation	Observation	Observation	Observation	Observation	Simulation
Setting	Satellite pharmacy serving medical wards in teaching hospital	1 Outpatient hospital pharmacy	Ambulatory care pharmacy	Outpatient pharmacy in general Army hospital	3 Minnesota hospitals	1 Teaching hospital	1 Teaching hospital	3 Large hospitals	1 Teaching hospital	1 Hospital pharmacy	1 Teaching hospital
Dispensing system	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual[a]	Manual and repackaging system	Manual[a]	Manual[a]
Unprevented (U)/ prevented (P) dispensing incidents	U	U	U	U	U	U	U	U	U	U	U
Definition for numerator	Total no. of errors	Total no. of errors	Unspecified	No. of prescriptions containing one or more error type	Unspecified	No. of prescriptions containing one or more error type	Total no. of errors	Total no. of errors	Total no. of errors	No. of prescriptions containing one or more error type	No. of artificial errors undetected
Numerator	Pharmacist = 45 Technician = 21	1165	Unspecified	369	Unspecified	1229	Pharmacist = 34 Technician = 10	Pharmacist = 107 Technician = 50	Manual = 34 Automated = 25	164	Pharmacists = 100 Nurses = 145
Definition for denominator	No. of doses	No. of prescriptions	Unspecified	No. of prescriptions	Unspecified	No. of prescriptions	No. of doses	No. of doses	No. of doses	No. of prescriptions	No. of artificial errors
Denominator	Pharmacist = 2420 Technician = 2403	9394	Unspecified	10 888	Unspecified	9846	Pharmacist = 3116 Technician = 7571	Pharmacist = 49 718 Technician = 55 470	Manual = 4029 Automated = 3813	5072	812
Incidence (%)	Pharmacist = 1.86% Technician = 0.87%	12.4%	Pharmacist = 5.17% Technician = 4.17%	3.39%	0.06%	12.5%	Pharmacist = 1.09% Technician = 0.13%	Pharmacist = 0.215% Technician = 0.09%	Manual = 0.84% Automated = 0.65%	3.23%	Pharmacists = 12% Nurses = 18%

(*Continued*)

Table 8 (*Continued*)

Reference	[61]	[62]	[63]	[65]	[66]	[67]	[68]	[69]	[70]	[71]
Country	US	US	US	US	US	Australia	Australia	Australia	Spain	Brazil
Research method	Observation	Simulation	Case-note review	Observation	Observation	Observation	Observation	Observation	Observation	Observation
Setting	1 Hospital	2 Tertiary care hospitals	Regional poisons control centre	1 Tertiary hospital	Teaching hospital	1 Hospital	1 Hospital	1 Hospital	1 University hospital	1 Public hospital
Dispensing systems	Manual[a]	Manual[a]	No details	Manual[a]	Repackaging system	No details	No details	No details	Manual[a]	No details
Unprevented (U)/ prevented (P) dispensing incidents	U	U	U	U & P	U	U	U	U	U	U
Definition for numerator	No. of prescriptions containing one or more error type	No. of errors discovered by auditors	Total no. of errors	No. of doses with errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	Total no. of errors	No. of drugs with one or more errors
Numerator	164	Pharmacists = 172 Technicians = 178	40	U = 1059 P = 4016	Unspecified	Unspecified	Study period 1 = 1 Study period 2 = 2 Study period 3 = 3	0	20	345
Definition for denominator	No. of prescriptions	No. of doses	Unintentional therapeutic exposures	No. of doses	Clinic orders	No. of items dispensed	No. of items dispensed	No. of items dispensed	No. of medication lines	No. of prescriptions
Denominator	5072	Pharmacists = 35 829 Technicians = 161 740	6450	140 755	Unspecified	Unspecified	Study period 1 = 84 Study period 2 = 520 Study period 3 = 360	24 174	2827	422
Incidence (%)	3.32%	Pharmacists = 0.48% Technicians = 0.11%	0.62%	U = 2.9% P = 0.75%	Pre-automation = 0% Post-automation = 1.2%	0.08%	Study period 1 = 0.4% Study period 2 = 0.4% Study period 3 = 0.8%	0	0.7%	81.8%

[a]Inadequate description of dispensing process or no reference to automated dispensing system in research paper, therefore the dispensing system was assumed to be manual.

post-automation = 1.8%, $P = 0.014$; site 2: pre-automation = 1.7%, post-automation = 1.9%, $P = 0.57$). Therefore, the type of dispensing system employed by the community pharmacy may also have influenced the incidence of unprevented dispensing incidents.

The highest rate of unprevented dispensing incidents (24%) was determined using covert patients.[21] In this study, three covert patients presented a prescription for a single item (warfarin, carbamazepine or theophylline) at 100 randomly selected pharmacies.[21] This paper may provide the most accurate measurement of the incidence of unprevented dispensing incidents in US community pharmacies as the findings are not influenced by under-reporting or the Hawthorne effect. However, only a limited range of drugs at high risk of dispensing errors[73] were included in the study, and thus the findings may not be comparable with other studies.

Postal surveys of pharmacists have also been used to estimate the extent of dispensing errors in US community pharmacies.[20,22,23,29] Ukens[20] reported that all retail pharmacists who responded to the survey ($n = 359$) were aware of making a dispensing error in the previous 3 years. In a further survey, 53% ($n = 109$) of retail pharmacists reported making a dispensing error in the previous 60 days (mean = 2.5 errors in previous 60 days).[22] In contrast, Bond and Raehl[23] reported that 34% ($n = 793$) of pharmacists surveyed perceived that at least one patient per week was at risk of a dispensing error. However, there is no significant difference in the number of dispensing errors made per month by mass-merchant/supermarket pharmacists (2.7 errors), chain pharmacists (2.4 errors) and independent pharmacists (3.4 errors).[29]

Incidence in Australia

A postal survey of Tasmanian pharmacists revealed that 71% ($n = 134$) of respondents were aware of making an unprevented dispensing incident within the previous 6 months.[31] The median number of unprevented dispensing incidents made by the pharmacist was three (range 1–50). The majority of respondents ($n = 171$, 82%) perceived that the risk of unprevented dispensing incidents was increasing but only 47% ($n = 96$) indicated that actual unprevented dispensing incidents were becoming more common.[31] However, the survey findings are highly subjective and may not truly reflect the incidence of unprevented dispensing incidents in practice.

