Effects of interdisciplinary collaboration in hospitals on medication errors: an integrative review

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Structured abstract

**Introduction:** Medication errors are commonly affected by breakdowns in communication. Interdisciplinary collaboration is an important means of facilitating communication between health professionals in clinical practice. To date, there has been little systematic examination of past research in this area.

**Areas covered:** The aims of this integrative review are to examine how interdisciplinary collaboration influences medication errors in hospitals, the areas of interdisciplinary collaboration that have been researched in previous work, and recommendations for future research and practice. An integrative review was undertaken of research papers (N=30) published from inception to August 2017 using MEDLINE, the Cochrane Library, CINAHL, PsycINFO, and Embase.

**Expert opinion:** Five different areas of interdisciplinary collaboration were identified in research involving medication errors. These areas were: communication through tools including guidelines, protocols, and communication logs; participation of pharmacists in interdisciplinary teams; collaborative medication review on admission and at discharge; collaborative workshops and conferences; and complexity of role differentiation and environment. Despite encouraging results demonstrated in past research, medication errors continued to occur. Increased focus is needed on developing tailored, individualized strategies that can be applied in particular contexts to create further reductions in medication errors. Greater understandings are also needed about the changing roles of various disciplines.

**Keywords**

medication safety, medication errors, interdisciplinary collaboration, communication, integrative review
Interdisciplinary collaboration has an important influence on medication errors, as demonstrated by the close links between medication errors and breakdown in communication.

There are five different areas of interdisciplinary collaboration identified in past research work: communication through tools including guidelines, protocols, and communication logs; participation of pharmacists in interdisciplinary teams; collaborative medication review on admission and at discharge; collaborative workshops and conferences; and complexity of role differentiation and environment.

Investigations of interdisciplinary collaboration have mainly focused on interactions between physicians, nurses and pharmacists.

While past interventions aimed at improving interdisciplinary collaboration have usually led to reductions in medication errors, medication errors continue to occur.

Involving diverse members of the health care team, such as speech pathologists, social workers and physiotherapists, in addition to physicians, nurses and pharmacists, provide future opportunities for enhanced interdisciplinary collaboration in medication safety.

Future work is needed on examining tailored approaches to interdisciplinary collaboration, particularly situations involving patients’ movements across transitions of care, and health professionals’ interactions with electronic medical records.
1. Introduction

Medication errors are widespread in hospitals, and comprise “any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer” [1]. Examples of medication errors include missed medications, administration of the wrong medication, administration to the wrong patient, excessive or insufficient doses, or the prescription of inappropriate medications to treat medical conditions. Medication errors can occur from gaps in knowledge, failure to follow rules or the use of inappropriate rules for managing medications, and the presence of slips, technical errors and memory lapses in carrying out medication activities.

The most serious outcomes of medication errors involve the occurrence of sentinel events. Sentinel events with medications, which cause catastrophic harm, often feature in the top 10 types of reported sentinel events [2]. Breakdowns in communication are closely tied to sentinel events [3]. Therefore, by targeting strategies aimed at improving communication between health professionals, there is the potential for reducing medication errors, particularly those causing harm.

An important facet of communication involves interdisciplinary collaboration, whereby health professionals of different disciplines share objectives, make decisions collectively, display shared responsibility and power, and work together to solve patient care problems [4]. Interdisciplinary collaboration is a different concept to multidisciplinary collaboration, which relates to individuals working in parallel with those of other disciplines rather than seamlessly working in mutual ways to achieve common goals.

The aims of this integrative review are to examine how interdisciplinary collaboration influences medication errors, to identify the areas of interdisciplinary collaboration found in previous research, and to consider recommendations for future work.
2. Methods

The integrative review was guided by the framework proposed by Whittemore and Knafl to ensure rigor of the methodological approach [5]. A search was undertaken from inception to the end of August 2017, of empirical studies using MEDLINE, the Cochrane Library, and the Cumulative Index to Nursing Allied Health Literature (CINAHL), PsycINFO, and Embase. Search terms included: medication error (OR medication incident) AND interdisciplinary AND collaboration. Inclusion criteria were research studies undertaken in adult hospital facilities, within inpatient units, comprising collaborative interactions between different health care disciplines. The search did not target research involving interdisciplinary collaboration in the community or ambulatory care, as the context in managing medications in these environments is very different. Similarly, the management of medications in paediatric situations is very different to that involving adults, and therefore is not within the boundaries of this review. Studies were excluded if they were not in the English language, had no focus on medication safety, or comprised editorials, commentaries, reviews or conference abstracts. In addition, studies were excluded if a particular health discipline group undertook medication management activities in isolation of other health disciplines.

An initial search yielded 1,430 papers. After excluding duplicates, a total of 1,113 papers were obtained. The abstracts of these papers were screened and excluded if they were considered irrelevant. Full texts were obtained of the remaining papers, which were read in full to determine their eligibility. The reference lists of included papers and targeted journals on medication safety were manually examined in effort to locate additional relevant papers. This process yielded an additional four papers. The process of screening and checking for inclusion was undertaken by two individuals independently who addressed any disagreements by a process of negotiation. In all, a total of 30 papers were included in the review (Figure 1).
3. Methodological approaches of studies

Of the 30 included papers, there were quantitative approaches comprising four randomized controlled trials [6, 7, 8, 9], four prospective cohort studies [10, 11, 12, 13], one retrospective cohort study [14], 12 pre-post interventions [15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26], and four cross sectional studies [27, 28, 29, 30]. In relation to qualitative approaches, critical ethnographic studies [31, 32, 33] and exploratory focus group and interview studies [34, 35] were undertaken (Table 1).

In 21 studies, research focused on collaboration between physicians, nurses and pharmacists in interdisciplinary teams. In seven studies, the emphasis was on physicians and pharmacists participating while in two studies, the focus was on collaboration between physicians and nurses in interdisciplinary teams. It was difficult to compare the prevalence of medication errors across studies due to variability in the denominator term used to calculate medication errors. For the 16 intervention type studies, six incorporated a control group to compare medication error outcomes [6, 7, 8, 9, 20, 23].

