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A Study on Information Induced Medication Errors

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Abstract

Preventable medical adverse events are a serious concern for healthcare. Medication errors form a significant part of these concerns and it is evident that these errors can have serious consequences such as death or disability. Many medication errors are a consequence of information failure. Therefore to prevent such adverse events, the associated information flow must be understood. This research used a systematic review methodology to conduct an analysis of medication error as a result of information failure. Its aim was to suggest solutions on reducing information induced medication errors. The results indicate that is apparent that human error such as slips or lapses can occur due to stress, tiredness and interruptions within the clinical process. Numerous information flow problems are evident within the clinical culture and it is this clinical culture that allows human error which results in medication errors. By changing the clinical culture and establishing effective information flow, clinical errors may be reduced. Thus, recommendations for reducing information flow induced medication errors include a change in clinical culture and the design of a framework which can establish uniformity of communication between healthcare providers. Finally, a major concern for patients is lack of patient information such as medication histories and allergies. Reconciliation of medication histories and a data base of patient information can assist practitioners in identifying any allergies to medications and thus prevent patient allergy related medication errors. Patient health summaries should be shared, for instance using the Australian national eHealth record in order to reduce errors in transcription and to reduce the time spent on collecting medication history.

Keywords

Medication Errors, Clinical Information Systems, Information Systems Theory, Information Flow, eHealth.

INTRODUCTION

Each year, approximately 200 million prescriptions are written in Australia. A large proportion of these prescriptions have some degree of error (Runciman, Roughead, Semple, & Adams, 2003). Medication errors are not the only types of errors in the clinical field. Medication errors can occur on all levels of the clinical process (Joanna Briggs Institute, 2005), including administration, diagnosis, treatment and discharge. Medication errors are a threat to patient safety and the health of the patients (Grober, 2005), can be costly, and can result in hospitalisation or death of a patient (Joanna Briggs Institute, 2005). It is suggested that for every adverse event prevented approximately $1125 would be saved (MTAA, 2010).

Clinical errors, and in particular, medication errors are evident in hospitals, emergency wards and even doctors' surgeries. Errors can also result from computer systems which do not have up-to-date patient information regarding medications and allergies. This is important in a country such as Australia where 59% of the Australian population use prescription medication (Joanna Briggs Institute, 2005). Approximately, 2 -3% of Australian hospital admissions are due to medication errors in the prescription process (Joanna Briggs Institute, 2005).The incorrect dose, incorrect type of medication, allergies to medication and missed dose are just some of the medication errors that can occur in a hospital.

A systematic review of the literature was undertaken in order to analyse and understand information system induced medication errors. It should also be noted that the articles used within the systematic review of the literature are related to medication errors rather than other types of clinical or surgical errors.

Medication errors are classified as the eighth leading cause of death in America (Australia, 2010). Whilst errors caused are attributed to a number of different reasons, initial investigation suggests that the main factor in medication error is a result of information failure (Services, 2005). Poor communication is reported in 50% of all medical errors and it is also evident 20% of these medication errors have resulted in adverse medical events (Services, 2005). According to Pietra (2005a), 51% of medication errors can be prevented. Unfortunately, according to Cushieri (2003), human error is natural and medical errors are common and will occur. Hence, human error will remain the main source of communication failure and medication error. Therefore, it is

necessary to develop an information flow model and a medication error table, in order to make recommendations on preventing reducing communication failure that results in medication errors.

The application of the methodology itself forms a major part of the research. As such the selection of the literature to be included is defined and presented in the explanation and application of the methodology. Hence the paper does not include a separate literature review as the research itself is a review of the literature. The results of the review are then used to map and inform the clinical information flow error framework design. Subsequently, examples of use-cases for the framework and error representation using the literature selected are provided.

METHODOLOGY

This research looked at information flow and communication failure events where medication error occurred. As such information systems theory is the foundation of this research project. For the purpose of the study, information systems (IS) are defined as "the entire set of software, hardware, data, people, procedures, and networks necessary to use information as a resource in the organisation" (Whitman, 2012, p. 588). From the definition it is apparent that information systems do not just refer to computer or electronic systems but also incorporates people and human information systems in healthcare. The research and formulation of the resultant model is based in information systems theory (Shanks, 1999) as it involves the function of information systems as a whole, inclusive of communication and coordination of information related activities.

As individuals communicate with each other, information flow will result. Problems can occur within the process of information flow within the underlying information system. Information, where it is interrupted or misconstrued because of an individual's knowledge or lack of knowledge, can create semantic misinterpretation (Shanks, 1999). This miscommunication of information the clinical setting can and does result in clinical and medication errors. Given that information systems include technology and human communication, this research investigates the impact that interruption of information flow has on medication management and the resultant errors that occur.