Incidence in Denmark

The overall rate of unprevented dispensing incidents in 40 Danish pharmacies was 0.01% (Table 7).[32]

Error types in the UK

Five reviewed papers investigated the types of dispensing error in UK community pharmacies.[14,15,17–19] All five papers reported the types of unprevented dispensing incidents but two papers[15,17] also recorded the types of prevented dispensing incidents. The most common types of unprevented dispensing incidents reported were supply of the wrong drug, strength and form, and printing the wrong directions on the label (Figure 3).[14,15,17–19] The most common prevented dispensing incidents reported were supply of the wrong drug, strength, form and quantity (Table 9).[15,17]

Error types in the US

Five reviewed papers investigated the types of dispensing error in US community pharmacies employing manual dispensing systems.[21,24,25,28,30] Flynn and colleagues[24] investigated the types of both unprevented and prevented dispensing incidents but combined the data to provide the main types of dispensing errors. These dispensing errors were predominantly labelling (58.24%) and drug/content errors (41.76%).[24] Four papers reported the types of unprevented dispensing incidents.[21,25,28,30] Unprevented dispensing incidents most commonly involved supply of the wrong strength, dosage form of medication and labelling medicines with the wrong directions (Figure 4).[21,25,28,30] Flynn and colleagues[28] compared the types of unprevented dispensing incidents reported at two pharmacies pre- and post-automation. In this study, automation reduced errors involving supply of the wrong dose (site 1: pre-automation = 8%, post-automation = 5%; site 2: pre-automation = 9%, post-automation = 5%) and wrong directions (site 1: pre-automation = 69%, post-automation = 64%; site 2: pre-automation = 74%, post-automation = 67%) (Figure 4).

Postal surveys of community pharmacists have also examined pharmacists' views on the most common types of dispensing errors.[20,22] These surveys have identified that pharmacists perceive that supply of the wrong dosage (47%, $n = 49$) and wrong drug (36%, $n = 38$) are the most common dispensing errors in US community pharmacies.[20,22]

Error types in other countries

Reviewed papers detailing research undertaken in Australian[31] and Danish[32] community pharmacies did not identify the types of dispensing errors.

Dispensing errors in hospital pharmacy

Incidence in the UK

Fourteen reviewed papers investigated the incidence of dispensing errors in UK hospital pharmacies.[3,33–36,38,39,42–47,72] Six of these papers investigated unprevented dispensing incidents,[3,33,36,39,44,47] five papers investigated prevented dispensing incidents[34,35,42,45,46] and three papers investigated both unprevented and prevented dispensing incidents.[38,43,72] The incidence of unprevented dispensing incidents ranged from 0.008 to 0.02% (Table 8). In contrast, prevented dispensing incidents occurred more frequently at a rate of 0.11–2.7% (Table 8). The wide range of error rates reported for unprevented and prevented dispensing incidents may be attributed to differences in research methods, operational definitions and dispensing systems (Tables 3, 4, 6 and 8).

Five papers involved hospitals with an automated dispensing system.[44–47,72] However, two of these papers were multisite studies and little information was provided on the incidence of dispensing errors at the participating hospitals employing automated dispensing systems.[47,72] Adedoye[45] reported that an automated dispensing system was associated with a prevented dispensing incident rate of 2.26%. However, a

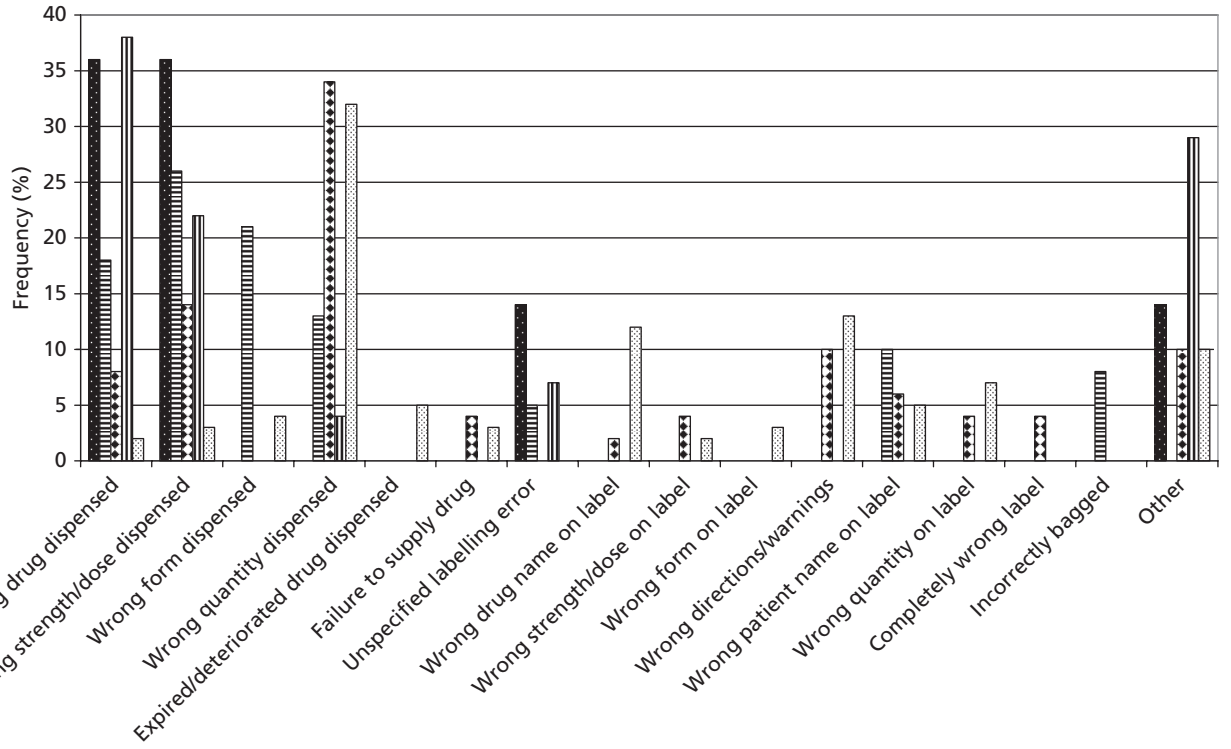

Figure 3 Most common types of unprevented dispensing incidents reported by UK community pharmacies with manual dispensing systems. Where (■) Kayne[14] (n = 50); (▤) Chua[15] (n = 39); (▣) Ashcroft[17] (n = 50); (▥) Murphy[18] (n = 434); (▨) Franklin[19] (n = 95).