3. Collaboration through guidelines, protocols, and communication logs

Seven studies involved interdisciplinary collaboration through guidelines, protocols, or communication logs [10, 13, 15, 16, 21, 22, 25]. In the pre-post intervention study by Bates et al. [15], a collaborative team-based approach was used to tailor a physician order entry system. Non-intercepted medication errors reduced from 10.4 errors/1000 patient-days at baseline to 4.81/1000 patient-days (p<0.001) at post-intervention with the use of the physician order entry system. However, no additional significant benefits were observed with the use of a daily communication log between nurses and pharmacists.
The pre-post intervention study by Chung et al. [16] related to collaborative development of oncology protocols and standardized formulary, and interdisciplinary review of medication orders. Development of these tools and review of orders was undertaken by oncologists, nurses and pharmacists. Medication error rates were reduced by more than 50% for various error types, including incorrect dose, incorrect medication schedule and missed pre-medication.

Three studies involved evaluating whether implementation of tools and protocols resulted in the prescription of recommended medications to treat specified medical conditions [10, 21, 22]. In one study, interdisciplinary collaboration comprised pharmacists and physicians [10] while in the remaining two studies, this process involved physicians, nurses and pharmacists [21, 22]. In a prospective observational study conducted by Axtell et al. [10], pharmacists placed a summary of expert guidelines for managing acute myocardial infarction in patient charts. This summary acted as a prompt for physicians to follow recommended prescribing practices for treating this condition. The intervention was extended to involve pharmacist collaboration with the physician in addition to providing the guidelines. While prescribing of recommended medications according to the guidelines were much improved between baseline and post intervention, there were only marginal additional improvements relating to collaboration between pharmacists and physicians.

In a before-and-after study, an interdisciplinary team worked together to develop an algorithm for appropriate antibiotic selection and a dosing kit for indicated antibiotics [21]. In two participating emergency departments, both demonstrated improvements in physicians’ prescribing of antibiotics for community acquired pneumonia following the intervention. The interventions developed by the interdisciplinary teams were effective because they were tailored to the policies and practices of each department and the characteristics of patients presenting with atypical infections. In the two emergency departments, 54.9% and 58.2% of
appropriate antibiotic prescribing occurred before the intervention while 93.4% and 91.3% occurred after the intervention.

In a large study with five Australian states, Peterson et al. [22] demonstrated modest improvements in the prescription of appropriate medications for managing acute coronary syndrome. While prescribing patterns improved for recommended medications, there were additional benefits that could be further gained. For instance, at post-intervention, the prescribing of short acting nitrates was 68%, whereas prescribing for angiotensin converting enzyme inhibitors and angiotensin II-receptor antagonists was 84% and the prescribing of β-blockers was 82%. The authors proposed that more sustained interactions between health professionals in inpatient, outpatient and community settings may have led to further improvements in prescribing patterns. Communication between health professionals at hospital discharge and general practitioners in the community contributed to improving prescription practices, as well as facilitating documentation processes for managing acute coronary syndrome. At post-intervention, there was a significant increase in accurate documentation of the medication regimen in the discharge summary. The number of general practitioners who reported receiving a discharge summary increased significantly at post-intervention (81% vs. 77%, p<0.05).

The pre-post observational study by Taber et al., relating to care of kidney transplant recipients, is an example of collaboration extending to numerous health professional disciplines aside from physicians, nurses and pharmacists [25]. This collaboration included: physicians, social workers, surgeons, physician assistants, transplant pharmacist, nurse coordinators, transplant nurses and clinic nurses. These individuals were actively involved in reviewing transplant order sets, protocols and pathways. Aside from reduction in medication errors from 9.9% to 5.5%, the 30-day readmission rate was also significantly reduced (from 15% to 8%). A key reason for sustainable outcomes associated with a reduced readmission
rate was because after discharge, patients in the intervention group had an early follow-up service with the interdisciplinary team. These patients were required to return to the transplant clinic on the day after discharge.

In a prospective observational study by Went et al. involving an intensive care unit, physicians, nurses and pharmacists worked collaboratively to develop, implement and evaluate an electronic prescribing system [13]. Collaboration among computing experts, medical consultants, intensive care fellows, pharmacists and nurses enabled the creation of an electronic prescribing system based on practices widely adopted by clinicians in the intensive care setting. Consequently, the resulting system was highly utilized by clinicians and was associated with significantly reduced medication errors (208 medication errors in the paper-based group and 28 errors in the electronic prescribing group).

Of the seven studies involving the development of tailored tools by interdisciplinary teams, all demonstrated reductions in medication errors. Additional reductions in medication errors, aside from interdisciplinary development of tools, were not readily apparent in studies that involved collaborations between physicians and nurses [15] or between physicians and pharmacists [10]. Conversely, collaborative efforts involving a large diversity of health disciplines facilitated wide uptake of tools, which led to improvements in medication errors. Early follow-up by interdisciplinary teams with health professionals in the community, and with patients returning to outpatient clinics, were also found to be beneficial.

4. Participation of pharmacists within interdisciplinary teams in clinical settings

Seven studies involved pharmacist participation in clinical settings [7, 9, 11, 12, 14, 17, 20]. This participation comprised involving pharmacists as active members of ward rounds, examining prescribing activities, and including pharmacists in ward consultations with other health care disciplines. In the retrospective evaluation study undertaken by Sin et al. [14],
Pharmacists contributed to a 24-hour medication management service within the emergency department. Over the 7-month evaluation period, pharmacists recommended 642 interventions, which were subsequently accepted by physicians.

In the prospective cohort study undertaken by Bedouch et al. [11], the investigators examined whether the presence of clinical pharmacists in a ward where computerized physician order entry was in use, influenced physicians’ acceptance of the pharmacists’ interventions. Communication during formalized ward rounds had 11.2 increased odds of pharmacists’ interventions being accepted by physicians compared with communication at other times, such as informal bedside conversations. When pharmacists communicated through oral means, there were 12.5 increased odds of physician acceptance for pharmacists’ interventions compared to communication through computers.

In Leape et al.’s [20] pre-post intervention study with a control group, in the intervention ward, pharmacists participated on ward rounds, were involved in ward consultations with other health professionals, and were on call throughout the day. At post-intervention, the rate of preventable ordering adverse drug events was 12.4 per 1000 patient-days in the control ward and 3.5 per 1000 patient-days in the intervention ward, p<0.001. Physicians approved 99% of the recommendations made by pharmacists during ward round discussions.

