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Evaluating information flow in medication management process in Australian acute care facilities: A multi-professional perspective

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Evaluating Information Flow in Medication Management Process in Australian Acute Care Facilities: A Multi-Professional Perspective

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Declaration of Authorship

This doctoral thesis is the candidate's own work and contains no material which has been accepted for the award of any degree or diploma in any other institution.

To the best of the candidate's knowledge, the doctoral thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Seyi Olatunbosun Lagoke   12/05/20
    Candidate's Name   Date

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Dedication

This research is dedicated to the good people of Australia who will be interacting with the medication management process, my family and the memories of those who have contributed to this research – Dr. Frank Moisiadis and Mrs. Adedapo Oni.

Abstract

Over the years, various interventions have been introduced to improve the medication management process. While these interventions have addressed some aspects predisposing the process to inefficiencies, significant gaps are still prevalent across the process. Studies have suggested that the goal of optimal medication therapy is achievable when information flow integrates across the various medication management process phases, stakeholders and departments involved as the patient moves through the process. To provide a cross-sectional view of the process, this study utilised a systemic philosophy to evaluate the information flow integration across the process..

The research approach adopted for this study takes a positivist paradigm, which is guided by the cause and effect (causality) belief. It explored numeric measures to evaluate the relationship between constructs that assessed information flow principles (accessibility, timeliness, granularity and transparency) within the medication process and the information integration. The research design was cross-sectional and analytical, and this ensures that findings are relevant to current situations across the Australian healthcare system. Data for this research was collected using an online self-administered survey and the data assessed information flow principles and technologies used in the medication management process. There were 88 participants in this study, including doctors, nurses and pharmacists. The questions and responses were coded for analysis and data analysis techniques used were frequency analysis, Pearson's chi-square test and multivariate analysis.

Findings from this study indicates that the constructs evaluating accessibility, transparency and granularity had moderate associations with the information integration in the medication management process. Further analysis highlighted accessibility as a significant principle in explaining an increase or decrease in information integration in the medication management process. The accessibility construct referring to information retrieval was significant across the two tests conducted. Accessibility is directly related to information sharing and the assessment and monitoring and evaluation phases in the medication management process were identified as having the highest challenges with information sharing. Furthermore, the hybrid (electronic and paper) channel was preferred to support information integration in the medication management process by the participants. Among the technologies evaluated for the medication

process, computer-provider-order-entry was found to be statistically significant in explaining an increase in information integration.

Overall, results from this study suggest that interventions for the medication management process in Australian acute care facilities should be directed towards improving accessibility, specifically information retrieval and the sharing of information with emphasis on the assessment and monitoring phases. Implementing strategies to address the gaps identified from this research can improve information integration across the process and thereby reducing medication errors, and improving patient care management. Furthermore, the technology adoption across the process highlights that technology adoption across participants' facilities remains a challenge in Australia.

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Definition of Terms

Acute Care

Healthcare facilities that provide treatment for a short period of time with the primary goal of stabilizing patients before discharge or transferring them to other medical institutions.

Information

A resource transmitted by a sender to convey meaning of concepts to a receiver with an objective of increasing the understanding of the receiver in a communication process and an asset recorded as a text or document.

Information Flow

The transmission, maintenance and update of a stream of information that is appropriate and in a timely manner from point A to point B.

Medications

Refers to drugs/medicines which are used to diagnose, treat or help in the prevention of diseases.

Medication Management Process

The healthcare process that involves assessing, prescribing, ordering, order communication (or order transmission) administering and monitoring of medications.

Process

Tasks that are connected in a logical manner and are performed with a primary goal of achieving an objective.

Process Integration

Refers to interconnecting steps and stages of a given process across an organisational or technical border.

Chapter 1 Introduction

1.1 **Background**

From that point when a patient visits a healthcare facility, a medication management journey may commence. This journey entails interacting with stakeholders and processes across departments within the facility and its suppliers. To ensure the goal of the journey is attained, it is crucial that information about the patient and medications flow across various processes, departments, and stakeholders in a way that ensures the accurate context of the treatment plan is not compromised. Allowing delays or disruptions to this flow of information can affect the contextual exchange of information and may lead to misinterpretation of information related to the treatment plan (Baker et al., 2010). Similarly, these processes require effective coordination which ensures the achievement of the principal objective of delivering accurate medication to the patient within the shortest possible time and an elicitation of the desired therapeutic effect. Furthermore, it is crucial that information relevant to the medication process is integrated across various processes and departments within the healthcare facility involved in the patient's journey through the process. This level of integration is required continuously and is critical to achieving the primary goal of good therapeutic outcomes for patients (Nguyen et al., 2013).

Healthcare organisations have a unique obligation, whether for profit or non-profit, they are required to care for the sick. However, the challenge of balancing quality with cost and remaining accessible are major concerns among these organisations globally (Porter & Lee, October, 2013). These challenges are making it imperative for healthcare organisations to explore more effective ways to manage and process information obtained in healthcare domain.

Medications are fundamental in patient care and contribute significantly in achieving treatment outcomes when used properly. Any deviation from 'proper use' (correct and appropriate use of medication), may result in errors or adverse events. (The Society of Hospital Pharmacists of Australia, 2019). Annually, Australian prescribers write more than 200 million prescriptions and unfortunately a considerable amount of these have a measure of error (Hermon & Williams, 2013). Australian medication incidents are reported to account for about 27% of medical incidents and cost the healthcare system over $660 million annually (Roughead & Semple, 2009). For instance, in New South Wales (NSW), Australia, medication and intravenous fluid-related incidents are the second-most frequently reported incident type, accounting for

approximately 20,000 incidents each year (Clinical Excellence Commission, 2011). Medication-related error is not only a phenomenon occurring in Australia but has also been reported internationally. An example of this is a study conducted on hospitals in Madrid, Spain, which reported up to 22% errors occurring across various stages in the medication management process (Rodriguez-Gonzalez, et al., 2012). While medication errors are not the only types of errors in the medical field, they contribute considerably to the medical incidence burden in the health system (Hermon, 2010).

Improving information flow in the medication management process will result in reduced incidences of medication errors. For example, Hermon and Williams (2013), pointed out that amongst, the many causes of medication errors, information related failure was identified as a primary cause of clinical errors. In the same vein, information related challenges were evident across the different contributory factors that predispose healthcare professionals to errors in the medication management process, however, research in this domain is limited (National Prescribing Service, 2020). While it has been widely accepted that information is a vital asset for organisations, not much emphasis has been put on its effective management. A possible explanation for this lack of perceived importance is because information is intangible and organisations are not applying concerted efforts in its management unlike tangible assets (Evans & Price, 2012).

1.2 Statement of Problem

How integrated is information flow across the medication management process in Australian acute care facilities? The response to this question can be drawn from the works of Kneck et al., 2019; Clay & Melder, 2018 and Paris et al., 2008. Notably, these studies span across different countries (USA, Australia and Sweden) and all highlight the challenge of information flow and integration in the medication management process within their health systems. From literature (Kneck et al., 2019; Clay & Melder, 2018; Hermon & Williams, 2013, Abraham et al., 2011; Paris et al., 2008) three main areas of challenges were identified. Firstly, information flow breakdown occurs at different phases within the process. Unfortunately, one single breakdown affects the other phases and this may predispose the process to errors. While these studies agree on the existence of this challenge, there is limited understanding of the extent of the process information flow integration. Similarly, the phases where information flow breakdown occurs within the process have not been holistically examined. For example, Hermon and Williams (2013), reported that most information flow breakdowns occur at the treatment phase but could occur in other phases. The reasons for this lack of consensus on the

phases where information flow occurs is probably because most studies have focused on specific phases within the process and the consequence of information failure (medication errors) rather than a system view of the process.

Another issue raised is the impact of technology on information flow. The studies explored have highlighted that little or no studies have evaluated the impact of technologies on the medication process. According to Abraham et al. (2011), information in electronic records may be dormant and not transferred to the next user, thereby creating a breakdown in communication. While health systems are gradually embracing technologies to improve patient care outcome, gaps still exists on the impact these technologies have on information flow within healthcare processes.

1.3 Aims and Objectives

Based on these challenges highlighted above, this research seeks to assess the information flows across the medication process in acute care facilities in Australia. It aims to identify the gaps in information flow that could lead to poor information integration that may predispose the process to errors. Specifically, this study will evaluate the information flows in the medication management process and the technologies used in the medication process. It intends to determine how information flow impacts on information integration. It will also assess the impact of technologies on information flow, to identify if these technologies either strengthen or weaken the flow. It is expected that findings from this research will suggest performance improvements for the medication process and contribute to the body of research in medication management. These aims thus, raise the following core objectives for the research:

- To identify which information principle/s impact the information flow integration in the medication management process

- To identify current gaps in medication management process information flows and suggest improvements to the process

- Analyse how these disruptions affect the integration of the medication management process in acute health settings

- Identify which information flow channel supports information flow integration across the medication management process

- Evaluate the technologies used in the medication process and understand the level of adoption and how it impacts on information flow and process integration.

1.4 Research Significance

In the healthcare system, there is frequent information exchange across various processes and departments, which can be viewed from an information flow perspective. A disruption of these information exchanges can have adverse impacts on patients, causing harm or even death (O'Daniel & Rosenstein, 2008). From a technological perspective, it has been asserted that the current technology systems in Australian healthcare facilities are challenged by inadequate information flow across systems. These gaps may, lead to information loss or breakdown, a resultant compromise to patient safety insufficient continuity of care and inability to access relevant treatment   data that is critical improving patient management outcomes (Osman, 2019).

To understand the current context and possible challenges within the process, this research will assess the medication management process from the perspective of the practitioners (i.e. healthcare team members). It will evaluate the current state of information flow in medication management, identify gaps that can potentiate medication errors, evaluate the technologies and suggest improvements for the information flow within the medication management process in Australian acute care facilities.

1.5 Research Questions

The primary research question to be answered from this study is:

> To what extent is the medication management process integration in Australian acute care facilities aligned with information flow principles?

As part of this study, we also seek to investigate which information flow pathway/channel enhances or weakens the medication management process integration in Australian acute care facilities and to what extent have health information technologies enhanced or weakened the information flow integration in the medication management process in Australian acute care facilities?

The research questions for this study were developed to ensure that the criteria of research validity and reliability is achieved in the outcome. The research questions for this study are relational in nature and seeks to understand relationships among several constructs which has been used in health related research (Tully, 2014). Namely, we seek to understand the relationship between information flow in medication management process in acute care

facilities, the information flow pathway and the role of technology within the process in the facilities.

1.6 Research Limitations

This research is limited in terms of the scope it covers. The evaluation of the information flow is based on data gathered from a sample of 88 participants. The use of information flow principles (timeliness, accessibility, transparency and granularity) have been found to be collectively exhaustive but not mutually exclusive. There have been instances of overlapping when trying to assess these constructs, however, this is alleviated through further categorisation of information transfer and transformation. This research also did not explore areas related to privacy and confidentiality associated with information flow.

1.7 Theoretical Perspective

For this research, a systems theory approach has been adopted based on the works of Chuang and Inder (2009), who proposed that to achieve an improvement in health outcomes, a holistic investigation into the coordination of the contributing entities to the system is beneficial. Ng et al., (2009), defined a system as a wholly cohesive entity which is structured with boundaries that distinguishes between internal and external elements. It can recognize inputs and outputs that relate and emerge from the entity. Thus, using a systems theory approach gives a holistic view of a phenomenon and not an additive effect of different parts working together. For this study, we seek to understand the information flow within the medication management process and not just a segment of the process (each of the phases). The approach provides insight into interactions, relationships and contextual understanding of the functioning and outcomes of an organisation. This perspective suggests a dialogue between holism (emphasises that gaining insights to different parts in a system requires understanding the whole system) and reductionism (entails breaking down problems into aggregates, also known as disaggregation) (Mele, Pels, & Polese, 2010). According to Grol et al., (2013), adopting system theory by healthcare facilities enables them to look beyond, and ensure that interdisciplinary relationships are improved. Thus, the adoption of systems theory perspective in this research would assist in identifying the gaps in information flow wholly rather than in fragments.

1.8 Related Research/Gap

Previous research in information flow in healthcare settings have primarily evaluated the communication aspect, for example, mobility issues and coordinating artefacts (Bardram & Bossen, 2005), sequential aspects (Reddy et al., 2006), channels of communication (Gurses & Xiao, 2006; Patterson et al., 2004), and information content (Bates & Gawande, 2003). From

these studies, we have gained considerable insight to the information flow process, challenges and barriers to operational information flow.

Similarly, there is strong evidence to suggest that systems factors contribute considerably to occurrence of errors in the medication process, yet research investigating integration of the process to reduce errors is limited (Roughead, 2008). To date, there have been no Australian studies that assess the impact of information flow principles as factors using a systems perspective to determine impact on medication management information and process integration as an outcome. Although there has been research that evaluates health information technologies in medication management, no research has evaluated their effect on information flow in the medication management process.

1.9 Methodology

The research paradigm adopted for this research is systems research. This paradigm explores relationships in human-process complexities without oversimplification and identify critical issues that can facilitate development of knowledge and shared understanding of the interactions (Bedinger, Beevers, Collet, & Visser, 2019). In this case, medication management in Australian acute care constitutes of processes, stakeholders and interactions via information exchange to achieve the good therapeutic outcome goal for patients. The methodology used align with this research paradigm and these are highlighted in this section.

1.9.1 Design

This research adopted an analytical and cross-sectional design to facilitate gathering of empirical data. An analytical design is suggested when a research involves inferential analysis of two or more variables (Edson, Henning, & Sankaran, 2017). For this research, our variables are information integration (dependent variable) and accessibility, transparency, timeliness, and granularity (independent variables). In addition, a cross-section design is used when an identified population or representative sample that can assess the cause and effect relationship are the study participants (Edson, Henning, & Sankaran, 2017). The research was organised in a stepwise process. Initially, a literature review which explored basic concepts related to the research and subsequently application of those concepts in domains such as information flow analysis, process modelling and technology adoption. From the review, a framework of the medication management process workflow and information flow was conceptualised. A high-level process chart was used for the conceptual workflow to facilitate understanding.. Using the identified conceptualisations as a set criterion, a survey was developed and validated and responses were solicited from healthcare practitioners in Australia. The survey tool

development was predicated on the assumption that there was poor information integration within the medication management process based on reviewed literature (Hermon & Williams, 2013; Chan, et al., 2016; Clay & Melder, 2018; Djenane, Brummel, & Miller, 2010; Holbrook, et al., 2016). Data collected from this survey provided the current state of information flow and technology adoption within the process in the facilities the participants worked. This data was analysed using statistical methods to determine the gaps in information flow and technology-adoption and to validate or discard the conceptual frameworks. The analysis also sought to determine the impact of the independent variables on information and process integration.

1.9.2 Site Selection

Recruitment of participants was carried out through the management of hospitals or departments of acute care facilities throughout Australia. Management approval is required for health practitioners to participate in studies in most facilities in Australia. The research also assumes that based on information relating to anonymity in the survey instrument there will be negligible response bias. To improve response rates, participants were also recruited through professional bodies such as the Society of Hospital Pharmacists, Australia.

1.9.3 Data Collection

Data was collected by administering an online questionnaire through SurveyMonkey. The completion of the questionnaire was anonymous, voluntary, and participants had the option to withdraw their responses at any stage prior to completing the questionnaires. Most questions required the participants to choose an answer from a list of options. The survey had three main components: (1) Questions relating to participants' general demographic details, (2) questions relating to technologies used in their acute care facilities, and (3) questions relating to the information flow in the medication management process at the participants' acute care facilities. The questionnaire had an average completion time of 10 minutes.

1.9.4 Data Analysis

A descriptive, multivariate and exploratory analysis was conducted using Statistical Product and Service Solutions (SPSS) version 24 application. The information flow principles within the medication process formed the building blocks that facilitated the understanding of information flow. This was assessed against the integration of the process. The integration of a process is described as a phenomenon where minimal effort is required to organise the principles of information flow across the process. Thus, practices that ensure this minimal effort facilitate a tighter coupling (interconnectivity) of the activities within this process.

The technologies used within the process were also evaluated to understand the important factors that influenced their adoption and how the technologies impacted on the information integration of the process. This would enable an understanding of the extent of how the technologies enhance or weakened the information flow within the process.

1.9.5 Data Management

Data collected in this research was anonymised to ensure no links to research participants exist. Data has been secured on the university network drive using a secured password by the chief investigator. The network drive is secured based on university security protocols and ensures data integrity. This was done in collaboration with staff of the University of Notre Dame Research office.

1.10 Ethical Considerations

The University of Notre Dame Australia's Human Research Ethics Committee approved the research project and substantiated its ethical suitability. The approval number is 015087S (Appendix 2). All participants involved were required to give consent. Participants were advised that participation is voluntary and that they could opt not to participate in the study or withdraw at any time. Participants were also assured that their responses were completely anonymous.

1.11 Anticipated Outcome

This study is the first study evaluating information flow across the phases of the medication management in Australian acute care facilities. Thus, its contribution is anticipated two specific ways. . Firstly, it will contribute to the body of research on information flow integration in the medication management process and how this relates to medication error reduction. Secondly, it is expected to enable stakeholders identify on phases that will require interventions within the process across acute care facilities. This will guide policy makers with regards to technologies and practices that enhance medication management process.

1.12 Thesis Outline

This thesis has been divided into nine chapters.

Chapter 1 [Introduction]: Presents an introduction to the research and defines the main concepts used in the research. The chapter describes the research background, goals, and significance from which the research question is derived. The strategy employed in the research is enumerated and the structure of the thesis is outlined.

Chapter 2 [Literature Review]: A summary of the existing literature covering the concepts of information, information flow, process and process integration, medication and medication management, and medication error. It equally highlights technology acceptance models and the current technologies used in medication management. The evaluation technique is described and the research gap for information flow in medication management in the literature is presented.

Chapter 3 [Theoretical Framework]: Discusses systems theory and its relevance in healthcare research. The philosophy of systems thinking is described and the justification for using General Systems Theory for the research is presented.

Chapter 4 [Research Methodology]: outlines the research methods for used in evaluating information flow in the medication management process. The chapter also describes the statistical approaches that were for the data analysis.

Chapter 5 [Demography]: This section presents the general demographic results of the participants in this study. Discussion of the results from a demographic perspective and its implications to the research are discussed.

Chapter 6 [Information Flow and Information Integration]: This section discusses the results relating to research question 1 (To what extent is the medication management process integration in Australian acute care facilities aligned with the information flow principles?). The discussion seeks to answer this research question.

Chapter 7 [Information Channel and Information Flow]: This section discusses the results relating to the sub-research question 1: Which information flow pathway/channel enhances or weakens the medication management process integration in Australian acute care facilities? The discussion will present possible answers to this sub-research question.

Chapter 8 [Technology and Information Flow]: This section discusses the results relating to sub-research question 2: To what extent have health information technologies enhanced or weakened the information flow in the medication management process in Australian acute care facilities? The discussion highlights possible answers to this research question.

Chapter 9 [Conclusions and Recommendations]: Summarises the findings in the previous chapters and provides a conclusion to the thesis. It highlights the implications of the research findings and suggests possible directions for further research.

Chapter 2 Literature Review

This chapter will give context to this study and address ambiguities about aspects of this study. It will also review empirical studies that have covered focal areas in the study, identify key issues and gaps and position the study appropriately.

The narrative review approach has been adopted for this research. This approach provides a summary and comprehensive synthesis of information drawn from published articles. It elucidates on the development of concepts relevant to the research and presents it in a user-friendly form (Noble & Smith, 2018). A broad point of view on the subject matter is explored and accumulated to demonstrate its value. The approach is particularly beneficial in fields such as e-health and other evolving domains because of their interdisciplinary nature (Paré & Kitsiou, 2017).

This literature review seeks to achieve two primary objectives: (1) To create a foundational knowledge on domains around the research topic, goals and questions. (2) It will also explore gaps in literature and seek a justification for undertaking this study. In the light of these objectives, the review is organised to cover three areas. The first part covers areas related to definitions and explanations of relevant concepts like information, information flow, process, process and information integration, acute care facilities and information flow in Australian acute care facilities. The second part covers explanations on medication, medication management process models, medication standards, requirements and medication errors. Finally, the technologies used within the medication management process are reviewed from the perspective of adoption and their impact on the process information flow.

2.1 **Information**

Information is all around us; across all disciplines, sectors, and continents. Developments in information science research have drawn our attention to the ubiquity of information (Melnikova & Melnikov, 2011). McReadie and Rice (1999), in their research sought to review the different definitions of information that had been proffered over the previous fifty years. McReadie and Rice (1999), posited that information can be described as; a medium that stores knowledge, data that is a result of different environmental interactions, a part of the communication process and as a commodity and/or resource. In a more recent study, Karavaev (2014), carried out a longitudinal review of information definitions. From the article, definitions of information were categorised using seven approaches: Ordinary, statistical,

semiotic, eliminant, absolutism, functional and attributional. The ordinary approach considers information as a fact, data, message and knowledge while the statistical approach views information as a message that decreases the uncertainty of the receiver. Likewise, the semiotic definition views information through the concept of data. Therefore, X is information if: 1) X consists of one or more piece of data, 2) the data in X are well formed, and 3) the data in X are meaningful. The eliminant approach denies the existence of information. Furthermore, Karanev (2014), indicated that this approach views information as abstract that cannot be seen or touched, thereby portrayed as a mysterious concept. Also, the absolutism perspective views information as the "universum for all existence". It believes in the ubiquity of information and describes it as the basis for all existence. Thus, affirming that information is everywhere and used in all our daily transactions. In addition, the functional perspectives view information as a tool that enables self-organising systems to function properly, whereas the attributional approach views it as the property or details of a matter.

Using a different methodological approach, Zins (2007), assembled a panel of 57 scholars across 16 countries who sought to conceptualise a definition for data, information and knowledge. From this approach, about 40 different definitions of information emerged. Of these definitions, the most relevant to our study which acknowledges the structure and organisational activities in healthcare was proposed by Prof. Elsa Barber from the University of Buenos Aires, Argentina. She posited two definitions of information as "(1) a message used by a sender to represent one or more concepts within a communication process, intended to increase knowledge in recipients and (2) a message recorded in the text of a document" (Zins, 2007, p. 480).