Table 9 Most common prevented dispensing incidents occurring in UK community pharmacies

	Chua *et al.*[15]		**Ashcroft *et al.*[17]**	
	n	%	*n*	%
Wrong drug dispensed	48	19.4	98	35
Wrong strength dispensed	56	22.7	35	12.5
Wrong form dispensed	39	15.8	0	0
Wrong quantity dispensed	45	18.2	38	13.6
Failure to supply drug	0	0	3	1.1
Labelling error	43	17.4	0	0
Wrong drug name on label	0	0	13	4.6
Wrong strength on label	0	0	23	8.2
Wrong directions/warnings on label	3	1.2	25	8.9
Wrong quantity on label	0	0	4	1.4
Wrong patient name on label	13	5.3	26	9.3
Completely wrong label	0	0	3	1.1
Other errors	0	0	12	4.3
Total	**247**	**100**	**280**	**100**

comprehensive study conducted pre- and post-automation at two London hospitals revealed that automation significantly reduced the incidence of prevented dispensing incidents (site 1: pre-automation = 2.7%, post-automation = 1%; site 2: pre-automation = 1.2%, post-automation = 0.6%).[46] This supports previous research by Fitzpatrick and colleagues[42] which reported that automation reduced the incidence of prevented dispensing incidents by 16%. However, not all medication is suitable for dispensing from an automated dispensing system and it is unclear whether items dispensed manually in the post-automation period were included in the study.[8,42,46] James and colleagues[44] reported that automation reduced the incidence of unprevented dispensing incidents from 0.01% (pre-automation) to 0.008% (post-automation). Excluding manually dispensed items, the incidence of unprevented dispensing incidents had been reduced by 67%.[44] Slee and

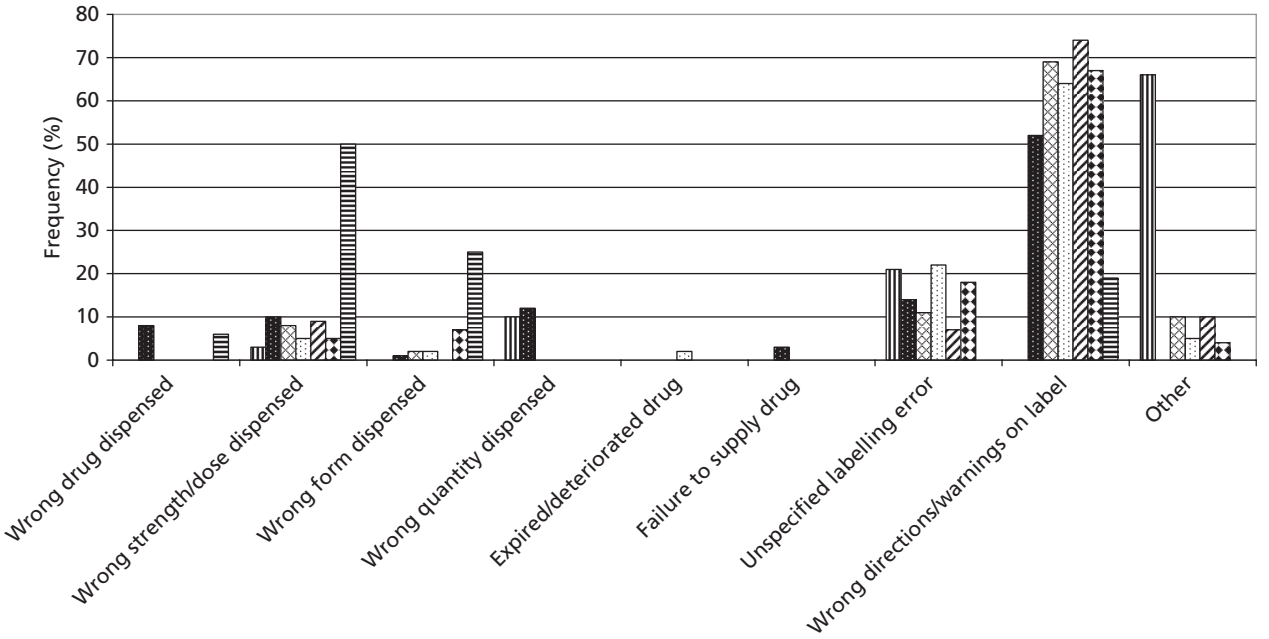

Figure 4 Most common types of unprevented dispensing incidents reported by US community pharmacies with manual[21,25,28,30] and automated[28] dispensing systems. Where (▥) Allan[21] (n = 100); (■) Flynn[25] (n = 77); (▩) Flynn[28] site 1: pre-automation (n = 92); (□) Flynn[28] site 1: post-automation (n = 58); (▨) Flynn[28] site 2: pre-automation (n = 58); (▤) Flynn[28] site 2: post-automation (n = 57); (▤) Varadarajan[30] (n = 16).

colleagues[36] also reported that automation reduced the rate of dispensing error by 40% but the operational definitions and research methods used in the study were not clearly defined.

Incidence in the US

Sixteen reviewed papers investigated the incidence of dispensing errors in US hospital pharmacies.[49–57,59–63,65,66] All of these papers reported the incidence of unprevented dispensing incidents but one paper[65] also reported the incidence of prevented dispensing incidents. The incidence of unprevented dispensing incidents ranged from 0.06 to 18% (Table 8). Prevented dispensing incidents occurred at a rate of 0.75% (Table 8).