In the pre-post intervention study by Jennings and colleagues involving review of anticoagulant therapy by pharmacists [17], the focus was on improving anticoagulant prescribing across the continuum of care. The rate of thrombotic events decreased from 4.6% in at pre-intervention to 3.9% at post-intervention, and further decreased to 0.0% for patients managed by collaborative physician and pharmacist practice. Key hospital executives also participated on ward rounds, which contributed to the economic impact of the pharmacy consult, with a benefit-cost ratio of 10.9 to 1.
In a randomized controlled trial by Willoch et al. [9], in the intervention group, pharmacist suggested solutions to drug related problems during team meetings comprising physicians and nurses. Following the intervention, in the intervention group, there were 49 drug related problems at discharge, while there were 148 in the control group. There were no differences in readmission rates to hospital between the two groups.

In a prospective, observational study involving pharmacists’ participation in daily ward rounds, Flood et al. [12] examined the appropriateness of prescribing in older patients with cancer. Pharmacists presented a review of patients’ medications, and documented recommendations for physicians on a form in the patient’s record. In all, 51 medication recommendations were made, and 82% of these were implemented. Twenty-five patients (53%) had changes made to their medication regimen, and 13 (28%) patients had a potentially inappropriate medication discontinued.

Of the seven studies involving pharmacists’ participation in clinical activities, all demonstrated improvements in medication error rates. One study showed improvements in the economic impact of this participation [17]. However, participation by pharmacists did not significantly affect readmission rates [9]. Suggested medication recommendations by participating pharmacists also consistently led to a high uptake by other interdisciplinary team members.

5. Collaborative medication review at patient admission and on discharge

Five studies focused on medication review interventions undertaken on patient admission and discharge [6, 8, 19, 23, 27]. In the open randomized trial by Eggink et al. [6], pharmacists identified potential medication errors ordered on patient discharge, and discussed these potential errors with cardiologists. In addition to detecting potential medication errors, the pharmacists provided medication lists for patients, undertook counselling with patients and
faxed medication lists to community pharmacists. In the usual care group, physicians documented discharge orders without involvement from pharmacists, and nurses provided counselling to patients. In the control group, 68% of patients had at least one medication error, while in the intervention group, 39% of patients had at least one medication error. Similarly, in Holland et al.’s study [27], pharmacists examined discharge medication orders to determine possible medication reconciliation problems. They found prescription non-reconciliation for 140 out of 224 patients, with 78 (55.7%) being fully resolved before discharge after discussions with the health care team.

Tong et al. [8] conducted a cluster randomized controlled trial on the prescription of medications following patients’ admission through the emergency department. Specially qualified credentialed pharmacists conducted face-to-face discussions with the admitting medical officer about medications to be prescribed. Following these discussions, the medication management plan was agreed upon, and the medication order was written. This approach led to a large reduction in medication errors. After the intervention, in the control group, there were 372 (78.7%) patients who had at least one medication error, while there were 15 (3.7%) patients who had at least one medication error identified.

In the prospective interventional study by Lang et al. [19], care for patients in a geriatric department was provided by an interdisciplinary team of psychiatrists, geriatricians, geriatric nurses, psychiatric nurses, ancillary staff, physical therapists, therapeutic recreation specialists, and psychologists. The focus of this intervention involved daily collaborative discussions between a geriatrician and a psychiatrist about the medication management plan for patients, which were then relayed to the wider interdisciplinary team. These discussions involved clarifying inappropriate medications that had to be ceased, and medications that had to be commenced. Incidence rates for potentially inappropriate medications reduced from 77% to 19% (p<0.0001) while prescribing omissions reduced from 65% to 11% (p<0.0001).
The novel aspect about this intervention, was that medication review occurred daily, thereby facilitating comprehensive decision making during patients’ hospitalization.

Rafferty et al. [23] examined the impact of having pharmacists review the medication history on admission, perform admission reconciliation by meeting patients and caregivers, review discharge reconciliation, and perform discharge education. The important aspect of this intervention is that the pharmacists directly communicated their findings to health professionals situated at the next level of care thereby enabling improved coordination of care. Pharmacists intervened on 904 occasions during the interventions period, which accounted for 2.4 interventions per patient. The intervention group also demonstrated 0.43 reduced odds of hospital readmission at 30 days compared to the control group.

All approaches using medication review resulted in improvements in medication errors. For three studies, the approach involved reviewing medications ordered on admission or discharge [6, 8, 27]. In two studies, the approach involved ongoing review of ordered medications during the patients’ hospitalization [19, 23].

6. Collaborative workshops and conferences with interdisciplinary teams

Four studies involved the conduct of workshops and conferences with interdisciplinary teams [18, 24, 26, 28]. Kostas et al. [18] undertook a pre-post evaluation study examining the effectiveness of a clinically-focused workshop in improving identification of inappropriate prescribing in older patients. This collaborative workshop included pharmacists, geriatricians and geriatric medical trainees. At the commencement of the workshop, pharmacists left the room to perform medication reviews on older patients. Geriatric trainees were instructed on how to conduct a medication review based on the Beers Criteria, Screening Tool of Older Person’s Prescriptions (STOPP) and Screening Tool to Alert doctors to Right Treatment criteria (START), and the Anticholinergic Risk Scale [36, 37, 38]. The pharmacists who left
the room then re-joined the group and presented their findings of the medication review, inviting input from geriatric trainees. Geriatric trainees' scores on their patients' medication lists improved significantly, from 5.6 out of 10 at the pre-intervention stage to 6.6 out of 10 at post intervention \((p<0.001)\). This intervention was effective in facilitating group discussions about appropriateness of medication prescribing, and enabling the identification of these medications.

In Ranchon et al.’s study [28], physicians and pharmacists examined case reports of medication errors involving antineoplastic agents. These case reports were presented at morbidity and mortality conferences for discussion. Unlike conventional morbidity and mortality conferences attended by physicians only, interdisciplinary teams of physicians, nurses and pharmacists participated in these sessions. In all, 91 errors were discussed with 34 corrective actions proposed for cultural change without any focus on shame and blame.

In the prospective before-and-after study undertaken by Romero et al. [24], a non-technological intervention was undertaken in the form of workshops and conferences in an intensive care unit. The workshops, which involved residents, interns, nurses, physical therapists, and the pharmacist, addressed the culture of the unit, the medication use system, and the standard operating plan for medications. The conferences acted as a motivational force, identifying the positive achievements of the unit in diverse areas of quality and safety. Conduct of the workshops and conferences successfully reduced medication errors rates from 41.9% at baseline to 28.6% at post-intervention.