The Systemic Review Method

A systematic review is a method used to abstract unbiased summaries from peer reviewed literature (Gasteen, 2010). The purpose of this method is to create a summary of research in order to answer a question posed, as well as provide evidence in order to aid in decision making (Clarke, 2011). There are many different approaches to systematic reviews and this research used the process described by Green (2005), as explained below:

The Six Stages of the Systematic Review Process

1. Defining an appropriate question

The purpose of the systematic review should be clearly identified (Bryman, 2008), which assists to answer the questions posed. In this study, the questions raised concern clinical areas and information flow issues. The overarching objective is to develop an information flow model and information error model that may support the research question:

Research Question: Can a framework be devised that improves information flow and reduces the resultant clinical errors.

To answer this question, analysis of literature regarding information flow systems within the clinical environment was required.

2. Searching the literature-

A wide range of literature was identified by searching online databases, libraries, and the Internet. The online medical databases Medline, Cochrane Library, EmBase, and Institute for Scientific Information were used to research literature. Conference papers, journal articles, books, research papers, fact sheets and statistics were included within the initial research phase. The search terms included are given in Table 1.

Medical Errors	Clinical Errors	Emergency Errors	Sentinel Events	Hospital Errors
Prescription Errors	Information Flow Errors	Communication Problems in hospitals	Adverse Medical Events	Adverse Drug Events
Adverse Drug reactions	Medication errors	Hospital admission errors	Medical diagnosis errors	Medical treatment errors
Medical discharge errors	Information flow	Information flow relation to clinical errors	Clinical Error solutions	Medical error solutions

Table 1: Search terms selected

Peer reviewed literature was deemed reliable and valid for the study. Literature coming from internet websites such as blogs was not considered of sufficient research quality and therefore excluded. The currency of publication was also considered. Literature that did not fit this criterion was excluded. Articles of interests had to meet all the criteria below to be included:

- Does the literature contain relevant information? I.e. does the article cover any or all of the questions?

    a. What is information flow?

    b. How does information flow relate to clinical errors?

    c. What are clinical errors?

    d. How often they occur?

    e. What are the causes?

    f. What are the consequences?

    g. Can a framework be devised that improves information flow and reduces the resultant clinical errors?

- Was the Literature peer reviewed?

- Was the Literature published less than 30 years ago?

- Is the literature from a high quality source?

3. Selecting the studies for inclusion in the review-

Step 3 of the systematic review process involved selecting appropriate studies for inclusion in the review. An identification of relevant, high value literature from the literature searched in step 2 was included in the review. The questions posed in step 1 aided identification of literature for inclusion. Poor quality studies were excluded from review. The literature selected was categorised into one of three categories and the following information analysed:

A. Context of errors

    a. What are clinical errors?

    b. How often they occur?

    c. What are the causes?

    d. What are the consequences?

B. Information flow impact

    a. What is information flow

    b. How does information flow relate to clinical errors

C. Potential improvement for information flow

4. Assessing and reporting the quality of included studies

Literature that met the selection eligibility was then assessed for quality and validity (Green, 2005). Comments concerning the quality of the literature included were made. The literature that has made it to this stage was assessed for its quality. Literature that contained systematic reviews was also included and is given in the results section.

5. Combining the results

Aggregation of the findings from the literature occurred in step 5 of the systematic review. The literature was summarised according to a criteria and the evidence synthesized to create a table categories. The final literature selected was used within the study were categorised and the context aggregation undertaken.

6. Placing the findings in context

The findings from the literature review were discussed in regards to the objectives of the systematic review (Bryman, 2008). The questions posed at the start of the review will be answered according to the findings of the data. The discussion will also evaluate any complications with the review (Davies, 2009).

Limitations of a Systematic Review:

Inaccurate findings can occur within a systematic review. It is evident studies are most often published several times and from several sources. Reviewing of the same study in different sources may lead to inaccurate results, as the data would have been repeatedly counted (Main, 2003). Another limitation suggested by Bryman (2008) is that the systematic review focuses more on the process of the reviewing of the literature rather than the results of the literature review. The timeframe of a systematic review can also be a limitation (Zumsteg, Cooper, & Noon, 2012). Missing and incomplete data are also key concerns and limitations associated with studies that are included for review (Hemmelmann & Ziegler, 2011). According to the National Council for Osteopathic Research "little assessment is sometimes given to the age, methodological quality, timing of outcome measurement, appropriateness of follow up period, competency of clinicians, competency of researchers, measurement tools used or heterogeneity of interventions used in the original trials" (Research, 2006, p. 3). It is also suggested that if the questions asked during the systematic review are too narrow and will result in bias. Although there are disadvantages associated with a systematic review of literature, it should be noted the advantages outweigh the limitations (Research, 2006).

RESULTS

The search of the literature resulted in 76 articles selected as potentially suitable for inclusion in the study. Each article was summarized to select those articles that met the selection criteria. This assessment resulted in 54 articles chosen for inclusion and categorised below into the context of the error, the information flow impact, and potential improvements.