In a study comparing the accuracy of pharmacists and nurses at checking dispensed items, nurses were found to have a significantly higher rate of unprevented dispensing incidents (nurses = 18%, pharmacists = 12%; $P < 0.05$) (Table 8).[60] In contrast, pharmacists were reported to have a higher unprevented dispensing incident rate than technicians.[49,51,55,56,62] However, these study findings may not be generalizable as the artificial errors and conditions imposed on pharmacists, nurses and technicians may not be consistent with real life.

Two papers reported the incidence of unprevented dispensing incidents pre- and post-automation at two US hospitals.[57,66] Klein and colleagues[57] reported that an automated dispensing system reduced the incidence of unprevented dispensing incidents from 0.84 to 0.65%. In contrast, Oswald and Caldwell[66] reported that automation increased the incidence of unprevented dispensing incidents from 0 to 0.12%. However, it is unclear whether these research papers included manually dispensed items in the post-automation analysis of unprevented dispensing incidents.[57,66]

Incidence in Australia

Three reviewed papers investigated the incidence of unprevented dispensing incidents in hospital pharmacies.[67–69] The reported rate of unprevented dispensing incidents ranged from 0 to 1.6% (Table 8). However, the research methods and operational definitions utilized in these studies were ambiguous.

Incidence in Brazil

The single research paper investigating unprevented dispensing incidents in a Brazilian hospital identified that 82% (n = 345) of dispensed prescriptions contained at least one unprevented dispensing incident.[71]

Incidence in Spain

The rate of prevented dispensing incidents in a Spanish hospital was 0.7% (Table 8).[70]

Error types in the UK

Fourteen papers investigated the types of dispensing error occurring in UK hospitals.[3,33–35,37,39,41–47,72] Five papers investigated unprevented dispensing incidents,[37,39,41,44,47] five papers explored prevented dispensing incidents[34,35,42,45,46] and four papers researched both unprevented and prevented dispensing incidents.[3,33,43,72] The most common types of unprevented dispensing incidents in hospitals with both manual and automated dispensing systems were supplying the wrong

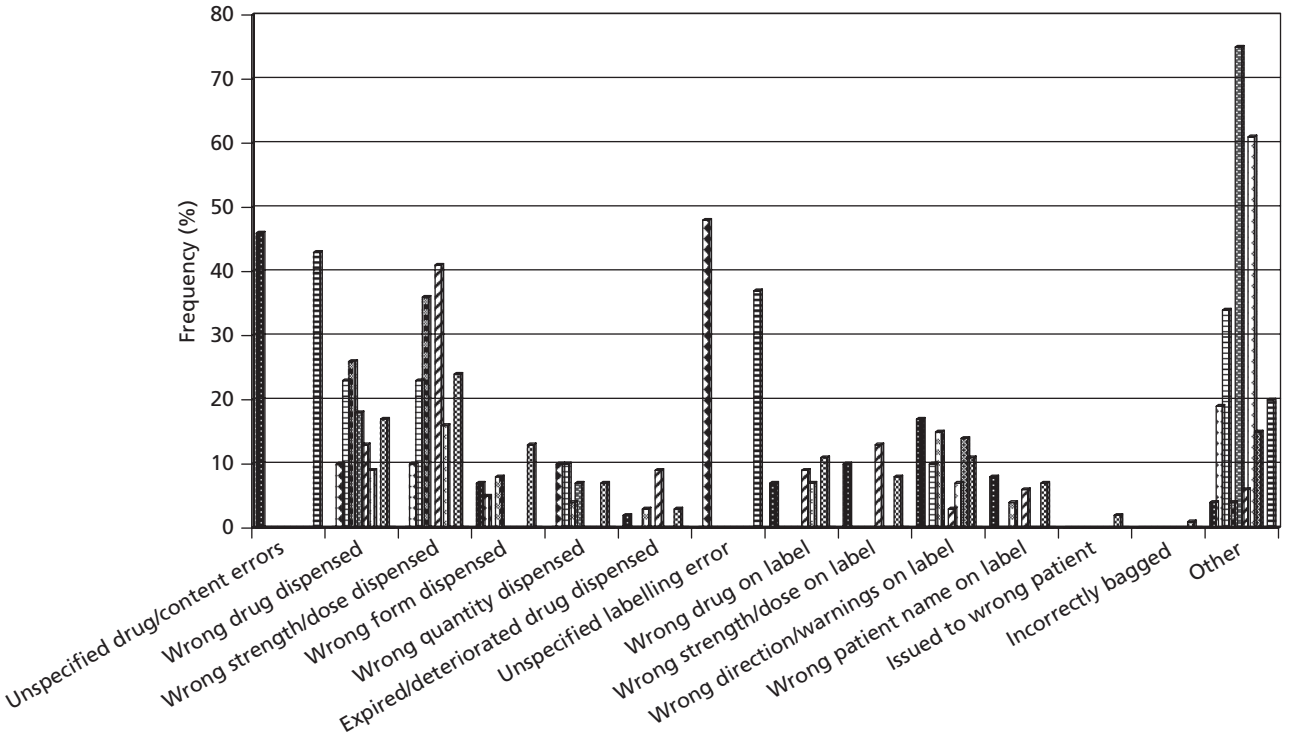

Figure 5 Most common types of unprevented dispensing incidents reported by UK hospital pharmacies with manual[3,33,37,39,41,43,44,47,72] and automated[44,47,72] dispensing systems. Where (■) Spencer[3] (n = 178); (▤) James[72] (n = 35); (▤) Roberts[37] (n = 7158); (▩) James[44] post-automation (n = 14); (▩) Roberts[41] (n = 2068); (▨) Beso[43] (n = 32); (□) James[44] pre-automation (n = 42); (▧) Bower[33] (n = 21); (▩) James[47] (n = 1005); (▩) Barker[39] (n = 208).