The pre-post quality improvement evaluation by Weeks et al. [26] involved the conduct of education planning sessions on medication management in a veteran administration system. In addition to these sessions, coaching and email support were provided to participants comprising nurses, physicians, and pharmacists. In all, 1,833 medication errors were averted
during the project, and a similar number were averted 6 months after the intervention. Regular follow-up testing of key learning, helped to facilitate sustainability of results.

Aside from the study by Kostas et al. [18], which targeted geriatric physicians and pharmacists, all studies involving collaborative workshops and conferences included health professionals from a diverse array of disciplines. All studies demonstrated reductions in medication errors or improvements in appropriate medication prescribing. In addition to providing content information, these sessions were characterized by driving cultural change and improving motivation to improve medication safety.

7. Complexity of role differentiation and environment

Seven studies examined the complexities of role differentiation between health professionals and influences of the environmental context on interdisciplinary collaboration. Three studies were ethnographic in nature, which were conducted in medical wards [31, 32, 33]. The remaining studies comprised focus group [34], interview [35] and cross-sectional survey designs [29, 30].

The focus of Liu et al.’s [31] ethnographic study was on verbal talk, and the language discourses employed by health professionals during medication conversations. Physicians used the discourse of normalization to regulate nurses’ and pharmacists’ roles in managing medications. This discourse of normalization was expressed through physicians giving direct instructions to nurses and pharmacists, while nurses and pharmacists usually accepted these instructions. Nurses were content to focus on clarifying orders and requesting changes to be made to patients’ medications based on alterations in their clinical manifestations. Similarly, pharmacists were satisfied with their roles in problem solving and suggesting medication changes. Neither nurses nor pharmacists played an active role in decision making with
physicians. Inappropriate medication judgements were made during ward round and bedside discussions that were not addressed.

By comparison, earlier work by Liu et al. [32] examined written discourses of communication through the medication order chart. Physicians had legal responsibilities to document medication orders in recommended ways. However, due to missing information or illegible details, nurses positioned themselves as arbiters as they attempted to clarify medication orders and prevent prescribing mistakes. These requests for clarification often occurred during times when physicians had competing priorities in different wards. With regards to pharmacists, they regularly wrote recommendations for prescribing and administration on medication charts; however, these recommendations were not often communicated verbally to nurses and physicians, leading to delayed identification of the issues to be addressed.

Past qualitative research has also identified concerns about the various medication roles undertaken by health professionals in clinical practice [34, 35]. Interviews with physicians, nurses and pharmacists about managing patients’ medications across transitions of care showed compartmentalized thinking about roles and responsibilities [35]. For instance, health professionals commented that health professionals of different disciplines lacked understanding of their roles and routines, sometimes leading to medication errors. Similarly, focus groups with physicians, nurses and pharmacists about ensuring safe use of insulin in hospital settings showed a lack of understanding of each other’s roles in managing insulin prescribing and administration [34]. Delays occurred between glycemic measurement and insulin administration, and each health professional group could detail their own medication activities relating to insulin, but there was lack of understanding about other health disciplines’ roles.
Past survey research involved examining perceptions about medication errors and barriers to safe medication practices. In Sharma et al.’s survey study [29], physicians, nurses and pharmacists commented that improving communication among all health professional groups was a key factor that enabled improved medication safety. More specifically, they indicated that having collaborative discussions about system defects relating to equipment and staffing issues, and sharing discussions about continuity of care and team approaches to medication management promoted improvements in practice.

Similarly, Varela and colleagues examined physicians’ and nurses’ views about barriers to establishing relationships with pharmacists [30]. While physicians and nurses perceived pharmacists to be medication experts, they believed that pharmacists lacked engagement with other professional groups about how medications were managed. According to physicians and nurses, part of the problem related to their lack of contact with pharmacists, and the limited allocated time with this professional group. More specifically, a large proportion of physicians and nurses perceived that interprofessional communication with pharmacists occurred either sometimes (56.9%) or never (25.8%), which created increased opportunities for medication error.

Computer systems can also affect functionality between team members to facilitate communication. In Wentzer et al.’s ethnographic study [33], the investigators examined opportunities and barriers for interdisciplinary collaboration between physicians and nurses using the computerized physician order entry system. In utilising the system, physicians and nurses had individual passwords and different user rights in the system. If patients required medication changes, nurses were required to register these changes, and the physician had to approve these changes by logging into the system. Due to space limitations, the most suitable place for using the computerized physician order entry was at stationary computers that were positioned in the central office area, away from patients. Unfortunately, the system was not
flexible enough to support mutual reliance between physicians and nurses, which therefore impeded possibilities for interdisciplinary collaboration, and created a greater propensity for medication errors to occur.

Studies on the complexities of role differentiation and the environment provided valuable information about how interdisciplinary collaboration occurred and the challenges and barriers impeding effective communication. Challenges related to lack of understanding of various disciplines’ roles, inability of the contextual environment to accommodate electronic systems at the patient bedside. Health professionals’ comfort in adhering to their traditional roles, and physicians’ responsibilities in different ward spaces, affected medication safety.

8. Conclusion

The review identified five various areas relating to the effects of interdisciplinary collaboration on medication errors. These areas were: communication through tools including guidelines, protocols, and communication logs; participation of pharmacists in interdisciplinary teams; collaborative medication review on admission and at discharge; collaborative workshops and conferences; and complexity of role differentiation and environment. Despite encouraging results, medication errors continued to occur. Figure 2 provides information about key points from evidence relating to effects of five areas of interdisciplinary collaboration. Tailored strategies need to be developed and applied in particular contexts to create further reductions in medication errors. Greater understandings are also needed about the changing roles of various health care disciplines.

9. Expert opinion

Interdisciplinary collaboration contributes extensively in reducing medication errors. Strong links exist between the various strategies utilized to encourage improvements in collaboration
and the reduction in medication errors. Despite positive results demonstrated in past research, medication errors continue to occur. Understanding the gaps in current research can help to clarify how additional improvements can be made.

Research in interdisciplinary collaborative research holds enormous potential in generating understandings of strategies used by health professionals of different disciplines. It is difficult to fully comprehend how these strategies impact on medication errors because health professionals are employed in diverse positions in health care environments, they have varying levels of experience, they work in diverse areas of practice and they manage the care of patients with complex needs. In view of this complexity, the ultimate goal is the development of tailored, individualized strategies that can be applied to particular contexts and involve health professionals of different backgrounds and positions. However, in the studies reviewed, assumptions were sometimes made that specific strategies used in one setting, could be utilized in other settings, with little consideration given to their applicability or potential modifications that may be needed. Conversely, in situations where the cultural dynamics and safety climate were examined, it was possible to identify contextual challenges and enablers for interdisciplinary collaboration [24, 31].