Further investigation has equally revealed that information is viewed from multiple perspectives. For example, it has been referred to as an asset or resource (Hicks et al., 2007), representation of patterns (Durugbo et al., 2009), a commodity (Demiris et al., 2008a), and also a constitutive force (Braman, 1989). Information has also been described as accurate and timely data that is organized, specific and presented for a particular purpose (Rowley, & Hartley, 2017). Furthermore, Zaveri et al., (2016), emphasized that when data becomes relevant and provides guidance and understanding to the person receiving it, transformation to information occurs. The study further explained it as a perceived stimulus that has a precise meaning for its recipient. Similarly, a prominent information theorist, Luciano Floridi pointed out that 'information is a conceptual labyrinth'. This is because of its multifaceted application – as a

process (depicted when notifying another person about an issue), a result (where a change of opinion or belief has occurred) and as an object (that which increases one's understanding) (Bygrave, 2015).

It is apparent that researchers are not able to conclude on a 'general definition of information' (GDI) (Dinneen & Brauner, 2015). Thus, researchers use operational definitions based on their fields of investigation. For example, in the field of business information is described as a fundamental factor that ensures prosperity and growth (Krovi et al., 2003), and viewed as a commodity which serves as a vehicle for trans-organisational communication (Demiris et al., 2008). Similarly, a New Zealand Court of Appeal stated a dictionary definition of information in a proceeding as that which 'informs, instructs, tells or makes aware' (Bygrave, 2015, p.112). Thus, the field of law posits that information represents a semantic content in law that is understood by the meaning it conveys (Bygrave, 2015).

To this this end, this study has adopted definitions in the area of information science and systems to present an operational definition that will facilitate an understanding of the term 'information" as it relates to healthcare and systems research. Drawing from these definitions, the most relevant of these definitions for this research was drawn from the works of Zins (2007) and Hicks et al. (2007). Hicks et al. (2007), conceptualises information as an asset and/or a resource and (Zins, 2007) a "message used by a sender to represent one or more concepts within a communication process, intended to increase knowledge in recipients and a message recorded in the text of a document" (p. 480). Thus, this research proposes its definition of information as a resource transmitted by a sender to convey meaning of concepts to a receiver with an objective of increasing the understanding of the receiver in a communication process and an asset recorded as a text or document. This definition emphasises the relationship of information in information flow and as an asset documented about a patient.

2.1.1 Information Flow

Researchers have emphasised the relevance of information flow in organisations. One of such is a study by Westrum (2014), where it was proposed that an examination of the information flow culture within an organisation indicates the degree of cooperativeness among the people and level of functioning within the organisation. This suggestion emanated from a review of cultures in high precision organisations like the US Air force and National Aeronautics and Space Administration (NASA). Westrum (2014), further emphasised that in cases where the information flow is considered good (meets the need of users, timely and presented in a usable

form), it leads to better functioning of the organisation rand vice-versa. Similarly, the works of Kuang-Hui (2006), have posited that information flow across an organisational process is related to the information flow across each activity within the process. Kuang-Hui (2006), further argued that information flow across an activity can be considered from five perspectives. These are: (1) The source of information (who is the sender or where is the information generated), (2) adequate knowledge to complete activity (Is the information understood by the user) , (3) information flow following completion of activity(is there a record of the information used for carrying out the activity), (4) operator or agent in the activity (who is the information user) and (5) the media for flow of information (was information transmitted as a mail note or report). Additionally, Yovits, Foulk, and Rose (1981) points out another significant aspect of information flow, the transmission of 'data of value' which facilitates decision making. While other paradigms that have evaluated information such as information theory by Shannon and Weaver (1951), focus on the transmission of information between sender and receiver, information flow extends this by focussing on context, meaning and effectiveness of the message.

Information flow exists in different forms. Within organisations, "information flows from person-to-person, person-to-machine and machine-to-machine, from sources such as electronic data interchange (EDI) and face-to-face conversations, and through channels for communication such as letters, reports, audio files and video recordings" (Tang et al., 2010, p. 494). In hospitals, information flows from a sender to a receiver either in a documented form or through verbal interactions. This flow of information is reliant on accessing the necessary information (Atani & Kabore, 2007). Furthermore, information flow is ubiquitous and essential for daily duties performed by clinicians across different spatial domains in a healthcare environment (Bardram & Bossen, 2005; Solet et al., 2005). Given this importance of information flow in healthcare settings, an uninterrupted flow of information is a requirement recommended by the United States National Health Infrastructure (Institute of Medicine (US) Committee on Assuring the Health of the Public in the 21st Century, 2003).

As observed with the multi-perspective views on information definition, researchers have also described the concept of information flow in different ways. The differences in information flow descriptions also emanate from different fields of study bringing different perspectives and approaches to its characterisation. For instance, in information and communication technology, it has been described as the rationality and interactions that exists in a distributed

system which comprises of agents (Bremer & Cohnitz, 2004; Corrêa & Agustí-Cullell, 2008). This implies that information flows between two separate parts that have a relationship and are bounded by defined rules. From the view of product-based organisations, Eppinger (2001), considers it as 'the lifeblood of processes such as product development'. In the same way, Westrum (2014), likened it to water flowing through a water pipe. In this definition, Westrum (2014), describes it as the transmission of information which is appropriate and relevant in a timely manner from point A to a receiver at point B. Also, De Wolf and Hovoet (2007), point out that information may transform as it travels to the recipient or vice versa. De Wolf and Hovoet (2007) further explain that, maintaining and updating a stream of information from a sender towards a recipient may result in an aggregated new information as it passes through various points. To convey the definition of information flow more explicitly, de Lange et al., (2019), described it as the patterns of communicating within a group or the route in which a message is disseminated within the group. This definition introduces a social perspective to the description of the concept.

To propose an operational definition for this research, we have drawn from the works of Westrum (2014) and De Wolf and Hovoet (2007). These definitions have been adopted based on how they represent the ways information is transmitted in the medication management process (Bell, Cretin, Marken, & Landman, 2004). Thus, we propose the definition of information flow as the transmission, maintaining and updating of a stream of an appropriate and timely information, from point A to point B.

2.1.1.1 Dimensions of Information Flow
In order to fully understand information flow at a granular level, it is important to breakdown the concept into its constituent parts. In particular, three fundamental dimensions of information flow has been proposed: (1) Information access, (2) information exchange and (3) documentation Durugbo et al. (2010). Information access (or accessibility of information) is the availability of data and the ease of retrieval of necessary information. This dimension also relates to how readily information can be used to carry out activities and thus, accessibility is identified as a function of the source, content usability and interactivity of the channel (Bergkvist et al., 2009). In information and communication technologies domains, accessibility would be required for transferring files, querying databases and remote systems (Howells, 1995).

Information exchange relates to how data or information flows among participants in a network their interactions and the generation of knowledge amongst themselves (Demiris et al., 2008a). Information exchange is necessary in the dissemination of information in social networks, gatherings and forums and draws similarities with information sharing (Durugbo et al., 2010).

The third dimension, documentation refers to the requirements of facilities to record, store data and further disseminate the information using different media such as newsletters, reports, surveys, newspaper and other sources (Mash et al., 2008). Document flow is a fundamental part of healthcare. Training across healthcare professions, emphasise good documentation practices, because it is the basis of collaboration in the industry. The works of Stapel et al. (2007) also pointed out that document flow is a means of information flow particularly when documents are used for disseminating information. Similarly, Durugbo et al. (2010), asserts that documents are inputs / outputs of activities.

In addition to the three dimension of information flow offered by Durugbo et al. (2010), Wamba and Boeck (2008), suggested information sharing as an additional dimension of information flow. This dimension facilitates the transmission of critical and proprietary information in supply chains. Blackburn (2010), emphasised that information sharing occurs through avenues such as social networking, team briefing and, meetings. These avenues for cascading information are valuable means for collaboration and information dissemination in healthcare and social services. According to Demiris et al. (2008a), information sharing occurs as a two-way communication process that involves three vital aspects. These relates to the information content, information channels (web portals, filing cabinets) and information system. The latter coordinates both the content and the channel to ensure that the information shared is clear and accessed by the receiver. Studies by large organisations have emphasised the importance of information sharing (Durugbo et al., 2014). For example, organisations like Walmart, Target and Sainsbury have traced information sharing quality as directly related to the safety assurances of their products. Importantly, researchers have cautioned that a risk of information sharing is information leakage (a situation where information could end up in the wrong hands) (Gavirneni et al., 1999).

The combined dimensions of information flow proposed by Durugbo et al. (2010) and Wamba and Boeck (2008) have been identified as elements that can improve outcomes in healthcare. For instance, healthcare professionals have acknowledged that accessing information is of great importance in healthcare delivery. Scantlebury et al., (2017), explains that the ability to access

health information improves decision-making and facilitates easy retrieval of guidelines and evidences that support patient management. Similarly, a study in four geriatric wards in Australian hospitals which examined medicines information exchange using social network analysis pointed out that information exchange is predicated on good communication and proposed that identifying key personnel who facilitate information exchange may improve therapeutic outcomes (Chan et al., 2016). Also, Vallette and Barrett (2012), while reviewing information alignment in a healthcare environment, posited that a lack of information sharing can strongly affect the quality of care in a healthcare environment.

2.1.1.2 Types of Information Flow

Information flow can be categorized as eight types: Sequential, deferred, real-time, parallel, wheel, one-to-many, many-to-many and M-1-M, (Kuang-Hui, (2006). This categorisation was derived from the perspective of agents who participate in business processes and are individually described below.

The first type - sequential information flows refer to a step-wise transmission of information from one activity to another. This occurs in a sequential manner indicating where the name was derived. Amstad and Fischer (2004), also described it as timely release of data in sequence. These are the most common types of information flow within organisations. The limiations of this type of information flow is evident where multiple stakeholders and checkpoints/approvals are involved, it becomes time consuming and expensive. Deferred information flow results from delays or discontuinities between activities. Occurences of this type of flow is quite common in many organisations. This may be due to limitations in information flow media, an agent in the process who has too much allocated work,thus, causing a delay and/or bottleneck in transmitting information. Real-time information flow is found when there is a rapid/non-stop transfer of information between processes and activities. This type of information flow empowers members of the organisation to respond faster to issues arising and make faster decisions which enhances management effectiveness. The challenge with real-time information flow is managing the volume of information collected.

Parallel refers to the flow of information that arises from two or more activities within a process running simultaneously. This occurs when information or documents are shared with different people within a given process. In contrast to sequential information flow, which requires repeating the process when amendments are made, parallel information flow permits concurrent processes to occur and is therefore more efficient. On the other hand, when errors

are made in a parallel information flow, the problem can rapidly escalate and identifying the source of the error can be hard to trace.

Wheel information flow occurs when information from a given process has to be sent to many other processes and feed back is required from each of the other processes. One-to-many flows occurs when the same information is transmitted to multiple participants within a process. An example is the announcement of a new policy through internal communication to members of a team. Information sent between two groups within the same process using the one-to-many method creates a many-to-many information flow. The information flow complexity in the many-to-many relationship can be expressed as N^2. Where N, refers to the number of participants sharing information within the process. This level of complexity introduces cost and time inefficiencies to the process. In cases where an agent is introduced into the many-to-many relationship, and serves as the focal point for gathering, handling and transmitting the information between the groups a many-to-one-to-many (M-1-M) information flow is created. This introduction of an agent reduces the level of complexity from N^2 to 2N.

2.1.2   Information Flow Paths/Channels

The flow paths through which information is transmitted across nodes in a network has been considered to be essential in understanding information flows (Garrett & Benedict, 2011). Different networks exhibit different configurations of information flow and these differences emerge from the different dynamics that characterise each of these networks. For example, patterns will differ in epidemics, or ecological disasters (Harush & Barzel, 2017). In the same vein, the patterns/pathways in medication management process is unique to the process.

Garrett and Benedict (2011), have identified two main information flow paths in the medication management process: Mediated and unmediated flow paths. The mediated flow paths are facilitated by the use of technology, particularly information technology. This path has the advantage of overcoming the barrier of time, storage of recorded data and distance. However, both sender and recipient must have appropriate technologies for entering and retrieving data. The unmediated path does not require technology and can be likened to the use of paper in the medication management process. While this path facilitates easy entering and retrieval of information without the complexities of technology, the challenges of storage, distance, and time are evident. Similarly, a 2014 report by the Department of Health in Queensland, Australia has recognised three forms of records collected by the state healthcare facilities and this is similar across Australia as corroborated by Rowlands (2019). These are: Electronic,

paper and hybrid (combination of electronic and paper). This suggests that three paths are used in information transmission across Australian healthcare centres: Electronic (mediated), paper (unmediated) and hybrid (a combination of mediated and unmediated). These information flow paths used in healthcare can be likened to information channels as proposed in the Information Channel Diagram modelling by Durugbo et al., (2011). These terms will be used interchangeably across this study. Likewise, this study will evaluate which pathway facilitates information integration within the medication management process.

2.1.3   Information Flow vs Information Quality

According to Roaimah et al. (2010), the quality of information that flows from a sender to the receiver is critical to the performance of any given process. Therefore, it is beneficial to examine the relationship between information flow and information quality. Information quality has been described as information that "meets the needs of the decision maker, and right data in a complete form and in the right context is needed." English (2001, p. 255). The author also emphasises attributes necessary for information quality which includes its accuracy, objectivity, appropriateness, fitness for purpose, timeliness and at the right level of understanding for the receiver. This means that the qualitative characteristics defined at the input must compare to the output to ensure it is reliable.

To understand how important information flow quality is, Kang and Malmgren (2017), in their study which examined the quality of information that flowed within the Malawian Health Information System (HIS) pointed out that an implementation of the dimensions of quality within the HIS would ensure that the information flowing through the system is relevant, correct and clear, thus, achieving the overall goal of implementing the HIS. In a similar vein, Durugbo et al., (2010), have highlighted that placing importance on feedback paths and striving to ensure that information is available to team members and stakeholders facilitates quality in information flow. Based on this, it can be deduced that information lacking quality is deemed to be useless. This view is further supported by Klajovic et al., (2004), where they sought to evaluate the quality diagnostic coding information (translation of disease, injuries and illness descriptions into standard classification codes) and information flow from hospitals to general practice in New Zealand. They observed that delays in information flow between these facilities was associated with poor diagnostic coding information when compared across the two facilities. This is in tandem with the report by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO; 2007), where communication failure was prominent

among the listed causes of adverse events. Thus, we can assert that a disruption in information flow may impact the quality of information to a receiver thus, predisposing the recipient to making errors. Therefore, information quality has a direct relationship with information flow and vice versa.

2.1.4 Evaluating Information Flow

To determine any issue or deficiency within information flow, it is important that appropriate frameworks are used for its evaluation. However, the volume of information that flows within organisations makes this a complex task. Organisations are communicating units that speak to each other and share information regularly. These communications involve processes, individuals, groups and communication channels (Clegg et al., 2011). Nevertheless, several frameworks have been developed and used in evaluating information flow across different fields. This review will examine frameworks that are relevant to healthcare processes.

In 1995, Grusenmeyer developed a framework to study communication exchange in a paper mill during shift change. Four phases of the communication exchange were identified in the article: end of a work shift, incoming operator arrival, operators' meeting, and taking over by incoming operator. This framework resulted from assessing dyadic communication among workers in an industrial setting while changing shift and was considered to be applicable across different information flow domains primarily because the observed phases were considered to universally exist. However, Lawrence et al. (2008), have argued that frameworks like this are limited due to its inflexibility and inability to recognise differences in work environment and culture and further posited that frameworks focussing on communication during hand-over have not taken factors such as socialisation, the difference in perspective the incoming worker may bring and the team cohesion generally into consideration. These limitations may result in more problems in the long-term.

In another study which reviewed information management among nurses, 'scraps' were emphasised in facilitating documentation of patient-related information and the flow of information when nurses change shifts (Hardey et al., 2000). Scraps in this case refers to nurses' 'personal notes' and the use of such was necessitated because of perceived inadequacies in the hospital information systems (Tang & Carpendale, 2007). However, the limitation presented with this model is its emphasis on the use of non-structured information objects which does not take the formal aspects of information flow into consideration.

In 2001, models were developed to evaluate and improve the quality of care for patients in chronic care and these are reviewed to see if it can be extrapolated to acute care. These models developed by Wagner, et al. (2001) and Glasgow et al., (2001) emphasised all elements of information flow distribution, its components, and posited that interactions at all levels involve information flow. It further emphasised that deployment of clinical information systems is directly related to information flow. However, a review of the model by Sendall et al., (2016), reported that no single health care organisation had implemented all components of the model thereby suggesting that the information flow model may not be pragmatic for healthcare organisations.

Hibberd and Evatt (2004), also suggested another model to evaluate information flow model. The model described the process of information transfer across different points through organisation communication channels. The motivation to model information flow with this approach was driven by a need to understand how processes can be coordinated and organised, reducing redundant processes and information flow, minimising information duplication and managing inter and intra – organisational information sharing (Durugbo et al., 2013). However, this approach to modelling information flow has been described as a partial view of an organisation which may not take other aspects of organisations into cognisance. Thus, an approach that focuses on process, functional and organisational aspects is required to present a complete view of an organisation (Durugbo et al., 2010).

In addition, the InfoFlow framework was developed by Tang et al. (2010) to evaluate information flow and new healthcare technologies. This framework is founded on six factors which are information, artefacts, personnel, spatiality, temporality and mode of communication. These factors may not be mutually exclusive and, possess constructs that are interrelated and contribute to information flow. Each of the factor acts or is acted upon by the other. Some of these factors had been identified in other studies but no framework had collectively investigated them to evaluate their contributions to information flow. To-date, the framework has only been used in evaluating nursing information flow but not in a general setting.

More recently, Armony, et al. (2015) suggested that drawing from a patient flow management paradigm may indirectly give a better understanding of information flow management in medication processes. This suggestion was on the basis that communication problems were identified to be associated with delays in patient transfers thus, predisposing patients to medical

errors. However, there were limitations in the application because the goals of both processes were not the same. Another patient-oriented model by Unertl et al., (2009), explored workflow and information flow models for three ambulatory clinics using observational methods. The objective of their study was to gain insight into how work is organised, and the flow of information required to manage chronic diseases with a view to developing context-appropriate technologies. The general nature of workflows was similar for all the three clinics. However, information channels (mediums for transmitting information) had some differences. Providers in one of the clinics (multiple sclerosis) frequently relied on paper charts for keeping detailed information on care of their patients. In contrast, the cystic fibrosis and diabetes mellitus clinics did not maintain paper charts and instead used electronic health record. Electronic health records were used by all three clinics for record review and secure messaging. The model by Unertl et al. (2009) was complex across the nodes and reflects the complexities surrounding information flow in chronic care. While this model has its merits, it had limitations because of the differences in acute and chronic care workflow and types of information shared. Another limitation pertaining to the model is its limited emphasis to medication information management rather, it focuses more on medical management.

Other frameworks that had been used in other fields have also been explored. For example, in computer systems, information flow can be analysed using distributed information flow analysis (Zhang, et al., 2004), static information flow inference analysis (Liu & Milanova, 2010), flow and path-sensitive information flow analysis (Li & Zhang, 2017), and dynamic information flow analysis (Chandrasekaran, 2017). For processes, the main types of information flow analysis include cognitive information flow analysis (Humphrey & Adams, 2013), static information flow analysis (Accorsi & Wonnemann, 2010), and information flows and business process integration (Berente, Vandenbosch, & Aubert, 2009).

Having examined the merits and limitations of the frameworks highlighted in literature, the framework proposed by Berente et al., (2009) was adopted for this research. This model is applicable to information flow within the medication management process because it has been applied in studying about 10 different processes including a healthcare process (Berente et al., 2009). The framework views information flow from a process perspective and asserts that "an integrated process is one in which the effort associated with information flows between activities is minimized." There are four principles in this framework -

(1) Timeliness: This refers to information that is available when required (Westrum, 2014). It is described as the currency of information as it moves across tasks within a given process. It

has been suggested that a more integrated process will require less time for information transfer within activities (Berente et al., 2009).

(2) Accessibility: This is described as information that is readily available for a given task. In this case, information is provided instantaneously (Browning, 2002). When information is readily available it facilitates sharing and can be depended on and appears like it is available in a central repository (Berente et al., 2009).

(3) Transparency: Refers to the comprehensibility of information as it moves from one task to another (Carlile, 2004). Transparency tends to determine the meaning the information flow or content has to the user and ensures that there is consistence in the meaning of information across a given process. It has been suggested that transparency can be achieved through standardisation or language translations (Berente et al., 2009).

(4) Granularity: This describes information the level of detail required. Required information detail varies between activities and groups, and there is a tendency to pass on too much or inadequate detail. Thus, information should balance completeness and conciseness across various tasks in a given process (Berente, Vandenbosch, & Aubert, 2009)

The information flow principles provided by Berente et al. (2009) aligns with the dimensions proposed by Durugbo et al., (2009) and Wamba and Boeck (2008), as well as take into account the importance of information quality suggested by (English, (2001). As such, this framework can facilitate a contextual understanding of the quality of information in the healthcare process.

2.1.5 Information in Healthcare

Hospitals are described as 'information-rich' environments and different levels of information are required for different phases in patient care management. Transmission of information occurs through a diversity of information artefacts and channels among co-located and distributed healthcare professionals with a principal goal of accomplishing collaboration (Solet et al., 2005). Therefore, exchange of information forms an important aspect of a clinician's daily routine and is essential in the continuity of patients' care in hospitals.

The importance of information to healthcare is likened to the way humans require oxygen for daily living (Al-Hakim, 2008). Information exchange is the core of communication and is critical in collaborative workplaces like healthcare settings. As a matter of fact, healthcare work is driven by information sharing and this is essential to complete tasks related to patient care (Strauss et al., 1985). Studies have also affirmed that the sharing of task-related information

across shifts consistently facilitates operation continuity irrespective of information flow process complexities (Grusenmeyer, 1995; Wilson et al., 2005). Lavin, Harper, and Barr (2015), have pointed out that without proper information, healthcare is compromised which may result in improper management of patients. This can inadvertently lead to deleterious effects on the patient prognosis and could be fatal on some occasions. Thus, it is important that members of the healthcare team have access to accurate and timely information about the patient.

From our proposed definition of information (as a resource for communication), we further extend our view of information to recognise the uniqueness of information used in healthcare. Thus, we view information to include "facts, knowledge, assessments, instructions, graphical representations, perceptions, and meanings received and interpreted" (Tang et al.,2010, p. 485). The article has affirmed that, two types of information were pertinent in a healthcare environment: Patient and interpersonal information. While the latter is essential for group collaboration and team motivation our emphasis for this study is related to sharing and exchange of patient information. The patient information in this case is specific (patient history and medication information) and this is distinctive for each patient's illness course. This type of information is important for caring, monitoring and implementation of specific treatment plan.

