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Implementation of electronic medication management systems in hospitals

A literature scan

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Preface

The Australian Commission on Safety and Quality Health Care (the Commission) is developing the third edition of *Electronic Medication Management Systems: A Guide to Safe Implementation*.

The Guide outlines what hospitals need to do when implementing electronic medication management (EMM) systems, to avoid potential systemic problems that could lead to medication or other mishaps.

The Commission engaged the Centre for Health Systems & Safety Research at the Australian Institute of Health Innovation, Macquarie University, to undertake a literature scan to inform the development of this third edition of the Guide.

The research questions asked were:

- What are the **safety** issues when implementing and using computerised systems with electronic prescribing in hospitals?
- What factors contribute to **successful implementation** and use of computerised systems with electronic prescribing in hospitals?
- How do **policy** and **regulations** impact on the **uptake** and use of computerised systems with electronic prescribing?

The review included 77 papers selected from a cohort of over 2000 papers and documents. The search parameters included published research, case studies, commentaries and news articles that focused on the implementation of electronic medication management systems in hospitals.

Key themes

Safety

The majority of research papers included in the literature scan employed user surveys and interviews with focus groups.

The safety issue most frequently reported in these papers was that EMM implementations were perceived to adversely affect either the time available for direct patient care or the quality of that care. However, the literature scan found that this perception was **not** substantiated by observational research.

The review also found that other EMM implementation safety issues mentioned in the selected documents could be addressed by good implementation and system configuration. These issues include:

- the need for workarounds
- missing information or information entered in the wrong field
- user identity and access management
- the adoption of longhand prescribing
- the approach to alerts
- workflows in hybrid paper/electronic environments.

Safety issues were rarely mentioned in case studies, commentaries and news articles.

Factors for successful implementation

The majority of documents included in the scan discussed the factors that contributed to effective implementation of EMM systems. Persistent themes included:

- governance
- leadership
- clinician engagement/communication
- strategy and planning
- adequate resourcing (including funding)
- vendor commitment
- training and support
- usability and workflow.

Policy and regulation relating to uptake

The literature scan shows that a number of government incentives programs appear to have increased the adoption of EMM systems in hospitals.

Various documents included in the literature scan have suggested additional strategies could be introduced to facilitate the implementation of EMM systems. These include education for providers and the public regarding the benefits of EMM systems.

State and territory poisons regulations require handwritten signatures to complete legal prescriptions. The literature scan notes that this requirement remains an obstacle in implementing EMM systems.

Conclusions

The conclusions of the literature scan regarding the implementation of EMM systems in hospitals are summarised as follows:

- Safety risks may be mitigated by ensuring system implementations are well planned, designed and integrated into workflows, and by limiting the use of 'hybrid' (paper/electronic) approaches.
- Documents were fairly consistent in the factors they identified as contributing to successful implementation of EMM systems. These included adequate planning involving clinicians, appropriate training, a user-friendly system, strong leadership and effective communication.
- Governments may be able to encourage successful implementation and use of EMM systems by:
 - providing incentives to organisations for system adoption and use
 - educating providers and the public
 - providing guidelines to standardise some components of systems, such as basic decision support, while allowing local customisation for other components.

The Commission's response

The Commission acknowledges that there is a lack of systematic research on this topic, and notes there is little apparent evidence to support the perception that implementation of EMM systems adversely affects either the time available for direct patient care or the quality of that care.

In particular, there is little in the way of published information about the most recent Australian implementations of electronic medication management systems.

The literature scan's key points and conclusions reflect the Commission's own expectations and are aligned with the Commission's consultations on EMM.

The literature scan serves as a summary reference for issues related to the implementation and safety of EMM systems, and more broadly to electronic medical records.

In particular, it is interesting to observe that while EMM implementations are among the most complex and challenging undertaken, no published evidence was found indicating that any Australian organisation had abandoned an EMM program once started.

The Commission also takes this opportunity to encourage Australian health care organisations to contribute their own experience to the literature base.



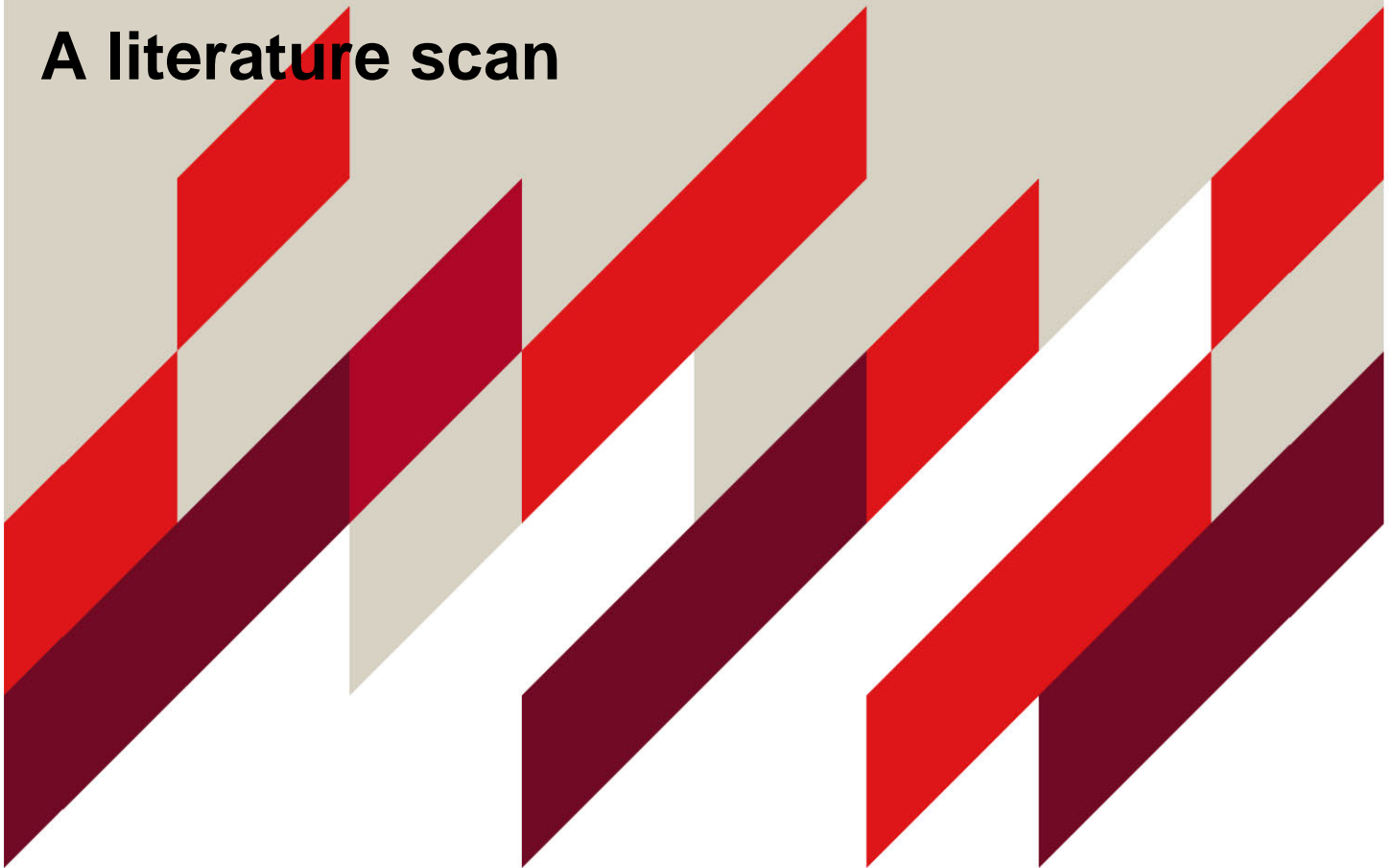
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Implementation of Electronic Medication Management Systems in hospitals:

A literature scan



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1. ABBREVIATIONS

CDS:	Clinical Decision Support
CPOE:	Computerised Provider Order Entry
ED:	Emergency Department
EHR:	Electronic Health Record
EMM:	Electronic Medication Management
EMMS:	Electronic Medication Management System
EMR:	Electronic Medical Record
ePS:	Electronic Prescribing System
HIMSS:	Healthcare Information and Management Systems Society
HIT:	Health Information Technology
ICU:	Intensive Care Unit
IT:	Information Technology
NHS:	National Health Service
NICU:	Neonatal Intensive Care Unit

2. EXECUTIVE SUMMARY

Background

The Commission has produced a range of resources to assist health service organisations and health professionals safely implement and use electronic medication management (EMM) systems, including a *Guide to Safe Implementation (Versions 1 & 2)*. This document comprises a literature scan to inform development of a third edition of this guide.

Research questions

The literature review addresses the following research questions:

- What are the safety issues related to implementation and use of EMM systems in hospitals?
- What factors contribute to successful EMM implementation and use in hospitals?
- How do policy and regulations impact on the uptake and use of EMM in hospitals?

Method

A search strategy was designed and applied to identify current literature on safe and effective implementation and use of EMM in hospitals. We included papers published in English between 2010 and 2016 that described a qualitative or quantitative evaluation of the implementation of a computerised system with prescribing functionality in hospitals, or described policy or regulatory impacts on the uptake of computerised systems in hospitals. We also included case studies, commentaries, editorials and conference proceedings.

Results

Seventy-seven papers were included in our review. Details of the papers included are provided in the Appendix (Table A1a includes systematic and narrative reviews, Table A2a includes research studies and Table A3a includes case reports, commentaries, and news articles).

We identified 50 research papers that focused on the implementation of a computerised system with electronic prescribing in a hospital setting. Eighteen studies were undertaken in the US, 11 in the UK, seven in the Netherlands and two in Australia. Most papers (n=32) focused on implementation of an Electronic Health Record (EHR) or Electronic Medical Record (EMR). Eighteen studies focused on implementation of a computerised provider order entry (CPOE) or electronic prescribing system (ePS).

Most research papers used surveys, interviews or focus groups (or a combination of these) to explore stakeholder perceptions of the system and its implementation. A number of papers supplemented this data collection with observations of systems being used (n=13), document analysis (n=9) or analysis of system data (n=1). Two papers did not utilise survey or interview methodologies. In one of these studies, chart review was used to identify medication errors associated with system use post-implementation, and in the other, a time and motion methodology was used to quantify the time nurses and doctors spent in various tasks before and after system implementation.

We identified 22 papers that focused on the implementation of a computerised system in a hospital setting(s), but were not research studies. Most frequently, these were commentaries (n=9) or case studies (n=8) and were US based (n=13). Most papers discussed implementation of an EMR or EHR. One paper focused on implementation of an EMM system, and six on a CPOE system.

What are the safety issues when implementing and using computerised systems with electronic prescribing in hospitals?