A. Context of errors

After the search the articles were analysed and categorised according to reliability and content information. 22 articles resulted. From these articles it became apparent that clinical information flow had four aspects. They include a process of Administration, Diagnosis, Treatment and Post Treatment/ Follow up. These process points can be found evident within the articles.

Table 2 shows the results of the analysis of the articles identifying the source (start of the error) of the error in the clinical information flow (Administration, Diagnosis, Treatment or Post Treatment/ Follow up), who caused error, what the error actually was, and adverse outcome.

	Article	Start of error	Who caused error	What the error was	Adverse outcome
1	Cushieri, 2003	Treatment-incident in surgery	Medical Staff	Technical error during surgery	Death
2	deClifford et al., 2007	Admin-missing medication history	Pharmacist	Prescription error-drug omission	Cardiovascular reaction
3	Directorate, 2011	Diagnosis-doctor/patient miscommunication	Doctor	Delayed Diagnosis	Complications
4	Fitzgerald, 2009	Admin-inaccurate medication history	Physician/nurse	Prescription error	Hypersensitivity reactions
5	Henneman *et al*, 2006	Admin	Emergency Department Staff	Medication error	Delayed treatment
6	Henneman *et al*, 2005	Diagnosis-wrong diagnosis	Emergency Department staff	Medication error-wrong medication	Death
7	Hodgkinson, 2006	Treatment-prescription error	Health professional	Wrong amount of medication	Overdose
8	Joanna Briggs Institute, 2005	Treatment	Staff	Prescription error	Side effect
9	McBride-Henry, 2005	Treatment	Nurse	Administration medication error	Adverse drug event
10	Miller, 2007	Treatment	Paediatrician	Medication error	Adverse drug event
11	Moyen, 2008	Treatment	Nurse	Medication error	Adverse drug event
12	Nichols, 2005	Diagnosis	Lab technician	Failure to order test	Delayed treatment
13	Nichols *et al*, 2008	Treatment	Pharmacy staff	Medication error	death
14	Pietra, 2005a	Post treatment	Resident	Post-medication error	disability
15	Rigby, 2000	Diagnosis	Health care team	Wrong diagnosis	Iatrogenic injury
16	Rogers, 2011	Treatment	Surgeon	Wrong site surgery	Loss of function
17	Runciman & Moller, 2001	Treatment	Medical staff	Medication error	Adverse drug event
18	Runciman *et al*, 2003	Treatment	Pharmacist	Medication error	Adverse drug event
19	Services, 2005	Admin	Administration	Medication error	Adverse drug event
20	Stoyanova et al., 2012	Diagnosis	GP	Medication error	Hospitalisation
21	Weingart, 2000	Treatment	Clinician	Medication error	hospitalisation
22	Williams, 2007	Treatment	Medical graduates	Medication error	Adverse drug event

Table 2: Medication error characteristics

Figure 1 was designed from analysis of the articles in Table 2 and represents the information flow and context in which error occur. This categorisation of the context and where in the process errors occurred was used to analyse the articles. This information is presented in Table 2. The original mapping model was constructed from the idea that clinical information flow could be mapped.
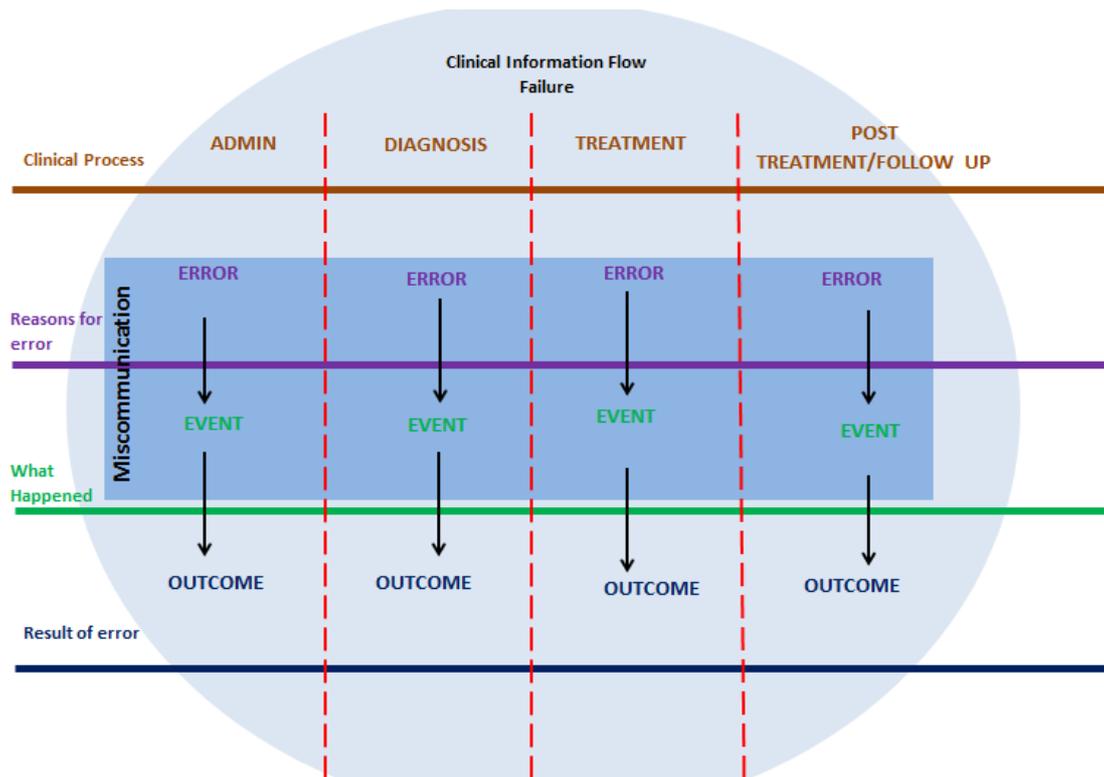
Figure 1: Mapping of Clinical Information Flow Failure