Information about a patient can be obtained in four ways. These are aesthetic, moral, empirical and personal information. These modes of obtaining information were derived from the works of Carper (1978) which provided the framework for nurse-patient knowledge in the fields of nursing and has served as the basis for decision making in patient management. The modes are not mutually exclusive and are inter-related, and facilitates appropriate decision making among healthcare practitioners. Aesthetic knowledge is considered as an art, particularly in nursing. This knowledge is obtained in the course of caring for a patient where the healthcare practitioner discovers information that gives them insight about how to best care for a patient (Garrett, & Cutting, 2015). Moral knowledge enables healthcare workers to know that is right and wrong for the patient thus, ensuring that the therapeutic outcome is achieved. Empirical information is obtained from the analysis and determination of facts and personal information is obtained through personal observations and experiences (Gurm, 2013). Once the perceived correct information has been obtained, this is documented and should be shared across the following healthcare processes.

2.1.6 Australian Acute Care Facilities

The Australian healthcare system has been applauded for its performance when compared with other member countries in the Organisation for Economic Co-operation and Development (Dixit & Sambasivan, 2018). Factors that may have contributed to this success include the government's investment in the sector and options between private and public healthcare which makes the services more accessible for its citizenry (Duckett & Willcox, 2015). Within the system, the healthcare professionals, including physicians, nurses, pharmacists and other allied medical professionals provide services across the community, primary care centres, emergencies, acute care, palliative and rehabilitation care amongst others (Australian Institute of Health and Welfare, 2016).

Despite these achievements, the Australian health system is now faced with challenges of a surge in demands, more complex health profile of patients because of an aging population, increased costs and improve health outcomes (Dixit & Sambasivan, 2018). Additional challenges include balancing technology costs, funding private and public facilities and medical research (Macri, 2016). A five-year review of the Australian health system identified weak information flow as one of the factors that impedes the achievement of an Australian integrated healthcare system (Productivity Commission, 2017).

Healthcare facilities are the platforms that provide health-related services to patients. These facilities include traditional healthcare and non-healthcare facilities. The traditional facilities are acute-care hospitals and long-term care which includes aged care facilities. Non-healthcare settings involve sites that are not usually designed for healthcare delivery such as medical clinics embedded in an organisation or school (Thomas-Brogan, 2009). The traditional facilities are further categorised based on length of days spent and conditions treated. This categorisation gives rise to acute- care facilities or hospitals and long-term care facilities. Long-term care would admit patients with chronic conditions for 30 days or more. Table 2.1 illustrates the types of acute-care and long-term care facilities.

Toussaint and Berry (2013), described acute care facilities as settings where immediate and short-term medical care is offered to patients, for serious and minor injuries or traumatic occurrences that require a prompt response. Hirshon, et al., 2013) further described the settings as facilities for curative, rehabilitative, preventive and palliative actions that aim to promote and restore the health of the sick people promptly. These facilities undertake treatment of unexpected and/or emergency conditions, which may result in untoward adverse effects in case

there is a delay. Basic acute care functions include emergency medicine, trauma centers, acute care surgery, urgent critical care, short-term in-patient stabilization as well as urgent care. In a typical acute care facility, the operations run 24 hours a day as an emergency can occur anytime. Hirshon et al. (2013), further asserts that the demand for acute care continues to increase because of changes in population dynamics such as population increase and ageing. The nature of acute care facilities also demands that information is properly organised across the spectrum and there is a need that adequate and correct information is available as the patient journeys through the system (Staggers et al., 2012).

Table 2.1: Description of Healthcare Facilities

Acute-care Facilities		Long-term care Facilities	
Type / Variable	**Description**	**Type / Variable**	**Description**
Demography	Anyone	Demography	Elderly or people living with disabilities
Care Need	Conditions like diseases, infections, accidents	Care Need	Conditions that have functional impairments due to chronic diseases or permanent disability.
Goal of Care	Treatment and cure	Goal of Care	Improving functional capacity through ongoing therapy and assisting in managing limitations to provide highest quality of life possible.
General Hospital	Services provided include general care, critical, emergency and intensive care. This is provided across a diverse spectrum of patients.	Assisted Living Facility	Services provide include house rentals usually bundled with other services such as daily living assistance, housekeeping and personal care. Patients in this type of facilities include aged (elderly) and persons living with disabilities.
Speciality Hospital	Specialised care services are provided to specific types of patients such as: Cancer, elderly and paediatrics	Independent Living Facility and Retirement Community	Services are provided to these specialised patients within patient's homes or specialised communities. These services include general care and social support and are provided at a fee.
Rehabilitation Hospital	Specific services are provided in these facilities such as speech, occupational, physical and recreational. Types of patients include people who have had stroke, trauma and debilitating injuries.	Nursing and Residential Care Facility	Services are provided throughout the day within a residential facility. These services include general medical including nursing and rehabilitation, personal, social and spiritual care.
Behavioural Hospital	Specialised care and social services for patients presenting with psychological and psychiatric conditions.		

Adapted from Thomas-Brogan (2009); Eldercarehelper (2019).

2.1.6.1 Information flow in Australian Acute Care

Effective flow of information is a fundamental requirement in an acute care facility, this enables effective patient management across the care continuum. For example, Gilardi et al., (2013), examined information flow management in 2 different emergency departments and insight was given into the nature of information flow in such settings. From the study, it emerged that information flow is organised across three domains; verbal and non-verbal exchanges, interaction of healthcare team with technology artefacts and team member movements. The initial collection and capturing of information is carried out by a triagist and entered into a technology artefact (computer) with basic details and an emergency code. In the treatment room, the physician receives these details, however clinical parameters must be viewed on a separate module. Furthermore, the study highlighted that perceived limitations were managed when triagists employed informal methods to ensure that physicians had adequate information about a patient. Some of these informal approaches include leaving the triage desk to exchange information with physicians, making phone calls and highlighting specific information in short notes entered into the application that collects patient information. Similarly, the study observed nurses were the focal points for information flow management in the facilities. They were the process organisers, provided decision making support to physicians and highlighted essential information that facilitates admission or discharge .of patients. Nair et al. (2012), also affirmed that in acute care facilities doctors and nurses work together to monitor patient responses to medications.

In an Australia context, the impact of information flow on the hospital workflow was examined against patient outcomes in an acute care department. Findings by Lederman and Morrison (2002) revealed that delays in information flow caused disruptions in workflow including delays in making important decision about patient care and delays for the transitioning through the care continuum. These delays could potentially cause adverse events for the patient and increase the overall cost of healthcare. In another study which investigated effective communication in an Australian emergency department, a focus on physicians and patients found that there were difficulties with patient and physician communications (Slade et al., 2008). These difficulties were attributed to the divergent goals of both parties with regards to treatment and terminologies used by clinicians when they tried to communicate with patients. Thus, patients were found to lack understanding of processes they had to undergo, presenting them as 'outsiders' in their own treatment (Slade et al., 2008). Likewise, a recent study by Black and Sahama (2016), observed that a patient's journey through an Australian health

facility is characterised by manual and redundant processes, information silos and a lack of systems integration. The study emphasised the value of the clinician's role in collecting patient information, however, it pointed out that the efficient flow of the collected information is critical for clinical decision making. It was equally suggested that introduction of electronic health records may assist in this flow, however the completeness, visibility, direction and security of the flow will be critical factors determining the acceptance by healthcare professionals.

2.1.7   Information Flow Challenges in Healthcare

There are several critical challenges to information flow within the healthcare system such as poor documentation, inadequate information and communication gaps among the healthcare practitioners themselves. Several Australian studies have reported that inadequate documentation or a total lack of information is prevalent across the system (McKenzie, Kudinoff, Benson, & Archillingham, 1999; Usher, Lindsay, & Sellen, 2001; Curtis & Capp, 2003). These articles identified poor documentation as a prevalent practice among healthcare professional particularly in the field of mental health. Usher et al., (2001), further highlighted the inadequate information around psychotropic medications which resulted in difficulties in clinical decision making.

In addition to poor documentation in progress notes, miscommunication between doctors and nurses often occurs, particularly relating to why a medication was prescribed and when it should be administered. When comparing physicians' intention for prescribing paracetamol (an analgesic/antipyretic medication) to children admitted to hospital with nurses' interpretation and action, Lamb and Henry (2004), found that there were several discrepancies. For example, nurses regularly gave the children paracetamol at a lower body temperature than physicians intended. Whilst, paracetamol was commonly prescribed by physicians to relieve pain and discomfort, the lack of information provided or illegible physician's handwriting led nurses to administer the medication for additional reasons such as child being unsettled, miserable irritable or distressed.

Furthermore, communication problems between physicians and nurses has also been reported as the main cause of medical errors in intensive care units (Donchin et al., 2003). The study utilised a human factors engineering approach to identify errors in the intensive care unit. Information transfer and communication between physicians and nurses were highlighted as critical factors in mitigating the occurrence of an error. Nurses monitor patients closely and

should be viewed as a liaison that can close the information gap thus, assisting the physician. For example, the study observed that nurses were not integrated into physician rounds thereby not formally part of the information exchange. Errors in the unit had a diurnal distribution with a peak time in the morning (during physicians' rounds) with error from nurses peaking an hour after that. These error peaks were attributed to the information exchange and transfer gaps between the physicians and nurses (Donchin et al., 2003).

Information-related challenges in patient care information systems (PCI) have also been identified during the entry and retrieval of information (Ash et al., 2004). These gaps present challenges with communication and coordination of information flows which is expected to support the patient care information system. A study by Schnelle et al., (2004), also made similar findings in nursing homes where inaccurate documentation in medical records about care delivery were observed. Similarly, a report from a large public hospital in Victoria, Australia by Lederman and Parkes (2005) identified poor information delivery, poor online accessibility and poor connectivity between applications as major causes of medication prescribing errors. According to the report, electronic management systems had been adopted for clinical and scheduling management, test and radiology results and prescribing-ordering-dispensing systems for medications but did not adequately achieve the goals for adoption due to inaccessibility and poor delivery at critical levels. Kuang-Hui (2006), equally suggested three factors as the causes of discontinuity in information flow. These are given as: Operational discontinuity (where there is an imbalance in job allocation and too much time expended in job preparation), time discontinuity (where required information is difficult to access), it could be taking too much time to access or use required information which may cause delay in other activities and space discontinuity (which occurs when different agents or operators of process activities come from different units or departments resulting in slowing down the flow of information).

Given the challenges of information flow within a single healthcare unit as described above, it is unsurprising that a lack of information or miscommunication would occur between hospital departments, hospital-based physicians and primary care physicians, and primary care physicians and specialists (Bodenheimer, 2008). Indeed, nearly one in three emergency department visits, patients' medical history and laboratory test results are absent (Gandhi, 2005). Up to 30% of adults visiting an emergency department have reported that their regular physician was unaware of the care they received there (Schoen et al., 2004), and less than 50%

of primary care physicians receive information about their patient's discharge plans and medication from hospitals (Moore et al., 2003). A review of the literature by Kripalani et al. (2007) also identified direct communication between physicians in hospitals and their primary care colleagues to be infrequent (less than 20%), the availability of discharge reports to be low (less than 34%) and when available, reports often lacked critical information such as test results, treatment plans or medication plans. Additionally, in cases where there were referrals to specialists, no information was sent in 49% of cases and in 45% of cases, the physician did not received feedback from the specialist about the patient they referred (Forrest et al., 2000). When information is exchanged between physicians and specialists, the information quality and delays in receiving information is often an issue (Gandhi et al., 2000).

Furthermore, van Leijen-Zeelenberg, et al. (2014) identified three barriers of information transfer in an acute care chain. These are: Current information transfer routines, barriers to information transfer implementation and timelines, and a lack of high sense of urgency among the acute care team. The study posited that these challenges of information transfer were actually a result of organisational factors. Therefore, interventions to improve the phenomenon may require an unlearning of previous dispositions towards information transfer by the healthcare team. In a similar vein, Phipps et al., (2017), identified organisational challenges as a major factor which resulted in disruption of information flows when evaluating medication management coordination in acute kidney injury across care boundaries. The disruptions created further disruptions in clinical care coordination. A study to examine communication between nurses and doctors in a paediatric inpatient setting, Borrott et al. (2016), found that while healthcare professionals were committed to the medication information communication process this remains an unresolved challenge. The hierarchical structure in healthcare and inadequate notifications of medication order changes by doctors presented major challenges within the facility. A study by Moyle et al. (2015), in a dementia acute care setting equally found that good communication improved patients' outcomes. In that study, communicating care requirements to family members was identified an important requirement for patients. Together these studies, demonstrates that organisational and social factor have a substantial impact on information flow in acute care.

2.2 Processes and Process Integration

The concept of "process" permeates many secctors and disciplines. Consequently because of the interdisciplinary nature of the concept, fields like business and management have carried

out extensive empirical research on the subject particularly in its management (Smart et al., 2007).

Describing processes from a business perspective, Milovanović et al., (2017), described it as consisting of tasks that are connected in a logical manner and are performed with a primary goal of achieving a business objective. A group of processes produces a system and defines the unique way each organisation operates. In this view, two fundamental charactersitics of process exists: 1) It possesses clients, whereby these clients receive specific business outcomes, and 2) it overcomes organisational barriers (borders), thus, they are carried out across different organisational units. Melão and Pidd (2000) also viewed processes as social systems that openly interact with each other and their environment. The advent of globalisation and technology over the last decades have resulted in processes crossing organisational and in some cases geographical boundaries (Gonzalez-Lopez & Bustos, 2019). Processes in healthcare are described as a sequence of activities working together to achieve the goal of managing and improving patient outcomes (Rojas et al., 2016). Buttigieg et al., (2016), argued that unlike many other fields, healthcare tends to focus more on outcomes rather the process itself. This is apparent in the healthcare description of process above.

In order to understand how to manage and optimise processes, it is necessary to examine process integration. Klichewski (2004) defined process integration as interconnecting steps and stages of a given process across an organisational or technical border. From this perspective, process integration can be evaluated on it interconnectedness. The concept of process integration has also been described from different perspectives of integration, including organisational integration, system integration, application integration and data integration (Barki and Pinsonneault, 2005). Other forms of integrations suggested include business integration, electronic integration and information flow integration (Berente, Vandenbosch, & Aubert, 2009).

Process integration can also be defined as a state of inter-organisational linking and coordinated information flows (Sabbath, 1995). This definition emphasised two key fundamental principles of process integration (inter or intra organisational linking and information flows). Furthermore, an integrated process is also viewed as one where the efforts required for information flow is minimal (Berente et al., 2009). Kock et al., (1997) also suggested that improving the elements of information flows between phases in a process is vital to achieving integration in the process. It was also pointed out that the more integrated a process is, the less

it is prone to error and security attacks (Aubert et al., 2004). Thus, process integration is concerned with practices that will ensure the effort is minimal and facilitate a tighter coupling among activities within a given process. This view is founded on the notion that the tighter coupled the activities within a process, the less effort is required to coordinate inputs and outputs for that process.

In 2010, Spaulding et al., (2010), posited that synergising business processes with information systems improves efficiency and creates a conducive environment. This synergy results in improved workflow coordination and information flow between participants and entities. Furthermore, their article affirmed that process quality and efficiency can equally be achieved through a restructuring of the process and information processing. Over the years, the healthcare industry has sought to improve integration in care management and at the organisational level. It is widely believed that the benefits that accrue from integration will promote improved care, patient satisfaction and efficiency (Smaling & Holt, 2005). It is important to point out that realising this benefit requires an the integration of people, processes, applications and technology.

2.2.1 Information Integration

Information integration is an emerging paradigm that has been applied in industrial environments to facilitate process improvement and operational efficiencies. It has equally been used as a benchmark to measure performance within healthcare organisations (Lancharoen, et al., 2020). The consequence of a lack of integration is data redundancy and an overlapping of tasks within processes (Escobar-Pérez, et al., 2016). These resultant effects make it difficult to coordinate organisational processes thus, creating avenues for inefficiencies. It should also be emphasised that integration is not limited to technologies or databases interacting with each other, it equally extends to processes (CGI, 2014). For example, about two decades ago, clinicians were the 'integrators' of all information related to patients in healthcare.

Durugbo and Erkoyuncu (2014, p.339), in a study of aerospace firms, described integration from an information flow perspective as "a form of transaction that enables firms to gain clarity and act decisively on short, medium, and long-term planning, for enhanced information sharing and coordination with partners and for fully utilising and integrating facilities, people, finance and systems". The article further emphasised that the strategies involved in integrating information flow would require building relationships between suppliers and customers and

effectively managing day-to-day operational information. Thus, integrating information requires organising information related to the organisation in a way that enhances access by all stakeholders which results in good coordination of tasks and facilitates planning. In the same vein, Roztocki & Weistroffer (2016), explained that information integration entails merging information from many sources with different concepts, contexts, and representation. Information integration supports organizations in sharing their data, and when processed within the organization, it brings out important insights. Berente et al., (2009), also pointed out that information integration is fundamental for process integration and requirements to facilitate information integration includes timeliness which represents the currency of information, accessibility this refers to accessing information across essential points within the process, transparency which refers to the ease of understanding the information transmitted across different process tasks and granularity which requires transmitted information is detailed enough across the process. Lancharoen, et al., (2020), also emphasised that integrating information is useful in evaluating patient service performances in healthcare. Indicators such as patient waiting times and safety, benefit considerably when information across the processes are integrated.

2.2.2 Processes in Healthcare

In healthcare one of the early proponents of using process perspective was Donabedian in 1966. From his study, he emphasised the link between organisational structures and processes as a determinant of patient outcomes. To further extend this approach Batalden and Stoltz (1993), suggested incorporating systems perspective to process evaluation because of its recorded success in quality evaluation. As highlighted earlier in this review, performance in healthcare has been focussed on patient outcome, however, refocusing measuring performance on processes has been suggested as a possible measure to improve morbidity and mortality among patients (Buttigieg et al., 2016) Drawing from processes across fields such as management and business, we gain a better understanding of transforming inputs to outputs which would be beneficial to the healthcare system. In recent times, industries have embraced systems thinking and business process management as benchmark approaches in management and with the rapid growth in healthcare, the sector is seeking for methods from industries like business to draw evidences that will improve process efficiencies and overall patient engagement (Buttigieg et al., 2016).

2.2.3 Process Modelling

To further understand how processes can be improved, we will examine process modelling which is a technique used to visually display the operations of an organisation or a system (Bandara et al., 2005). The term modelling refers to the act of presenting a prototype, to assist or solve a particular problem (Gero & Maher, 2013). It characterises entities and activities while showing the relationships between them (Bandara et al., 2005). A model seeks to represent a real and expected system in the future and can be modified accordingly before deploying the system. According to Nigam et al. (2014), modelling involves the creation of the replica of a certain situation or activity. It is commonly used by organisations to reduce complexity and increase both knowledge and awareness of business processes (Bandara et al., 2005).

Developing a process model requires a structured approach, which assists in describing a set of related activities or processes (Hook, 2011). A top-down approach is used and high-level processes are first mapped, then subsequent levels will highlight more detail of the modelled process. The completed model is able to communicate to different functional levels of an organisation based on the details represented on each level in the model (White, 2004). Following a review of the literature on modelling hospital processes, van Sambeek et al., (2010), proposed that there is considerable benefit in understanding process design problems in a given process if it is modelled. Benefits such as improved managerial decision making and resolving bottlenecks in processes. Thus, the development of a model that describes the tasks in medication management could assist in describing how the information flows across the process in acute care facilities.

2.2.2.1 Process Model Levels

As a result of the complexities associated with modelling, three levels of modelling have been given to meet the need of users. These three levels are descriptive, analytical and executable modelling (Silver, 2012). The descriptive level provides mapping of business processes at a high level of detail. It highlights the interactions of the roles and business units. It can be represented using simple diagrams or text to show the relationships across the depicted business process. Its primary goal is to emphasise the relationship across units in a manner that is easily understood by executives. The analytical models provide a higher level of detail of the process. It points out the variances and exceptions within a process. A level of expertise is required for the development of an analytical model. The model is usually required by the IT department for the implantation of a project. The executable model is used to directly automate a given

process. This requires a greater level of detail than the two previous ones. The modelling tools used in this model differs from the standard modelling tools to ensure feasibility (Wilkins et al., 2011). Given the context of the healthcare system, the descriptive model is the most suitable for representing the medication management process.

2.3 **Medications**

The concept of medication has two different meanings or ways it is used in the field of medicine. It can mean a drug or medicine or the act of taking or administering the medicine (Shiel (Jr), 2018). For this research, medication is viewed as a drug or medicine. Medications have been described as a potent tool that facilitates the management of diseases in current medical systems (Nguyen et al., 2013). It can be defined as "a product that contains a compound with proven biological effects, plus excipients or excipients only; it may also contain contaminants; the active compound is usually a drug or prodrug, but may be a cellular element" (Aronson & Ferner, 2005, p. 514). Shoemaker et al., (2008), also described medications as "one of the main options in the cure, treatment, and prevention of numerous medical conditions" (p. 87). Aronson (2009), further extended this definition to emphasise that medicinal products which are proposed to be administered to an animal or human with the intent of achieving an outcome which may include; "as a placebo; to prevent a disease; to make a diagnosis; to test for the possibility of an adverse effect; to modify a physiological, biochemical or anatomical function or abnormality; to replace a missing factor; to ameliorate a symptom; to treat a disease; to induce anaesthesia" (p. 601). These definitions also point out that medications include pro-drugs (not active until they get into a biological medium), and cellular products (used in immunisation, gene therapy and stem cell therapy) (Aronson, 2009).

While these definitions have attempted to address all spheres covered by medications, however, development in the field of pharmacy and medicine will continuously expand these definitions. Thus, it is important to point out that while these definitions may not be all encompassing, they are sufficient for the scope of this research.

The decision to start a medication is a result of an information exchange between physician and patient in an examination room and usually occurs as a face to face encounter. This interaction represents the "informative" aspect as presented by Roter (2000), and the patient receives "both technical information, expertise and behavioural recommendations in a manner that is understandable, useful, and motivating" (Hall & Roter, 2007, p.327). An increase in number of medications taken by an individual will increase the complexity of their regimen.

Further complexities arise with differences in dosage forms, dosing frequencies and specific dosing instructions (George et al., 2004).

2.3.1   Medication Management Process

Medication management is a multifaceted process that involves various stakeholders (healthcare professionals, patients and their families) and multiple steps (Australian Council for Safety and Quality in Healthcare, 2014). Medication management is usually patient-centred and aims to ensure an optimised and effective therapeutic outcome. Medication management is costly and serves the purpose of promoting well-being among more than half of residents in developing nations (McKibbon et al, 2011). To achieve these goals, members of the healthcare team usually take initiatives to ensure that proper medication therapy is delivered. The primary goal of medication management is to ensure that administration of a medication is done in such a way that the basic five rights of medication administration: "Right drug, right patient, right dose, right route and right time" are achieved (ISMP Medication Safety Alert, 2007). Recent articles have included two more; right reason and right documentation (Smeulers, et al., 2015).