drug and strength (Figure 5).[3,33,37,39,41,43,44,47,72] In contrast, labelling medicines with the wrong directions, dispensing the wrong drug and strength were the most common prevented dispensing incidents in hospitals with manual and automated dispensing systems (Figure 6).[3,33–35,43,46,72]

Five papers investigated the impact of automation on the types of dispensing errors.[42,44–47] Three papers analysed prevented dispensing incidents[42,45,46] and two papers examined unprevented dispensing incidents.[44,47] Adedoye[45] reported that the most common prevented dispensing incidents associated with an automated dispensing system were labelling errors (76%, n = 81) and drug/content errors (18%, n = 20). However, comparison of prevented dispensing incident types pre- and post-automation at two London hospitals revealed that automation significantly reduced drug/content errors (site 1: pre-automation = 1.1%, post-automation = 0.4%; site 2: pre-automation = 0.7%, post-automation = 0.2%) but had no marked effect on labelling errors (site 1, pre-automation: 1.5%, post-automation: 0.6%; site 2, pre-automation: 0.6%, post-automation: 0.4%).[46] This is consistent with another reviewed research paper which reported that automation decreased drug/content errors such as wrong drug (–22%), wrong strength (–46%), wrong form (–4%) and quantity (–14%) but increased labelling errors with the wrong directions (+35%).[42] Similarly, analysis of unprevented dispensing incidents revealed that automation was frequently associated with labelling errors (37%, n = 10), combined drug and labelling errors (33%, n = 9) and drug/content errors (30%, n = 8).[47] However, James and colleagues[44] identified that automation significantly increased combined drug and labelling errors (pre-automation: 19%, n = 8; post-automation: 79%, n = 11). Thus, labelling errors are commonly associated with automated dispensing systems and can result in supply of the wrong drug.

Error types in the US

Nine papers investigated the types of dispensing errors occurring in US hospitals.[49,50,52,54,57,58,60,63–65] All nine papers reported the types of unprevented dispensing incidents but one paper[65] also reported the types of prevented dispensing incidents. The most common unprevented dispensing incidents associated with both manual and automated dispensing systems were supply of the wrong drug, dosage form, strength and quantity, and printing the wrong directions on the label (Figure 7).[49,50,52,54,57,58,63–65] The most common prevented dispensing incidents were supply of the wrong quantity (62%, n = 2471), drug (11%, n = 451), strength (10%, n = 419) and dosage form (8%, n = 330).[65]

Error types in Australia

Reviewed papers detailing research undertaken in Australian hospitals did not identify the types of dispensing errors.[67–69]

Error types in Brazil

The most common types of unprevented dispensing incidents reported by a Brazilian hospital were failing to supply a drug (57%, n = 412), dispensing the wrong strength (13%, n = 91),

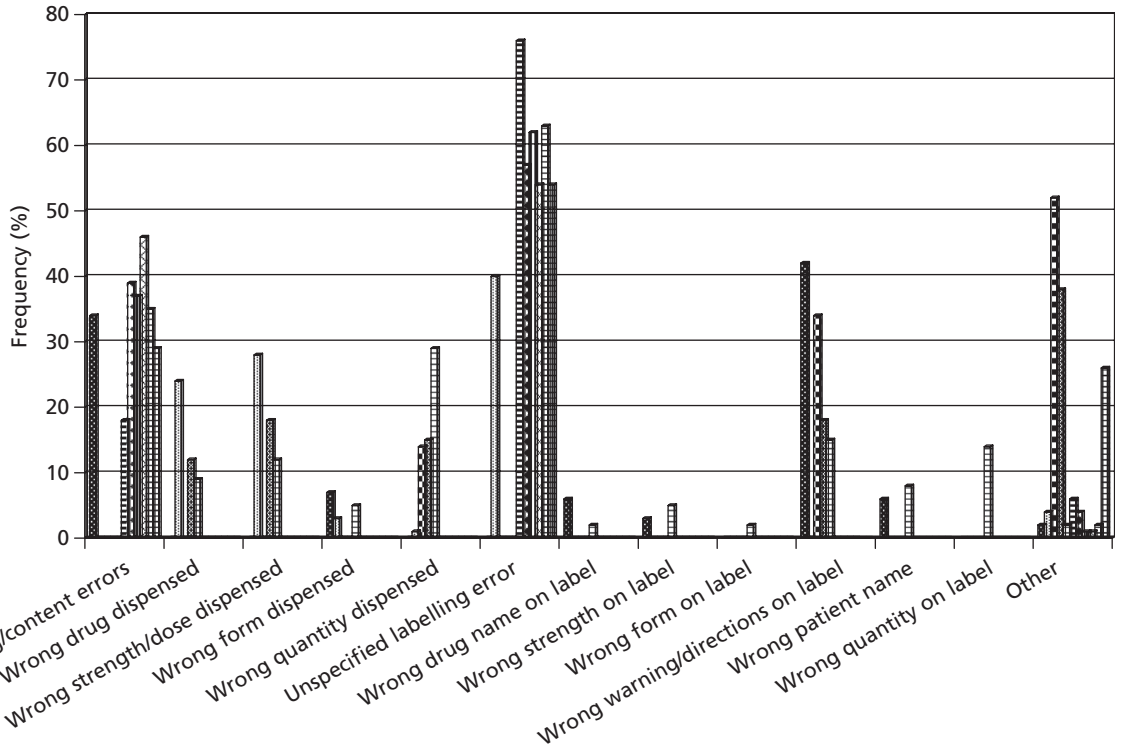

Figure 6 Most common types of prevented dispensing incidents reported by UK hospital pharmacies with manual[3,33–35,43,46,72] and automated[45,46,72] dispensing systems. Where (▩) Spencer[3] (n = 1500); (▤) Adedoye[45] (n = 108); (▦) Franklin[46] site 1: pre-automation (n = 245); (▨) Franklin[46] site 2: pre-automation (n = 217); (▤) Franklin[46] site 2: post-automation (n = 51); (▥) Bower[33] (n = 98); (▩) Wu[35] (n = 352); (▤) Beso[43] (n = 130); (▧) Banning[34] (n = 180); (▥) James[72] (n = 291); (▥) Franklin[46] site 1: post-automation (n = 93).