Mapping clinical information was suggested as a process that could be affected by a variety of factors such as miscommunication, which could subsequently result in medication errors. Therefore, the model was created to represent the possibility of miscommunication occurring at any stage of the clinical information process. It was also necessary to depict the outcome, event and original error that caused the medication error. Note: The process definition of the information flow errors does not include other errors in the clinical process that may have occurred.

Figure 1 depicts clinical errors, the reason for the error, what happened and the start of the error. The final diagram resulted from various drafts that were created previously. Initially there were four levels; however, it was also noticed that the clinical information flow was a process rather than a levelling system. Miscommunication was added to the diagram as it was evident that some clinical errors resulted from a form of information flow failure. The analysis revealed that a trend amongst the articles that involved the clinical process.

B. Potential improvement for information flow

The second aspect noted as important was the information flow and how this information flow relates to clinical errors of the original 54 articles. Form these articles, 18 were identified as containing specific information and how information flow related to clinical errors. Table 3 lists the articles that demonstrate the reasons clinical errors occur.

	Article	Reasons they occur
1	Airaksinen, Otero, Schmitt, Cousins, & Gustafsen, 2006	Clinical culture, miscommunication,
2	Alvarez & Coiera, 2006	Stress, Poor communications
3	Aoki, Uda, Ohta, Kiuchi, & Fukui, 2008	Miscommunication
4	Galliers, Wilson, & Fone, 2007	Lack of information
5	Gong, Zhu, Li, Turley, & Zhang, 2006	Poor team communication

6	Greenwald, Denham, & Jack, 2007	Poor delineation of discharge responsibilities among hospital staff
7	Joshi, Anderson, & Marwaha, 2002	Lack of reporting
8	Moorman, 2007	Failed leadership and inadequate communication
9	Parker & Coiera, 2000	Forgetfulness, poor communication between nurse and physicians
10	Simpson et al., 1991	Poor physician listening skills, poor communication between doctor-patient
11	Singh, Thomas, Petersen, & Studdert, 2007	Inexperienced trainees; team work breakdowns, errors in judgement, lack of technical competence
12	Stetson, 2002	Lack of appropriate information at appropriate time, lack of drug knowledge, lack of skill
13	Sutcliffe, Lewton, & Rosenthal, 2004	Hierarchical differences, miscommunication
14	Unruh & Pratt, 2007	Human performance, skill, rule, knowledge based.
15	Webster et al., 2008	Ineffective teamwork communication
16	Wipfli & Lovis, 2010	Alert fatigue
17	Woolf, Kuzel, Dovey, & Phillips, 2004	Physician- patient miscommunication, physician provides incomplete information
18	Zhang, Patel, & Johnson, 2002	Cognitive factors; individual, social dynamics, organisational.

Table 3: Articles identified as relating specifically to information flow rather than other causes.