According to McKibbon et al., (2011), it can be described as a continuum that comprises of tasks covering all aspects of prescribing a medication. McBane et al. (2015), further described it as a process which consists of the steps and procedures from the time a patient gets into the hospital to the time when the relevant drugs are administered. Findings by Werner et al., (2017, p.257), identified three emergent properties of the medication management process. These are: "(1) role and task ambiguity/confusion related to the medication process were ubiquitous at all stages for all actors, (2) the process involved individuals performing work across systems in loosely-coupled teams, and (3) cross-boundary spanners played a key role in the execution of the medication process". The study defined 'cross-boundary spanners' as information gaps that occur during patient transfers across facilities. This cross-boundary spanner was identified as a barrier across all stages, thus, impeding the process and creating coordination challenges.

Medication management has also been defined by tasks in the process as - prescribing and ordering, order transmission among healthcare professionals, dispensing, administering, monitoring, reconciliation, adherence, and education (Bell et al., (2004); Abboud et al., 2006). An overview of the medication management process reveals opportunity for medication optimisation and innovations driven by technology to enhance tasks within the process. Werner et al. (2017), recommended that a process-level analysis approach can be used for assessing the medication management process. This approach describes and provides resultant insights

that can improve the process and enable the identification of key attributes of the process, the emergent properties and barriers across the process and system. It also gives insight into how the barriers are propagated across the process. Hermon and Williams (2013), also suggested that mapping the medication management process will allow the identification of gaps in the information flow across the whole medication management process.

2.3.2   Medication Management Process Models

Several frameworks have been developed to explain the workflow in the medication management process across different healthcare settings. Stowasser et al. (2004), emphasised that a good understanding of the pathway is fundamental in gaining insight on areas where initiatives can be introduced to improve the process. Examples of these initiatives include seeking to understand the transferring of medicine information through the continuum of care and the introduction of technology to improve the process. These two examples are essential components of this study. Thus, this section reviews some of the pathways identified from various studies.

The different models reviewed have proposed workflow pathways that consists of different phases ranging from 4-9 phases. The differences in these number of phases may arise from the dynamic nature of the medication management process which may be influenced by organisational, environmental, and technical factors. Similarly, different people have varying perspectives on a typical workflow path, thus, it is important to review different perspectives to identify overlaps and gaps (Oberweis, 2005). This will enable us propose a workflow path for the medication management process that has taken various views into consideration.

The "Drug Use Process" was suggested by Smith and Knapp (1992), and comprises six phases: Awareness for the need for a drug, selecting a specific drug product, choosing a treatment regimen, procuring drug product, administration of drug and reviewing the effect of the therapy. Bates et al. (1995) developed a model which identifies four phases within the process: Prescribing, transcribing, dispensing and administration. A United Kingdom study of the process within an in-patient setting identified three key phases which are: prescribing, transmission and dispensing (Dean et al., 2001). Studies from the USA by Anderson et al. (2002), Clancy (2006) and Bell et al. (2007), were in agreement about two phases in the process which are the prescribing and dispensing activities. However, Anderson et al. (2002), had an additional phase highlighted which was the transmission phase and Bell et al. (2007), highlighted transmission and monitoring. Studies from Canada by Wong et al. (2003), Abrams

and Carr (2005), Zamora et al. (2006) and Nickerson et al. (2008), concurred on two main phases of prescribing ad dispensing similar to the USA studies, however the other three studies have included transmission as another phase in the process. An Australian study by Stowasser et al. (2004), identified 9 steps and 3 background processes. The steps in their model comprised of both cognitive and physical steps. The steps from their model are: Decision to treat and prescribe, record medicine order, review of medicine order, issue of medicine, provision of medicine information, distribution and storage of medicines, administration of medicine, transfer of verified information back into the process. The three background processes are: Medicines procurement and materials management, reporting and quality safety audit review and communication. The model from Stowasser (2004), has served as a guide for Australian health system and has been recommended across different models of care (Australian Pharmaceutical Advisory Council (APAC), 2005).
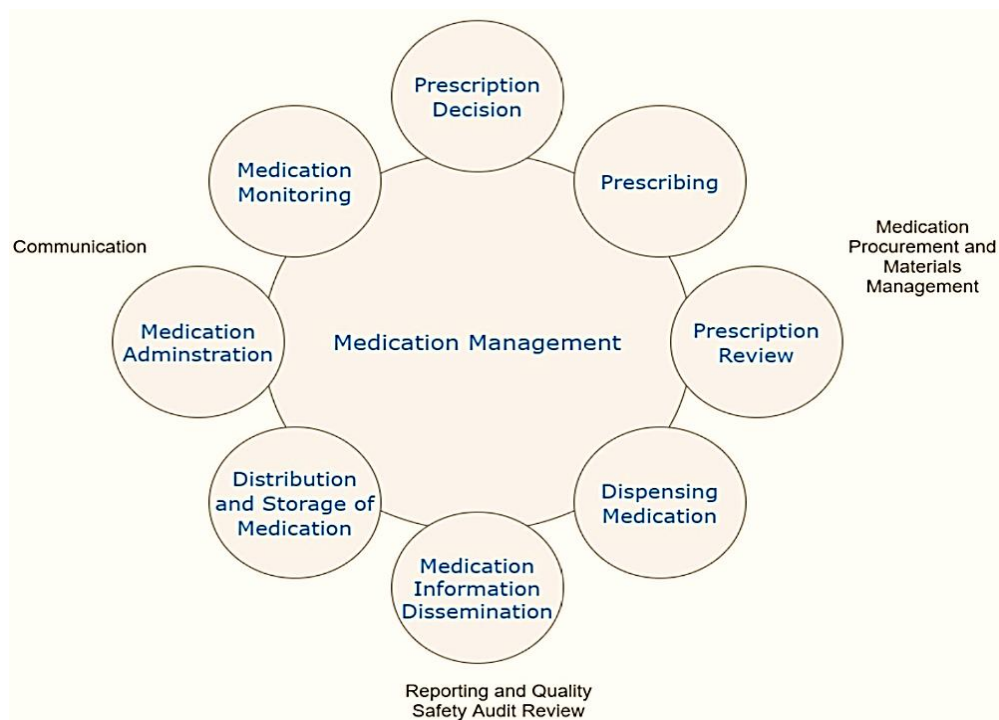
Figure 2.1: The medication management process (Cognitive and Tasks)

Adapted from Stowasser et al. (2004)

Recent studies have validated some of the phases as well as included additional phases. One of such studies is by Helmon (2014), while investigating medication use in Netherland hospitals highlighted six phases in the process. These are: Ordering, verifying, dispensing, distribution, administration and monitoring. In 2016, a white paper by the National Council for Prescription Drug Programs (NCPDP) on the phases in the model noted history taking, ordering, pharmacy

management, administration management and surveillance. In a similar vein, a Chinese study by Wang et al. (2015), also identified the phases in the process as prescribing, transcribing, prescription auditing, preparing, dispensing, administration, and monitoring and a study from Bangladesh by Mahmud et al. (2011) equally identified six (6) key phase which are: Assessment, prescription/ordering, transcription, dispensing, administering and monitoring. A recent report in Australia has equally proposed five phases for an in-patient medication use process. These phases are admission, prescription, dispensing, administration, and monitoring (National Prescribing Service, 2020).

From these studies, we can identify key phases that have been mentioned across all the reviewed articles (prescribing, dispensing and administration). However, some studies have also included monitoring and evaluation particularly the recent ones. Similarly, Bell et al., (2004) mentioned the transmission phase and the model by NCPDP have equally suggested history taking which Mahmud et al. (2011) describes as the assessment phase. This phase assessment phase equally represents the activities that goes on in the admission phase suggested by National Prescribing Service (2020), where a detailed medication history is taken. Thus, this phase is worth taking into consideration and will be important in preventing medication errors from admission to discharge (Johnston, Saulnier, & Gould, 2010).

Figure 2.2: The medication management process (Tasks and Information flow)
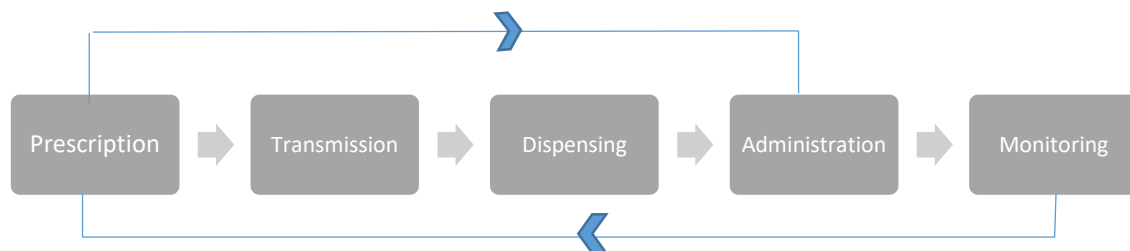
Adapted from Bell et al. (2004)

In this research, we will be emphasizing the task-based phases, thus, our conceptual model would emphasize process activities that capture carrying out physical tasks. Our suggested conceptual model is a high-level process model for the medication management process and the phases include the following: Assessment, prescribing, transmission, dispensing, administering, monitoring and evaluation. These suggested phases are similar to a conceptual model by Kitson et al. (2013). However, the assessment phase was described as the "determine the need" phase and monitoring and control was highlighted as a continuum across the phases in the model. This sequence is consistent with the models as suggested by Wang et al (2015),

Mahmud et al. (2011) and NCPDP (2016). Thus, our conceptual model positions monitoring and control after administration. These phases would be validated from our survey with participants. To gain a holistic understanding of the medication management process, the background processes as suggested by Stowasser et al. (2004) would be described in detail and further explore the process phases as suggested in our conceptual model.

2.3.3 Medication Management Background Processes

The background processes were initially identified by Stowasser et al. (2004). According to their article, these are system-wide processes which occur across the entire medication cycle. Thus, it is not specific in managing an individual's medication journey. These processes have the goal of ensuring that quality use of medicines is accessible to patients. There are three of them and are discussed below.

1. **Medicines Procurement and Materials Management**

The use of various health products including pharmaceuticals and vaccines is vital component in today's health systems. The health expenditure on pharmaceuticals takes up a considerable part of healthcare spending across low-income and middle-income countries. In these countries, health products account for 7.7 – 67.6% of health budgets (Seidman & Atun, 2017). Reports have emphasised that an improved procurement and supply chain of these products will reduce cost and ensure availability which may inadvertently improve health outcomes of the population (Seidman & Atun, 2017).

The medicines procurement and materials management process includes the planning, selection and procurement, and the storage of the medicine. It includes the identification of the medications that are needed in a hospital and the quantities required (Clark, 2012). There are many ways through which this is carried out. First, there are the basic medications that are required in large quantities and in large dosages, such as morphine and painkillers. In a typical hospital day, it has been reported that one out of every two patients complains of pain (Costantini et al., 2002) making it a common symptom and painkillers a necessity. The pharmacist or procurement official is charged with the responsibility of making a list of all the required medications that needs to be restocked, and contacting the relevant pharmaceutical companies. Once the order is made and they have been duly supplied, proper storage ensues. Most of the medications are kept in a cool environment, and away from direct sunlight. Furthermore, storage areas are well-aerated to ensure the medicines remain in the best

conditions possible. The stored medications are available for the patients who need them. This process ensures that medications needed within acute facility are continuously available.

2. Reporting and Quality Safety Audit Review

As part of the medication management process, data is collected for background processes during the prescribing, dispensing and administration phases. The data is analysed and reported on as a system-wide basis. The collected data is also used for audit purposes to ensure medication safety (Stowasser et al., 2004). In Australia, one of the tools used for reporting on analysis of this data is the National In-patient Medication Chart. This chart is utilised for a continuous national quality improvement of the medication management process. Hospitals that participate in this review are presented with a longitudinal view on their level of compliance with safety benchmarks in healthcare facilities across the country, which can be used to inform local medication incident trends and the level of compliance (Australian Commission on Safety and Quality in Health Care, 2013). Since September 2018, this has been replaced by the National Standard Medication Chart.

3. Communication in Medication Management

Communication has been described as a distinct type of information flow (Stapel & Schneider, 2014). Communication is the aspect concerned with conveying information from person to person. This conveyance can be through channels such as letters, reports, audio files and video recordings and face-to-face conversations. For communication to be successful the assumed context from the part of the sender should match the actual context of knowledge or information that is received. Thus, sender and receiver ought to have a framework that enables understanding of shared information to have a successful communication.

The medication management process entails considerable level of collaboration and communication among the process participants. Naturally, these interactions directly contribute to the effectiveness or ineffectiveness of the process (Kitson., 2013). To ensure that the process provides optimum outcome/s for the patient, it is important that comprehensive and accurate information is communicated across the process phases (Stowasser et al., 2004).

2.3.4 Medication Management Process Phases

Following a review of literature relating to the phases in the medication management from a task-oriented approach, this study has suggested that the process comprises of six key phases which are: Assessment, prescribing, transmission, dispensing, administration, and monitoring

and evaluation. These phases have been determined to represent various tasks that occur within the medication management process and closely aligns with Medication-Use Process in hospitals reported by NPS MedicineWise in March, 2020 an organisation that promotes quality use of medications in Australia. These phases are discussed below:

Assessment

The works of Mahmud et al. (2011) described the first activity in the medication management process as an initial assessment by a doctor to determine current medications the patient had been using. In countries such as Bangladesh, doctors carry out the initial assessment. However, in Australia, this assessment is usually carried out by a triage nurse. The goal of triaging is primarily to distinguish patients that require emergent medical attention from the non-emergent cases (Roscoe et al., 2016). In an emergency department, workflow model by Kramer et al., (2014) has shown the assessment phase was understood to continue as the patient is admitted and this is carried out by the admitting registered nurses so that a medication report can be provided for the physician or any other nominated prescriber to guide the prescription of medicines for the patient. This initial assessment phase is also regarded as the point where a decision on an appropriate treatment is identified (Stowasser et al., 2004).

A study by Mazer et al. (2011) indicated that medication history taking at the triage stage among emergency department patients had significant levels of discrepancies which was reported at 37% using a level of significance of 5%. Concerns about which member of the healthcare team would take the medication history more effectively (physicians, pharmacists, nurses or pharmacy technicians) was also highlighted in this study. However, another study reported increased inaccuracies when pharmacy technicians were used (Michels & Meisel, 2003).

Prescribing

Prescribing is a fundamental part of clinical practice and it accounts for a significant part of patient treatment and it is required to be carried out ethically and professionally (Diogène & Figueras, 2011). Aronson (2006) explained that the word prescribe could be traced back to a Latin word which means to write a given medicine in advance. However, in practice, prescribing is not done in advance but after a careful consideration of a number of factors. It has been defined as "an iterative process involving the steps of information gathering, clinical decision-making, communication, and evaluation that results in the initiation, continuation or cessation of a medicine" (National Prescribing Service, 2012).

A medication prescriber is expected to possess professional skills and updated knowledge of available medications to meet the requirements of the WHO guidelines on prescribing. The guidelines recommend that the rationale for drug selection should include the comparative benefit of effectiveness, convenience, safety and cost (Husnain et al., 2019). Thus, prescription reflects the clinical knowledge, experience and behaviour of the prescriber (Aronson, 2006).

For effective prescribing to occur, an accurate diagnosis must be made with a good understanding of the pathophysiology of the patient's condition. The prescribed medication should be matched to the diagnosed pathophysiology. To complement the diagnosis, prescribers recommend the conduct of clinical tests to confirm or determine the diagnosis. Other considerations that affect prescribing include weighing the potential benefit of the treatment against the potential harm. For example, weight up if is it necessary to treat with medication at all, is the dosage regimen appropriate for the patient, what are the potential adverse reactions and possible drug-drug interactions (Aronson, 2006). In essence, a good pharmacological understanding of the drug and pathophysiology of the condition will increase the effectiveness of a medication order. Aronson (2006, p.488) advises that "like marriage, prescribing is not something to be undertaken 'unadvisedly, lightly, or wantonly".

There are two types of prescribing practiced across countries like the USA, Canada, New Zealand, UK and Australia. These are: Medical prescribing and non-medical prescribing. The medical prescribing is limited to doctors and dentists. The non-medical prescribers include nurse practitioners and pharmacists (South Australia Health, 2012). In Australia, debates are still ongoing about expanding the role of pharmacists to include prescribing, which is in current practice in many other countries (Hendries, 2019).

The output from the prescribing phase is a prescription. The prescription is a document which is written manually or electronically. It contains instructions which specifies the medication plan for a given patient which should be followed through by either the patient or caretakers like nurses, pharmacists, or another therapist (Husnain, et al., 2019).

Transmission

Bell et al., (2004) described the transmission phase as the process of delivering a prescription for fulfillment. This could be achieved electronically or manually by the patient themselves or by a healthcare staff. From a nursing perspective, the transmission phase refers to the act of transferring details of medication orders into medication administration records (Nursing and

Midwifery Board of Ireland, 2007). However, in cases of emergencies, transmisssion of medication orders may be verbal or by the use of telephone calls. It is recommended that to avoid errors, medication orsere cshould be repeated for verification (Nursing and Midwifery Board of Ireland, 2007). The increase in technology has also lead to an increase in e-prescribing adoption, and thus, transmission is also occuring via electonic means. Once a prescriber has completed a prescription and has opted to transmit the order electonically, it is routed to the pharmacy system where an alert is displayed and the order queues to be processesed, thus, initiating the dispensing process (Grossman et al., 2012).

Dispensing

The dispensing phase in medication management involves sequential tasks that are repetitive, self-paced and interdependent (Croft et al., 2017). The dispensing phase combines three activities in the model suggested by Stowasser et al. (2004). These are the prescription or order review, medication dispensing and providing of medication information.

Reviewing of medication orders is carried out by pharmacists or other endorsed personnel. The process seeks to evaluate the appropriateness of the prescribed medicines, understanding the rationale, checking duplications and/or contraindications. The activities related to issuing medicine include filling medication order, preparation or supplying medicines (Stowasser et al., 2004). It is expected that the medication is selected and verified for accuracy, properly labelled and details of the medication order properly documented. Details on how the medication should be used is provided to nurse or patient and information on the right storage conditions are also communicated.

In the traditional dispensing model, medication is dispensed to the wards using manual processes. The medications are dispensed into cups from large containers and manually transported across the wards to the patient's bed side using trolleys. Recent developments to dispensing has seen introduction of technologies like the automatic dispensing cabinets (Houlind et al., 2018). However, gaps have been reported in both traditional and automated dispensing medication systems (Nazarko, 2015). Some of the gaps include labour-intensive processing, high susceptibility to errors (traditional) and errors due to wrong entry and wrong labelling (automated).

Administration

Administration of medication in acute facilities is usually the responsibility of nurses and it is carried out routinely at specific time intervals in hospital wards and units. Activities within the process may vary across hospitals, however, the process is usually guided with policies and procedures given by the administration. Thus, medication administration systems are usually developed locally (Wimpenny & Kirkpatrick, 2010). One of such procedures was given by Choo et al., (2013), medication administration practices in a Singaporean hospital. These procedures are given in 7 steps below as:

- Confirming medication bottle against patient's prescription
- Confirming medication against the patient's prescription one more time
- Notifying the patient on name of medication to be administered
- Notifying patient on medication dose to be administered
- Confirming the medication against the prescription finally
- Administering the medication to patient
- Documenting administered medication accurately.

The study identified three other steps between the first two steps (taking medication to a patient, confirming patient's allergy, verifying patient's identity), however, these steps were not consistent across most medications administered. There may be variations in these steps across facilities, however the goal of the process across most facilities are similar. This goal has been summed in the five rights of medication administration which are "the right patient, the right drug, the right dose, the right route, and the right time" (ISMP Medication Safety Alert, 2007).

Monitoring

According to Bell et al., (2004), monitoring is primarily concerned with the response of the patient to an administered medication. The patient is the subject of observation and assessments taken by a clinician and this serves as the basis for making medication adjustments or not.

In addition, Steinmann et al., (2011), suggested three steps in the monitoring phase. The first step requires the clinician to educate the patient on the anticipated benefits of the medication and possible adverse reactions that may occur. In this step, the patient is encouraged to report any problems they may experience while taking the medication.

The second step assesses the medication efficacy on an ongoing basis. Cuddy (2000), suggested that this assessment would require that clinicians should answer two fundamental questions with the first question relating to identifying the anticipated benefit of the medication. This helps in determining whether the therapeutic goal is being achieved. The second question relates to the possible adverse effects likely to occur. Adverse effects could be classified into predictable and unpredictable. A higher percentage of predictable adverse reactions should be evident following a medication treatment, however, in cases where the unpredictable adverse reactions should occur, clinicians should be capable of identifying them (Cuddy, 2000). However, it should be noted that medication assessment is not only about simple evaluation of a measure of positive response to a medication, but it entails an ongoing risk-benefit considerations throughout the therapy (Anderson et al., 2009)

The third step captures the decision to adjust a medication regimen based on the assessment if necessary. These adjustments should be supported by evidence and guidelines. Guidelines should identify what markers to monitor, how to identify necessary information on symptoms and level of adherence. It should also take cognisance of patient preferences and feasibility.

2.3.5   Professionals in the Medication Management Process

Studies across different countries have categorised healthcare professionals to be responsible for different phases in the medication process. The doctors are responsible for the prescription phase, pharmacists manage the dispensing phase, while nurses are responsible for the administration (Fleming et al., 2014). While this maybe the practice in a number of countries, however, roles have evolved and this categorisation does not encompass all the phases of the process. This section seeks to review the roles of these professionals with the view of providing context on the operations of the process.