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, the main safety issues associated with implementation of computerised systems with electronic prescribing are:

- Reduced time for patient care
- Reduced communication between professionals
- Introduction of new types of errors (e.g. incorrect selection from a drop-down menu)
- Workarounds

Reduced contact with patients as a result of a computerised system being introduced was the most common complaint among users when interviewed and surveyed. However, a direct observational controlled pre/post EMM study of 129 doctors and nurses found that this concern was not substantiated. This study found that doctors on wards with EMM did not spend less time with patients relative to doctors on the control wards with paper medication charts.

Based on observations of staff on hospital wards and chart review, the main safety issues associated with implementation of computerised systems with electronic prescribing are:

- New types of errors
- Workarounds

Ensuring systems are well-designed and integrate well into workflow, and limiting the use of hybrid (paper/electronic) systems may mitigate these risks.

What factors contribute to successful implementation and use of computerised systems with electronic prescribing in hospitals?

Systematic and narrative reviews, research papers, case studies, commentaries and news articles were fairly consistent in the factors they identified as contributing to successful implementation and use of computerised systems with electronic prescribing.

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, the main factors identified were:

- Adequate planning (including clinician involvement), resources and governance
- Appropriate staff training (of different types and modalities) and support, including super users
- A user friendly system that integrates well into users' workflows
- Strong leadership, including clinician champions
- Effective communication
- Staff with positive prior experiences of technology

Although case studies and observational studies demonstrated instances of successful implementation, and the perceptions of individuals involved in implementation are extremely valuable, no studies systematically examined the impact of a particular factor or factors on system implementation. This makes it difficult to determine which individual factor or combination of factors is necessary for successful implementation, and consequently hinders the formulation of recommendations on organisational and system factors needed to ensure systems achieve their desired effects.

How do policy and regulations impact on the uptake and use of computerised systems with electronic prescribing in hospitals?

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, governments can encourage successful implementation and use of computerised systems by:

- Providing incentives to organisations for system adoption and use
- Providing incentives to suppliers and vendors to allow production of quality systems
- Educating providers and the public
- Providing guidelines to standardise some components of systems (e.g. basic decision support) while allowing local customisation for other components

Conclusion

Health information technology implementation has been shown to improve safety and efficiency of care; however, not considering all aspects of system implementation can lead to poor acceptance of systems by users. Thus, it is crucial for organisations to be aware of the factors that contribute to successful implementation as well as potential barriers, and to prepare for potential safety issues that may result. In this review, we report on key findings from both the evidence (i.e. research papers) and lessons learned (e.g. commentaries and case studies).

We identified the major factors for successful implementation to be adequate planning (including clinician involvement), appropriate staff training, a usable system that integrates well into users' workflow, staff with positive prior experiences of HIT, adequate resources including funding and support staff, strong vendor support, and strong senior leadership and support including the use of super users and clinical champions. The most common barrier to successful implementation was identified to be a lack of resources including the funding required for the initial procurement of the system and its ongoing maintenance.

Effective mitigation of potential safety issues resulting from the system, such as new errors, reduced patient care and workarounds, begins at the early planning stages of implementation. Conducting assessments of clinical and administrative workflows prior to system introduction, and then selecting/customising a system that is unlikely to disrupt this workflow, appears to be the first step in ensuring systems are used safely and optimally. Also, monitoring these potential safety issues post implementation and evaluating outcomes of system introduction, both positive and negative, is critical for ensuring systems achieve their desired effects.

3. OVERVIEW

The Australian Commission on Safety and Quality in Health Care (the Commission) promotes, supports and encourages the implementation of safety and quality initiatives in Australia. One such initiative is the widespread adoption of electronic medication management (EMM) systems in Australian hospitals. EMM systems can improve the quality, safety and efficiency of patient care, but implementations are complex, the result sometimes being a system that is not adopted or used optimally in practice. The Commission has produced a range of resources to assist health service organisations and health professionals safely implement and use EMM, including a *Guide to Safe Implementation (Versions 1 & 2)*.

The research proposed here comprises a literature scan to inform development of a third edition of this guide. The literature review identifies:

- Safety issues and ‘cautionary tales’ pertaining to implementation and use of hospital EMM systems
- Characteristics of and dependencies for successful EMM implementation
- Policy and regulatory levers and impediments that have had positive or negative impacts on the uptake and use of EMM in hospitals, in a sample of international jurisdictions

4. RESEARCH QUESTIONS

Based on the three focus areas above, the literature review addresses the following research questions:

- What are the safety issues related to implementation and use of EMM systems in hospitals?
- What factors contribute to successful EMM implementation and use in hospitals?
- How do policy and regulations impact on the uptake and use of EMM in hospitals?

5. METHODS

A search strategy was designed and applied to identify current literature on safe and effective implementation and use of EMM in hospitals. To answer our research questions, we applied three separate search strategies using databases PubMed, EMBASE and Medline (Tables 1-3). Databases OpenGrey and FACTIVA were utilised to identify grey literature (Tables 4). We also hand-searched the reference lists of relevant reviews to ensure all pertinent papers were captured.

5.1 INCLUSION CRITERIA

We included papers published in English between 2010 and 2016 that described a qualitative or quantitative evaluation of the implementation of a computerised system with prescribing functionality in hospitals, or described policy or regulatory impacts on the uptake of computerised systems in hospitals. We also included case studies, commentaries, editorials and conference proceedings.

5.2 EXCLUSION CRITERIA

We excluded papers describing computerised systems in other settings (e.g. primary care), papers where the primary focus was not a system that included prescribing functionality, papers where the primary focus was to evaluate the computerised system (e.g. pre-post studies), and papers describing software or products. We also excluded conference abstracts.

Table 1: Terms used for database searches of the safety issues related to implementation and use of EMM in hospitals

PubMed	MEDLINE	EMBASE
Safety OR negative impact OR adverse event OR harm AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computerized physician order entry OR computerised physician order entry OR computerized provider order entry OR computerised provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient	Safety OR negative impact OR adverse event OR harm AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient	Safety OR negative impact OR adverse event OR harm AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient

Table 2: Terms used for database searches of the factors that contribute to successful EMM implementation in hospitals

PubMed	MEDLINE	EMBASE
adoption OR acceptance OR implement* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computerized physician order entry OR computerised physician order entry OR computerized provider order entry OR computerised provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient	adoption OR acceptance OR implement* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient	adoption OR acceptance OR implement* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient

Table 3: Terms used for database searches of the policy and regulations that impact on the uptake and use of EMM in hospitals

PubMed	MEDLINE	EMBASE
Policy OR policies OR regulat* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computerized physician order entry OR computerised physician order entry OR computerized provider order entry OR computerised provider order entry OR CPOE OR electronic prescribing OR EMR OR electronic medical record OR e-prescribing AND hospital OR inpatient	Policy OR policies OR regulat* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient	Policy OR policies OR regulat* AND electronic medication management OR EMM OR EMMS OR electronic health record* OR EHR OR e-health OR computeri#ed physician order entry OR computeri#ed provider order entry OR CPOE OR electronic prescribing OR e-prescribing OR EMR OR electronic medical record AND hospital OR inpatient

Table 4: Terms used for grey literature searches of the safe implementation of EMM in hospitals, the successful implementation of EMM in hospitals, and the policy and regulatory impacts on the uptake of EMM in hospitals

OpenGrey search	Factiva search
Electronic medication management system	Electronic medication management system
EMM	EMM
EMMS	EMMS
CPOE	Computerised physician order entry
Computerised physician order entry	Computerised provider order entry
Computerised provider order entry	CPOE (limit to Australia only)
e-prescribing	e-prescribing (limit to Australia only)
EMR	e-health (limit to Australia only)
e-health	Electronic health record (limit to Australia only)
Electronic health record	HER (limit to Australia only)
EHR	Electronic prescribing (limit to Australia only)
Electronic prescribing	Electronic medical record (limit to Australia only)
Electronic medical record	EMR (limit to Australia only)

6. RESULTS

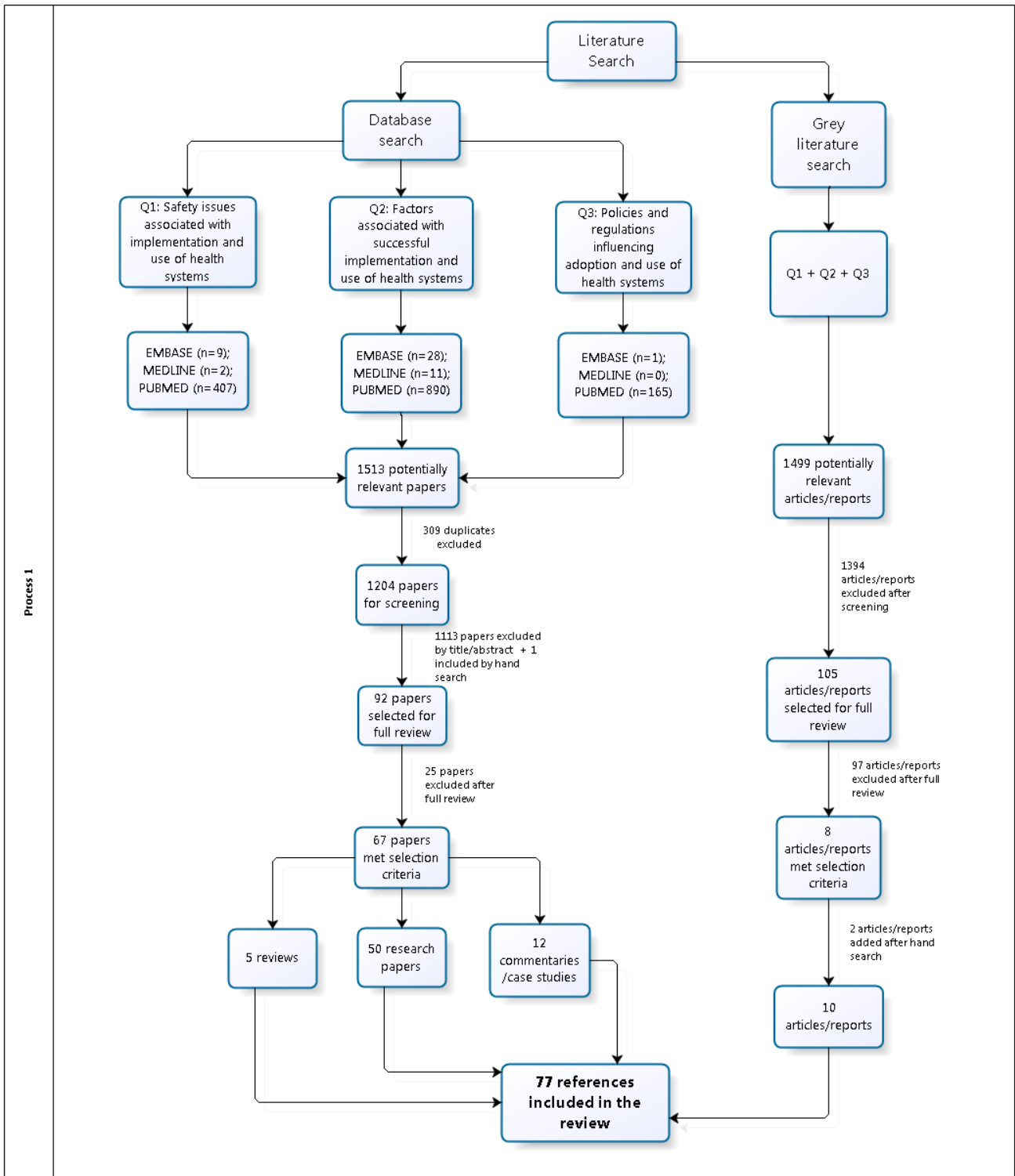


Figure 1. Flow diagram of paper search and selection process

As shown in Figure 1, 77 papers were included in our review. Details of the papers included are provided in the Appendix (Table A1a includes systematic and narrative reviews, Table A2a includes research studies and Table A3a includes case reports, commentaries, and news articles).