excessive dose (9%, n = 67), dispensing the wrong drug (3%, n = 25) and other errors (18%, n = 124).[71]

Error types in Spain

The most common unprevented dispensing incidents reported by a Spanish hospital were drug omission (30%, n = 6), wrong patient (30%, n = 6), wrong drug (15%, n = 3), wrong dosage form (15%, n = 3) and wrong dose (10%, n = 2).[70]

Causes of dispensing errors

Twenty-three reviewed papers investigated the factors contributing to pharmacy dispensing errors.[16–18,20,22,23,29–31,33,35,37,40,43,47,48,50,52,54,58,59,71] Factors most commonly cited in the reviewed papers as contributing to dispensing errors were workload (n = 13), similar drug names (n = 12), similar drug packaging (n = 9), staffing levels (n = 9), interruptions (n = 6) and poor handwriting (n = 6) (Table 10). However, research has shown that the number of prescriptions dispensed per hour (r^2 = 0.285, P < 0.001), pharmacist job dissatisfaction (r^2 = –0.422, P < 0.001) and pharmacy dispensary design are perceived by pharmacists to significantly increase the risk of dispensing errors.[23,29]

Reason's human error theory was employed in three reviewed papers to understand the aetiology of prevented dispensing incidents in UK hospital pharmacies.[40,43,48] Analysis of staff interviews[40,43] and self-completed critical incident report forms[48] revealed that prevented dispensing incidents were caused by a complex interweaving of active failures (slips, lapses and mistakes), latent conditions and error-producing conditions. Slips were identified as selecting the wrong drug or strength of medication, lapses involved forgetting to remove inappropriate cautionary labels during label generation, and mistakes involved assumptions that products were interchangeable, doses were the same as previously recorded in patient medication record and dispensing in accordance with labels rather than prescriptions.[40,43,48] A reported violation involved the dispensing of medication without reference to the prescription.[48] Various error-producing conditions reported as contributing to the dispensing incidents were shift-patterns, lack of knowledge, hunger, illness, complex prescriptions and agitated patients. Latent conditions identified were lack of guidance on dealing with interruptions, poor labelling or packaging of medicines and unclear presentation of drug selection lists on computer software used to generate labels.[40,43,48] However, these studies involved the retrospective reporting of the causes of prevented dispensing incidents 24–48 h after the incident occurred. Consequently, the findings are highly subjective and may be biased by failure to divulge or recall details of incident.

Few studies have objectively measured the impact of contributory factors on dispensing errors in community and/or hospital pharmacy. Guernsey and colleagues[50] objectively measured the impact of dispensary workload on unprevented dispensing incidents in a US hospital outpatient pharmacy. They concluded that a linear relationship existed between the number of prescriptions dispensed and potentially serious

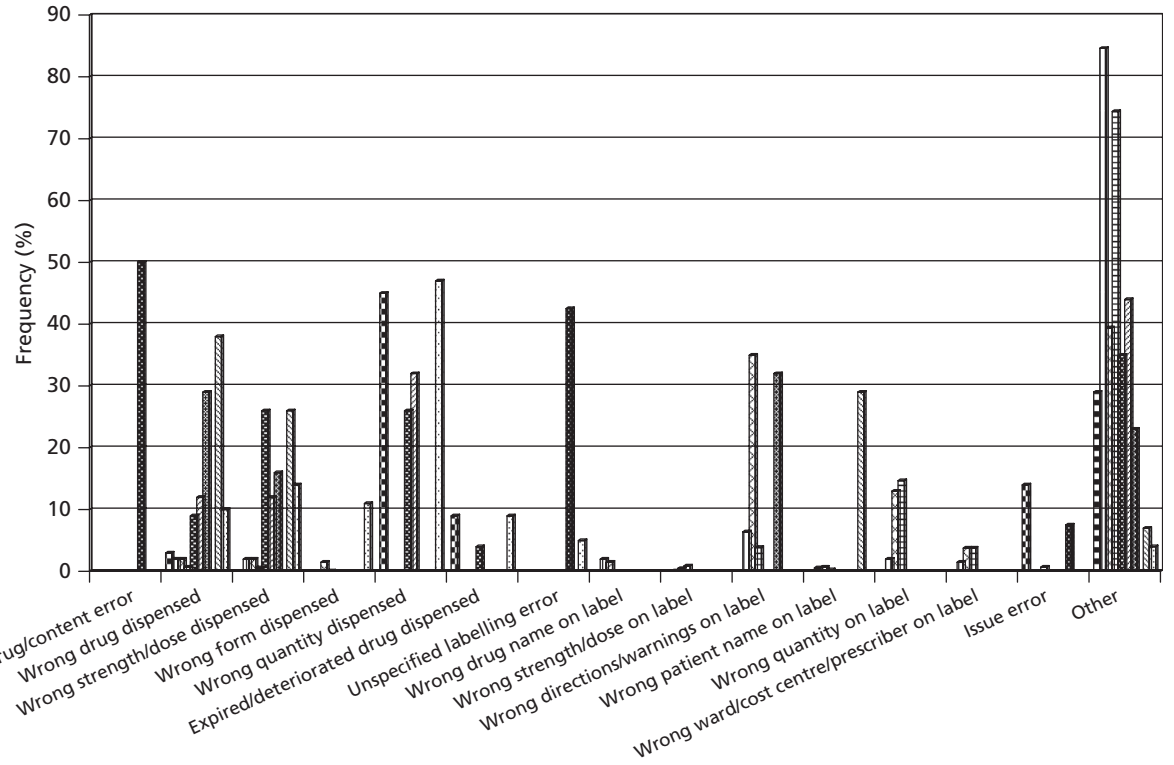

Figure 7 Most common types of unprevented dispensing incidents reported by US hospital pharmacies with manual[49,50,52,54,57,58,63–65] and automated[57] dispensing systems. Where (▣) Becker[49] (n = 66); (▥) Guernsey[50] (n = 1165); (▨) Buchanan[52] (n = 369); (▤) Kistner[54] (n = 1371); (▩) Klein[57] pre-automation (n = 34); (▨) Klein[57] post-automation (n = 25); (▩) Leape[58] (n = 38); (▩) Seifert[63] (n = 40); (▧) Rolland[64] (n = 82); (▦) Cina[65] (n = 1059).