To further advance the goal of generating knowledge of tailored strategies for interdisciplinary collaboration, greater understandings are needed about the changing roles of various disciplines. The traditional roles of responsibility of medication management have followed specific designated roles of responsibility, encompassing physicians, nurses, and pharmacists. Various health professionals are involved in prescribing, such as nurse practitioners, pharmacists and podiatrists. Yet, the prescribing activities of these individuals in terms of how they function within an interdisciplinary team, have not been included in past work. Aside from physicians, nurses and pharmacists, other individuals play an active role in medication management in hospitals, including physiotherapists, social workers and
dietitians. Physiotherapists are involved with efforts to mobilise patients following surgery and during rehabilitation. This mobilization requires physiotherapists to closely interact with physicians to order appropriate analgesics, and with nurses to administer the medications at appropriate times to tie in with mobilization. Social workers who assist in securing monetary support for patients, and help with psychosocial health care needs, are critical in creating the right environment for patients to consume their medications upon discharge from hospital. Speech pathologists assess the ability of patients to swallow while dietitians address food-drug interactions. The biggest challenge is ensuring that diverse members of the interdisciplinary team are actually included in the collaborative work being conducted.

With advances in technology and health, there is a greater proportion of older patients with complex treatment regimens and increased co-morbidities. These advances place further demands on how health professionals work together across transitions of care. With reduced lengths of hospital stay, health professionals need to be very cognizant of medication management concerns as patients move across clinical settings. As movements across settings continue to increase as different specialists address patients’ needs, there is a greater likelihood that interdisciplinary communication will become fragmented [39, 40]. To date, much of the medication transition work has concentrated on the role of pharmacists performing medication reconciliation across different points of care [41]. Troubleshooting medication errors across transitions before they actually occur by addressing some of the communication barriers that exist, is an important area of focus.

Another key area of current research interest involves the development, implementation and evaluation of electronic medical records. With increased uptake of electronic medical records across diverse hospital environments, there is greater propensity for comprehensive patient information to be available through electronic databases. Many hospitals currently use hybrid forms of paper and electronic means of communication, which can act as barriers for
effective interdisciplinary collaboration. Interchanging between paper and electronic channels of communication is likely to generate additional challenges in enabling medication safety, which need to be addressed in future research.
References


** Key hospital executives participated on ward rounds, which contributed to the economic impact of the pharmacy consult.


** In the intervention used in this study, pharmacists directly communicated their medication management findings to health professionals situated at the next level of care, thereby enabling improved coordination of care.


** Sustainable outcomes were associated with a reduced readmission rate, which occurred partly because after discharge, patients in the intervention group had an early follow-up service with the interdisciplinary team.


** Regular follow-up testing of key learning helped to facilitate sustainability of results.


** Computerized physician order entry system showed that it was not flexible enough to support the complex practices of physicians and nurses in ordering, continuing, and ceasing medications, thereby increasing the possibility of medication errors.


Table 1. Characteristics and results of included papers (N=30).

<table>
<thead>
<tr>
<th>Study, year and country</th>
<th>Research Design</th>
<th>Setting and sample</th>
<th>Data collection process and intervention</th>
<th>Results</th>
<th>Implications on medication errors</th>
</tr>
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<tbody>
<tr>
<td>Axtell et al. 2001 [10]</td>
<td>Prospective two-phase, observational design</td>
<td>General hospital. Coronary care unit.</td>
<td>Data collection – Review of medication charts.</td>
<td>Prescription rates for angiotensin enzyme inhibitors at discharge – Baseline: 30% of patients. Phase 1: 50% of patients (p&lt;0.05). Phase 2: 40% of patients (p=0.13).</td>
<td>Pharmacists’ placement of guidelines in charts and contact with physician improved medication prescribing for aspirin, beta blocker, angiotensin enzyme inhibitors and calcium channel blockers.</td>
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<tr>
<td>Bates et al. 1998 [15]</td>
<td>Pre-post intervention study</td>
<td>Tertiary care hospital. Medical and surgical intensive care units, medical and surgical general units. Baseline: 2,491 admissions. Post-intervention: 4,220 admissions.</td>
<td>Data collection – Reports of medication incidents. Visits to ward to collect data on actual and potential incidents. Review of medication charts. Intervention – Physician order entry system developed by physicians, nurses and pharmacists. Implementation of daily</td>
<td>Phase 1: 22% of patients (p&lt;0.05). Phase 2: 21% (p&lt;0.05). Prescription rates for beta blockers at discharge – Baseline: 55%. Phase 1: 74% (p&lt;0.05). Phase 2: 76% (p&lt;0.05). Number of non-intercepted serious medication errors – Pre-intervention: 10.4 errors/1000 patient-days. Post-intervention with physician order entry: 4.81/1000 patient-days (p&lt;0.001). Post with physician order entry and team changes: 6.01 errors/1000 patient-days (p=0.49). Impact of the physician order entry system could have obscured team contribution for communication log.</td>
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Chung et al. 2011 [16]  
United States  