We identified 50 research papers that focused on the implementation of a computerised system with electronic prescribing in a hospital setting. Eighteen studies were undertaken in the US, 11 in the UK, seven in the Netherlands and two in Australia. Most papers (n=32) focused on implementation of an Electronic Health Record (EHR) or Electronic Medical Record (EMR). Eighteen studies focused on implementation of a Computerised Provider Order Entry (CPOE) or electronic prescribing system (ePS). Please see Table A2a.

Most research papers utilised surveys, interviews or focus groups (or a combination of these) to explore stakeholder perceptions of the system and its implementation. A number of papers supplemented this data collection with observations of systems being used (n=13) [1-13], document analysis (n=9) [2, 4, 6, 8, 10, 11, 14-16] or analysis of system data (n=1) [1]. Two papers did not utilise survey or interview methodologies [17, 18]. In one of these studies, chart review was used to identify medication errors associated with system use post-implementation, and in the other, a time and motion methodology was used to quantify the time nurses and doctors spent in various tasks before and after system implementation.

We identified 22 papers that focused on the implementation of a computerised system in a hospital setting(s), but were not research studies. Most frequently, these were commentaries (n=9) or case studies (n=8) and were US based (n=13). Most papers discussed implementation of an EMR or EHR. One paper focused on implementation of an EMM system, and six on a CPOE system. Details of these papers appear in Table A3a.

6.1 WHAT ARE THE SAFETY ISSUES WHEN IMPLEMENTING AND USING COMPUTERISED SYSTEMS WITH ELECTRONIC PRESCRIBING IN HOSPITALS?

6.1.1 RESEARCH PAPERS THAT REPORTED SAFETY ISSUES

A number of research papers discussed potential safety issues associated with use of computerised systems with electronic prescribing in hospitals. Most frequently, these safety issues were identified by hospital staff during surveys, interviews or focus groups, with only a small number of papers (n= 8) using alternative methods (i.e. observation or document review) to identify actual occurrences of safety issues.

6.1.1.1 REDUCED TIME AND QUALITY OF DIRECT CARE

The most frequently cited potential safety issue following computerised system implementation was reduced time for and quality of direct patient care. Reduced contact with patients as a result of a computerised system being introduced was the most common complaint among users when interviewed and surveyed [3, 11, 19-23]. However, a direct observational controlled pre/post EMM study of 129 doctors and nurses found that this concern was not substantiated [18]. That study found that doctors on wards with EMM did not spend less time with patients relative to doctors on the control wards with paper medication charts. EMM use was also not associated with any significant changes in the proportions of time that nurses and doctors spent on medication tasks overall [18]. Poor usability of the system, including slow response times, a constant need to sign in, and the length of time required for charting medications and documenting, were also perceived by users to result in more time spent at the computer and less time interacting with patients [3, 19, 20, 22]. Hospital staff reported that the system interfered with their ability to speak to and make eye contact with patients [19, 21] and highlighted the importance of computers fitting into their workflow rather than restricting users to a workstation with their backs toward their patients [22].

6.1.1.2 WORKAROUNDS

To overcome limitations of system functionality or usability, users in a number of studies were observed to adopt various workarounds [3, 8, 24]. Workarounds were reported to result from time pressure, perceived changes to professional roles, poor system usability, technical challenges, lack of resources, and coexisting electronic and paper systems (hybrid systems) [15, 24]. A variety of specific workarounds were described by users and observed by researchers [8, 11, 21, 24, 25], including for example:

- Delaying entering patient information
- Relying on other staff to update the system on their behalf
- Information being copied and pasted
- Using other systems (e.g. Microsoft Word) to store text temporarily
- A failure to complete or update information
- Information being entered into the wrong place in the system
- Users accessing the system logged in as a different user or by leaving identity authentication cards in the computer terminal to avoid the log-in process

Observed and reported consequences of workarounds included delayed access to information, difficulties finding necessary information in the computerised system, and incorrect information being entered into the system [8, 24]. To mitigate their negative effects, authors recommended that workarounds be assessed prior to implementation and potential solutions communicated to staff [15, 24, 26].

6.1.1.3 REDUCED COMMUNICATION

In one survey study, users reported that the quality of documentation declined after implementation of a computerised system because users were required to check boxes or complete set templates which restricted the amount of information they could enter into systems [19]. Interviews and observations of pharmacists before and after CPOE implementation revealed that information documented in the computerised system by physicians was often missed by pharmacists [5].

6.1.1.4 NEW ERRORS

Hospital staff reported that some medication errors were easier to make when using a computerised system than paper chart (e.g. wrong patient errors) [9]. Users perceived potential reasons for increased error rates to include increased workload (i.e. additional tasks for users) [27] and limited system functionality [15], with errors more likely when users adopted shortcuts like copying and pasting blocks of information [25, 28]. Other opportunities for error were reported by staff to include not entering patient information into the system correctly [21, 22, 29], missing orders in the system, or ignoring alerts because users were accustomed to receiving false alarms [28]. Users being over-reliant on potentially erroneous information was also identified as a potential risk by physicians, suggesting that information contained in systems should be independently reviewed for accuracy [28].

One study utilised chart review to identify new types of errors associated with the use of two ePS in Australia [17]. Selection errors (i.e. prescribers making an incorrect selection from a drop-down menu) were the most frequent type of error identified, followed by editing errors (i.e. prescribers editing a predefined order sentence). The study also found that a number of system-related errors were determined to be the result of specific design features of systems. For example, a system that encouraged long-hand prescribing and so provided greater opportunities for selection errors generated these errors at a rate four times higher than a system that utilised order sentences and so required only one selection per order [17].

6.1.1.5 RISKS ASSOCIATED WITH DUAL ELECTRONIC AND PAPER SYSTEMS

Difficulties associated with integrating coexisting electronic and paper-based systems has led some organisations to temporarily adopt dual or hybrid systems (i.e. some hospital areas adopting the electronic system, and others still writing paper orders, or some functions performed electronically and some on paper) [15, 17]. Survey studies have shown that stakeholders believe this practice to have a negative impact on communication with some users reporting missing patient information [9, 12, 15, 30]. Furthermore, hybrid systems can contribute to increased medication errors. For example, in one study utilising chart review, a number of errors determined to be the result of system introduction were identified to be the result of some functions being completed on paper and some electronically (e.g. complex medication orders managed on paper charts, but their associated alerts in electronic formats) [17].

6.1.2 CASE STUDIES, COMMENTARIES AND NEWS ARTICLES THAT DISCUSSED SAFETY ISSUES

Safety issues associated with computerised system introduction were not frequently mentioned or discussed in the case studies, commentaries, or news articles included in our review. Note that these papers typically conveyed the opinions of an author or a stakeholder group and did not include systematic data collection. We included one narrative review here [31] as it also discussed potential safety issues.

6.1.2.1 NEW ERRORS

The most frequently cited safety issue in commentaries and case studies was the introduction of new kinds of errors following system implementation. Many of these were reported to be due to poor system design [31, 32]. For example, in one commentary, the author described an increased potential for medication errors that arose when administration schedules were not designed to account for variables that may cause a delay in administration (e.g. delivery time from the pharmacy) [33]. In another commentary, the author explained that information overload (four screens were needed to view patient medicines) resulted in users becoming overwhelmed and making errors in a pharmacy department [34]. New errors were also reported to be the result of users becoming over-dependent on technology [31, 32, 35], or from providers misunderstanding or incorrectly using computerised systems [36].

6.1.2.2 WORKFLOW DISRUPTION

Another potential safety issue resulting from system implementation was identified to be disruption to clinical work. A frequent complaint accompanying system introduction was described to be the creation of additional or different work for clinicians [31, 33]. Poor system design, including inconsistent interface design, was perceived to have led to disruptions to standard hospital processes [32]. A common cause of workflow disruption was identified to be computerised alerts. The dangers of over-alerting and alert fatigue were mentioned in a number of commentaries and case studies [32, 33, 37, 38].

Other safety concerns raised by authors in commentaries included:

- Changes in communication patterns and practices [31]
- Perceived loss of autonomy and the shifting of power among clinical disciplines [31, 38]
- Sluggish workflows as physicians integrate data from paper-based systems to electronic systems [35]

6.1.3 SUMMARY BOX

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, the main safety issues associated with implementation of computerised systems with electronic prescribing are:

- Reduced time for patient care
- Reduced communication between professionals
- Introduction of new types of errors (e.g. incorrect selection from a drop-down menu)
- Workarounds

Despite reduced contact with patients being the most common complaint among users following system introduction, a direct observational controlled pre/post EMM study of doctors and nurses found that this concern was not substantiated. Based on observations of staff on hospital wards and chart review, the main safety issues associated with implementation of computerised systems with electronic prescribing are:

- New types of errors
- Workarounds

Ensuring systems are well-designed and integrate well into workflow, and limiting the use of hybrid (paper/electronic) systems may mitigate these risks.

6.2 WHAT FACTORS CONTRIBUTE TO SUCCESSFUL IMPLEMENTATION AND USE OF COMPUTERISED SYSTEMS WITH ELECTRONIC PRESCRIBING IN HOSPITALS?

6.2.1 SYSTEMATIC AND NARRATIVE REVIEWS THAT REPORTED CONTRIBUTORY FACTORS

We identified three systematic reviews and two narrative reviews (see Table A1a) that summarised the literature on implementation and use of computerised systems with electronic prescribing in hospitals.

In one systematic review, Boonstra et al. provided an overview of existing literature on EHR implementation in hospitals and identified lessons learned [39]. In another, the literature was reviewed to identify factors associated with successful implementation of EMR systems in low-resource settings [40]. In the third systematic review, Chang et al. reviewed the literature on EMR adoption in Canada to identify perceived benefits of and barriers to adoption [41].

One narrative review summarised the impact of CPOE on medication safety, the efficacy of CPOE, key measures of impact in practice, and important implementation issues, in order to provide a guide to healthcare providers with plans to adopt CPOE [42]. The other narrative review assessed the challenges and benefits associated with EHR implementation in Emergency Department (ED) settings in order to determine the steps EDs can take to facilitate the implementation process [31].