unprevented dispensing incidents ($r^2 = 0.78$, $P < 0.001$). In contrast, Kistner and colleagues[54] found there was no correlation between the number of prescriptions dispensed per hour and the total number of unprevented dispensing incidents in a US hospital outpatient pharmacy. In both studies,[50,54] workload was measured according to the number of prescriptions dispensed per hour but this could be considered a surrogate marker as it does not account for the number of staff in the dispensary at any given time. In addition, it is unclear in these studies whether the term prescription refers to a single prescribed item or single medication order with multiple prescribed items. The use of the term prescription to represent a single medication order with multiple prescribed items would lead to an inaccurate measurement of workload.

Buchanan and colleagues[52] investigated the impact that lighting had on the incidence of unprevented dispensing incidents in a high-volume US outpatient military pharmacy. In this study, the illumination level in the pharmacy was set at three different levels (45, 102 and 146 foot candles) and the unprevented dispensing incident rate was determined by observers double-checking dispensed items. The study found that overall the level of illumination had a significant effect on the incidence of unprevented dispensing incidents ($F = 9.25$, $P < 0.01$). There was little difference between the impact an illumination level of 45 and 102 foot candles on the unprevented dispensing incident rate of 3.8 and 3.9% respectively. However, an illumination level of 146 foot candles was associated with a significantly lower incidence of unprevented dispensing incidents (2.6%, $F = 10.48$, $P < 0.05$). The authors acknowledge that the observer's accuracy at detecting unprevented dispensing incidents may also have been influenced by the lighting, so therefore it is possible the observer may have failed to detect some errors.[52] It is unclear from the paper whether the dispensary staff, prescription items dispensed and workload were the same during the different lighting periods. Consequently, it is uncertain whether the observed differences in error rate are due to the lighting or other working conditions, for example different staff, prescription items and workload.

Flynn and colleagues[59,61] investigated the impact of ambient sounds and interruptions on unprevented dispensing incidents in US hospital pharmacies. Pharmacy staff involved in dispensing were videotaped over a 23-day period and a study investigator performed final accuracy checks on the dispensed medication. Details of unprevented dispensing incidents recorded by the investigators were compared with information on ambient noise, interruptions and distractions obtained by reviewing the videotapes.[59,61] It was found that unpredictable audible stimuli, controllable audible stimuli and noise were statistically associated with a lower incidence of unprevented dispensing incidents.[59] In contrast, interruptions and distractions per half hour were both significantly associated with unprevented dispensing incidents (interruptions, $F = 8.22$,

Table 10 Factors cited in research papers as contributing to dispensing errors

Contributory factor	Number of papers cited
Workload	13
Similar drug names	12
Similar packaging	9
Staffing levels	9
Poor handwriting	6
Interruptions/distractions	6
Design of dispensary	5
Staff inexperience	5
Ambiguous directions	3
Failure to check	3
Lack of procedures	3
Job dissatisfaction	3
Poor communication	3
Computer software	3
Noise	3
Proximity of drugs on shelves	2
No breaks	2
Failure to follow standard operating procedures	2
Hunger	2
Fatigue	2
Stress	2
Lack of training	2
Lack of concentration	2
Lighting	2
Lone worker	2
Complex prescription	2
Lack of knowledge	2

Factors cited once were misread prescription, medicine stored in wrong place, typing, incorrect drug selected on computer screen, use of previous drug/dose on patient medication record, swapping of labels, tablet counting error, confusing label, staff inflexibility, lack of space, inadequate support/supervision, delivery problems, pre-typed prescriptions, large number of drugs prescribed, parenteral drugs, lack of time for counselling, lack of privacy, assistants, non-professional activities, original-repeat, regulatory requirements, generic drugs, technical resources, staff skill mix, shift patterns, pressure to dispense quickly and lack of responsibility.

$P = 0.004$; distractions, $F = 6.28$, $P = 0.012$).[61] These studies had a number of limitations; notably, data on ambient sounds, interruptions and distractions were missed when videotapes were changed.[59,61] In addition, the authors acknowledge that the observers' accuracy at detecting unprevented dispensing incidents was not verified.[59,61] Consequently, these studies may underestimate the occurrence of sounds, interruptions, distractions and unprevented dispensing incidents but provide the only objective measurement of these factors on unprevented dispensing incident rate.

Discussion

Dispensing medication is inherently risky and this review reveals that dispensing errors are inevitable occurrences in community and hospital pharmacies across the world. This review identified 60 papers investigating the incidence, type and/or causes of dispensing errors in community and hospital pharmacy. The overall incidence of dispensing errors varied greatly depending on the type of dispensing error (unprevented or prevented dispensing incident), research method and the dispensing error rate definition (Tables 7 and 8). In general, prevented dispensing incidents occurred more frequently than unprevented dispensing incidents. The most common types of unprevented and prevented dispensing incidents were supply of the wrong drug, strength, form and quantity, and labelling medication with the incorrect directions. Factors subjectively reported by pharmacy staff as contributing to dispensing errors were workload, staffing, look-alike sound-alike drugs, interchanging formulations and computer selection errors resulting from unclear presentation of drug-selection lists on computer software. Studies employing objective measurements demonstrated that high workload, interruptions, distractions and inadequate lighting increased the incidence of unprevented dispensing incidents. However, comparison of study findings was difficult due to differences in study setting, operational definitions and research method.

This is the most comprehensive review of the literature on dispensing errors. This extensive literature review has attempted to identify publications on dispensing errors which fulfil the inclusion criteria and are available via a selection of electronic bibliographic databases. However, it is inevitable that individual community and hospital pharmacies will have undertaken their own audits or investigation of dispensing errors to meet the needs of clinical governance. These small-scale studies may not have been published in peer-reviewed journals cited in the searched bibliographic databases. Consequently, the review findings may be subject to publication bias.