1. **Physicians**

The role of physicians in the medication process cannot be overemphasised. It is an essential role as he/she manages the prescribing of medication, which is considered a physician's prerogative in many countries (Chaaban et al., 2018). However, recent changes in policies as described in the prescribing phase have empowered other professionals to assist in that task. The primary goal of physicians in the process is to ensure medication therapy is effective and costs and risks of achieving this is minimized while considering the patient's preferences (Hoffmann et al., 2014). Additionally, physicians are also responsible for medication history retrieval, medication reconciliation, selecting correct medications, prescription writing,

communicating goals, risk and details of administration of medication with patients and communicating with the pharmacist to confirm correct medication is dispensed (van Stiphout et al., 2014). The decisions required to carry out these tasks are often a function of the physician's expertise, however, this has evolved to become a shared decision, which is done in conjunction with other professionals like nurses and the patient being treated (Chaaban et al., 2018; van Stiphout et al., 2014)

2. Nurses

The role of nurses in the medication management process is fundamental to the success of the process. Their roles enable a facilitation of collaboration among the medical professions involved in multidisciplinary medication management in health facilities and thus, promote a desirable therapeutic outcome (Chaaban, et al., 2018). Edward et al., (2011) reported that the essential roles of nurses in the medication management process is the application of prescription, which goes on at the medication administration phase. They are also involved with monitoring the effects of the medication and providing medication advice to patients. The aspect of monitoring according to Mahlknecht et al., (2017), refers to monitoring as the process where nurses evaluate a patient's condition and documents any suspected medication-related problem. Nurses are a part of the team that drafts and develops policies and guidelines for the rational use of medications and exert a level of influence in the prescription process (Casteldine, 2006). They also share and influence medical-prescribing decisions through facilitating medication compliance and prescription monitoring which inadvertently reduces medication errors, and influence physicians with warnings and recommended dose, frequency and dosing errors in medications ordered (Edward et al., 2011; Kazemi et al., 2010). In Australia, nurse practitioners have been licensed to prescribe in some jurisdictions since 2001. However, granting prescriptive authority to registered nurses continues to be debated (Fong, 2017).

3. Pharmacist

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2.4 Medication Management

2.4.1 Standards and source of imformation

The National Safety and Quality Health Service has recommended medication safety standards which encompass all aspects around the medication management process. It strives to ensure that both clinicians and patients understand the requirements in this process. For the clinicians it ensures that the phases of prescribing, dispensing and administering is safely carried out and appropriately. For the patients, it aims at ensuring they have adequate information of the medicines and risks associated with given medications. The standards emphasise the importance of information in ensuring medication safety. It affirms that the process can be compromised if information requirements are not met.

A study by Norri-Sederholma et al. (2016), sought to understand the information requirements in the medication management process of a home care setting. According to the study information management starts with an understanding of the information requirements of the different actors that participate in the medication managmnet. It further stated that if the information requirements are known, it will ensure that the specific needed information for each actor's role is transmitted during the process. Two fundamental types of information were identified for the medication process in this facility: Patient/client related information and medication information. Learnings from this study can be applied across different healthcare settings.

Patient/client related information refers to details of the clinical status of the individual. These details inlude the demography, medical diagnosis, functioning capacity and medical history. The medical history is expected to give details on recent hospital visits, medication allergies, family history and next of kin. Medication information refers to details on the currrent information the patient/client is currently taking, names of prescribed medications, types of dosage forms, indications, contraindications and possible side effects. Other details that may be needed will include level of adherence or compliance and patient reaction to previous administration of current medications and possible medication errors.

Luukkonen et al. (2014), further added to the types of information necessary within the process. These include: Guidelines and recommendations for medication treatment implementation and information on professional information. The guidelines and recommendation includes updated medication protocols for treating diagnosed conditions and the professional; information relates to prescriber licence details and other legal frameworks that guide the medication managment process.

2.4.2 Information Flow in Medication Management Process

Healthcare facilities operate as a system of interacting departments, each having their distinct role in the treatment and medication process of a patient (Toussaint & Berry, 2013). Information and communication are pivotal in the medication management process. They act as the force that binds the process enabling it to deliver good therapeutic outcomes. The entire process depends on good quality information and an inability to access the information may compromise the process and deliver unfavourable outcomes (Hughes & Blegen, 2008). The transmission of the information within the departmental units and among the relevant healthcare workers is very sensitive and should be carried out with utmost professionalism and precision, in a bid to prevent errors (Grol et al., 2013). To ensure that the desired health outcomes are achieved, healthcare workers should receive relevant patient and medication information in a timely, efficient and correct manner (Flemming & Hübner, 2013).

Information flow in medication management in acute care facilities is an important aspect of the entire process. It is important to understand that there are specific activities that run sequentially from the time a patient presents in a facility, the order they receive treatment, and subsequent discharge or transfer (Toussaint & Berry, 2013). This suggests that a typical patient is handled by multiple people during their hospitalisation, and it is important that practitioners collaborate to ensure that adequate care is given to the patients.

Perhaps the most crucial element of information flow is during changes in shifts (Flemming & Hübner, 2013). Since the different healthcare workers are charged with the similar responsibility of taking care of the same patients, it is imperative that they are across all the information that pertains to the patient. Therefore, care has to be taken to ensure that they get all the information in a timely, efficient and correct manner (Flemming & Hübner, 2013).

2.4.3 Process Integration and Challenges in Medication Management Process

In 2010, Spaulding et al. evaluated the effect of automation and integration on medication management process workflow and performance. Three indicators were used in this study: pharmacy costs, drug revenue and process quality. While the data measures for costs and revenue were easily deduced, process quality had to be collected from the Hospital Quality Alliance (HQA) which collects data from hospitals to measure success at meeting key indicators such as appropriateness of medication for a diagnosis. Findings from the study indicated that automation had a significant correlation with cost and revenue but limited impact on quality. The automation arm required a costly investment though it increased revenue. However, when integration of adjacent activities in the process were carried out, process quality increased, costs were reduced and revenue increased. The effect of integration was separated from automation by holding the level of automation constant. Therefore, it could be argued that systems integration across process phases will improve process quality.

Laxmisan et al. (2007), identified gaps in information flow within the workflow in an emergency department due to multi-tasking and shift changes of clinicians and residents. Information transfer problems started with shift changes and handoffs and continued into subsequent activities like consultation, documentation, teaching and using computer resources. These continuation of problems may predispose the patient to safety concerns like medication errors thus, the study suggested that introducing technologies to automate some processes in such environments may address these gaps. In a similar vein, findings reported by Keenan et al. (2013) equally identified gaps in care information particularly during nurse's shift change and within the entire multi-disciplinary team across different times and settings. Variations in nurse documentations and communications were apparent, inter-disciplinary communications were rare, and there was a total absence of a centralised overview of the patient health records. These three factors affected information flow in patient care leading to poor coordination and management, undetected medical errors, and ultimately medication errors. Holly and Poletick (2014) affirmed that information transferred at the time of nurses' hand-offs could be variable,

random, inaccurate, inconsistent, incongruent and even absent and this inadvertently affects the medication management process.

Similarly, a reviewed on how workflow affects quality of care by Cain and Haque (2008) found that there was a common breakdown of information transfer at hand-off and staff transition, which led to medication errors and disruption of workflows inefficiency in patient care. They also identified dual records (paper and electronic) led to inefficient and redundant information documentation. In addition to formal information channels, they further identified the existence of informal channels where records were not maintained (such as personal notes or verbal communication) thus, leading to misunderstanding of prescriptions and administration schedules. Usually, when changes to recorded prescriptions are required due to emergent circumstances, oral communications are used and during shift changes these may not be passed on to the right personnel. The problem is aggravated when the line of responsibility is not clear. Interruptions in information transfer may also occur. Their study suggested that intra- and inter-professional information transfers can be improved by using structured formats. Such strategies would enhance better coordination and management of information flow.

Analysis of 75 anonymous error reports filed by 18 US physicians by Woolf et al. (2004), revealed a chain of medication errors. Diagnosis and treatment errors were most frequent but were initiated with communication errors of informational or personal nature. Informational miscommunication breakdowns occurred among the team and with patients, misinformation in medical records, mishandling requests and messages of patients, medical records which were inaccessible and inadequacies of reminder systems. About half of these errors were harmful to the patients. In the context of using patient healthcare records, longitudinal care planning becomes relevant in improving communication and coordination as the patient is moved across diverse care settings. The observations by Dykes et al. (2014) showed that these records were not documented or lost, are in an outdated format, or was not shared across the care settings. Types and formats of care information of individual hospitals varied widely and reflected in the nature and content of information as the patient was shifted from one care setting to another. The most common communication method was paper or fax, and that modern communication tools such as email were not used. Insufficient and inefficient patient care information transition can lead to medication and other errors.

2.5 **Medication Errors**

Medication errors have been described as an age-old threat to patient safety (Choo et al. 2010). A medication error can be described as "any preventable event that may cause or lead to inappropriate medication use or patient harm while medication is in the control of a health care professional, patient or consumer" (National Coordinating Council for Medical Error Reporting and Prevention, 2018, e.1). Researchers have described the phenomenon as any preventable occurrence that result from inappropriate medication use in any of the prescription stages which consequently harms the users (Hermon & Williams, 2013; Hansen et al., 2006; Wolf et al., 2006). Michaels et al. (2010) also described it based on the presentations as wrong dosage or timing, administration of incorrect or irrelevant medication, incorrect and inappropriate prescription. The events that predispose to medication errors include gaps in the phases of the medication management process of assessment, prescription transmission, dispensing, monitoring and use. The systems and procedures that manage this process may predispose to medication errors (Polnariev, 2014; Simonsen & Daehlin, 2011).

Torrance and Pryor (1998) have presented a notion that the word "error" may present negative connotations that may perpetuate a culture of blame and negatively affect perpetrators. However, Aronson (2009) posited that eliminating the word "error" may limit the goal of prevention, management, causes and effects of medication errors. Battard (2017), has affirmed that removing the blame game in errors is an effective way of promoting patient safety and well-being.

Previous studies indicate that about 7,000 to 9,000 people die annually from medication-related errors in the USA and several hundreds of thousands other adverse reactions incidences and medication-related complications were not often reported (Wheeler, Scahill, Hopcroft, & Stapleton, 2018). Similarly, in Australia an estimated 2-3 % of all the hospital admissions are related to adverse medication event resulting in about 230,000 hospital admissions, arising from overdose, underdose, or giving a wrong medication (Roughead et al., 2016). Research also shows about 10% of new patients end up suffering from adverse drug reactions (Roughead et. al., 2013). The cost of managing complications arising from these errors is estimated to exceed $40 billion dollars annually. These errors present psychological and physical toll on patients (Tariq & Scherbak, 2018). In the same vein, the National Institute of General Medical Science and Institute of Medicine in the US have classified medication errors as one of five medical error categories (Mrayyan et al., 2007).

In a study by Landrigan et al., (2004), results indicated that overworking interns predisposes them to medication errors due to lack of sleep. Similarly, a study by Balas et al., (2006), reported that approximately 30% of the nurses recorded at least one incident over a 23-day period, citing regular interruptions, heavy workloads, patient complexities, and uncoordinated inter-professional communication as causes of errors. Tang et al. (2007), found similar trends while investigating factors that caused medication errors among nurses. Their study pointed out work-life imbalance, heavy workload, new staff recruitment and lack of confirmatory checking before medication preparation as leading causes of medication errors. Westbrook et al. (2010), also posited that frequent interruptions in the duties of nurses leads to considerable rise in the number of procedural and clinical errors, especially related to medication administration errors. In the same vein, pharmacists identified the existence of drug therapy problems primarily due to sub-therapeutic dosage and underutilisation of medications in a longitudinal study that evaluated medical therapy management programmes in large integrated health care systems over a 10-year period (Djenane et al., 2010). Zeraatchi et al., (2013), equally emphasised that a higher percentage of recorded medication errors in hospitals occurred as omissions, under dose or overdose of the drugs across the whole process.

Medication errors occur at different stages in the process. According to Carayon et al. (2014), 32% of medication errors occurred at the ordering stage and 39% occurred at administration stage. Such errors led to preventable adverse drug events of 2.9% per admission or 0.4 events per patient day. A study by William (2007), assessed the content, format and variance in the container of prescriptions drugs dispensed in an outpatient setting within a population as a precursor to medication error, found that the main labels were generally consistent. However, there were significant variances observed with the instructions and warning stickers across different pharmacies. The pharmacy chains were more consistent with using these stickers while the independent pharmacies were less likely to use it. These discrepancies predispose the dispensing stage to errors.

In Australia, Hodgkinson et al. (2006), who investigated medication error in a geriatric facility pointed out that the common medication errors in the facility were found at the prescription, medication ordering, dispensing and administration stages. Common errors were drug reactions, inappropriate drug or dosages and medication recording errors. According to the study, the factors that contributed to these errors are poor communication between health professionals and between health professionals and patients, judgement errors, patient

consulting other medical professionals, inadequate review of patient history. Other factors observed were inadequate recognition of signs and symptoms, misunderstanding patient instructions and poor situation assessment. A subsequent study by Jeetu and Girish (2010), also reported that about 25% of medication errors are ascribable to name confusion and another 33% related to similarity of packages. Findings from these studies highlights the criticality of information flow and its management as factors that can improve quality outcomes across the medication management process.

In 2006, Ferner and Aronson proposed adopting different approaches to classify medication errors. The first approach identifies errors that occur across different phases of the medication process (assessment, prescribing, transmission, dispensing, administration and monitoring). Another approach classifies based on common errors that have occurred such as incorrect medication, dosing, frequency or route of administration or classify based on types of errors as suggested by Reason (1990). Aronson (2009), further classified the errors in a more structured manner as contextual, modal and psychological. The contextual focusses on aspects like the place, time, medication and people involved. The modal focusses on the actions which causes errors (for example by substitution, omission, or repetition). The psychological classification which is based on the work of Reason's (1990), explains the cognitive aspects predisposing individuals to these errors. These suggested approaches are not mutually exclusive, however they form a basis for understanding the nature of errors that exist in healthcare and particularly in the medication management process.

This research adopted the contextual and psychological classification. The basis for adopting these classifications is related to their applicability in the medication management process. To this end, contextual classification approach will primarily focus on the phases in the medication process and the psychological would seek to explain medication errors in more detail. These two approaches broadly cover the errors reviewed in this study and it aligns with the suggestions by Lapkin et al., (2016), who posited that medication-related incidences need to be categorised in a meaningful manner that will enable an identification of potential and actual risks within the process.

2.5.1 Contextual Errors in Medication Management Process

Contextual errors are viewed from outside the boundaries of the patient's body. Thus, it focusses on the organisation, stakeholders and environment across the delivery of a healthcare

process such as the medication within the process (Weiner & Schwartz, 2016). These types of errors will be further explored across the phases in the medication management process.

Assessment phase: The error identified in this phase is the error of omission which is demonstrated as inadequate medication history taking (Tam et al., 2005). This leads to discrepancies which may lead to morbidity or mortality (Mazer et al., 2011).

Prescription phase: Errors in this process include inappropriate medication selection, irrational and ineffective prescribing, over and under prescribing (Aronson, 2009). Other errors in the phase include mistakes in concentration, wrong frequency or timing of dosage (Gorgich et al., 2016).

Transmission phase: includes errors due to the illegibility in the written prescriptions (Velo & Minuz, 2009). In facilities where electronic transmission was used, most prescriptions had incorrect instructions that had to be clarified or re-written by pharmacists (Grossman et al., 2012).

Dispensing phase: Aronson (2009) broadly categorised the error in this phase as dispensing incorrect medication, formulation and wrong labelling. A study by Cheung et al. (2009) further expanded this to include giving a patient the wrong medication once or entirely, a medication with the wrong strength, wrong frequency or time, incorrect dosage form, an expired or soon to expire medication and an omission of a particular medication from the prescription. Other identified errors include dispensing a medication of inferior quality (substandard medications), an incorrectly compounded medication, providing wrong information such as patient's or medication details. Another source of error involves providing the wrong verbal instruction, which can emerge when the pharmacist is counselling the patient on how to use the medication.

Administration phase: Errors at the administration phase are critical because this is the final phase before the medication is received by the patient. In reviewing the medication administration errors in eight public hospitals over a 6-month period, Blignaut et al. (2017) found that the most common errors observed was incorrect time of administration, wrong route, wrong medications, wrong frequency, incorrect dosage and omissions. Another notable error was due to incorrect calculations of dosages of medications.
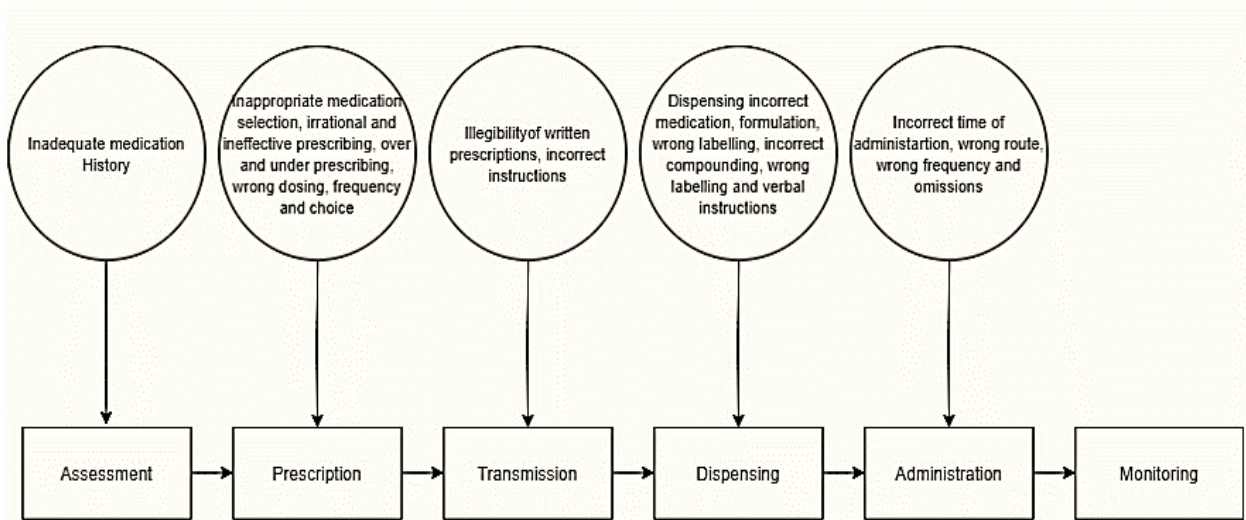
Figure 2.3: Contextual Medication Errors in Medication Management Process

The above figure (Figure 2.3) has summarised the contextual errors drawn from literature to give a visual understanding of the nature of these types of errors across the medication management process.

2.5.2 Psychological Errors in Medication Management Process

Aronson (2009) suggested that psychological classification of medication errors in a typical healthcare setting can be categorised into two broad types: Mistakes and skill-based errors (Figure 2.4). As illustrated, the medication errors resulting from mistakes are considered as errors emanating from planning actions and the skill-based errors results from a lack of execution of correctly-planned actions.

Under Aronson's (2009) definition, mistakes take place when non-routine tasks are undertaken in cases where conscious attention or supervision is required. These tasks would require theoretical knowledge, judgements, problem-solving skills which may be outside the experience of the person undertaking these tasks. Similarly, McDowell et al., (2009) has also pointed out that mistakes results from insufficient knowledge which leads to poor planning or applying good plans in wrong conditions. Errors from mistakes are further categorised into knowledge-based and rule-based errors. On the other hand, skill-based errors are described as action-based errors (slips) or memory-based errors (lapses in professional judgement). McDowell et al., (2009) also emphasise that slips occur because one of the steps in a procedure has been incorrectly executed while lapses occur because one of the steps have been omitted.

These are further categorised into action-based (slips) and memory based (lapses) errors. These errors are further described below as they apply to the medication management process:

Figure 2.4: Psychological Classification of Errors
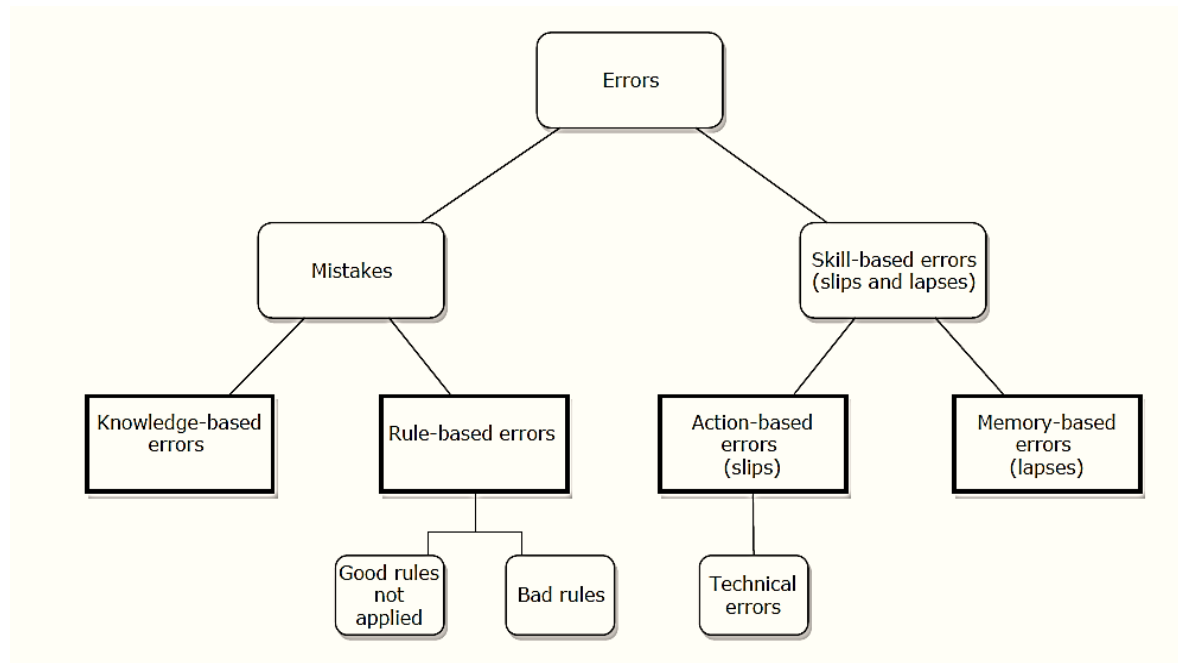
Adapted from Aronson (2009).

2.5.2.1 Knowledge-based Errors

These are errors which occur as a result of insufficient or lack of adequate knowledge pertaining to a particular procedure or process. For example, side-effects or allergic reactions caused by certain medications. Some of these medications include penicillin, a common drug which has compounds that trigger allergies in a number of patients. Inadequate knowledge about patients that are susceptible to the allergy by a healthcare practitioner would result in an adverse event when administered (Aronson, 2009). Another example is a situation where warfarin (an anticoagulant) has been administered in three doses of 10 mg on consecutive days before coagulation monitoring is carried out. This may lead to "over-treatment" of the patient because treatment guidelines require daily monitoring and dose adjustments based on results (Witt et al., 2016).