All five review papers identified the use of **physician champions** to promote system use and reduce staff resistance as key for successful system implementation and use [31, 39-42]. In addition, Chang et al. reported the availability of full-time **super users** (e.g. nurses, doctors, or pharmacists with experience in using computerised systems) other key strategies to be a facilitator for successful implementation [41].

Four of the five review papers identified the use of **multiple training methods** to suit staff needs and the provision of adequate **real-time support** after 'go-live' to be important [31, 39, 41, 42]. Poor availability and quality of training, and a lack of support were identified as being associated with problems post-implementation [40, 41].

Other factors that contributed to successful implementation and use of systems included **strong leadership** with commitment to implementation and project budget [39, 41, 42], establishing an **interdisciplinary planning and implementation group** comprising developers, IT staff, and end-users (nurses, doctors and pharmacists) [39, 40, 42], a supportive organisational **culture** that fosters collaboration and teamwork, and allows for changes to be made quickly without excessive bureaucracy [39-41], devising a **comprehensive implementation strategy** offering both clear guidance and flexibility for change [39, 41], and providing **sufficient resources** for the implementation process in terms of staff and funding [39, 41]. Having a plan to deal with downtimes and having a process in place for troubleshooting post 'go-live' were also identified to be factors associated with successful implementation [31].

To promote system use, a number of design and usability factors were identified. These included procurement of a **fast, reliable and user-friendly system** [39, 40, 42], and creating standardised **order sets** prior to implementation (e.g. chemo order sets in cancer specialty) [42]. High computer literacy among users also helped successful adoption [40, 41]. Studies identified in the reviews showed that time-consuming and complex systems hindered system implementation and use [41, 42]. Anticipating workflow changes as a result of implementation and creating a good fit between the system and users by **adapting both the technology and work practices** was identified as a critical factor [39, 42].

In addition, reviews found that implementation of a computerised system with electronic prescribing was more likely to be successful if the organisation identified a **vendor who is committed** to providing a system that fits with the needs and work processes of an organization [39], and if a productive relationship is established with this vendor [31]. Hospital staff with **previous HIT experience** also facilitated successful implementation [39]. Resistance from clinical staff, in particular physicians, was a major barrier to implementation. Boonstra et al. also found that large (or system-affiliated), urban, not-for-profit, and teaching hospitals were more likely to have implemented an EHR system probably because they had greater financial capabilities, greater change readiness, and less focus on profit [39]. Classen et al. found that rural hospitals, limited by financial constraints, experienced difficulties when introducing systems [42]. A lack of **funding** was also identified to be a major barrier to system adoption in the Canadian review [41].

6.2.2 RESEARCH PAPERS THAT REPORTED CONTRIBUTORY FACTORS

All research papers included in our review identified one or more factors that contributed to successful implementation of computerised systems with electronic prescribing. Again, most papers adopted surveys, interviews or focus groups to identify *perceived* contributing factors.

6.2.2.1 HOSPITAL SIZE

In two studies, surveys were distributed to large numbers of hospitals to examine the prevalence of system uptake and identify factors associated with adoption [23, 30]. Both studies found that large hospitals were more likely to succeed in adopting a computerised system [23, 30]. For example, in South Korea, 14.5% of hospitals with more than 800 beds had adopted comprehensive EHRs, and only 5.1% of hospitals with less than 400 beds had adopted comprehensive EHRs [23].

6.2.2.2 STAFF CHARACTERISTICS

A number of papers (n=8) discussed the impact of staff characteristics on computerised system adoption. Completion of a survey by 151 physicians revealed that respondents with personality traits such as openness to experience, agreeableness and extroversion were more likely to be receptive to system implementation and use [43]. Survey and interview studies have shown that staff who were familiar with using IT found the implementation process less daunting and struggled less during the transition from paper to electronic systems than those with no IT experience [1, 7, 21, 44]. This was particularly true for staff with more years of work experience [7, 44, 45].

Survey and interview studies have also shown that users' perceptions can influence acceptance of computerised systems [46, 47]. A study that surveyed physicians pre-implementation, three months post-implementation and 20 months post-implementation found that existing negative perceptions of HIT were a significant barrier to adoption, and these perceptions were difficult to change [47].

Interestingly, one survey study demonstrated that better-connected physicians tended to use the system less, the authors suggesting this was because physicians' social networks provided them with a substitute mechanism to access some of the information that is available via the electronic system [43].

6.2.2.3 USABILITY AND FUNCTIONALITY

System usability and functionality were frequently mentioned as contributing factors and discussed in the majority of papers (n=31). Via interviews and surveys, users reported that they were more likely to use a system if it was reliable, flexible, simple and easy to use, and provided beneficial functionalities [12, 27, 43, 48-51]. A computerised system that was accessible both on and off-site and was able to be accessed by multiple users concurrently were perceived to be critical factors by staff [4, 8, 12, 19, 25, 28, 49]. In addition, the creation of specific order sets was perceived to reduce the time and effort needed to enter medication orders [49].

One of the most frequent complaints made by hospital staff during interviews, surveys and focus groups post-system implementation was that adoption of the computerised system had resulted in a loss of efficiency (i.e. prescribing, administration and review of medications appeared to take longer on computer than on paper) [1, 8, 12, 15, 19-22, 28-30, 44, 49, 52]. However, in a study that quantified the time hospital staff spent in various tasks before and after system introduction, no significant change in the proportion of time spent by doctors or nurses on medication-related tasks was found [18].

Some systems were also perceived to create additional amounts of clerical/administrative work for physicians [3, 8, 11, 19], and users reported that a large amount of time was wasted waiting for the system to respond or waiting to log-in and out of systems [3, 13, 22, 27, 29]. In the one study that actually measured delays in system functioning, system response times were measured following implementation of an EHR in a regional hospital in Denmark [1]. Response times were found to range between 1-15 seconds and increased during the first 2½ months, most likely because of increased numbers of users and functionality.

Some systems were perceived by hospital staff to reflect developers' lack of understanding of clinical processes, resulting in systems that did not map to the actual complexities of clinical practice [2, 3, 8, 11, 16, 19, 21, 50, 52]. Thus, authors and some users suggested customising systems to minimise disruption to workflow [1-3, 20, 21].

Several technical/hardware problems were also identified by hospital staff via surveys and interviews following system implementation, including:

- Aged hardware [19, 21]
- System instability [5, 21, 29, 52]
- Lack of updating and maintenance of system software [30]

In one survey study, nurses reported that problems were further exacerbated by a lack of support when computer hardware or software did malfunction [22].

6.2.2.4 PLANNING AND GOVERNANCE

Implementation teams, clinical and non-clinical staff reported that a critical factor for ensuring successful implementation of computerised systems is clinical staff driving the implementation process. The involvement of as many staff as possible in the selection, design, development and implementation phases was thought to have facilitated the implementation process [1, 4, 25, 45]. Via surveys and interviews, study participants reported that having key staff members throughout the hospital (e.g. doctors, nurses, pharmacists, IT staff) assigned to design teams and committees helped tailor the system to the hospital environment [7, 9, 25, 30, 53]. This provided reassurance that staff opinions and expertise were taken into account, created a sense of ownership and buy-in to the system, and reduced concerns that administrators had *imposed* an external system onto users [9, 10, 25, 54]. Interviews with IT professionals and physicians revealed that they believed the failure to involve clinicians in the implementation process was likely to lead to procurement and implementation of systems that reflect the needs of IT staff and organisation leaders rather than those of end-users [55].

Other key strategies for improving implementation outcomes identified by hospital staff (users and implementation teams) and vendors during surveys and interviews included:

- Documenting workflow and system requirements thoroughly to ensure the procured product suits and addresses organisational needs [2, 14, 23, 54]
- Managing expectations by highlighting that the main benefits of the system are likely to be gained in the longer term [10, 26]
- Employing managerial staff with past implementation experience [10, 14]
- Sending staff members to other organisations that have successfully adopted computerised systems to learn from existing practices [7]
- Employing a step-wise implementation process so that staff have time to adjust to the system [7, 54]
- Recruiting sceptics to work with designers until their needs are met [25]
- Conducting a risk assessment during system implementation [56]

Difficulties in finding a suitable system to meet an organisation's needs [23, 54], unrealistic expectations of staff competence in IT [27], and not consulting or involving staff in the decision making process [2] were identified as hindrances to successful implementation of computerised systems.

6.2.2.5 TRAINING

A number of papers (n=17) discussed the importance of effective training in ensuring computerised systems are adopted and used optimally. Via surveys and interviews, managers, implementation teams and clinicians reported that a one-size-fits-all approach to training and education had not been effective [9, 14]. Understanding how much training each individual needed, and recognising that more experienced staff and clinicians (who may be less savvy with IT than younger individuals) may need more intensive training, proved to be an effective approach [9, 14, 21, 28, 57]. In other interview studies, a range of stakeholders (managers, IT staff, vendor and users) suggested that workflow familiarisation sessions may be more useful than generic classroom training [10], and that training should be portable (i.e. CD-based or on-line) for practice and familiarisation at home [7]. In addition to formal training, implementation teams reported that pocket cards were useful to remind physicians on how to perform common system functions [25].

Other useful training approaches identified by managers, users, and implementation teams during interviews and surveys were:

- Training a group of users who were more comfortable with technology and then using these individuals as trainers for other staff members [7]
- Making training mandatory, with all staff required to attend training and pass a proficiency test before using the system [25]
- Providing opportunities for continuous training whereby users shared their experiences of system use [13]
- Encouraging the individual pursuit of learning skills [26]

Poor training can be counter-productive; training that showed steps to complete a task without putting it into context was not viewed as useful by users [19, 49, 57]. Other ineffective training approaches identified by hospital staff included:

- Long intervals between training and implementation which resulted in staff forgetting what they had learnt [21]
- Lack of continuous training and support from information technology staff in the hospital [5, 52]
- Not having enough practice time before going live [22]
- The use of trainers from non-clinical backgrounds [13]

6.2.2.6 SUPPORT, LEADERSHIP AND COMMUNICATION

A common factor that emerged from papers was leadership and support. The availability of super users (e.g. nurses, doctors, or pharmacists with experience in using computerised systems) was found to be particularly helpful in facilitating adoption because it provided staff with someone to approach for support who understood their work and with whom they were familiar [9, 13, 25, 27, 44, 58]. In one study that used observations and interviews to examine in-depth the super users' role in implementation, key behaviours of super users were identified to include raising unsolved problems at cross-departmental meetings, promoting 'learning by doing', and one-on-one sessions with individuals struggling with the change [13]. However, this research also showed that super users' engagement was shaped by whether they viewed the demands of the role as an opportunity or as a burden [13]. Volunteer super users were found to be more proactive (more effort-intensive), encouraging, explained why something was done, used positive framing (e.g. safer for patients) and shared information about the system. On the other hand, appointed super users were more reactive, waited for others to approach them with problems, failed to explain logic behind actions, used neutral framing (e.g. 'you'll get used to it'), and limited sharing of information to individuals they interacted with the most (e.g. friends in the workplace) [13]. Thus, in order to maximise the positive impact of super users, care must be taken in the selection process.