<table>
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<tr>
<th>Study Type</th>
<th>Setting</th>
<th>Pre-implementation</th>
<th>Post-implementation</th>
<th>Incorrect dose – Pre-implementation</th>
<th>Incorrect dose – Post-implementation</th>
<th>Incorrect schedule – Pre-implementation</th>
<th>Incorrect schedule – Post-implementation</th>
<th>Missed premedication – Pre-implementation</th>
<th>Missed premedication – Post-implementation</th>
</tr>
</thead>
</table>
| Pre-post intervention study | Community teaching hospital.  
Oncology wards.  
Pre-implementation: 96 medication orders.  
Post-implementation: 75 medication orders. | Data collection – Audit of medication orders.  
Intervention – Development of pharmacy driven protocols.  
Inclusion of pharmacy oncology specialist and oncology clinical nurse specialist in protocols.  
Review of orders by pharmacist, nurse and oncologist.  
Development of standardised formulary. | Incorrect dose – Post-implementation: 5 (7%).  
Incorrect schedule – Post-implementation: 11 (15%).  
Missed premedication – Post-implementation: 4 (5%) (p<0.0625) | Clinical monitoring performed by pharmacists.  
Collaborative approach to review of orders. |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Setting</th>
<th>Data Collection</th>
<th>Intervention</th>
<th>Outcomes</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ostrowsky et al. 2013 [21]</td>
<td>Quasi experimental before and after study</td>
<td>Urban, multi-campus academic medical center. Two emergency departments.</td>
<td>Data collection – Printouts from Pyxis MedStation identified patients who received antibiotics. Intervention in both EDs – Newly formed antimicrobial stewardship team (infectious diseases physician and 2 pharmacists). Algorithm for ED providers identifying appropriate antibiotic selection. Development of a community acquired pneumonia kit with indicated antibiotics and dosing regimens bundled with the treatment algorithm. Preloading of antibiotics into an automated</td>
<td>Patients who received an appropriate community acquired pneumonia antibiotic regimen – First ED before intervention: 54.9%. First ED after intervention: 93.4% (p&lt;0.001).</td>
<td>Patients who received an appropriate community acquired pneumonia antibiotic regimen – Second ED before intervention: 58.2%. Second ED after intervention: 91.3% (p=0.004).</td>
<td>Combination of interdisciplinary teamwork, antibiotic stewardship, education, and information technology contributed to replicable and sustained improvements in prescribing of community acquired pneumonia.</td>
</tr>
<tr>
<td>Peterson et al. 2012 [22] Australia</td>
<td>Quality improvement cycle of audit, feedback, intervention, and reaudit.</td>
<td>Mix of hospitals across 5 Australian states.</td>
<td>Data collection – Medical record review. Survey of general practitioners. Patient phone survey. Intervention – Academic detailing of prescription guideline. Provision of education on cardiovascular risk factors. Communication of the acute coronary syndrome management plan to the patient, carer and general practitioner at discharge. Antiplatelet agents (aspirin and clopidogrel) – Baseline: 1,503 (97%) Postintervention: 1,567 (99%) (p&lt;0.01). ACE inhibitor and angiotensin II-receptor antagonist – Baseline: 1,207 (78%) Postintervention: 1,333 (84%), (p&lt;0.0001). β-Blocker – Baseline: 1,166 (75%). Postintervention: 1,307 (82%) (p&lt;0.0001). Statin – Significant enhanced adherence to evidence-based guidelines for managing patients with acute coronary syndrome following implementation of interdisciplinary intervention.</td>
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</table>
476 patients.  
6,284 notes written by providers in medical records and transplant reports. | Data collection – Medical records review of patient and graft survival, acute rejections, infections, readmission rates, and medication errors related to readmissions or delayed discharges.  
Intervention – Review of transplant order sets, protocols, and clinical pathways.  
Early outpatient follow-up. Designated staff for | Medication errors and adverse drug events –  
Start of study period: 622/6284 (9.9%).  
End of study period: 346/6284 (5.5%).  
30-day readmission rate –  
Start of study period: 15%.  
End of study period: 8%.  
Involvement from all discipline groups (surgeons, physician extenders, a transplant pharmacist, nurse coordinators, and transplant floor and clinic nurses) was crucial in reducing medication errors and readmission rates. |
supply of discharge medications. Diabetes management consult service.
Revised process for education about discharge medication

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<tbody>
<tr>
<td>United Kingdom</td>
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<td>Paper prescription charts: 408.</td>
<td>Intervention – Introduction of electronic prescribing system with involvement of physicians, nurses and pharmacists in design and development.</td>
<td>Electronic system: 28 prescriptions contained a total of 27 errors (0 omissions, 17 rule violations, 10 incomplete directions).</td>
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<td>Electronic prescriptions: 329.</td>
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</table>

**Participation of pharmacists within interdisciplinary teams in clinical settings**

<table>
<thead>
<tr>
<th>Bedouch et al. 2012</th>
<th>Prospective cohort study</th>
<th>Teaching hospital. Seven wards.</th>
<th>Review of medical records.</th>
<th>448 pharmacists’ interventions – Medication errors affected by oral versus computer communication and presence of pharmacist</th>
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<tbody>
<tr>
<td>France</td>
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</table>


| 272 patients with 2,862 medication orders. | Intervention – Pharmacists' interventions communicated to physicians in wards where computerised physician order entry system was used. | Non-conformity to guidelines or contraindications (22%).
High doses (19%).
Drug interactions (15%).
Improper administration (15%).
Changes in drug choice (41%).
Dose adjustment (23%).
Drug monitoring (19%).
Optimization of administration (17%).
Physician acceptance – Oral vs. computer communication): OR = 12.5, 95% CI 4.16–37.57 (p<0.01).
Communication during ward round: OR = 11.20, 95% CI 1.48–84.57 (p<0.01). | and physician during medical ward rounds. |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Setting</th>
<th>Data Collection</th>
<th>Medication Recommendations</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood et al. 2009 [12]</td>
<td>Prospective, observational study</td>
<td>University teaching hospital. Oncology–acute care for elders unit, cancer unit.</td>
<td>Daily review of patients' medical charts and nursing notes.</td>
<td>51 medication recommendations made. 42 (82%) confirmed by documentation.</td>
<td>Goal directed at reducing polypharmacy during ward rounds.</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Setting</td>
<td>Data Collection</td>
<td>Intervention</td>
<td>Preventable Adverse Drug Events</td>
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<tr>
<td>Sin et al. 2015 [14]</td>
<td>retrospective cohort descriptive study</td>
<td>Urban community teaching hospital with a trauma centre. Emergency department. 3,779 medication orders.</td>
<td>Data collection – Clinical review of number of medication orders reviewed. Number of interventions recommended and accepted. Number of intravenous admixtures prepared.</td>
<td>642 clinical interventions were recommended by pharmacists, and accepted by clinicians over a 7-month period. Most interventions involved providing drug information for physicians and nurses (45.9%), adjusting drug dosages (21.1%), and recommending antimicrobial therapy (15.1%).</td>
<td>Participation of various disciplines in collaborative activities ensured safe and effective medication use.</td>
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<td>Readmission to hospital – Intervention group: 11 out of 40 patients. Control group: 10 out of 37 patients.</td>
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<td>39</td>
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</tbody>
</table>