Mapping the results to the Clinical Information Flow Diagram

The information in Table 3 was subsequently used to create mapping use-case examples of where, when and the impact of when errors occur. A number of examples of this mapping are given below in figures 2-5. Below is a mapping for each of the articles in Table 2 showing where the error originated through to the resultant outcome.
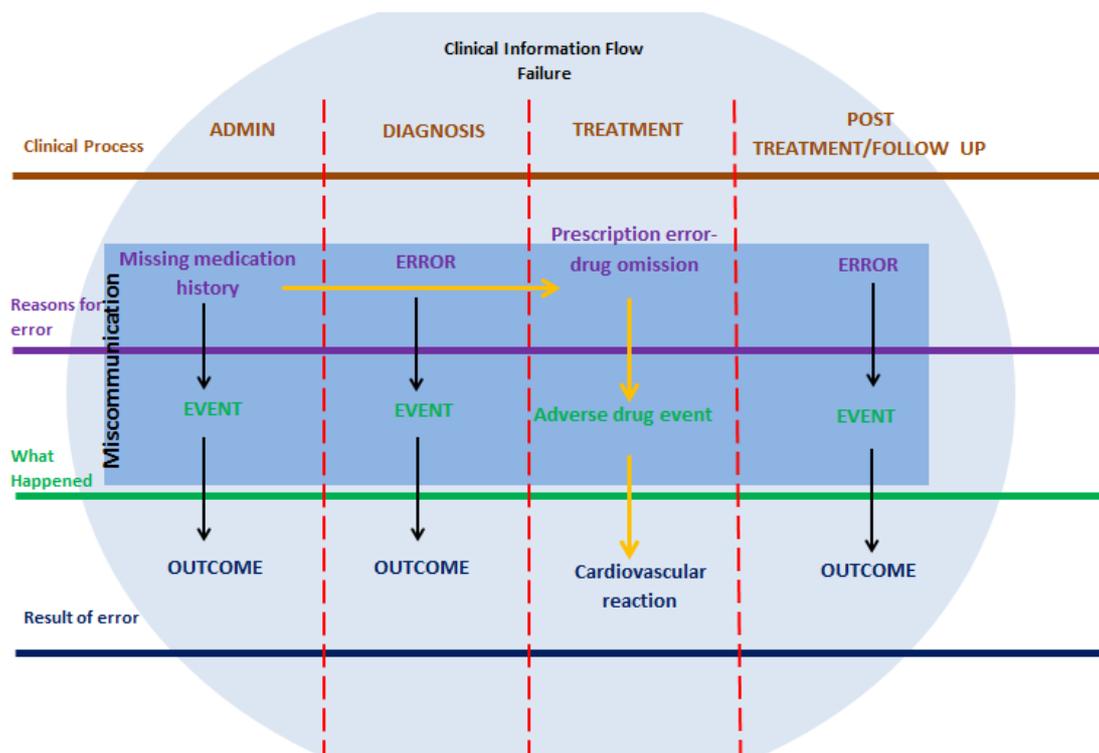

Figure 2. Mapping for deClifford et al., 2007.

Figure 2 demonstrates an Emergency Department pharmacist providing timely medication histories, which resulted in admitted patients who were significantly more likely to receive an accurate medication chart early in their hospital stay and thus avoid adverse events due to a lack of information.
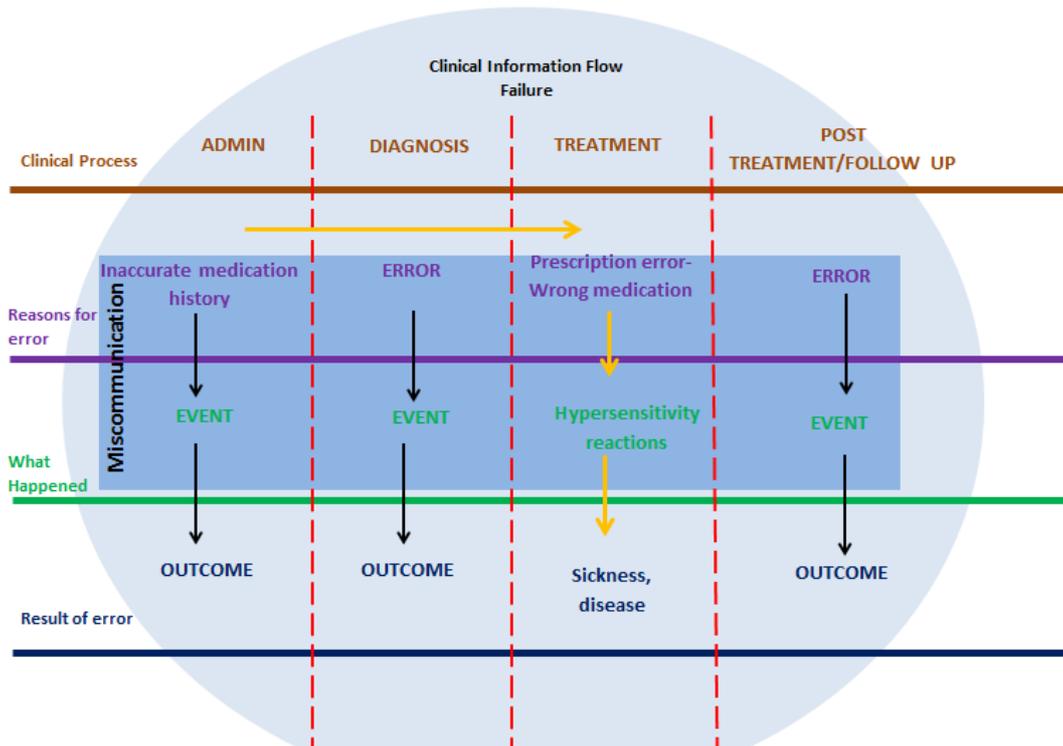
Figure 3. Mapping for Fitzgerald, 2009.