A study by Nichols et al. (2008), in an Australian hospital, found that the major cause of knowledge-based errors in prescribing could be attributed to communication problems with senior staff, lack of access to critical information pertaining to the drugs and inability to follow protocols. Similarly, a study by Al Khaja et al., (2010), in Bahrain carried out a nation-wide

retrospective audit of prescriptions relating to cardiovascular/anti-diabetic medications which had been issued by primary care physicians, found that 22.2% of these prescriptions had knowledge-based errors. The most common errors observed were irrational prescribing which includes prescribing medications that had contra-indications to each other, prescribing multiple anti-hypertensive medications with similar mechanism of actions (for example, two angiotensin converting enzyme inhibitors) and polypharmacy (prescribing multiple medications to treat one single condition).

Researchers from these studies have emphasised that education/training and adopting measures to ensure safe prescribing would reduce the incidences of knowledge-based errors. Nichols et al., (2008) also suggested that ensuring medication information is available at point of prescribing, improving communication flow among healthcare workers and increasing the number of healthcare staff available to patients will be beneficial to the medication process.

2.5.2.2   Rule-based Errors

Humans strive to make meanings by matching patterns. This intrinsic attribute is brought into play when we try to assess complex situations. There is a tendency to match the patterns we perceive from the situation with our long term memory. However, this may be incorrect and cause rule-based errors (Reason, 2005). These errors occur based on applying the wrong rules or an erroneous perception or interpretation of an existing rule. It can be categorised into two types, on the basis of this description: Applying a bad rule or misappropriation of a good rule. An example of applying a bad rule is administering an overdose. On the other hand, misappropriation of a good rule could involve giving an intra-venous injection instead of an intra-muscular injection (Williams, 2007). The rule-based errors are in most cases very personal, as the practitioners acted impulsively. Minimising the error entails strict adherence to the good rules and proper education to ensure that sufficient knowledge about processes are acquired.

2.5.2.3   Action-based Errors

These are also known as slips and they occur unintentionally. An example of an action-based error is selecting a wrong prescription bottle at the pharmacy resulting in dispensing an incorrect medication. In this scenario, the person involved has full knowledge of the required medication however, an error has been made by picking a wrong bottle (Aronson, 2009). Nichols (2008) asserted that most errors in an Australian hospital could be attributed to distractions during the medication process. The study suggested that minimising conditions

that could predispose to distractions, will include introducing double-checks and the use of identifiers which is expected to reduce the susceptibility to errors. These errors can be mitigated by having clear labels that emphasises the differences on medications that sound-alike or look-alike, use of technology and using of fail-safe equipment (Zhu, 2018).

2.5.2.4   Memory-based Errors

These errors are also known as lapses and occur due to instances of forgetfulness. For instance, a physician may forget that a patient is allergic to specific chemical compound and administers a medication containing this compound, resulting in an adverse reaction. Wilkins and Shields (2008) have suggested factors that contribute these errors are referred to as latent factors. These factors arise from systemic issues that increases the prescribers' vulnerability and susceptibility to making errors. Some of these latent factors include poor working conditions, overtime and job insecurity, which results in stress and inattention to details. These conditions place a psychological toll on healthcare workers, contributing to the increased prevalence of the errors. Also, in situations where practitioners have worked long hours, fatigue may impair their judgement and this would eventually lead to increased incidence of errors.

It is important to note that medication errors significantly affect both patient outcomes and overall healthcare expenditure. As discussed earlier, a significant part of the resources that fund Australian healthcare system is borne by the government from tax-payers. When a medication error occurs, there are various consequences that ultimately causes increased healthcare costs. First, the drugs administered have increased the complexity relating to managing the patient and the cost of management. The drugs are obtained at a cost, and the error translates to loss of revenue. With the increased complexities, other indirect costs would be borne by the patient, family, friends and even employers.

2.5.3   Non-Technological Interventions

Minimisation and elimination of medication errors can considerably improve healthcare outcomes. Thus, adopting strategies that will drive organisations towards attaining these goals is worth embracing. Over the last two decades, researchers have been engaged in investigating and identifying interventions that will facilitate attainment of these goals of error minimisation or elimination. This section will enumerate some of these interventions and review their merits or limitations.

A notable strategy that has been studied among many of these researchers is the suggestion to expand the role of the pharmacist in the medication management process as a means to reducing errors. According to Bond et al., (2001), decentralisation of the pharmacist-to-patient-care could be an effective way of reducing medication errors. This requires the pharmacist to be distributed across all the points of care within a hospital setting. A subsequent study by Bond et al., (2002), showed that drug evaluation, drug information services, drug reaction management, and drug protocol management improved with an increase in pharmacy staff per bed per year. In the study, pharmacists participated in medical rounds and were part of reviewing the medication admission histories. In a similar vein, Kucukarslan et al., (2003), reported that the inclusion of a pharmacist reduced medication errors considerably, particularly in instances where changes to doses or adding and removing medications were involved. Their study further suggested that medication errors may be reduced through interventions such as performance of risk analysis by pharmacists where the goal was to develop methods to detect high risk patients, high risk adverse drug events and other possible risks. Performing such a risk analysis may be useful in optimisation the medication distribution chain. Indeed, Guchelaar et al., (2005) reported that pharmacists can effectively oversee the quality of the whole drug distribution chain, right through prescription to administration. Their findings observed that reinventing the role of the pharmacist can be pivotal in reducing medication error both at organisation and individual patient levels. Similarly, in a longitudinal study by Bergkvist et al., (2009), who compared an intervention group that had pharmacists involved in the preparation of discharge summaries for medication reconciliation to enhance the quality of discharge summaries found that this resulted in reduced medication errors as the medication information was transferred across different healthcare centres. A randomised multi-centre controlled trial by Avery et al., (2012), also supported this finding where they observed that pharmacist-led medication error interventions were more effective than simple feedback based methods. In another article by De Oliviera et al., (2017), an investigation was conducted to determine if pharmacist-based transition of care was an effective intervention in reducing medication errors post-hospitalisation. A systematic review of ten studies was carried out and the results highlighted the effectiveness of the intervention in reducing medication errors. However, a limitation of the study is that investigated only post-hospitalisation and not during the hospitalisation period.

Several other interventions have been recommended, with some of them drawing from other fields that are error prone. One of such is the study by Revere and Black (2003), where they

sought to utilise the Six Sigma framework to work towards an error-free medication management process. The goal of the framework is achieving an error rate of 3.4 per million opportunities for error and this is achieved through waste and defect reduction, which eventually leads to improved operational efficiency across the organisation. This framework was initiated and expanded by General Electric in the 1990s. From the article, it was highlighted that previous frameworks adopted in healthcare like the total quality management had limitations because they were not taking variations in processes into consideration but Six Sigma complements these previous methodologies by focussing on detailed statistical techniques and sustainable methods. The framework utilises a ratio of the number of identified errors to the number of opportunities that can potentiate an error. This framework was used across the prescription, dispensing and administration phases. Findings for the hospital that was assessed indicated that the error of death from medication errors met the required Six Sigma level. However, using the framework for every error may be very expensive to implement and will require all participants in the process to be Six Sigma certified. These limitations make it challenging to implement the framework across the medication management process.

Another framework that was introduced by Henneman and Gawlinski (2004), is the Eindhoven model which had been in use in the chemical industry to detect near-miss errors. This model was adapted for a clinical setting to explore the possibility of nurses detecting, interrupting and correcting medical errors. The model sought to point out mismatches between diagnosis and prescription and prescription and drug delivery and prevent medication errors arising from various causes. Findings from this study emphasised that with proper trainings, nurses had the capacity to quickly address and prevent medication errors. The works of Moyen et al., (2008), argued that rather than focussing on only fragmented strategies for the process, a human factors strategy should be used to address medication errors, and suggested three strategies that may reduce medication errors which is similar to what is adopted in high-reliability organisations like aviation. These 3 strategies are: Recognising that current methodologies are inadequate, improving the system/s of error-reporting to focus on performance improvement rather than punishment and striving to understand current limitations and enhancing human performances within the process. These strategies emphasise the fallibility of humans and implementation of controls and safeguards around identified human prone error areas.

Interventions such as the medication reconciliation process have also been postulated, which has become a core part of the medical process across healthcare facilities, however, the

challenges of getting the best possible medication history limits this strategy (Camiré et al., 2009). Sammer et al., (2010), suggested that establishment of a patient safety culture in institutions would promote reduction in medical errors. Their study identified components of patient safety culture as leadership, teamwork, communication, learning, evidence-based, and patient-centred. This practice of patient safety culture may help organisations develop institutional methods to reduce error incidences using their organisational culture variables. In another approach, White et al., (2011), sought to find out if the introduction of checklists in an out-patient chemotherapy unit will enhance detection rates of specific types of errors in the medication administration phase. Results indicated a significant increase in detection rates of each type of error. There were variations in detection rates of each error which was attributed to the differences in the innate characteristic of each error and checklists used for detection. Interestingly, a systematic review by Koyama et al., (2019), sought to investigate if double checking at the point of medication administration was effective in reducing medication errors. A total of twenty-nine were evaluated and three of these articles were deemed to be high quality. Among these three, only one article identified an association between medication error reduction and double checking. Thus, it was concluded that evidence was not strong to indicate that double checking had a relationship with reduction of medication administration errors when compared with single checking. Given the mixed results of these interventions and the already heavy cognitive workload of clinicians, mandating additional work such as double checking or introducing a checklist is unlikely to be adopted.

In 2013, Nguyen et al. proposed a model that served as an intervention in prescription errors based on associations between appropriateness of a medication and the indicated disease. It was developed from a retrospective evaluation of 103 million prescriptions in a Taiwanese hospital. While the model had good results, its benefits was only realised when incorporated into the computerised physician order entry. The model also had further limitations because only appropriateness was evaluated against the disease, other factors like age, gender and laboratory results were not taken into consideration. The intervention model could only cover the prescription phase and not across the whole process.

As summarised by Manias et al., (2012), intervention strategies for the minimisation or elimination of medication errors involve work schedule changes, medication reconciliation, involvement of pharmacists, having protocols and guidelines, education, and clinical decision support systems. Importantly, the works of Teoh et al., (2015), noted that doctors and

pharmacist affirmed that the fear of blame needs to be removed so that honest reporting of medication errors will naturally lead to finding methods to reduce them.

2.5.4 Technology Interventions

Bell et al. (2007) have opined that adoption of technology would be beneficial in addressing medication error incidents. This suggests that a facility that implements any of these technologies targeted at the medication management process may considerably reduce medication errors. The last two decades have witnessed a gradual adoption of technology in healthcare and there have been differences in findings.

Early studies by Bates, et al. (1998) evaluated two interventions, a computerised provider order entry intervention and a team intervention with a pharmacist leading the second group in an expanded role. Findings indicated a reduction in the rate of non-intercepted medication errors by over 50% in the computerised provider order entry group. However, both interventions did not have an effect on the propensity to commit errors. In 2002, Anderson et al. evaluated the effectiveness of simulation technology in identifying and preventing medication errors leading to adverse drug effects. The STELLA software simulated an integration of four phases and incorporated interventions drawn from literature into the simulated process. The outcome revealed a reduction in medication errors, hospitalisation days and cost. One notable observation from the study was that incorporating interventions into single phases did not produce a significant effect in these highlighted outcomes. In another study by Kim et al. (2006), which sought to determine if errors in paediatric could be reduced following the implementation of a computerised provider order entry (CPOE). Findings indicated that errors in dosing and errors with dosage calculations of chemotherapy orders were reduced. Interestingly, errors arising from incorrect matching of a treatment plan to a specific chemotherapy increased. This may have arisen as a result of over-dependence on the technology. Similarly, a study by Walsh et al. (2008), evaluated the effect of CPOE on inpatient medication adverse event in a paediatric unit. The study was conducted nine months after the implementation of the technology. Results revealed a decrease in non-intercepted severe medication adverse events (7%), however, this did not mitigate the injuries that were caused when the errors occurred. There were also challenges relating to human-computer interactions observed in the study. At about the same period, a meta-analysis by Shamliyan et al. (2008) reported that the introduction of computerised physician orders entry resulted in reduction in prescription errors. Similarly, Devine et al. (2010) studied the effectiveness of a CPOE and compared handwritten with electronic prescriptions in a multi-speciality ambulatory setting.

The study showed errors declined by about 10% with the technology, which resulted from illegibility, improper use of abbreviations and absence of specific information. Recent technologies have attempted to further reduce errors by incorporating an alert and warning system which notifies the healthcare practitioners in cases of drug-drug interaction or contra-indications with a particular existing disease condition for immediate attention or correction (Palen, et al., 2010). Technologies like electronically assisted prescription writing have also been introduced to reduce drug transcription errors (García-Ramos & Utrilla 2011).

A study by Poon et al. (2006) evaluated the implementation of barcode technology in a hospital pharmacy to assess if targeted dispensing errors and potential adverse drug events incidences were reduced. The study used a pre and post implementation evaluation to determine whether there were any changes following implementation. Results indicated a relative reduction in both dispensing errors and adverse drug-related incidences, however, on when there was no need to scan doses of a medication, reduction in target dispensing errors was marginal and a 2.4-fold increase in potential adverse event incidences were recorded. The variation was attributed to the limitation in the technology, where scanning for doses and medication name had to be done separately.

A study by Sun et al., (2008), integrated the radio frequency identification (RFID) tags with the barcode technology to present a system: Wisely Aware RFID Dosage system. The goal of the integration of both technologies was to facilitate a quick identification of medications thus, preventing medication errors. Results indicated satisfaction among users and a facility-wide patient-centric-safe environment was introduced. However, the cost of implementation makes it commercially challenging project to undertake. Similarly, the study by Morriss et al., (2009), reported a reduction (47%) in preventable adverse medication incidences following the implementation of barcode medication administration technology in a neonatal intensive care unit. Chapuis et al., (2010), also investigated the impact on medication errors relating to picking, packing and administration after the introduction of an automated drug dispensing system in the intensive care unit of a university hospital in France, and reported a reduction in opportunities for errors. In addition, a recent study by Truitt et al., (2016), found that the use of bar code medication administration technology and electronic medication administration record reduced overall adverse events particularly administration errors due to transcription.

These technological interventions have presented mixed findings over time, though recent findings have reported better outcomes following implementation of the technologies. This

may be because there has been improvement in technologies over the years and a better alignment of the technologies to the medication process. However, as highlighted in the simulation model by Anderson et al. (2002), an integrated intervention may be more appropriate than the current fragmented approach of improving specific phases in the medication process.

2.6 Technology Acceptance in Healthcare

The last four decades has witnessed a significant revolution in in information technology (IT). Literature has suggested that improved IT competencies among staff positively enhances the organisational performance. The industry has focussed on delivering on value propositions for any IT implementation. This development has made the IT garner competitiveness across many industries including the healthcare industry (Posthumus et al., 2010). However, as healthcare invests in acquiring technology to improve its operations the degree of user acceptance is equally beginning to draw attention (Luo et al., 2011). In Australia, the last two decades has recorded a change in the landscape in delivery of healthcare services and technology has been a major driver in this transformation, primarily focussing on ensuring that health system efficiency, safety, quality, privacy and confidentiality is improved across the industry (Hambleton & Aloizos, 2019). As part of these improvements, the National E-Health Transition Authority introduced the Personally Controlled Electronic Health Record in July 2012 which was superseded by the My Health Record (MHR) in January, 2016 (Australian Digital Health Agency, 2016). However, there were challenges in the uptake and utilisation among healthcare professionals. These challenges relates to distrust of computer systems, absence of integration into clinical systems and concerns on privacy and confidentiality (Hambleton & Aloizos, 2019).

Safi et al. (2018) have explained that health technologies strive to achieve a goal of bringing sustainability, stability, security and high quality values into healthcare processes. However, attaining such goals is dependent on the degree of acceptance of the technologies by doctors, pharmacist, nurses and other medical staff. This is important because these are the end-users of most of these technologies and they either benefit from its usage or must confront the challenges imposed by the technologies. Toloui et al. (2018) reported that digitisation in healthcare has resolved many challenges encountered, however, it has also introduced different problems. For example, the introduction of electronic health records has contributed to burnout among physicians rather than facilitating patient care (Schäfer & Keppler, 2013).

Schäfer & Keppler (2013), have described acceptance as a perception that is formed based on the evaluation of the benefits and limits of a new experience. The outcome of this evaluation can be seen in the attitudes and choices that follow decision to use a technology. Ausserer and Risser (2005), have also described the concept of acceptance as a phenomenon that indicates the degree to which individuals are disposed to using a particular system. Vlassenroot et al., (2008), further identified two areas of acceptance related to technology as user acceptance and social acceptance. According to their article, user acceptance emphasises on ergonomics of the technology while the latter focuses on an indirect assessment of the consequences of the system. Development of acceptance is dependent on an interplay of 3 core elements: The context, subjectivity and objectivity of the acceptance (Schäfer & Keppler, 2013). A modification of any of these three elements can affect the degree of acceptance. Other factors that have been identified to impact on acceptance include psychological, emotional and sociodemographic (Safi et al., 2018).

In a methodological review by Holden and Karsh (2010), it was reported that the fit between technology and the clinical workflows significantly determines if the users will accept or reject a technology. The authors further asserted that this fit would also determine if the technology is abandoned or incorporated into routine hospital processes. Thus, rejection or acceptance is determined on the work-floor. Safi et al., (2018), also suggested that the risks, which relates to the ability of the technology to deliver an effective and secured care and the ease of use, which relates to the capacity of the technology to facilitate execution of health-related tasks are the factors that potentiate technology acceptance. Other factors include organisational and social environments, organisational culture, type of implementation process, legal frameworks, economic and political influences within the country of operation (Taherdoost, 2018).

2.6.1 Theories of Technology Acceptance

Studies relating to technology acceptance and adoption have explored various approaches to understand the fundamental drivers that guide the decisions of end-users to embrace or abandon a newly introduced technology. Most of these studies have looked into the human elements as active and fundamental in the implementation and adoption of technology. From these studies, nine different theories have been reported. These theories are: Theory of reasoned action, theory of task-technology fit, social cognitive theory, theory of diffusion of innovation, motivational model, theory of use and gratification, model of personal computer (PC)

utilisation, unified theory of acceptance and use of technology, and technology acceptance model.

2.6.1.1 Theory of Reasoned Action

This model was first developed by Fishbein and Ajzen in 1975. It was developed as a tool for sociological and psychological research. In recent times, it has been found useful in the evaluation of technology acceptance and adoption (Kuo et al., 2015). The theory emphasises that human behaviour can be influenced by three cognitive components and attitude. These 3 components were cited by Taherdoost (2018) as: Disposition (negative or positive) of an individuals' feelings to a specific behaviour, social norms and intention. It is important to note that disposition refers to the individual's perception of an object and behaviour as a result or intention (Lai, 2017). The usefulness of this model lies in its ability to predict an individual's response or action based on certain criteria (Mishra et al., 2014), and has thus, been widely accepted across a number of disciplines. It is however, limited by its inability to include constructs such as habit, cognitive deliberation, survey misconceptions and moral factors. Furthermore, it does not address voluntariness which is fundamental in determining acceptance of technology (Taherdoost, 2018).

2.6.1.2 Theory of Task-Technology Fit

This theory was developed by Goodhue and Thompson in 1985. They defined task-technology fit as "the degree to which a technology assists an individual in performing his or her portfolio of tasks" (p. 216). This definition served as the precursor to the theory of task-technology fit which proposes that an alignment between tasks and technology positively impact performance outcomes. This match can predict the success of the information system (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998). This theory has been proven to have a positive association between task and technology. Since its inception, it has found use across a diverse range of contexts seeking to understand relationship between technologies, tasks, utilisation, performance and user reactions (Chung et al., 2019). Studies have indicated that different authors have altered the original philosophy that underpins the theory, thus, producing disparate findings and inferences. This may have been possible because of the limited scope that the theory covers. Howard and Rose (2019) have extended the theory by focusing on three major points: Improving the conceptualisation away from utility which is what is commonly used, appropriately operationalising scales to represent outcomes and proposing mediating, and moderating effects as against direct effect which is widely used. While this extension to the theory may address some of its limitations it requires further validation.

2.6.1.3 Social Cognitive Theory

This This theory was derived from the fields of social psychology and seeks to understand the reasons why individuals adopt certain behaviours. The theory has found use across a range of contexts which include business, specifically in organisational management, in task complexity and technology adoption (Ratten & Ratten, 2007). It is built on three main factors: Environment, behaviour and self-efficacy. The theory is based on the assertion that an individual's anticipation of a behavioural outcome is related to observation of other individuals and their direct experience. Therefore, in terms of technology adoption, its primary focus is the role of self-efficacy. The concept of self-efficacy has been defined as "the judgment of one's ability to use a technology to accomplish a particular job or task" (Compeau & Higgins, 1995, p.193). The theory maintains the bi-directional nature of causation of behaviour which is constantly mutually influenced by cognitive, emotional and environmental factors. This means that an individual's self-efficacy when using a technology is a function of successful previous experiences and the capability of the technology (Carillo, 2010). The drawback of this theory are its assumptions. Specifically, it assumes that changing the environment will spontaneously change the individual, which is not necessary the case. It does not take biological and hormonal influence on behaviour into cognisance, focusses more on past experiences and pays little attention to the effect of motivation, and has been described as loosely organised because it does not emphasise which factors are more significant in predicting behaviours (LaMorte, 2018). These limitations have made it difficult to operationalise this theory in the healthcare setting.

2.6.1.4 Theory of Innovation Diffusion

This theory assesses uptake of technology from an organisational and individual perspective. It investigates the innovation development process from inception stage to the end-stage, which may be acceptance or rejection (Taherdoost, 2018). The theory proposes fundamental characteristics associated with technology innovation as the basis for adoption (Rogers, 2003; Taherdoost, 2018). The limitations of the theory have been attributed to it not fostering participation or collaboration. It is useful with adoption of behaviours, however where mistakes have been learnt, it is limited in behaviour cessation. It equally does not consider individual resources to support the new behaviour or innovation (LaMorte, 2018). Taherdoost (2018) also identified a drawback with this theory based on the interpretation of relative advantage which has been described as a subjective factor. Its focus on cost versus benefits comparison may be

important but it ignores motivational factors such as the ease of use as a factor for technology adoption.

2.6.1.5 Motivation Model

The motivational theory has also been used to evaluate technology adoption (Davis et al., 1992). The Motivation Model is premised on two fundamental paradigms: Extrinsic and intrinsic motivations, which have been identified as key drivers that influence user behaviour. Extrinsic component emphasises a perception that there is a willingness to utilise the technology based on perceived utility and ease of use. The intrinsic component is subjective and refers to deriving pleasure from using a technology (Vallerand, 1997). According to the Information Resources Management Association (2018), intrinsic motivation can be described as the "enjoyment" derived from using a technology. Criticisms of the theory have been attributed to its inadequacy in evaluating technology usage and acceptance, primarily because the intrinsic and extrinsic paradigms alone are insufficient in describing factors that influence technology usage or adoption (Information Resources Management Association , 2018).