**Collaborative medication review at patient admission and on discharge**
<table>
<thead>
<tr>
<th>Eggink et al. 2010 [6]</th>
<th>Open randomized intervention study</th>
<th>General teaching hospital. Department of cardiology.</th>
<th>Data collection – Responses to Brief Medication Questionnaire (BMQ) — Regimen Screen. Review of medication orders at follow-up consultation with nurse or cardiologist.</th>
<th>At least one discrepancy or prescription error – Control group: 68% of patients. Intervention group: 39% of patients, RR 0.57 (95% CI 0.37–0.88).</th>
<th>Pharmacists able to compare a patient’s inpatient medication list and preadmission list to what is required at discharge, convey information to cardiologist and nurse.</th>
</tr>
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<tbody>
<tr>
<td>The Netherlands</td>
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<td>Control group: 44 patients. Intervention group: 41 patients.</td>
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<td>Intervention – Pharmacist identified potential prescription discharge errors. Discussions between pharmacist and cardiologist. Pharmacist created medication list for patient. Pharmacist provided counselling to patient. Pharmacist faxed medication list to community pharmacist.</td>
<td>Medication adherence – Control group: 79.5% had BMQ score &gt;= 1 (potentially non-adherent). Intervention group: 78.0% had BMQ score &gt;= 1, RR: 1.07 (95% CI 0.47–2.44).</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Setting</td>
<td>Data Collection</td>
<td>Prescription non-reconciliation identified:</td>
<td>Collaboration, between pharmacist and physician improved completeness and accuracy of discharge prescriptions.</td>
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<td>Holland et al. 2015</td>
<td>Cross-sectional observational study</td>
<td>Ireland</td>
<td>Acute teaching hospital. Medical and surgical wards. 224 patients with 2,245 medications.</td>
<td>Prescription non-reconciliation: 140 (62.5%). Prescription non-reconciliation: 78 (55.7%). fully resolved before discharge. 67.9 % (n = 53) resolved by physician. 26.9 % (n = 21) resolved by pharmacist. 5.2 % (n = 4) by joint input of physician and pharmacist.</td>
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<tr>
<td>Lang et al. 2012</td>
<td>Prospective and interventional study from admission to discharge.</td>
<td>Switzerland</td>
<td>Mixed acute and rehabilitation care hospital. Medical-psychiatric unit. Data collection – Medication records and completion of STOPP/START criteria (STOPP - Screening Tool of Older Persons’ Prescriptions, and START - Screening Tool to Alert)</td>
<td>Number of medications prescribed – Admission: 1347. Discharge: 790 (p&lt;0.0001).</td>
<td>Prescription of medicines in acutely ill patients with mental comorbidities can be improved by daily and active collaboration between senior geriatricians and</td>
</tr>
</tbody>
</table>
150 patients. Geriatrician and psychiatrists designed, implemented, and monitored comprehensive care and discharge plans for patients with mental comorbidities across a care continuum. Incidence for potentially inappropriate medications –

Admission: 116 (77.3%). Discharge: 25 (18.6) (p<0.0001).

Incidence for potential prescription omission –

Admission: 97 (64.7%). Discharge: 15 (11.2%) (p<0.0001).

Rafferty et al. 2016 [23] United States

Prospective intervention study with historical control

Tertiary care community hospital.
Pulmonary care unit and a medical-surgical unit.

1,529 discharges.

Data collection – 30-day re-presentation rate.
Secondary outcomes included 60, 90, and 365-day re-presentation rates.

30-day re-presentation rate–

Control group: 272 patients.
Intervention group: 43 patients, OR = 0.43; 95% CI = 0.30-0.61.

Incorporation of transitions of care pharmacist into interdisciplinary team of physicians and nurses impacted on re-presentation rate and detection of medication errors.
<table>
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<tr>
<th>Study</th>
<th>Design</th>
<th>Setting</th>
<th>Participants</th>
<th>Data Collection</th>
<th>Intervention</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Tong et al. 2016 [8]</td>
<td>Unblinded cluster randomised controlled trial</td>
<td>Adult major referral hospital. General medical units and emergency short-stay units.</td>
<td>881 patients. Control group: 473 patients. Intervention group: 408 patients.</td>
<td>Data collection – Patient’s medication chart with a medication error detected within 24 h of the patient’s admission.</td>
<td>Reconciliation. At least one medication error identified – Control group: 372 patients (78.7%). Intervention group: 15 patients (3.7%) (p&lt;0.001).</td>
<td>Partnering between physicians and pharmacists to jointly chart initial medications on admission significantly reduced inpatient medication errors (including errors of high and extreme risk).</td>
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<td>Australia</td>
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<td>Met the patient and caregiver to assess barriers, reviewed discharge reconciliation. Performed discharge education. Communicated with next level of care.</td>
<td>of medication errors) during the index presentation.</td>
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</table>
current medical and medication-related problems.

Medication management plan agreed upon.

Second pharmacist independently reviews all medications charted by a pharmacist within 24 hours.

<table>
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<tr>
<th>Collaborative workshops and conferences with interdisciplinary teams</th>
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<td><strong>Kostas et al. 2014</strong> [18]</td>
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<td>United States</td>
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<td>Study</td>
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<td>Ranchon et al. 2013 [28]</td>
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</table>
Training and motivation with workshops and conferences.

Developed by physicians, nurses and pharmacists on the culture of safety.

Creation of a medication error reporting system.