Figure 3 shows medication histories are important in preventing prescription errors and consequently lowering risks to patients.
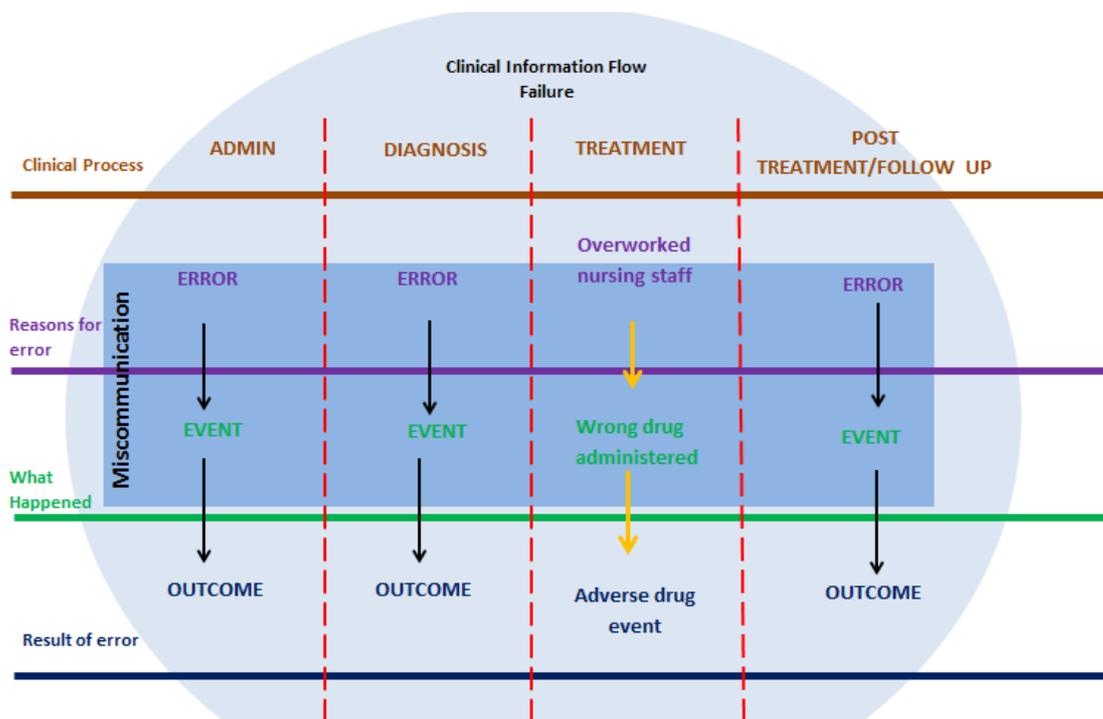

Figure 4. Mapping of McBride-Henry, 2005.

Figure 4 depicts medical administration errors can be defined as mistakes associated with drugs and intravenous solutions that are made during the prescription, transcription, dispensing and administration phases of drug preparation and distribution.
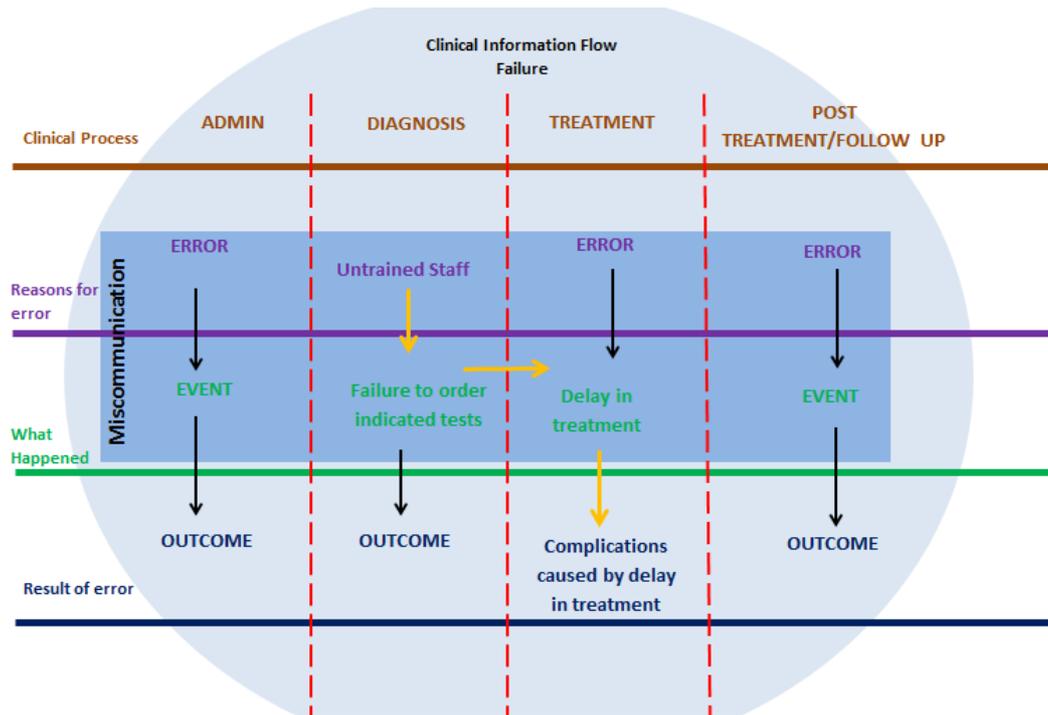
Figure 5. Mapping of Nichols, 2005.