In addition to super users, surveys and interviews with hospital staff revealed the importance of identifying and supporting a 'champion' among each stakeholder group (e.g. physician champion, nurse champion, pharmacy champion) who can serve as a liaison for stakeholders, ensuring concerns are addressed by institutional leadership, and providing reassurance to his or her peers [2, 9, 46]. Champions were described to be either supporters of adopting a computerised system from the start or became enthusiastic early in the process [25].

Highly engaged senior management that articulated a clear vision, held staff accountable, and were a visible presence on hospital wards during implementation was also perceived to positively impact on the implementation process [1, 13, 25, 28, 46, 51]. During interviews with implementation teams, participants explained that a successful implementation might depend on leaders occasionally taking a tough stand (e.g. not tolerating disruptive or resistant behaviour) [25]. Insufficient organisational support [27], hierarchical structures hampering the use of 'clinical champions' [2], and a lack of senior commitment from lead physicians and/or chief executives to support implementation efforts [54] have all been reported to be hindrances to the implementation process.

In one UK study, a range of stakeholders identified a lack of understanding among staff of the aim of system introduction as a barrier to implementation [6]. In another interview study, hospital staff working in mental health hospitals attributed poor system uptake to hospital managers not communicating to their staff how implementing the system fits into the organisation's wider vision of improving patient care and efficiency [21].

6.2.2.7 RESOURCES

Several papers (n=15) identified the availability of sufficient resources as a key factor ensuring successful implementation of computerised systems. Implementers, vendors and users identified the following resource needs during surveys and interviews:

- Assigning additional staff and funding to implement, manage, develop and grow the system in use [14, 27, 53]
- Defining and resourcing new roles within the organisation capable of supporting and sustaining the change [4]
- Retaining skilled staff with system experience [54]
- Setting up in-house technical support to provide assistance to system users, especially during early stages of implementation [23, 26, 28]

Lack of funding was identified to be a significant barrier to system adoption [23, 30, 59]. Other reported resource barriers included: Low levels of available IT skills, and lack of IT infrastructure, including not having enough computers [6, 21-23, 54].

6.2.2.8 VENDOR ISSUES

Surveys and focus groups with US clinicians (obstetricians and gynaecologists) revealed that they often found vendors difficult to get a hold of [19]. In a number of UK studies, both clinical and non-clinical staff described convoluted communication channels between hospitals and vendors and slow response times to deal with requests for software fixes [6, 14, 21]. Users reported that vendors would take months (even years) to make changes to the system [14]. This appeared to be the result of centrally negotiated contracts (between hospital trusts and suppliers, rather than local service providers and suppliers) and restricted customisation due to contractual arrangements under a government National Health Service (NHS) modernisation programme (see Section 4.3.1.2 below).

In a focus group study, vendors highlighted the importance of building relationships with hospitals well before system implementation, viewing contracts as a 'partnership' between suppliers and hospitals, and including in the contract processes surrounding conflict resolution and ways to deal with implementation delays [54].

6.2.3 CASE STUDIES, COMMENTARIES AND NEWS ARTICLES THAT DISCUSSED CONTRIBUTORY FACTORS

Table A3b shows the main factors identified to contribute to successful implementation of computerised systems with electronic prescribing in the papers that were not research studies. These papers did not involve primary data collection. Instead, they typically conveyed the opinions of an author or a stakeholder group.

6.2.3.1 PLANNING AND RESOURCES

The most frequently cited contributory factor to successful implementation was adequate planning. One or more aspects of planning (e.g. piloting, testing, resources) were mentioned in the majority of commentaries and case studies identified (n=17).

Having a clearly defined vision with achievable goals was viewed as essential [60, 61]. Generating enthusiasm at the right time, not too early, was reported to be important, or enthusiasm will wane [62].

Many papers highlighted the importance of having sufficient resources available for successful implementation. This was said to begin with an understanding of the resources required for implementation [38] and often involved taking a thorough inventory of hardware and software needs [33]. Lack of appropriate funding was seen to be a significant barrier to system implementation [60, 63]. Financially, implementation of a computerised system involved high initial costs (e.g. purchase of a system, training, support etc.) and this was viewed to be generally underestimated [33, 35].

A number of papers highlighted the importance of undertaking a comprehensive workflow analysis to understand how workflow will change with system introduction [64, 65]. It was recommended that workflow and clinical processes that are less than optimal not be automated [33]. Instead, making workflow and process changes (consistent with the new system's capabilities) before the 'go-live', will give staff time to adjust to changes before implementation [33].

Requiring different team members to test the system using fictitious patients was highlighted to be imperative in one case study [65]. In another, conducting mock-live sessions allowed the organisation to answer questions regarding hardware, software, and licensing needs (e.g. Were there enough work stations? How many employees can be on the system at once?) [64]. Authors of one paper were adamant that testing should be done in production environments to give a true sense of system performance and response times [66]. In their perspective paper, Wright et al. explain that testing environments often differ from production environments and testing in production offers the ability to test the complete system, including any interfaces with outside applications, modules and devices [66].

Several papers suggested adopting a phased or step-by-step approach to implementation [37, 61, 65]. Piloting the system in an area with a high level of provider support also appeared to be effective [33]. In two case studies, having a champion physician initially use the system on a small group of patients, and then expanding to more patients if no problems are encountered, was a strategy that worked [37, 65].

A major theme that emerged from these papers was the importance of user involvement in all stages of planning, including vendor selection, design, implementation, and ongoing use [33, 35, 36, 62, 65, 67, 68]. Creating a sense of ownership among clinical staff was viewed as critical by many authors for ensuring systems are accepted and used.

Several other tips for planning were discussed in case studies and commentaries, including:

- Plan for a period of decreased productivity during initial 'go-live' [64]
- Plan for increased staff before, during and for the first month after implementation [34]

- Integrate a clinical informaticist into the hospital team [69]
- Have multidisciplinary planning and decision-making groups [33, 65]

6.2.3.2 TRAINING AND TECHNICAL SUPPORT

Adequate training and technical support was identified to be another major factor contributing to successful implementation of computerised systems with electronic prescribing. In one commentary, this was believed to be one of the most important aspects of implementing new technology [70] and in another, it was viewed to be essential in preventing system misuse and errors [71]. Training and/or technical support was cited in more than half of the non-research papers (n=15).

Although variability existed in the type and quantity of training delivered to staff, the following recommendations were made:

- Customise training to be relevant to the user speciality (i.e. use unit-specific scripts and patients to make education real and relevant to day-to-day situations) [65, 70]
- Use on-line training, as this allows few people to train many, allows training to take place in any location and makes it possible for learners to work at their own pace [70]
- Offer training in various modalities, to meet the diverse work schedules and different learning styles of staff [65]
- If possible, train users in varied aspects of the system — for example, pharmacists trained in the basics of prescribing and administration functions can act as a resource on the wards for medical and nursing staff [34, 37]
- Evaluate whether extra training is needed before 'go-live' and if so, address this need immediately [64]
- Dedicate time 'off-unit' for training [64]

Giving users an opportunity to practise using the new technology in an environment that mirrors the actual system was also considered critical [34]. Rewarding employees for practising proved to be an effective approach in one case study [64].

One author suggested that training should be provided before 'go-live' but also after implementation [64]. As the basics of system use are mastered, more advanced classes could be used to ensure optimal use of the system [64].

In addition to training, technical support on-site was viewed as another factor essential for successful implementation. In one press release, it was suggested that support be provided 24/7 during and immediately after 'go-live' and should be provided by both the vendor and hospital IT staff [67].

A number of papers also recognised the value of having clinician champions providing training and support [32, 37, 69].

6.2.3.3 LEADERSHIP AND SUPPORT

Several papers (n=6) viewed strong executive support as critical for successful implementation of systems [62, 65, 68, 69], with leadership from doctors, pharmacists, nurses, information technology employees and the administration department also seen to be an important factor [37, 68].

6.2.3.4 USABILITY AND DESIGN

Eleven papers reported that system usability and design were factors influencing successful implementation. For a system to be successful, the system must be user friendly [65, 67], with some authors of case studies specifying consistency (in function and interface design) as a key feature of well-designed systems [32, 65]. In another case study, local adaptability of the system was viewed as essential [37], with a press release stating that systems able to be configured to suit the way users want to do work, better integrated into workflow [67].

Computer access (e.g. remote access) and hardware availability for all end users were also identified as critical factors in case studies [32, 65], as was interoperability [38]. A system that offers a high level of interoperability with existing information systems (e.g. automated dispensing machines) was seen to be more likely to be successful [33, 38].

A system's adverse impact on workflow was viewed by one author to be the biggest impediment to system adoption [72]. Other design problems thought to contribute to unsuccessful implementation included tedious data entry, increased workload, poor user interface, faulty connectivity, and inadequate software updates [60].

Some specific design recommendations discussed in case studies and commentaries included:

- Pharmacy building an accurate drug library that reflects the formulary options, substitution practices, and medication preferences of the organisation [34]
- The use of order sets and templates to reduce time of ordering and errors associated with system use [33, 58, 65]
- Provide only limited decision support, with careful introduction initially to avoid user frustration [37]

6.2.3.5 COMMUNICATION

A number of papers (n=8) referred to communication as an essential component of successful implementation of computerised systems. Communication can be via a range of channels (meetings, in-service training sessions, paper and electronic updates) [37], with one case study highlighting face-to-face communication as the most efficient [65]. In another case study, communication was found to be necessary not just across sub specialties, but across disciplines (doctors, nurses, allied health) [62]. Effective communication between IT and end users was found to be particularly important [65, 69].

The subject matter of communication ranged in papers and included:

- Responsibilities of clinical and non-clinical staff [64]
- System issues and problems [35]
- Information required for safe and effective use of the system [34]

- System updates (e.g. tip sheets, system notices, clinical decision-support updates) - A major barrier to the successful implementation of technology has been identified to be poor communication of system changes and updates to users [34]

In one case study, communicating with other organisations using the same software also proved to be an effective way of improving processes and helped prevent many surprises [64]. One paper highlighted the importance of communicating with the community, so that patients have an understanding of why things might slow down initially when they are admitted into hospital, as staff adjust to using a new system [62].

6.2.3.6 STAFF ACCEPTANCE

Several papers (n=5) discussed staff attitude towards the new system as a factor influencing successful implementation. Clinician acceptance of this major organisational change was seen to be vital [37, 68]. Support from clinical staff was also viewed as integral in getting an organisation to embrace the change [35]. In one case study, actively listening, and providing extra training and practice opportunities for staff with a negative attitude towards the system proved to be a useful strategy [64].

6.2.3.7 EVALUATION

Although not frequently mentioned (n=2), evaluation was seen to be an important mechanism for identifying problems related to software, process and practice [33, 37].