<table>
<thead>
<tr>
<th>Weeks et al. 2001 [26]</th>
<th>United States</th>
<th>Pre-post quality improvement evaluation</th>
<th>Veterans administration system.</th>
<th>Data collection – Telephone interviews. Leadership questionnaire. Cost data. Reported adverse drug events.</th>
<th>Number of medication errors averted – During formal project: 1,833 errors. During follow-up: 1,866 errors.</th>
<th>If team structure and leadership support remained intact, benefits were maintained for 6 months after the intervention.</th>
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<tr>
<td>Complexity of role differentiation and environment</td>
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<td><strong>Liu et al. 2016 [31]</strong></td>
<td>Critical ethnography</td>
<td>Australia</td>
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<td>Public teaching hospital.</td>
<td>Acute medical wards.</td>
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<td>76 nurses, 31 physicians, 1 pharmacist and 27 patients.</td>
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<td>Data collection - Participant observations, field interviews, video recordings and video reflexive focus groups and interviews.</td>
<td>Physicians used language discourse of normalisation to standardise patients’ illness experiences.</td>
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<tr>
<td>Nurses and pharmacists used language discourses of preparedness and scrutiny to ensure medication safety was achieved.</td>
<td>Nurses and pharmacists were keen to be informed of medication changes or to be resources for medication knowledge rather than being actively involved in influencing medication changes.</td>
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<td>Patients used discourse of politeness to raise medication concerns and question decisions.</td>
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<td>Health professionals extensively used body language in communication.</td>
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<td>Study</td>
<td>Methodology</td>
<td>Setting</td>
<td>Data Collection</td>
<td>Key Findings</td>
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<td>Nurses scrutinised medication charts to prevent prescribing errors.</td>
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<td>Pharmacists wrote recommendations on the medication chart for nurses and physicians.</td>
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<td>Nurses’ progress notes were ‘devalued’ while their observation charts were valued in contributing to medication decisions.</td>
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<tr>
<td>Manias et al. 2014</td>
<td>Qualitative descriptive study</td>
<td>Two public teaching hospitals.</td>
<td>Data collection – Semi-structured interviews about management of</td>
<td>Health professionals valued synchronous communication, but verbal instructions were</td>
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<td>Potential for fragmented care existed from communication problems and</td>
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<tr>
<td>Rousseau et al. 2014 [34] Canada</td>
<td>Qualitative exploratory study</td>
<td>University hospital. Diverse clinical wards. 31 registered nurses, licensed practical nurses, endocrinologists,</td>
<td>Data collection – Conduct of focus groups with health professionals.</td>
<td>Lack of documented insulin doses in electronic medical record. Extensive time elapsed between blood glucose monitoring.</td>
<td>Insulin errors related to incorrect documentation of dose in electronic medical record, lack of training, lack of understanding of each other’s roles in managing insulin, and</td>
<td></td>
</tr>
<tr>
<td>Sharma et al. 2016</td>
<td>Cross sectional survey</td>
<td>Public hospitals, private hospitals, nursing homes, and solo practice clinics.</td>
<td>389 respondents: 189 physicians, 106 nurses and 94 pharmacists, response rate: 77%.</td>
<td>Data collection – Development and distribution of survey addressing perception of medication errors and safety, sources of error, and error-reporting practices.</td>
<td>Respondents believed improving communication between health professionals across work areas was needed for medication safety.</td>
<td>Improved communication between health professionals was identified as the major reason for reduction of medication errors.</td>
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<td>India</td>
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Unanswered questions about different disciplines’ perceptions about insulin therapy and difficulties in training personnel.

Frequent staff turnover.
<table>
<thead>
<tr>
<th>Study Authors</th>
<th>Study Design</th>
<th>Setting</th>
<th>Population</th>
<th>Data Collection</th>
<th>Findings</th>
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</thead>
<tbody>
<tr>
<td>Varela et al. 2011</td>
<td>Descriptive and cross-sectional study</td>
<td>Hospitals and primary health care clinics. Diverse settings.</td>
<td>763 professionals (40.9% physicians and 59.1% nurses)</td>
<td>Data collection – Self-administered questionnaire.</td>
<td>Responses relating to barriers in establishing a relationship with pharmacists – No knowledge about the pharmacist: 37.6%. No contact from the pharmacist: 36.0%. Lack of time by physicians and nurses: 33.4%. Lack of time of the pharmacist: 33.4%. Interprofessional communication occurs sometimes (56.9%) and never (25.8%). Pharmacists were considered medication experts but lacked involvement with other health professionals and patients about how medications were managed.</td>
</tr>
<tr>
<td>Wentzler et al. 2007</td>
<td>Ethnographic study</td>
<td>Teaching hospital. Internal medical wards.</td>
<td>48 hours observations, six semi-structured</td>
<td>Data collection – Interviews, Observations in the use of computerized physician order entry system (CPOE with no decision support).</td>
<td>Best working conditions for the users were at the stationary computers in the ward office away from patients and medication storage. Critical situations occurred in nurses’ and physicians’ attempts to facilitate interdisciplinary care. A greater level of safety concerns to promote learning.</td>
</tr>
</tbody>
</table>
interviews with primary users (two physicians and four nurses).

System was not flexible enough to support mutual dependencies of physicians and nurses for making requisitions, continuing, and ceasing medications.

flexible functionality was required of CPOE.
Figure 1. Flowchart for determining included papers.

- **Identification**
  - Records identified through database searching (n = 1,430)
  - Additional records identified through other sources (n = 317)

- **Screening**
  - Records after duplicates removed (n = 1,113)

- **Eligibility**
  - Records screened (n = 1,113)
  - Records excluded (n = 977)
  - Full-text articles assessed for eligibility (n = 136)
  - Full-text articles excluded (n = 109). Reasons:
    - Conference abstracts only (n = 47)
    - Not interdisciplinary collaboration (n = 21)
    - Not research (n = 17)
    - Not hospital based (n = 11)
    - Not focused on medication errors (n = 6)
    - Not adult care (n = 4)
    - Not English (n = 3)

- **Included**
  - Studies included in qualitative synthesis (n = 30)
  - Studies included in quantitative synthesis (meta-analysis) (n = 0)
  - Additional articles screened after review of reference lists of full text papers (n = 4)
**Figure 2. Key points from evidence about the effects of five areas of interdisciplinary collaboration on medication errors.**

<table>
<thead>
<tr>
<th>Area</th>
<th>Points</th>
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<tbody>
<tr>
<td>Communication through tools including guidelines, protocols, and communication logs</td>
<td>Ensure wide diversity of health disciplines use tools. Develop, use and evaluate tailored tools based on medication practices in clinical settings.</td>
</tr>
<tr>
<td>Participation of pharmacists in interdisciplinary teams</td>
<td>Allocate pharmacists to clinical settings. Enable pharmacist participation on ward rounds. Use oral forms of communication in preference to computers or non-verbal means.</td>
</tr>
<tr>
<td>Collaborative medication review on admission and at discharge</td>
<td>Ensure shared accountability for medication reconciliation between medicine, nursing and pharmacy. Conduct frequent medication reviews across transitions of care.</td>
</tr>
<tr>
<td>Collaborative workshops and conferences</td>
<td>Test key learning goals in health professional education sessions with actual patients. Educate health professionals about how cultural, environmental, managerial and resource factors affect medication errors.</td>
</tr>
<tr>
<td>Complexity of role differentiation and environment</td>
<td>Understand medication roles of different health discipline groups. Redesign ward space to enable joint decision making at the bedside.</td>
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</table>