Figure 5 shows the mapping of many mistakes, called laboratory error, but there are in fact due to ineffective communication; actions by others involved in the testing process, or poorly designed processes outside the control of the laboratory. Errors can occur in disease prevention, diagnosis, and drug treatment. Among the laboratory-related errors in diagnosis, 50% were a failure to order the indicated tests, 32% were a failure to act on the results of tests, and 55% involved avoidable delays in diagnosis. Research on medical errors indicates that more than half these errors could have been prevented.

C. Information Flow Improvement.

The third aspect under consideration was the potential improvements in the information flow. 14 articles as listed in Table 4 identified how information flow can be improved and clinical errors reduced.

	Article	*Reduction in error potential solution*
1	Al-Assaf *et al*, 2003	Reporting system(errors traceable), performance standards, improving IT
2	Ash, Berg, & Coiera, 2004	Patient care information systems (PCISs)
3	Buetow, 2003	Reward quality practices, loosen professional control over accreditation, trade consistency for validity, acknowledge cultural diversity, and be transparent
4	Brindley & Reynolds, 2011	Strong verbal communication skills,
5	Fricton & Davies, 2008	The personal health record (PHR)
6	Macpherson, 2005	Critical thinking
7	Moss, 2005	Technological system solutions, improving communication
8	Runciman *et al*, 2006	Integrated framework for safety, quality and risk management
9	Thompson, 2001	Systems approach to error management
10	Unertl *et al*, 2009	health information technology (HIT)
11	Walsh, 2010	Electronic adverse incident reporting system
12	Welzel, 2012	Culture of safety
13	Woods et al., 2008	(1) technology, health information technology (HIT), and electronic medical record (EMR) elements and organization; (2) coordination of care and communication around care plans; (3) communication in transitions; (4) knowledge and experience gaps; (5) team-oriented solutions; (6) orders and consultations; (7) organizational responsibility and communication about errors
14	Yan & Hunt, 2000	Computer-assisted decision support programs that are integrated with systems that cover each stage of the drug ordering and delivery process provide the most powerful prevention tools.

Table 4: Articles with potential impact on error reduction.

The information in Table 4 is used to inform the discussion on improvements in information flow design, provided in the discussion in the next section. The articles cited actual and inferential potential improvements.

DISCUSSION

The systematic review of mapping literature resulted in the mapping of clinical errors within the clinical process. From construction of the information flow diagrams it was apparent that a pattern was emerging. This pattern was that the majority of the medical errors were occurring within the treatment stage within the clinical process. 19 out of 22 articles that were mapped represented an error within the treatment stage of the clinical process. It is evident that 7 articles out of the 19 that involved treatment were found to have errors that started in another stage of the clinical process. This indicates that although information flow may failure in one area of the clinical process it can affect other areas and result in several adverse outcomes. However, it is also understood that 12 of the errors out of the 19 started within the treatment process point of the clinical process. The clinical errors which occurred were a result of human factors. Human mistakes such as slips and lapses were due to tiredness, stress, poor time and inexperience or lack of knowledge. 10 of articles described adverse outcomes that were a direct result of information flow failure. 12 of the errors were due to a direct incorrect communication or lack of knowledge. The 12 errors that occurred mainly had to do with lack of medication history which resulted in medication errors within the treatment point within the clinical process. These medication errors were found to result in significant adverse events. It is also apparent from the data that human factors influenced lack knowledge concerning medication history. Many of the errors that were mapped were a direct cause of incorrect communication. The majority of errors that occurred were preventable. It is evident from the articles that were reviewed that suggestions reduce the risk of clinical errors are shown.