2.6.1.6 Theory of Use and Gratification

The Use and Gratification Theory was initially proposed by Katz in 1959, and was subsequently revised in 1974 (Lin & Chen, 2017). In this model, consumers or users actively determine the selection and use of a technology. The theory suggests that users will assess available media and select one which they perceive will meet their needs and requirements (Hasan, 2015). Thus, the perceived usefulness of a given media determines if it will be selected by the user. In recent years, the theory has been applied in studies on information communication technologies including social media to determine the motives of why the media is used. Lampe et al. (2010) applied this theory to investigate the underlying factors that generated content in online communities and users' willingness to participate in further content generation. A major criticism of this theory is its over-reliance on the intrinsic paradigm, which only focuses on the enjoyment of using a technology (i.e., the gratification). For example, in task-based technologies which is often adopted for its utility and may not inherently provide enjoyment to the immediate user, this becomes a limitation (Luo et al., 2006). The task-based nature of technologies in the healthcare setting means that this model may have limited application in these settings.

2.6.1.7 Model of Personal Computer (PC) Utilization

This model was derived from the works of Triandis in 1977, who proposed the notion of interpersonal behaviour, which emphasised the role of social factors and emotions in establishing intentions, as well as the influence of past behaviours or experiences on the present (Triandis, 1977). In 1991, the model was elaborated on to include six constructs as predictors of technology acceptance and usage. These constructs include: "individuals' feeling (affect) towards the use of PCs, social norms related to using PC for the work purpose, general habit regarding to computer usage, expected consequences to PC utilization by individuals, and the extent of facilitating conditions' availability at the workplace to assist using PCs" (Thompson, Higgins, & Howell, 1991, p. 139). A major limitation of the model is that it can only be used to assess technology adoption in a voluntary setting such as personal choices and preferences (Alkhwaldi & Kamala, 2017). This model therefore has limited application in a professional setting, where end-user preferences is often not factored into technology adoption.

2.6.1.8 Technology Acceptance Model

The Technology Acceptance Model was proposed by Fred Davis in 1989 with a goal of explaining the general contributing factors to technology acceptance from the perspective of explaining user's behaviour across end-user technologies (Lai, 2017). This model has been commonly used to gain insights into reasons why individuals chose to use or reject technological innovations (Safi et al., 2018). The basic model is hinged on two fundamental principles: Perceived usefulness and perceived ease of use. Perceived usefulness refers to the subjective likelihood that a potential user has to use a system primarily based on how they perceive it will enhance their jobs while perceived ease of use is described as the level of effortlessness that a potential user expects when attempting to use a system (Safi, Thiessen, & Schmailzl, 2018). These two constructs are a result of previous existing theories of self-efficacy and contingent decision behaviour (Smith & Woo, 2017).

2.6.1.9 Unified Technology Acceptance and Use of Technology

The Unified Technology Acceptance and Use of Technology model was developed from the Technology Acceptance Model framework and hinges on 4 factors: Performance expectancy, effort expectancy, social influence, and facilitating conditions (Hamzat & Mabawonku, 2018). Performance expectancy refers to a user's perception of the extent to which a new technology would enhance their work and is reportedly the most significant predictor for acceptance (Taherdoost, 2018). Similar to Technology Acceptance Model's perceived ease of use, effort expectancy refers to the user's perception of the technology's usefulness and complexity. The

social influence refers to the user's perception of the level of social acceptability while facilitating conditions refers to the extent to of awareness of the technology, for example, the community of users and/or the existing technical infrastructures. This model has been widely applied to explain acceptance. Criticisms of this model emphasise that a low focus on endogenous components such as the technology's innovation as a factor for adoption (Taherdoost, 2018).

2.7 Technologies in Medication Management

A plethora of technological advances have evolved with a focus on improving medication management process safety and efficiency. Technology is now available to assist in most phases of the medication process. In Australia, the government has continually supported the development of medical technologies as a means to improving healthcare system efficiency (Baysari & Raban, 2019). According to Wyatt et al. (2006), the adoption of technology into healthcare enhances clinical leadership particularly in areas of procurement. It facilitates an improved quality and reliability of the process and increases savings considerably. The introduction of these technologies has raised concerns on how these technologies align with processes they were designed to enhance. Thus, it is expedient to understand the complex interactions between people, information and the technologies involved (Simonsen & Daehlin, 2011). Although literature has suggested that introduction of technology has facilitated reduction of medication errors and improved safety, other researchers have raised issues associated with their clinical usability (Carayon & Hoonakker, 2019). This is because recent studies have demonstrated that prevention of medication errors may not be wholly addressed with the introduction of technology, but aligning it with clinical processes and the users who work with it (the sociotechnical environment) is equally important (Meeks et al., 2014). Thus, there is a need to evaluate its impact on the information flow and the medication management process integration to determine if there is an improvement and to what degree it is. A number of technological devices that have been implemented in Australian hospitals to support the medication management process. Some of the technologies identified at the commencement of this research include: Computerized Physician Order entry (CPOE), Automated Dispensing Cabinets (ADC), Computer on Wheels (COW) and Electronic Medication Administration Record Technology (eMAR or EMRT).

The CPOE is also referred to as Computerized Provider Order Entry by some researchers. It is a computer application where medication orders are directly entered and transferred to the

pharmacy for review and dispensing (Hidle, 2007). Introduction of this application into health care facilities is usually associated with a change in the medication ordering from written, verbal and fax to an electronic mode. Most of the applications have other features that can enable the ordering of tests like laboratory and radiological, admitting patients or generating a referral and assisting with dosage calculations following entry of the patient's details (Dixon & Zafar, 2009). Based on these features, the application may equally provide alerts to physicians based on patient's status (for example impaired renal function) to order a change of medication or a dosage adjustment (Hidle, 2007). The CPOE has been reported to improve information transfer and communication in health facilities and has an increased value when integrated with a clinical decision support system. This integration increases the ability of the application to access current information related to contraindications, drug-drug interactions and allergies. This results in a considerable improvement in patient safety, reduction in susceptibility to medication errors, improvement in quality of care, a reduction in cost of care, enhancing regulatory compliance and organising hospital workflow (Dixon & Zafar, 2009).

ADCs are also known as Automated Dispensing Systems, Automated Distribution Cabinets, Automated Dispensing Devices, Automated Dispensing Machines and Unit-based Cabinets (Lehnbom, et al., 2013). The technology is a computerized device where medications are stored and dispensed and also facilitates the tracking and distribution of medications in a health facility (Institute for Safe Medication Practices, 2009). Lehnbom et al. (2013), reported that there were three types of which are: Automated unit-dose, ward-based and pharmacy-based automated dispensing cabinets. The automated unit-dose type had medications stored in a canister and these medications will be ejected into a packing strip where they are sealed and labelled following the entry of a dispensing order. In the case of the ward-based type, the medications are stored in electronic cabinets that are connected to a computer. The medications are accessed by entering the patient's details and a password by a requesting nurse. The specific drawer that contains the dispensed medication is opened and the picked out to be administered. The system collects data on who accessed a specific medication order. The pharmacy-based type uses robots in its operations. The robots pick medications from the shelves where they are stored and transfers them to designated points within the pharmacy. The medications are checked at this point by the pharmacy staff and labelled before dispensing (Lehnbom et al., 2013). The goal of the technology is to facilitate dispensing at the patient's bedside, however, the achievement of this goal is dependent on how aligned it is to nurses behaviour and workflow (Boyd & Chaffee, 2019).

The EMRT has been widely adopted in acute care. It is a digital device that has taken over some of the manual processes like medication documentation and transcription. Its adoption is widely associated with medication error reduction, improved patient safety and better workflow efficiency (Fei et al., 2019). The Barcode Medication Administration systems usually integrate with the EMRT. The integration ensures that patients and medications are accurately identified because accurate patient identification has been reported to be a precursor to clinical safety (Salyer, 2014). From an operational perspective, the Barcode Medication Administration technology is used to scan a patient's identification tag and prescribed medication to confirm accuracy of details. Furthermore, the details are checked against the electronic record to ensure that the goal of right patient, right medication, right dose, right route and right time are achieved and validated (Baiden, 2018).

The COW which is also referred to as Workstation on Wheels comprises of a computer or laptop on a mobile cart. They are available in various sizes and their prices vary based on the features they possess. These devices are targeted towards ensuring the available of patient data at the point of decision making which is the patient's bedside (Krogh et al., 2008). The devices support clinical documentation and are used by the different professionals involved in patient care particularly during ward rounds. The use of the device has been reported to promote safe medication administration. In American hospitals, a COW is assigned to a nurse for use throughout the shift, however, COWs are usually in short supply when there are patients in isolation (Beam, et al., 2016).

Some other technologies identified include the Smart Intravenous (IV) Pump. This technology comprises of an infusion pump that has a software embedded in it. The software has libraries at the backend that contain details of institutional dose limits, medications and other pre-set parameters (Melton et al., 2019). The technology equally has a Dose Error Reduction System integrated into the backend (Giuliano & Niemi, 2015). The system searches the libraries and sends 2 types of alerts (soft alerts and hard stops) when dosing is programmed wrongly. The soft alert sends notification to the user indicating that the selected dose is beyond specified dosing range. These types of alerts can be overridden by the user. The hard stop sends notification that the selected dose is beyond safe limits and automatically cancels the selection and does not allow infusion to proceed (Melton et al., 2019).

2.8 Summary of Literature

This chapter has explored previous research to determine where gaps exist and propose future directions in information flow management for medication management processes in Australian acute care facilities. The first part of the review explored concepts that were related to this research and sought to propose relevant definitions for this study. The second part explored literature related to the medication management process, the current process workflow and described the current challenges in managing the process. Furthermore, it reviewed how information flow gaps predispose the process to errors and identified the different interventions that had been employed to improve the process. Thirdly, the technological interventions, technological adoption theories and the technologies used in the medication management process were also discussed.

Following this review, areas that had not been explored by previous researchers were identified and these includes: Limitations of current definitions of concepts such as information, information flow and information integration for health information research and a general acceptable framework that could evaluate information flow in healthcare processes. A task-based workflow model that could represent the essential tasks in the medication management process for hospitals in Australia was lacking. The reviewed models did not emphasise some key task-based phases. Additionally, current interventions that had been employed in the medication management process focussed on specific phases of the process or agents in the process such as nurses, physicians but had not explored evaluating information flow across the process even though information-related challenges are evident in all the multifactorial contributions to medication errors. Futhermore, current available research has not evaluated the contribution of the technologies adopted in the process on information flow, rather previous research had focussed on how the technologies automated specific phases in the process and their ability to reduce medication errors.

In the light of these gaps, this research has proposed definitions for these concepts that will serve as a guide for this study and for other researchers requiring relevant definitions in subsequent studies. The study is equally proposing a high-level workflow model highlighting six phases for the medication management process. In the same vein, a framework proposed by Berente et al., (2009), using four information principles has been adopted to evaluate information flow in the medication management process and the study has also reviewed how information integrates across the process. The impact of technologies to information flow has

also been assessed. To guide this research, the General Systems Theory has been adopted and this will be discussed in the subsequent chapter.

Chapter 3 Theoretical Framework

This chapter reviews the theoretical framework that has been adopted for this research. According to Grant and Osanloo (2014), a theoretical framework serves as the building blocks from which knowledge required in a study is constructed. Thus, it serves as the support to the approach or paradigm utilised in undertaking a research. For this research a general systems theory approach has been selected to guide the research. This approach has been selected because it emphasizes that isolating components of a system may not be adequate for evaluation, particularly in domains where challenges are observed (Heil, 2017). It posits that insights into a phenomenon can be gained through analysing a system and its constituting parts from there, a root cause of a problem can be determined.

The healthcare industry has been described as a sociotechnical field which is similar to the aviation industry (Patterson et al., 2002) and the aviation industry is said to be a 'system of systems' based on 5 unique traits which it possesses. The traits include: "operational independence of elements, managerial independence of elements, evolutionary development, possessing emergent behaviour and geographical distribution of elements" (Harris & Stanton, 2010, p. 145). In a review of operations of both industries, comparable operational elements affirming suggestions of similarities between the industries were observed (Kapur et al., 2016). The aviation industry has had safety and human factor challenges and a systems approach has been used over the last few decades to bring improvements in the reliability of its processes (Stanton et al., 2019). Therefore, the analysis of the medication management process in acute care through the lens of systems theory will provide a holistic understand of the "system of systems".

3.1 Systems Theory

The concept of systems theory can be traced back to the great philosopher, Aristotle, as highlighted by his famous quote: "The whole is greater than the sum of its parts" (Natali, 2013, p. 2). In studying the human anatomy, Aristotle argued that the whole body had much greater significance than the individual functions of its parts. Philosophers had varying views on this perspective and this is apparent in the divergent views of Aristotle and Descartes. While Aristotle considered wholeness, Descartes opined on breaking into smaller parts resulting in both philosophers having different views on the human body. Aristotle conceptualised that the whole body should be viewed not only as a sum of the different parts while Descartes argued that each of the constituting entities can be studied in isolation (Cordon, 2013). According to

Aristotle, though a whole thing may consist of different parts, the operation of the whole is different from its parts. He further conceptualises that it is "the connections between bodies or elements that creates unity and one-ness" (Cordon, 2013, p. 15).

Over the last decades, systems thinking has extended across disciplines, from social sciences to applied sciences. For example, in the 1980s and 1990s, the business field embraced the philosophy and it has been widely applied across different facets (Anderson, 2016). Other applications of this theory gave rise to different insights into its underlying philosophy. These include service systems in service management, viable systems approach in viable systems, economic systems in economics, living systems in natural sciences, instructional systems in law, cybernetics in technology, conceptual systems in psychology and ecology in ecosystems. Overall, the plurality of the systems theory application has yielded a rich diversity of interdisciplinary contributions (Mele et al., 2010). However, the plurality has presented problems and reports have suggested that conflicting elements and different perspectives in meanings may have been introduced. This diversity have made it difficult for researchers to formally agree on a definition of systems theory (Adams, 2012).

3.2 Systems and System Thinking

To gain an understanding and draw a contextual meaning for this research, it is important to describe what a system is and what its attributes are. According to Kuhlmann (2001, p.955) a system can be defined as "a conglomeration of actors, institutions and processes all functionally bound together, whereby certain characteristic core functions of each form the demarcation criteria against other societal (sub)systems". A more recent definition by Koskinen (2013, p. 16) described a system as "a set of interacting or interdependent entities, real or abstract, forming an integrated whole; and a set of regularly interacting or interrelating groups of activities".

Although different definitions of systems exist, they share similarities in terms of philosophies, principles and theories (Mele et al., 2010). All systems comprise of two main components: 1) Elements – the parts, and 2) self-rationale – the logic of the system, the relationship of the parts with each other and relationship with other systems and its ability to self-organise (Carayannis et al., 2016). The elements that make up a system exists at varying structural levels from molecules, biological cells, organisms, organs, humans, organizations, cities, nations, or even planets (Cordon, 2013). Each of these constituting elements are distinguished from other elements within the system and are bounded by the environments they operate in (Sheridan,

2010). It is important to emphasise the demarcation between a system and the environment it operates in as it highlights the limit between the system's elements and the environment, which ensures the integrity and autonomy of the system (Systems Innovation, 2019). The self-rationalising ability of the system also distinguishes the system visibly from other systems and its operating environment. This is particularly useful in the cases of overlap where there can be complications in defining the borders of specific systems (Carayannis et al., 2016).

Systems can be further divided into four core components. 1) Consisting of a group of subunits, elements, objects or fundamental entities, 2) Existence of interaction or relationships among the groups within the environment they operate in, 3) aggregation of these groups make up a larger whole entity and 4) the functioning capacity of the system as a whole is dependent on the smaller subunits (Cordon, 2013). Drawing from these descriptions, we can deduce that when a subunit is severed from a system, the sub-unit may retain all its constituents, however its functioning capacity may be different from when it was connected with other parts within a system.

Researchers have sought to develop a classification of systems over the last decades, however, most of the proposed classifications were plagued with issues of not adequately covering the different presentation of systems. The classifications by Boulding (1956), a major proponent of the general systems theory highlighted 9 levels of systems. These are given as static structures or frameworks (example is the arrangement of electrons round a nucleus), dynamic or clockworks (example is the solar system), cybernetic or thermostat (example is the physiological homeostatic model), open or self-maintaining (example is the biological cell), "genetic-societal" or lower organism (an example is a plant), animal (possessing ability to take in more information), human (possessing capacity for self-consciousness), social organisations (interactions with other humans) and transcendental (exemplified with God). Subsequently, Checkland (1981, p.110), further simplified the classification into 5 broad categories. "1) Natural systems, 2) designed physical systems, 3) designed abstract systems, 4) human activity systems, and 5) transcendental systems". The natural systems draw their existences from the universe and are products of processes and forces that interact within the universe. The designed physical system is designed to meet a particular intended purpose; an example is a screwdriver. These systems are created to meet specific human needs. The designed abstract systems exist in form of literary works, arts, philosophies, or theories. These are developed from a logical or creative reasoning of the human mind. Human activity systems explains human behaviours and interactions. These systems are intangible though observable.

Transcendental systems are beyond our comprehension (Checkland, 1981). However, a recent categorisation by Tien and Berg (2003), presents that "a system can be natural (e.g., lake) or built (e.g., government), physical (e.g., space shuttle) or conceptual (e.g., plan), closed (e.g., chemicals in a stationary, closed bottle) or open (e.g., tree), static (e.g., bridge) or dynamic (e.g., human)". This classification is a further iteration on the classification suggested by Checkland (1981), and resonates with the sources of classification later suggested by Magee and de Weck (2004). From the perspective of their interaction with their environment, systems can also be classified as open and closed systems. From this classification an open system interacts with its environment while a closed system has no interaction. However, realistically this is an absolute view of the categorisation.

From an organisational perspective, closed-system models do not take cognisance of their external environment (political, technological, cultural, demographical, community trends and legal). These models assume the environment is predictable, stable and does not impact organisational functions. Therefore, solutions to challenges are not sought from the external environment, instead explores internal mechanisms to resolve arising concerns (Allen & Sawhney, 2018). Theoretically, closed systems are easier to navigate than open systems (Daft, 2001). For example, if a problem is encountered during a surgical procedure, the surgical process is reviewed to identify where gaps exist and changes are implemented. The retrospective review does not consider externalities as the cause of the problem. Conversely, open-system model assumes that external factors or variables can significantly explain issues arising within an organisation. Researchers believe that open-system models are more representative and pragmatic than closed-system models. However, the inherent existence of dynamic interactions found in open-system models pose difficulties in interpreting results from studies (Allen & Sawhney, 2018). In summary, open systems have extensive interactions while closed systems have negligible interactions (Emery, 2013).
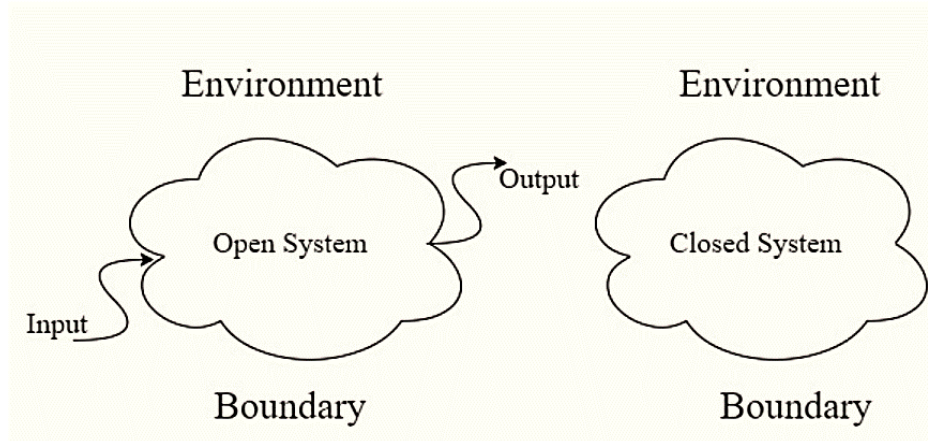
Figure 3.1 Open and Closed Systems

Adapted from Scott, (2015).

The relationship between systems and system thinking is that it is an extension to viewing a system. While a system may not have an obvious objective or goal like in the case of natural systems, system thinking always has a defined goal. According to Richmond (1994), system thinking is defined as the art and science of drawing credible inferences of behaviour by increasingly acquiring a deeper understanding of underlying configurations. In other words, proponents of system thinking should focus on both "the tree and the forest" (Richmond, 1994, p.7). However, the definition is inadequate in emphasising interconnections within a system which is the core of the paradigm. A more recent definition proposed by Arnold and Wade (2015), has attempted to capture the essence of the concept. They described the concept as "a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects. These skills work together as a system". The benefit of this definition stems from its simplicity, ease of use and its emphasis on a solution-focused perspective which is important to the paradigm.

The focus of the systems thinking research has always been to understand patterns and relationships in the systems that operates within. Systems thinking also emphasises that a good understanding of system operations can be derived from studying the non-linear and dynamic relationships of agents within a network and their interactions with their environments (Mitchell, 2009). Therefore, this research will investigate the medication management system through the lens of systems thinking. It will enable us analyse and understand the system, in order to predict behaviours and propose solutions to gaps in interactions between healthcare practitioners (i.e., nurses, doctors, and pharmacists) and the processes in acute care.

3.3 General System Theory

The development of General Systems Theory is largely credited to the Austrian biologist Karl Ludwig von Bertalanffy. He was a major proponent of the systems movement and generally referred to as the father of the theory. Following a series of lectures presented in the 1920s, von Bertalanffy sought to identify limitations on reductionism which was widely propagated at the time. The philosophy of reductionism which laid foundation for fields like physics and mathematics and was popularised by Newton and Alfred Lotka. Reductionism posits that complexities can be explained by breaking down into smaller parts. It assumes that studying each of these parts will not adversely affect the phenomenon under study. It infers that each part acts the same as the whole when evaluated separately or together as a whole (Checkland P. , 1981). While this prevailing philosophy was logical, particularly in the physical domains, there were limitations with biological and social systems. This led to Von Bertalanffy proposing the General Systems Theory which was presented in a seminal work in 1956 (Von Bertalanffy, 1972). The theory addressed the limitations on the concepts of closed systems and linear cause and effect proposed by Isaac Newton. Linear systems assume causation is unidirectional. Though the theory drew some principles from physical domains like physics and engineering, however, it emphasised the complexities of biological systems and its constitution of smaller parts like tissues and cells. It equally posited that capabilities of a biological system are a result of the interrelation of its subunits and its innate self-organisation. Thus, the postulation that the ability of the whole is not a summation of abilities in constituting parts but a higher order was introduced (Von Bertalanffy K. , 1968). Consequently, this theory brought in new approaches of holism, organismic and an interdisciplinary framework that could be used across fields like sociology, philosophy, psychology, cybernetics and psychiatry (Weckowicz, 1988). Another major contributor to the theory was Kenneth Boulding. Unlike Bertalanffy, he was an economist and was reported to have developed the framework for the theory (Johnson, 2019). Other contributors to the theory include Anatol Rapport, Ross Ashby, Gregory Bateson, Margaret Mead, West Churchman and Ralph Gerard (François, 2004).