This review examined published dispensing error research undertaken across the world. The majority of reviewed papers originated from the UK and US but some Australian, Spanish and Brazilian studies were identified. Cousins[74] has reported that dispensing systems vary greatly across the world. In US hospitals, inpatients are often supplied unit doses of medication labelled with the physician's directions, whereas in European countries patients are supplied a manufacturer's original pack of medication without a dispensing label.[74] In general few of the reviewed papers adequately described the dispensing systems at participating pharmacies. Consequently, comparison of the reviewed papers was problematic as the study may not be generalizable to other countries or pharmacy settings.

This review identified a multitude of terms and definitions used to define a dispensing error and classify error types. To date, Franklin and O'Grady[19] have developed the most comprehensive and valid definition for a dispensing error. However, this definition is not exhaustive. The definition restricts dispensing errors to those 'unintended deviations from an interpretable prescription'.[19] Nevertheless, research employing Reason's human error theory has shown that dispensing errors arise due to intended actions (mistakes and violations) and unintended actions (slips and lapses).[40,43,48,75] Therefore, application of this definition would result in exclusion of dispensing errors stemming from violations. In addition, the definition specifies that 'both content and labelling errors are included'[19] but does not

acknowledge errors in the issue of medication to patients. Issue errors have the potential to be serious if a patient inadvertently takes another's medication and are included in other research papers and the Royal Pharmaceutical Society of Great Britain's dispensing error audit criteria.[17,44,47,49,76] Similar to other research papers,[25,43,46,61,65] 'deviations from...guidelines affecting dispensing procedures'[19] or standard operating procedures (SOPs) were included as dispensing errors. This may be problematic in multi-site studies, where the SOPs may vary. Therefore, data collected on errors may not be consistent across sites unless explicit information is provided on the content of the SOPs. Furthermore, the definition does not distinguish between errors detected within and outside the pharmacy.

To facilitate data collection, a standardized definition for a dispensing error, distinguishing between unprevented and prevented dispensing incidents, and classification system for error types would be desirable. In 2004, the UK NPSA developed a standardized system for classifying patient safety information according to incident types and harm.[1] However, the UK NPSA patient safety taxonomy for unprevented and prevented patient safety incidents was only adopted by four of the reviewed UK papers undertaken after 2004.[44,47,48,72] The World Health Organization is currently developing global patient safety taxonomy.[77,78] Therefore, it is anticipated that the World Health Organization taxonomy will facilitate consistent data collection, sharing of patient safety information and the development of global solutions.

There was great variation in the dispensing-error rate definitions employed by the reviewed papers. Consequently, it was difficult to compare and estimate the overall incidence of dispensing errors (unprevented and/or prevented dispensing incidents) in community and hospital pharmacy. Allan and Barker[13] recommend that error rates should be calculated as 'the number of actual errors (incorrect in one or more ways) divided by the total opportunities for error. This figure is then multiplied by 100 to arrive at a percentage'. Dispensing error researchers could adopt this standard definition for calculating dispensing error rates. However, the 'total opportunities for error' needs to be explicitly defined to ensure accurate calculation of dispensing error rates and aiding the comparison of studies.

Numerous research methods were employed by the reviewed research papers to evaluate the incidence, type and causes of dispensing errors (Table 3). Self-completed incident forms and observation were the most common methods employed to investigate the incidence and type of dispensing errors in community and hospital pharmacy. In a study comparing the efficiency of observation and incident reports at detecting dispensing errors, observation was found to detect significantly more dispensing errors than incident reports.[30] However, observation has a number of limitations, notably the influence of the observer on the behaviour of the pharmacy staff (Hawthorne effect). Barker[79] suggests that the subjects of an observational study will revert to normal behaviour within 1–3 h. In contrast, Savage[80] suggests that habituation may take longer to develop. Therefore, the Hawthorne effect must be taken into consideration when employing observation to investigate dispensing errors. In addition, observational studies may overestimate the incidence of unprevented dispensing incidents as errors detected by the observer are logged and rectified before patient counselling. Thus, errors which may have been detected during patient counselling before issue to the patient (prevented dispensing incidents) would be classified as unprevented dispensing incidents in an observational study. Furthermore, the reviewed observational studies failed to validate the accuracy of the observer at detecting dispensing errors. The expense and time taken to conduct an observational study limit its use as a routine quality-assurance or risk-management procedure. In contrast, incident forms are low in cost and can be used routinely to monitor dispensing errors within community and hospital pharmacy. Also, the use of anonymous incident forms and the establishment of a non-punitive culture could improve reporting.[13]

The majority of reviewed papers investigating the causes of dispensing errors relied on the subjective reporting of perceived contributory factors by pharmacy staff in interviews and on incident forms. Consequently, the validity of contributory factors is questionable. High workload, interruptions, distractions and inadequate lighting have been objectively shown to increase the incidence of dispensing errors in hospital pharmacy.[50,54,59,61] However, two studies employed a surrogate marker (number of prescriptions dispensed per hour) to measure workload.[50,54] Further work is needed to objectively measure the impact of other proposed contributory factors, for example staffing levels, on dispensing errors.

Conclusions

Dispensing errors are a major concern for the pharmacy profession. To date extensive research has been undertaken to investigate the incidence, type and causes of dispensing errors. This review has revealed that dispensing errors occurred in community and hospital pharmacy and most commonly involved supply of the wrong drug, strength and form of medication. High workload, interruptions and inadequate lighting were both subjectively and objectively reported as contributing to dispensing errors. However, comparison of the reviewed papers was confounded by differences in study setting, research method and operational definitions for dispensing errors, error rate and classification of error types. A standardized, global taxonomy for dispensing errors and types is essential to facilitate consistent data collection. Future studies evaluating dispensing errors should clearly describe the pharmacy dispensing system, research methods and operational definitions. This will facilitate comparison of research studies, and assist the global sharing of information and the development of error-reduction strategies, thereby enhancing the quality and safety of patient care.

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Conflict of interest

The Author(s) declare(s) that they have no conflicts of interest to disclose.

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