In order to prevent information failure and clinical errors, it is recommended that clinical culture must be changed to allow for effective standardization. Standardization of medicine names, policies and procedures as well as the standardization of an easy to use reporting system for errors will result in a barrier of defence in regards to medical errors. Effective communication skills are required of health providers. As well, medication histories must be reconciled in order to prevent medication errors. Patient information systems and information sharing between healthcare providers will reduce the lack of information concerning the patient. Human and computer system integration will enable easy to use reporting systems for errors, although it must be acknowledged that the human element will tend to hide errors if there is a 'blame' culture or one that does not openly demonstrate transparency. Medication error can then be traceable and prevented. One potential factor to promote this transparency is that healthcare practitioners could be rewarded for incident reporting, whilst being mindful that this may also lead to over reporting. Proper labelling of medicines and proper understanding of patient information will also reduce the likelihood of information failure. Tiredness and stress can also be reduced in the clinical environment through support and policies on reducing long shift hours. Double looping and double checking of patient charts and patient information can identify any mistakes made. As evident there are multiple problems therefore multiple solutions are required. The Swiss cheese model is able to represent this. Each barrier that is implemented into the clinical process will reduce the likelihood of an adverse event occurring.

Impact of Results

From the clinical process model it is evident that clinical errors can start from any point in the clinical process. It is also evident from the model that clinical errors can start in one position of the clinical process and end up affecting other areas of the clinical process. The literature suggests that clinical errors arise from information flow failure. Human error is evident to be the main cause of information flow failure and therefore the root cause of clinical errors. It is suggested by Reason (2000) that the clinical error defensive layer is like the Swiss cheese model. Procedures, policy and administrative controls all make up barriers that safeguard against adverse events. Yet it is also understood that adverse events are a result of active failures and latent conditions. A combination of these factors consequently results in holes within the defence layer therefore comparable to Swiss cheese. The clinical error is able to go through the holes of the defence layer and result in an adverse event. Both active failures and latent conditions are related to human errors. Active failures refer to mistakes, slips and lapses. While latent conditions arise from the system and stems from management. It is suggested that "we cannot change the human condition, but we can change the conditions under which humans work" (Reason, 2000, p. 769). The practical significance of this research indicates that a framework could be developed to change system in which latent conditions arise. Preventing latent conditions will also contribute to preventing clinical errors. Appropriate procedures and training can also reduce the opportunity for human error which causes information flow failure and consequently clinical errors.

Accurate medication histories, aside from preventing prescription errors, are useful in detecting drug-related pathology or changes in clinical signs that may be the result of drug therapy. A good medication history should encompass all currently and recently prescribed drugs, previous adverse drug reactions including hypersensitivity reactions, any over-the counter medications, including herbal or alternative medicines, and adherence to therapy. The mapping of medication errors can depict medication history inaccuracy going across continuum of clinical information flow. It is then revealed more than one area of clinical information flow can be affected by a medication history inaccuracy.

Verbal medication orders can easily result in miscommunication and result in a medication error which consequently results in an adverse medical event. However, if hand written and verbal medication orders are replaced with electronic written orders this in fact reduce any possible latent conditions in which mistakes can occur. Therefore, the error can be prevented before it occurs.

Lastly, one potential solution that is currently used is to issue medication alerts. Indeed, software alerts can be considered an appropriate method of alerting practitioners to medical errors. In addition, such alerts can remind practitioners to undertake certain procedures in regards to a patient. Medication history as well as any possible complications may be alerted to the practitioner. However, it is understood that alert fatigue is common within the clinical process. Alert fatigue is an aspect that may be the subject of future research. In the process of information flow, interventions appear to be most effective as the information is departed from the source. Obviously, potential occurrence of errors should take place before the error occurs.

CONCLUSION

This research aimed to assess whether a framework could be devised that improves information flow and reduces the resultant clinical errors. The literature raised questions concerning information flow and possible solutions in regards to medication error. A systematic review was designed to analyse and identify articles in order to answer the questions which had been raised. A model that represents information flow failure in the clinical process was developed to demonstrate and identify the point in the process where errors occur and the how this relates to communication. Medication errors that were found within the articles were then placed within the model. This was to identify the cause of the error, what the error was and what the outcome was within the clinical process. A table that identifies the cause of the clinical error was created as well as a table identifying possible solutions.

Clearly, interventions, such as alerts can play a role in reducing medical errors and can be effective if delivery in a timely and appropriate manner. Electronic system alerts are useful in reminding practitioners to detect errors before they occur. Human errors occur in human communication. In order to improve clinical safety integration of electronic systems and human users will enable effective communication through electronic systems to reach human recipients. An example of which is to prohibit verbal medication orders.

In many of the examples mapped from the systematic review, the timely availability of medication history was an aspect in the error event, and thus improvement in the accuracy and availability of medication history may be a key factor reducing errors. Future research into the development of a clinical framework to prevent clinical errors is required. More data in regards to medication and other clinical errors and what causes them is essential. In addition, data concerning potential solutions is also recommended and the articles could be analysed further based on location of the medical error incident (e.g. hospital, primary care, etc.). A framework that is supported by management would prevent information flow failures from occurring.

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