6.2.3.8 VENDOR ISSUES

A small number of papers (n=3) discussed the role of vendors in ensuring the successful implementation of computerised systems. Fostering a productive relationship with the software vendor was viewed as critical to adjusting the product to meet local needs and specifications [36, 37]. One author also highlighted that vendors are likely to be required to provide technical assistance when problems arise [35].

6.2.4 SUMMARY BOX

Systematic and narrative reviews, research papers, case studies, commentaries and news articles were fairly consistent in the factors they identified as contributing to successful implementation and use of computerised systems with electronic prescribing.

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, the main factors identified were:

- Adequate planning (including clinician involvement), resources and governance
- Appropriate staff training (of different types and modalities) and support, including super users
- A user friendly system that integrates well into users' workflow
- Strong leadership, including clinician champions
- Effective communication
- Staff with positive prior experiences of technology

Although case studies and observational studies demonstrated instances of successful implementation, and the perceptions of individuals involved in implementation are extremely valuable, no studies systematically examined the impact of a particular factor or factors on system implementation. This makes it difficult to determine which individual factor or combination of factors is necessary for successful implementation and consequently hinders the formulation of recommendations on organisational and system factors needed to ensure systems achieve their desired effects.

6.3 HOW DO POLICY AND REGULATIONS IMPACT ON THE UPTAKE AND USE OF COMPUTERISED SYSTEMS WITH ELECTRONIC PRESCRIBING IN HOSPITALS?

6.3.1 RESEARCH PAPERS THAT REPORTED ON POLICY AND REGULATIONS

A small number of research papers discussed the impact of policy or regulation on uptake and use of computerised systems.

6.3.1.1 GOVERNANCE

Governance was raised several times, mainly with respect to implementation timelines. In a study that conducted focus groups with vendors, it was found that financially driven milestones could lead to rushed implementation and poor outcomes [54]. In other studies, hospital staff (clinical and non-clinical) viewed time pressure as a factor leading to premature deployments. For example, planned deployment schedules in the UK were widely viewed by hospital staff as politically and contractually driven and described by some as 'unrealistic' from the outset [6, 8]. Authors have therefore suggested that implementations should be more outcome driven rather than date and milestone driven [8].

Several papers discussed the impact of incentives on computerised system adoption. In the United States, the *American Recovery and Reinvestment Act of 2009* injected \$50 billion into HIT, including approximately \$44,000 per practicing clinician and between \$2 million and \$10 million for each hospital qualifying as a 'meaningful user' of EHRs [55]. Although the meaningful-use incentives were not the primary force behind EHR implementation at some early-adopter hospitals, the government policies have since affected the timing, selection, and modification of EHR systems. Surveys and interviews with US implementation teams revealed that hospitals actively sought and used meaningful-use payments to recoup some of their EHR costs [25].

However, this US incentive program failed to include important healthcare providers, including nursing homes, home health agencies, long-term acute care hospitals, inpatient rehabilitation hospitals, and inpatient psychiatric hospitals [73]. These providers were excluded primarily because of funding constraints and uncertainty about their readiness to adopt EHR systems, and the result was lower uptake of systems. A 2009 American Hospital Association survey showed that, although 6% of long-term acute care hospitals had adopted an EHR system (basic or comprehensive), and 12% of short-term acute care hospitals had a system, only 4% of rehabilitation hospitals and just 2% of psychiatric hospitals had any system [73].

Although incentives have primarily been discussed in the US, a survey of EHR adoption rates in 122 South Korean hospitals revealed that incentives for implementation were also successful in facilitating system adoption there [23].

6.3.1.2 STANDARDISATION

Standardisation is often viewed as a facilitator to successful implementation of computerised systems. However, a top-down, centrally driven policy to deliver standardised systems to diverse local NHS organisations became a barrier to implementation in the UK, resulting in deployment delays and frustrations [3, 6]. Hospitals were hampered by a lack of budgetary control, lack of information about contractual arrangements, and the inability to configure the software (constrained by contractual clauses). They were also not able to engage in direct communication with the software vendor [8]. This centralised program was revised and more recent policy allows NHS organisations to invest in a range of locally chosen solutions within a framework of national standards [21].

6.3.2 CASE STUDIES, COMMENTARIES, AND NEWS ARTICLES THAT DISCUSSED POLICY AND REGULATIONS

A small number of non-research papers discussed the impact of policy or regulation on uptake and use of computerised systems.

6.3.2.1 GOVERNANCE

A common theme that emerged from papers was governments' roles in encouraging the adoption of computerised systems [60]. As discussed above, rewarding and incentivising health professionals that adopt IT with 'meaningful use' has demonstrated some benefits in the USA. In an interview with a Hospital and Health Systems Administrator in India, they suggested that professional autonomous bodies could also provide competitive awards to hospitals for excellence in quality and safety [60]. More specifically, a case study paper revealed that including adoption requirements and performance metrics into physician contracts led to strong uptake and sustained use of CPOE systems in several US hospitals [69].

Incentives can also be used to ensure staff participate in training prior to computerised system implementation. For example, in one commentary it was suggested that waiving of professional staff fees and offering continuing medical education credits could be used to encourage staff to participate in training sessions [35].

A risk of incentivised system adoption identified in a commentary paper was a rushed rollout to avoid penalties and meet deadlines. The consequences may be staff that are not trained properly and limited feedback to vendors on system redesign [36].

In addition to encouraging adoption, authors have suggested governments facilitate uptake and use of computerised systems by:

- Educating care providers and the public at large about the benefits of EHR [60]
- Offering a tax incentive for suppliers and vendors to allow production of quality systems that can accommodate growing technological advances [35]

Although limited information was available in the non-research papers on the impact of policy or regulation on system uptake, a barrier to implementation was identified to be the requirement for handwritten signatures on prescriptions [60, 74]. A change in legislation permitting electronic signatures on prescriptions may be required to allow widespread system adoption.

6.3.2.2 STANDARDISATION

In several papers, authors discussed the need for standardisation in systems. In an interview, a Hospital and Health Systems Administrator in India suggested that governments should provide guidelines to standardise record formats, nomenclature, and communication protocols to enhance interoperability of IT applications across healthcare systems [60]. In a prescriptive paper, it was recommended that a set of minimum system functionalities should be defined [38]. Standardisation was viewed to be particularly important for paediatric systems, where lack of standardisation has been identified as a major technical barrier to adoption [71] and to clinical decision support [38]. Inclusion of a basic set of clinical decision support rules in all ordering systems was seen to facilitate implementation and to be more cost effective [38]. The NHS in the UK has adopted an approach of clinical governance to provide more uniform decision support across its systems. The US is also beginning to oversee the certification and the availability of basic clinical decision support across its EMRs.

6.3.3 SUMMARY BOX

Based on the perceptions of stakeholders (including users, managers and vendors), and a review of case studies, commentaries and news articles, governments can encourage successful implementation and use of computerised systems by:

- Providing incentives to organisations for system adoption and use
- Providing incentives to suppliers and vendors to allow production of quality systems
- Educating providers and the public
- Providing guidelines to standardise some components of systems (e.g. basic decision support) while allowing local customisation for other components

7. CONCLUSION

HIT implementation has been shown to improve safety and efficiency of care, however, not considering all aspects of system implementation can lead to poor acceptance of systems by users [7]. Thus, it is crucial for organisations to be aware of the factors that contribute to successful implementation as well as potential barriers, and to prepare for potential safety issues that may result. In this review, we reported on key findings from both the evidence (i.e. research papers) and lessons learned (e.g. commentaries and case studies). We identified 77 papers that evaluated or discussed the implementation of computerised systems with electronic prescribing in hospitals, with only three undertaken in Australia which focused on EMM systems [17, 18, 37]. More frequently, papers were US-based and discussed EMR or EHRs in general.

We identified 50 research papers, however, the majority of these used interviews, focus groups or surveys to elicit the opinions of hospital staff (users, managers etc.) or stakeholders (e.g. vendors) on system implementation. Although it is extremely valuable to understand the experiences and perceptions of all stakeholders involved in implementation, in the absence of systematic evaluations of an implementation factor(s), determining which factor or combination of factors is necessary to ensure successful implementation of computerised systems is difficult. There is now little doubt that implementation of computerised systems is highly complex and dependent on a range of factors related to the intervention itself, the organisation, individuals, and the implementation process.

In this review, we identified the major factors to be adequate planning (including clinician involvement), appropriate staff training, a usable system that integrates well into users' workflow, staff with positive prior experiences of HIT, adequate resources including funding and support staff, strong vendor support, and strong senior leadership and support including the use of super users and clinical champions [39-42]. The most common barrier to successful implementation was identified to be a lack of resources, including the funding required for the initial procurement of the system and its ongoing maintenance [41].

Effective mitigation of potential safety issues resulting from the system, such as new errors (e.g. incorrect selection from a drop-down menu), reduced patient care, and workarounds, begins at the early planning stages of implementation [15, 17, 24]. Conducting assessments of clinical and administrative workflows prior to system introduction, and then selecting/customising a system that is unlikely to disrupt this workflow, appears to be the first step in ensuring systems are used safely and optimally. Also, monitoring these potential safety issues post implementation and evaluating outcomes of system introduction, both positive and negative, is critical for ensuring systems achieve their desired effects.

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9. APPENDICES

Table A1a. Details of systematic and narrative reviews that focused on implementation or use of computerised systems with electronic prescribing in hospitals

Author year country	System type	Study aim	Method
Boonstra et al, 2014 [39] (Netherlands)	EHR	To create an overview of existing literature on implementation in hospitals and to identify generally applicable findings and lessons for implementers	Systematic review - Databases included Web of Knowledge, EBSCO, and Cochrane Library. Relevant references in the selected articles were also reviewed. Search terms included: Electronic Health Record (and synonyms), implementation, and hospital (and synonyms)
Chang et al, 2015 [41] (Canada)	EMR	To determine the rate of adoption by physicians across Canada, and evaluate provincial incentives, and perceived benefits of and barriers to adoption	Systematic review - Data on EMR adoption in Canada were collected from CINAHL, MEDLINE, PubMed, EMBASE, the Cochrane Library, the Health Council of Canada, Canada Health Infoway, government websites, regional EMR associations, and health professional association websites
Classen et al, 2010 [42] (USA)	CPOE	To summarise the impact on medication safety, the efficacy, key measures of impact in practice and important implementation issues in order to provide a guide to health care providers adopting	Narrative review
Fritz et al, 2015 [40] (Germany)	EMR	To identify and collect literature about successful criteria of implementations in low-resource settings and to summarize them into recommendations	Systematic review - The search strategy relied on PubMed queries and manual bibliography reviews. Studies were included if EMR implementations in low-resource settings were described
Handal et al, 2010 [31] (USA)	EHR	To review the challenges and benefits associated with implementation in ED settings and the steps EDs can take to facilitate the implementation process	Narrative review

Note: EHR=Electronic Health Record; EMR= Electronic Medical Record; CPOE= computerized prescriber order entry; ED= Emergency Department

Table A2a. Details of research studies evaluating the implementation or use of computerised systems with electronic prescribing in hospitals

Author, year, country	System type	Setting	Study aim	Method	Participants
Aldosari et al, 2014 [30] (Saudi Arabia)	EHR	Public (n=16) and private hospitals (n=6)	To establish the rates, levels, and determinants of system adoption	Survey	Project managers, medical directors, heads of IT departments, and senior members of the EHR development team (n=280)
Allenet et al, 2011 [46] (Netherlands)	CPOE	University hospital	To identify and describe perceptions of benefits and factors influencing successful implementation	Electronic and paper mail survey	Physicians (n=101)
Alsweed et al, 2014 [57] (Saudi Arabia)	CPOE	Public hospital	To assess nurses' perspectives of the system impact on their workflow, patient safety and medication errors	Cross-sectional survey	Nurses (n=112)
Bossen et al 2013 [1] (Denmark)	EHR	Departments (n=2) of a regional hospital	To describe methodological approach to, and results of an evaluation post implementation	Surveys, individual interviews, observations, analysis of system data	Clinical and non-clinical staff (n=244)
Chang et al, 2016 [27] (Taiwan)	EHR	Teaching hospital	To explore the adoption process	Focus groups	Nurses
Cho et al, 2015 [75] (Korea)	EMR	Public hospitals (n=3)	To evaluate adoption behaviour	Survey	Doctors (n=159) and nurses (n=1004)
Cornford et al, 2010 [53] (Netherlands)	EPS	Hospitals (n=13)	To gather lessons learned from hospital sites that have implemented systems	Literature review, interviews	Hospital staff

Author, year, country	System type	Setting	Study aim	Method	Participants
Cresswell et al, 2011 [2] (UK)	EHR	Public hospitals (n=4)	To examine approaches to, and experiences of, user engagement during implementation	Observations, interviews, data from documents	Hospital staff (health care professionals and managers) (n=123) and stakeholders (n=15)
Cresswell et al, 2012 [3] (UK)	EHR	Secondary and specialist care hospitals (n=3)	To understand how software was integrated	Interviews, observations, field notes	Doctors, nurses, allied health professionals and administrative staff, managers, IT staff, clinical leads, psychologists, social workers and therapists (n=66) and stakeholders (14)
Cresswell et al, 2015 [54] (UK)	CPOE/CDS		To study perspectives about potentially transferable lessons surrounding procurement of systems	Focus groups via teleconference	Vendors (n=9)
Cresswell et al, 2016 [24] (UK)	EPS	Urban and rural acute care and teaching hospitals (n=5)	To investigate types of workarounds users employed, the underlying reasons offered and implications for care provision and patient safety	Interviews, observations, project documents	Information technology managers, clinical implementation team members, doctors, nurses, pharmacists, allied health professionals and pharmacy technicians (interviews n=173; observations n=24; documents n=17)
Cucciniello et al, 2015 [4] (UK)	EMR	Major teaching hospital	To examine the interaction of sociological and technological factors during implementation	Documentary analysis, interviews, observations	Member of strategy board, director of electronic health, finance office staff, clinical advisors, senior nurses, senior clinicians and receptionists (n=19)
El Mahalli et al, 2015 [52] (Saudi Arabia)	EHR	Governmental hospitals (n=3)	To assess adoption and barriers to use	Paper-based survey	Nurses (n=185)

Author, year, country	System type	Setting	Study aim	Method	Participants
Holden, 2010 [28] (USA)	EMR and CPOE	Tertiary care community hospitals (n=2)	To identify beliefs about system use, to identify what factors shape IT use behaviour	Semi-structured interviews	Physicians (n=20)
Hong et al, 2013 [48] (Korea)	EHR	Teaching hospital	To investigate factors affecting satisfaction	Online survey	Physicians, pharmacists, and other health care service providers (n=54)
Hoonakker et al, 2013 [49] (USA)	CPOE	ICUs (n=4) in teaching hospital	To examine satisfaction with implementation	Survey pre and post implementation	Nurses, providers and physicians (n=397)
Jeon et al, 2014 [50] (Canada)	CPOE	Oncology institutions	To determine the current status of adoption, and to identify and prioritize knowledge gaps in usability and adoption	Survey, workshop	Oncology clinicians, human factors engineers, patient safety researchers, policymakers, and hospital administrators
Laramée et al, 2011 [26] (USA)	EHR	Rural academic medical centre	To determine what interdisciplinary healthcare team members perceive led to successful implementation	Focus groups, survey	Health professionals (n=40)
McMullen et al, 2015 [5] (USA)	CPOE	Hospitals (n=3)	To evaluate the implementation and early user experience	Surveys, direct observations, interviews, focus groups	Pharmacists (n=54 before, n=42 after)
Mozaffar et al, 2016 [14] (UK)	CPOE/CDS	Hospitals (n=6)	To explore reasons for delays in implementation	Interviews, discussions, document review	Clinical staff, implementers and suppliers of the systems (n=214)

Author, year, country	System type	Setting	Study aim	Method	Participants
Muslin et al, 2014 [45] (USA)	CPOE	217-bed rural hospital	To investigate the implementation of a CPOE	Survey	Physicians (n=19)
Nakamura et al, 2010 [59] (USA)	EHR	General acute care children's hospitals (n=108)	To assess potential barriers to or facilitators of adoption	Survey	Chief information officers
Niazkhani et al, 2010 [16] (Netherlands)	CPOE	Academic hospital	To assess the system effects on inter-professional workflow in the medication process	Semi-structured interviews, analysis of handwritten and system-generated documents	Physicians, nurses and pharmacists (n=22)
Niazkhani et al, 2011 [15] (Netherlands)	CPOE	Academic hospital	To evaluate the problems experienced after implementing the system, their possible root causes, and the responses of providers in order to incorporate the system into daily workflow	Interviews, analysis of documents and educational training material	Physicians (n=6) and nurses (n=12)
Park et al, 2014 [76] (Korea)	EMR	Small general hospitals (n=144)	To investigate the factors affecting adoption	Surveys	
Raglan et al, 2015 [19] (USA)	EHR		To explore the experiences of use	Surveys, focus groups	Obstetricians/gynaecologists (survey: n=671; focus groups n=6)

Author, year, country	System type	Setting	Study aim	Method	Participants
Robertson et al, 2010 [6] (UK)	EHR	Secondary care hospital trusts (n=5)	To describe and evaluate the implementation and adoption	Semi-structured interviews, observations, analysis of documents and field notes	Trust staff, implementation team, clinical staff, and administrative staff (n=114)
Schenk et al, 2016 [20] (USA)	EHR	Regional tertiary hospital	To understand perceptions of a newly adopted system	Surveys, interviews	Nurses (survey: n= 285; 131 in pre-EHR survey and 154 in post-EHR survey; interview: n=11 (pre); n=10 (post))
Scholl et al, 2011 [7] (India)	EMR	Eye hospital	Presents challenges related to implementation and methods and strategies that were utilised to overcome these challenges	Observations, semi-structured interviews	Hospital managers, IT staff, health staff, and vendor employee (n=30)
Ser et al, 2014 [21] (UK)	EHR	Mental health hospitals (n=2)	To identify specific examples of workarounds reported by hospital staff and possible contributing factors	Secondary analysis of semi-structured interviews	Hospital staff (n=33)
Shaha et al, 2015 [55] (USA)	EHR		Present and compare survey results on clinician and information technology professionals' satisfaction post-implementation	Telephone interviews	Information technology professionals and physicians

Author, year, country	System type	Setting	Study aim	Method	Participants
Sheikh et al, 2011 [8] (UK)	EHR	Acute hospitals and specialist care settings (n=12)	To evaluate the implementation and adoption of the system in 'early adopters'	Semi-structured interviews, observations, field notes, conferences, national health service documents, national and regional documents	Healthcare professionals, hospital managers and administrative staff, hospital based IT implementation leads, national health service staff from 'Connecting for Health', local service provider staff, patients and carers, and other stakeholders (n=431)
Shu et al, 2013 [77] (PR China)	EHR	Chinese tertiary hospitals (n=848)	To assess adoption in Chinese tertiary hospitals using a nation-wide standard EHR grading model	Cross-sectional observational study	
Silow-Carroll et al, 2012 [25] (USA)	EHR	Hospitals (n=9)	To examine hospitals that implemented a comprehensive system	Surveys, interviews	EHR implementation teams
Simon et al, 2013 [9] (USA)	CPOE	Community hospitals (n=5)	To characterise the experiences of hospitals that have successfully implemented the system	Formal structured observations, in-depth semi-structured interviews	Clinicians and hospital staff (n=24)
Smith et al, 2011 [29] (USA)	EMR	340-bed, not-for-profit, tertiary-care medical center	To explore changes in nursing satisfaction and attitudes toward computerized charting pre-implementation and post-implementation	Pre and post-implementation survey	Nurses (pre-implementation n=148; post-implementation n=119)
Struik et al, 2014 [51] (Netherlands)	EMR[10]		To quantify the relative importance of known barriers and facilitators experienced by users	Online survey	Nurses (n=148) and physicians (n=150)

Author, year, country	System type	Setting	Study aim	Method	Participants
Sykes et al, 2011 [43] (USA)	EMR	800-bed private hospital	To explain system use and consequent performance among physicians during early stages of the implementation	Survey either online or on paper (embedded within a larger survey employed by the hospital)	Physicians (n=151) and patients (n=8,440)
Takian, 2012 [10] (UK)	EHR	500-bed general district hospital	To describe the arrival, implementation process, and stakeholders' experiences of the system	Semi-structured interviews, observations, documentary data	Managers, implementation team, IT, healthcare practitioners, software developer, and other stakeholders (n=36)
Takian et al., 2012 [11] (UK)	EHR	Mental health hospital	To describe the arrival, the process of implementation, stakeholders' experiences and the local consequences of implementation	Semi-structured interviews, field notes, observations, documentary data	Internal and external stakeholders (n=48)
Van der Sijs et al, 2011 [12] (Netherlands)	CPOE	Oncology (paper) and cardiology (electronic) wards at a 506 bed general hospital	To describe the bottlenecks and workarounds resulting from implementation of EPS	Semi-structured interviews, observations	Doctors, nurses, and a pharmacist (n=9)
Van der Veen et al, 2012 [56] (Netherlands)	CPOE	General, university and teaching hospitals (n=72)	To determine the association of performing risk analysis with user satisfaction after system implementation	Survey	Doctors, nurses, and a pharmacist
Vishwanath et al, 2010 [47] (USA)	EMR, CPOE	Outpatient clinic of a large research hospital	To understand the antecedents to the physicians' workflow expectation from the new EMR and to track physicians' satisfaction post implementation	Survey	Physicians pre implementation (n=20), 3 months post implementation (n=22), and 20 months post implementation (n=26)

Author, year, country	System type	Setting	Study aim	Method	Participants
Ward et al, 2011 [44] (USA)	EMR	300-bed rural referral hospital	To compare changes in nurse's perceptions about patient care, processes and workflow before and after implementation	Survey	Nurses and other non-identifiable hospital staff (n=1395)
Westbrook et al, 2013 [17] (Australia)	EPS	Public hospitals (n=2)	To compare the manifestations, mechanisms, and rates of system-related errors associated with two systems	Chart review	
Westbrook et al, 2013 [18] (Australia)	EMMS	Public hospital	To measure whether the proportions of time spent in medication tasks, direct care, and communication changed following introduction of the system	Direct observation (time & motion)	70 nurses, 59 doctors
Wolf et al, 2012 [73] (USA)	EHR		To determine adoption rates among all types of inpatient providers that were ineligible for these same federal meaningful-use incentives: long-term acute care hospitals, rehabilitation hospitals, and psychiatric hospitals	Survey data analysis	
Yontz et al, 2015 [22] (USA)	EHR	Not-for-profit, integrated tertiary health network	To identify perioperative attitudes toward use	Survey	Nurses (n=80)
Yoon et al, 2012 [23] (South Korea)	EHR	Tertiary teaching and general hospitals (n=122)	To examine prevalence and identify the factors that impede or facilitate adoption	Survey	

Author, year, country	System type	Setting	Study aim	Method	Participants
Yuan et al, 2015 [13] (USA)	EHR	Medical units (n=2) of a large, urban academic hospital	To determine how super users' influenced use and examine their effects on implementation outcomes	Observations, in-depth interviews	Nurse super users, nurse managers, nurses, patient care associates, and secretaries (n=24)

Note: EHR=Electronic Health Record; EMR= Electronic Medical Record; EMMS= Electronic medication management system; CPOE= Computerised Provider Order Entry; ED= Emergency Department; EPS= Electronic Prescribing System; CDS= Clinical Decision Support; IT= Information Technology; ICU= Intensive Care Unit

Table A2b. Main implementation factors reported in research papers evaluating the implementation or use of computerised systems with electronic prescribing in hospitals

Factors that influence implementation and use of computerised systems

Author year country	Training	Usability & functionality	Standardisation	Staff characteristics	Vendor issues	Resources	Planning & governance	Support, leadership & communication	Hospital size
Aldosari et al., 2014 [30] (Saudi Arabia)		X				X	X	X	X
Allenet et al., 2011 [46] (Netherlands)				X				X	
Alswweed et al., 2014 [57] (Saudi Arabia)	X								
Bossen et al., 2013 [1] (Denmark)	X	X		X				X	
Chang et al., 2016 [27] (Taiwan)		X				X	X	X	
Cho et al, 2015 [75] (Korea)	X	X				X			

Factors that influence implementation and use of computerised systems

Cornford et al., 2010 [53] (Netherlands)					X		X	
Cresswell et al, 2011 [2] (UK)		X					X	X
Cresswell et al, 2012 [3] (UK)		X	X					
Cresswell et al, 2015 [54] (UK)				X	X		X	X
Cresswell et al, 2016 [24] (UK)		X			X			
Cuciciniello et al, 2015 [4] (UK)		X			X		X	
El Mahalli et al, 2015 [52] (Saudi Arabia)	X	X						

Factors that influence implementation and use of computerised systems

Holden, 2010 [28] (USA)	X	X		X		X
Hong et al, 2013 [48] (Korea)		X				
Hoonakker et al, 2013 [49] (USA)	X	X				
Jeon et al, 2014 [50] (Canada)		X				
Laramée et al, 2011 [26] (USA)	X			X		X
McMullen et al, 2015 [5] (USA)	X	X				
Mozaffar et al, 2016 [14] (UK)	X			X	X	X
Muslin et al, 2014 [45] (USA)			X			X

Factors that influence implementation and use of computerised systems

Nakamura et al, 2010 [59] (USA)							X		
Niazkhani et al, 2010 [16] (Netherlands)		X							
Niazkhani et al, 2011 [15] (Netherlands)		X							
Park et al, 2014 [76] (Korea)								X	
Raglan et al, 2015 [19] (USA)	X	X				X			
Robertson et al, 2010 [6] (UK)		X	X			X		X	X
Schenk et al, 2016 [20] (USA)		X							
Scholl et al, 2011 [7] (India)	X				X			X	

Factors that influence implementation and use of computerised systems

Ser et al., 2014 [21] (UK)	X	X	X	X	X	X	X	X
Shaha et al, 2015 [55] (USA)							X	
Sheikh et al, 2011 [8] (UK)		X	X				X	
Shu et al, 2013 [77] (PR China)						X		
Silow-Carroll et al, 2012 [25] (USA)	X	X					X	X
Simon et al, 2013 [9] (USA)	X						X	X
Smith et al., 2011 [29] (USA)		X						
Struik et al, 2014 [51] (Netherlands)		X						X

Factors that influence implementation and use of computerised systems

Sykes et al, 2011 [43] (USA)		X		X		
Takian, 2012 [10] (UK)	X					X
Takian et al., 2012 [11] (UK)		X				
Van der Sijs et al, 2011 [12] (Netherlands)		X				
Van der Veen et al, 2012 [56] (Netherlands)						X
Vishwanath et al, 2010 [47] (USA)				X		
Ward et al, 2011 [44] (USA)		X		X		X

Factors that influence implementation and use of computerised systems

Westbrook et al, 2013 [17] (Australia)									X
Westbrook et al, 2013 [18] (Australia)		X							
Wolf et al, 2012 [73] (USA)									X
Yontz et al, 2015 [22] (USA)	X	X						X	
Yoon et al, 2012 [23] (Korea)							X	X	X
Yuan et al, 2015 [13] (USA)	X	X							X

Table A3a. Details of papers focused on the implementation of computerised systems with electronic prescribing in hospitals that did not report data/results (e.g. case studies and commentaries)

Author year country	System type	Setting	Paper aim	Paper type
Agno et al, 2013 [35] (USA)	EMR/EHR	N/A	To discuss specific challenges faced by hospitals adopting these systems	Commentary
Anonymous, 2011 [67] (Australia)	EMR	ED	To describe the experiences of implementing 'Ascribe' software (ED clinical system)	Press release
Anonymous, 2011 [60] (India)	EMR	N/A	To share insights into the status of implementation in India	Interview
Anonymous, 2013 [63] (New Zealand)	N/A	N/A	Interview with chair of the National Health IT Board about the new healthcare system in New Zealand, which is being executed and delivered under his leadership	Interview
Bhatia, 2013 [71] (India)	HIT	Paediatric settings	To discuss adoption	Commentary
Chen et al, 2011 [58] (USA)	CPOE	Paediatric oncology department of a hospital	To evaluate the implementation of the system with additional functionality	Case study

Author year country	System type	Setting	Paper aim	Paper type
Cooley et al, 2012 [33] (USA)	CPOE	Public and university hospitals and clinics (n=4)	To describe collective experiences and factors that are essential to successful implementation	Commentary
Daly et al, 2011 [36] (USA)	IT in general	N/A	To summarise the intersection of IT and patient safety	Commentary
Day et al, 2011 [37] (Australia)	EMMS	Teaching hospital	To describe the implementation of the system	Case study
Digital Healthcare, 2016 [62] (Australia)	EMR	Health district	To describe Monash Health's EMR project	Case study
Dunnigan et al, 2010 [72] (USA)	EHR	Ambulatory care department of a medical centre	To describe the steps taken in planning the implementation, how it was carried out, and lessons learned	Case study
Gellert et al, 2015 [69] (USA)	CPOE	Adult general hospitals (n=3) and a children's hospital	To describe the most valuable strategies deployed to achieve strong adoption, focusing on strategies that are not commonplace (e.g. Training and support)	Case study
Horning et al, 2011 [34] (USA)	EMR and CPOE	Non-profit critical access hospital pharmacy department	To review issues and benefits of the systems implementation	Commentary

Author year country	System type	Setting	Paper aim	Paper type
Jimenez, 2010 [70] (USA)	EHR	N/A	To discuss approaches for training staff to use the system	Commentary
Maust, 2012 [64] (USA)	EMR	Critical access hospital	To describe the successes, challenges and lessons learnt during implementation	Case study
Mclean, 2011 [74] (New Zealand)	EPS	Hospital	To describe a successful pilot	News article
Mominah et al, 2013 [32] (Saudi Arabia)	CPOE	Teaching and tertiary care hospital	To discuss the experience of using the system and its impact on clinical workflow in the pharmaceutical department	Case study
Nigam, 2012 [61] (India)	N/A	N/A	To summarise electronic business transformation in healthcare	Commentary
Phansalkar & Bates, 2012 [38] (USA)	CPOE/CDS	N/A	To provide an overview of technology and patient safety	Commentary
Prestigiacomo, 2011 [68] (USA)	EMR	Medical centre, university health system and children's health system	To describe how three hospital systems achieved HIMSS stage 7	Commentary
Ramirez et al, 2010 [65] (USA)	CPOE	NICU	To describe the experience of planning, building, training, and implementing the system	Case study

Author year country	System type	Setting	Paper aim	Paper type
Wright et al, 2016 [66] (USA)	EHR	N/A	To propose recommendations for how to incorporate testing in production into current testing practices	Perspective

Note: EMR= Electronic Medical Record; EHR=Electronic Health Record; ED= Emergency Department; HIT= Health Information Technology; CPOE= Computerised Provider Order Entry; IT= Information Technology; EMMS= electronic Medication Management System; EPS= Electronic Prescribing System; CDS= Clinical Decision Support; HIMSS=Healthcare Information and Management Systems Society; NICU= Neonatal Intensive Care Unit

Table A3b. Main implementation factors reported in papers that focused on the implementation of computerised systems with electronic prescribing in hospitals that did not report data/results (e.g. case studies and commentaries)

Factors that influence implementation and use of computerised systems										
Author year country	Training & technical support	Communication	Usability & design		Staff acceptance	Vendor issues	Planning & resources	Governance	Leadership & support	Evaluation
Agno et al, 2013 [35] (USA)		X			X	X	X	X		
Anonymous, 2011 [67] (Australia)	X		X				X		X	
Anonymous, 2011 [60] (India)			X	X			X	X		
Anonymous, 2013 [63] (New Zealand)							X			
Bhatia, 2013 [71] (India)	X			X						
Chen et al., 2011 [58] (USA)			X						X	

Factors that influence implementation and use of computerised systems

Maust, 2012
[64]
(USA)

X

X

X

X

Mclean,
2011 [74]
(New
Zealand)

X

Mominah et
al, 2013 [32]
(Saudi
Arabia)

X

X

Nigam, 2012
[61]
(India)

X

Phansalkar
& Bates,
2012 [38]
(USA)

X

X

X

Prestigiaco
mo, 2011
[68]
(USA)

X

X

X

Ramirez et
al, 2010 [65]
(USA)

X

X

X

X

X

Factors that influence implementation and use of computerised systems

Wright et al,
2016 [66]
(USA)

X

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