Further review of the theory has affirmed that it facilitates investigation into interdisciplinary and complex systems. It focusses on "order and disorder, patterns, complexity and change over time" (Ingram, 2007, p. 2). It emphasises that understanding a system would require a knowledge of the interrelations of the parts within the system rather than each part functioning in isolation (Anderson, 2016). An analogy that can describe the theory is the human body as it comprises of cells and tissues. The tissues are made up of cells working together for proper

functioning. Each of the cells cannot work independently, they interact with each other to make the body function properly. An anomaly in the cells will result in improper functioning of the tissue and the body eventually. Thus, General Systems Theory believes that interrelated entities work together through a dynamic relationship to achieve a common purpose. The theory equally assumes that structural composition of systems is isomorphic (structurally similar), particularly with living systems.

In addition, Kenneth Boulding's renowned paper on "General Systems Theory, the Skeleton of Science" suggested two fundamental approaches. These approaches assert that systems are characterised by a common phenomenon (which is their interdisciplinary nature) and a hierarchical complexity of its constituting elements (Boulding, 1956). It also places emphasis on interactions (Mele et al., 2010). These interactions produce a contextual system behaviour and these behaviours can be measured based on three dimensions of interactions: between the components/entities/parts, between system and experimental method (social interactions) and between system and environment. The interaction between components examines the responses one component produces as a that result of an input from another component within the system. The interaction between system and experimental method evaluates how the system respond to the complexities within the system, the social interactions, and the use and meaning of language. The system and environment interactions refers to the response of the system to pressures and influences from its environment (Kitto, 2014).

The merits of this theory lie in its ability to propose broadly accepted principles widely applied across different systems to understand their operations and suggest improvements. This wide application was required across different fields to avoid replication of similar ideologies (Cordon, 2013). The approach employs a systematic paradigm across different fields including management and technology (Peters, 2014). Laszlo and Krippner (1998), have equally indicated that the theory has the ability to model interactions between individuals and groups without reducing the phenomenon on individual perception levels.

3.4 General Systems Theory in Healthcare

Current healthcare system is complex and characterised with different levels of engagement. Stakeholders in the system include policy makers, health organisation administrators and workers who are all working together to deliver healthcare services. The system comprises of different levels of care ranging from prevention, acute, chronic and palliative care. The delivery of health services is provided by multiple professionals which include physicians, nurses,

pharmacists, social workers, occupational therapists, medical laboratory scientists and many other professionals (Cordon, 2013). The various health disciplines found among professionals healthcare bring a diversity of epistemological perspectives which creates silos of clinical information in patient management (McMurtry, 2007). Traditional approaches to studying health service delivery are inadequate and there is a demand to apply sociotechnical approaches to carry out investigations in the field (Cordon, 2013).

Applying the General Systems Theory has been suggested as a framework that can provide quality improvement (QI) in healthcare systems. This is based on the premise that the theory integrates the systems thinking philosophy which is essential to systems and relationships of constituting parts (Petula, 2005). A focus on relationships within the healthcare system is expected to improve quality of care. The relationships places emphasis on areas like team building, effective communication, conflict management, skills and behavioural competencies, education and process management (Petula, 2005). Focussing on these areas presents a systematic view that is expected to improve healthcare outcomes (Chuang & Inder, 2009). Furthermore, the application of general systems theory requires setting defined boundaries for a system. This is necessary to have a clear view of the system under investigation and its unique wholeness. While it is apparent that most systems in healthcare are open systems, the general system theory , which provides a systems-within-systems approach can provide benefits in this regard. It posits that the components within a system could be systems in themselves (Johnson, 2019). The approach evaluates defined boundaries for each system and recognises the interrelationships with other systems. Utilising this framework in organisations helps to direct efforts towards process improvement models (which emphasise faulting processes) rather than the punitive model (which emphasise faulting individuals). The approach facilitates self-reporting on identified or potential errors because the punitive consequences have been de-emphasised. It recognizes the complexities in human behaviour and understands their inclinations to report errors and explore alternatives when there are no fears of consequences. (Anderson, 2016).

This theory has been applied across a range of processes in healthcare, including - physiological monitoring, patient order entry, medication administration and electronic documentation with reported good outcomes (Plesk, 1999). For example, an American study "A Systems Approach to Analysing and Preventing Hospital Adverse Events" by Leveson et al., (2016), which sought to demonstrate that Causal Analysis based on Systems Theory (CAST) was superior to the

"chain-of-event accident model" that was used in the medical centre. The results reported CAST to be superior to the currently used method. Findings also revealed errors in the facility were a result of weak controls within the system. Similarly, CAST left an audit trail that could be easily reviewed by stakeholders and recommendations generated from the approach were acknowledged to be more detailed when compared to other methods. Similarly, another study by Real et al., (2018) used the systems theory to evaluate the impact of changing physical design structures to communication and preferences of patient and nurses for decentralised and centralised designs. Results identified differences in preferences between both study groups. Nurses preferred centralised units while patients preferring decentralised ones. These design preferences were equally related to communication impacts, nurses desired communication that could foster mentoring and team collaboration, however, patients were concerned with privacy of details. The benefit of the systems approach in this study can be observed from the inclusion of patients who are the primary recipients of the service but rarely consulted about preferences.

It is expected that applying the general systems theory will facilitate a better understanding of the interactions among the professionals, information about the medication process and the tasks and activities that constitute the medication management process. The adoption of the theory hinges on the nature of the process. Literature has pointed out that professionals make effort to work in the right way, however, different influences and pressures exerted on them may impede these efforts (Leveson et al., 2016). The adoption further relies on the philosophy of the General Systems Theory which emphasises that correcting errors should not focus on the individual but attention should be on the environment that enabled such events thrive. It further asserts that favourable outcomes can be achieved based on data-driven interventions that results from a considerable study of patterns and behaviours within the system (Anderson, 2016).

3.5 Medication Management as a System

The medication management process has been described as a system in different literature (Baumgartner et al., 2020; Vlahu-Gjorgievska et al., 2018). Drawing from the literature review, it can also be deduced that the inherent design of the medication management process reflects a system in many respects. For example, as a system, it involves various actors (health and allied health professionals, patient and family members), different processes and the healthcare environment. These interdependent entities are continuously interacting across these processes to achieve the overarching goal of delivering a good patient outcome. As a system, it can be

categorised as an open system as it has extensive interactions with other healthcare processes within the facility.

Similarly, factors that have led to inefficiencies within the process have been identified as system-based. For example, Baumgartner et al., (2020) identified gaps in system workflow and communication as major contributory factors that impact on medication safety. While there are many exchanges going on within the system, this research seeks to evaluate information exchange and flow only. As highlighted in the literature review, information is the critical resource in this process (Borrott, et al., 2016) and a breakdown of this may result in adverse outcomes. Therefore, this research evaluates only the information flow and views the process as a system thereby adopting systems theory as a framework to suggest improvements.

Chapter 4   Methodology

The methods and process adopted in this research have sought to achieve the research objectives, which is to evaluate how information flow impacts on the medication process integration in Australian acute care facilities. The research also seeks to evaluate the technologies used in the medication management process and how it impacts information flow in medication management process integration.

As highlighted in the previous chapter, the guiding theory for this research is the general systems theory. Therefore, this research is classified as systems research. Systems research, has a strong emphasis on relations (Edson, Henning, & Sankaran, 2017). It mediates across diverse orientations to promote a system perspective and foster integration across disciplinary boundaries. While traditional research seeks to predict and control the external environment thereby detaching themselves from the studied phenomenon, system research eliminates the barriers between knowledge and action and facilitates multidimensional analysis and transition orientations from objectivity to self-awareness (Adams, 2012). The theory will facilitate a better understanding of the interactions among the professionals, information about the medication process and the tasks and activities that constitute the medication management process.

This chapter describes the research design and approach using relevant literature. The choice of the adopted approach, design and framework will be justified. Furthermore, the methods used for data collection and analysis are described and contextualised.

4.1   Research Approach

The research approach outlines the procedures that a research follows. It spans across assumptions, methods of data collection, analysis and interpretation (Creswell, 2014). The research philosophy for this research is positivist and it utilises quantitative research methods.

The positivist paradigm has evolved over the years and is described as a scientific view or empirical science theories (Creswell, 2014) . The paradigm takes the position that true reality can be attained, identified and justified. Thus, it is guided by a belief in cause and effect (causality) and proposes that reality can be predicted and controlled (Kinsler, 2011). Knowledge drawn from a post-positivist paradigm is predicated on measurements and careful observations. Developing numeric measures is critical in studying behaviours in this framework.

Quantitative research methods are described as research that seeks to explain a phenomenon through exploring numerical data which has been analysed using mathematical and statistical procedures. It could be further described as a form of empirical research that objectively measure trends from observing a human problem or social phenomenon with a view to gain an understanding of the relationship between one variable and another (Yilmaz, 2013).

From an epistemological perspective, the quantitative researcher approaches research as an objectivist. They seek to advance universal laws to explain behaviours using statistical tools to understand reality. Thus, there is an emphasis on causal or associations in relationships among variables that are tested. The perspective further emphasises that phenomena can be studied objectively and independent of the subjects studied. Thus, researchers are more likely to have minimal influence on the research outcome (Yilmaz, 2013).

Quantitative methods are carried out using different designs: Quasi-experimental, experimental, and non-experimental (Farghaly, 2018). For this research, a non-experimental design was used. In non-experimental research, the researcher does not manipulate any variable, thus, reducing the biases that may be introduced by the researcher. This type of research seeks to find associations or linkages among variables. It is less costly, easy to execute and useful in survey research. It can be used in quantitative, qualitative and mixed methodologies (Reio Jr, 2016). The ability of the design to minimise researcher's biases and identify rudimentary associations among variables makes it an appropriate design to carry out this research investigation.

4.2 Research Design

Research design is a fundamental part of a research study and highlights the organisation of the study once the research idea and questions have been determined (Toledo-Pereyra, 2012). The design outlines the best plan to obtain the most accurate results for the study. The research problems addressed are determined on the basis of the research gaps identified.

For this study, a mixed design was employed consisting of a cross-sectional and analytical design. A cross-sectional design is characterized by collecting data over a specified period of time usually a short period with all phenomena under study (Bowden, 2011). With this design, studies can be conducted in an inexpensive and faster manner. It serves as a precursor to cohort studies and has been found to be useful in domains such as health planning and evaluation (Setia, 2016). The study administered surveys to healthcare professionals in both private and public acute care facilities across Australia. data was collected over one year for the research.

The cross-sectional design has been found to be useful in health research where the objective is to "describe and better understand relationships between variables at a fixed point in time" (Bowden, 2011, p.127). An analytical design is suggested when a research involves inferential analysis of two or more variables (Edson, Henning, & Sankaran, 2017). This design seeks to establish associations from the variables or data. For this research, our variables are information integration (dependent variable) and accessibility, transparency, timeliness, and granularity (independent variables).

Adopting an analytical cross-sectional design is useful when time does not affect the exposure to the outcome. In this study, the information flow factors are not affected by time when as they relate to information process integration. Furthermore, the design uses quantitative, non-experimental methods to "gather data from a group of subjects at only one point in time" (Schmidt & Brown, 2019, p. 206). Cross-sectional studies often utilize surveys or questionnaires to gather data from participants (Schmidt & Brown, 2019, pp. 206-207).

4.3 Research Framework

One of the primary aims of this research was to provide an understanding of how information flow impacted on the information integration and process integration of the medication management process in acute care. Similarly, the study seeks to suggest improvements extrapolated from existing frameworks that could describe how the different elements in information flow influence process integration.

To achieve these goals, the study has adopted the General Systems Theory as our theoretical framework. The theory holds that disruptions or breakdown in information flow within a system will impair the flow of inputs to outputs. This impairment will break the interchange that occurs within a system, affecting the information and process integration. Thus, General System Theory will guide us to focus on the medication management process, its interdependencies, linkages and assist in evaluating the interactions across the phases within the process (Fitch, 2004).

From the existing literature on information flow analysis, the framework used by Berente et al., (2009) was determined to be of significant relevance to this research. As highlighted in our review of literature, the framework has been widely applied and in about 10 different processes including a healthcare process (Berente et al., 2009). It also aligns with dimensions of information examined in this study, and its principles aligns with the General Systems Theory.

The framework by Berente et al. (2009), uses four principles of information flow as predictors of process integration. These four principles include; accessibility, transparency, timeliness and granularity (Berente et al., 2009). These principles have been reported to be pivotal in predicting improvements within a given process (Berente & Vandenbosch, 2008). A further evaluation of these principles revealed that these four principles could be categorised into two consolidated groups; activities that transfer information and activities that transform it. Transparency and granularity were identified as principles that implied a transformation of the information content from the state from which it was initially received while timeliness and accessibility did not reflect a change of state of the information content (Berente et al., 2009). According to their article, transfer of information can be automated, however information transformation is a value add within activities in a process. Thus, expert judgement is required in information transformation. Based on the General Systems Theory tenets which posits that parts of a system draw relevance and meaning from the whole and not by focusing on completing off only one task, the results from transferring and transforming information flow may give us an overview of the significant activities that influence the medication management process integration, however reviewing from the granular level using the 4 principles would give us more details on the specifics and thereby address the issues that could facilitate the improvement of the medication information integration. This framework is represented diagrammatically in Figure 4.1 and 4.2:
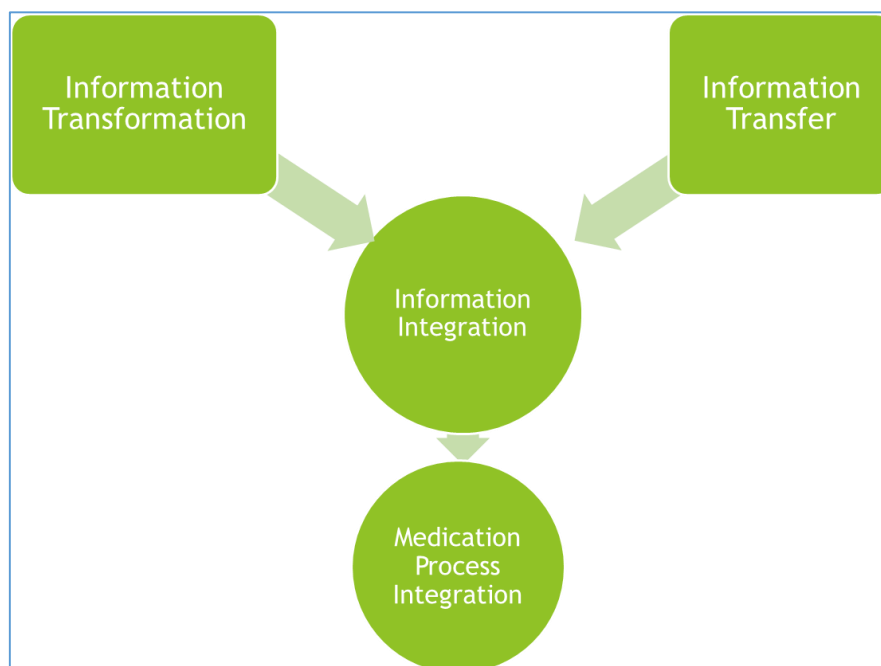
Figure 4.1: Consolidated Principles of Information Flow Framework

Adapted from the framework by Berente et al., (2009)
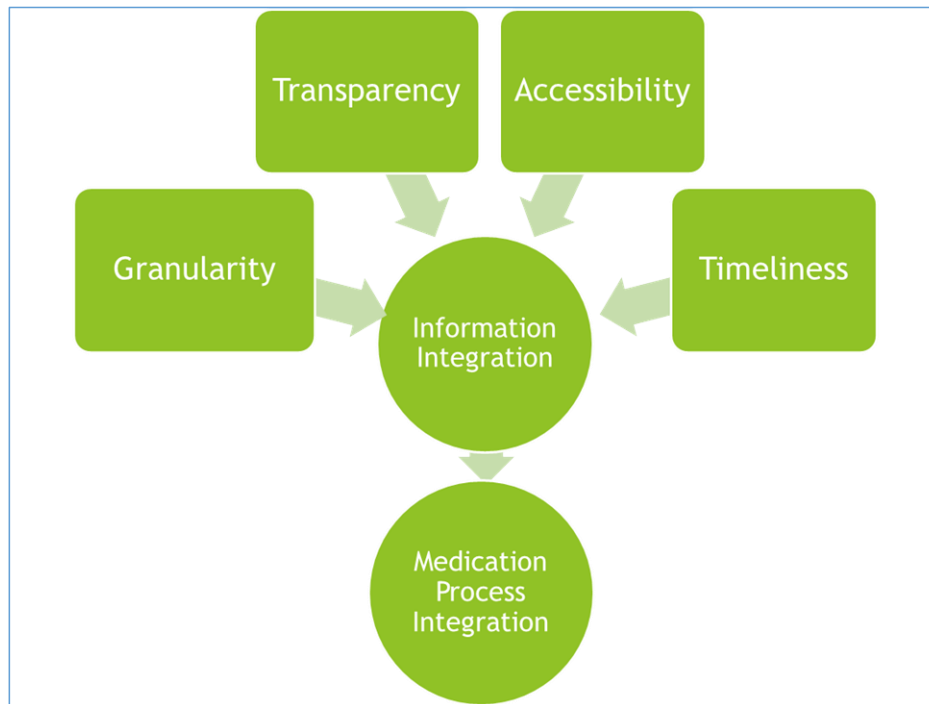
Figure 4.2: Principles of Information Flow Framework

Adapted from the framework by Berente et al., (2009)

4.4 Data Collection

The effect on information flow on the medication management process for this study was evaluated based on the perceptions of healthcare professionals involved in the process. These healthcare professionals are the active participants and primary stakeholders in the process (Australian Government Department of Health, 2012). The perceptions of stakeholders has been identified as a significant factor in improving and innovating existing processes (Lewis, Young, Mathiassen, Rai, & Welke, 2007). These perceptions can be measured using surveys as instruments for assessment (Dell-Kuster, et al., 2014).

In the light of this, data for this research was collected using an online self-administered survey via the online platform Survey Monkey (www.surveymonkey.com). The platform included tools that assisted in developing surveys, which were utilised to improve the interactivity of the survey. The survey collected data on information flow and the technologies used in the medication management process in Australia. The methods used in collecting data for this research were in two ways and they are:

1. Sending of survey link to email addresses of targeted participants.

2. Distribution of hard copies to some participants and following up to collect completed surveys. These copies had no identifiers on them. The responses were entered into the Survey Monkey platform.

Each survey had an introduction that covered the subject, objective of the study and summary of questionnaire structure. This introduction had the goal of giving a background and providing a basic understanding of the study to participants. For hard copy responses a signed consent form was obtained and for the digital version, consent was sought through a question to proceed with participating in the research or not. Responses to the survey were anonymous and confidential. No associations to any individual or identifiable data were recorded.

The survey was opened up over a period of a year and was expected to be completed within 20 minutes. The number of responses were checked periodically and email reminders were sent as a follow-up. After the designated period for the data collection and when responses had stopped, the collected data was downloaded for analysis.

The Study Population

The target population for this survey were healthcare professionals in Australian acute care facilities. According to the Australian Institute of Health and Welfare (AIHW) (2018), the estimated size of healthcare workers in public hospitals is 365,000 full-time staff in 2016-2017 of whom; nurses constitute the highest percentage (41%) in the workforce, followed by doctors (12%), the allied health and diagnostic professionals (16%) while the other 26% represents other professions working within the system. In comparison, private hospitals had about 66,800 full-time equivalent staff. Among these professionals, nurses also constitute the largest (53%), while doctors follow (2%), and diagnostic and allied health were third (6%). The other 36% represents other professional within the hospitals (Australian Bureau of Statistics, 2018).

Over 1000 surveys (online and hardcopy) were sent out to doctors, nurses, heads of medical and nursing units and allied healthcare professionals who are involved in the medication management process. Convenience sampling was used in collecting data from the respondents. Our target response was a minimum of 100 participants to ensure that our margin of error (1/Square Root (n)) is not higher than 0.10 (Creswell, 2014). However, response rate was low; 88 respondents participated in the study (doctors 54.5%, nurses 27.3%, pharmacists 15.9% and nursing students 2.3%), however, calculated margin of error was within 0.10 margin of error, therefore analysis proceeded.

Questionnaire Design

As described in the research framework, constructs were identified for assessing information flow. Questions that relate to assessing these constructs were used within the questionnaire to address this. However, in line with Alsos, Clausen and Solvoll (2014), a broad exploration of other constructs that were identified from literature were also used in this study to improve measures of cause and effect. Their study acknowledges that use of narrowly focussed constructs may limit other salient constructs from being identified and evaluated, thus, exploring other constructs broadens an understanding of other variables that may have associations with the medication process integration (Alsos et al., 2014).

The primary response scale used in this study is a 5-point Likert scale which yields better quality data than 3, 7-or 11-point scales (Dawes 2008; Revilla, Saris, & Krosnick 2014). Numeric rating scales were also used in assessing perceived performance of technologies and the medication management process as recommended by (Dell-Kuster, et al., 2014).

The questionnaire was divided into three domains. These three domains were based on the primary research question and two sub-questions that were intended to be addressed in this study. The first set of questions were demographic questions relating to participants' profession, gender, professional experience and type of hospital they were employed. The remaining questions within the first domain surveyed the steps in the medication management used in the participant's facility, their technological competence and identifying the technologies used in the medication management process in their facility.

The second set of questions assessed the technologies used within each facility. Participants were asked to evaluate the technology that was used in their facilities or if more than one was used, the ones they directly work with.

Questions in the third domain focused on the information flow within the process. The questions include identifying the medium used in transferring information, assessing the constructs for information flow (the primary 4 constructs and other constructs from literature), relationship of the flow to medication error, the impact of technology on the information flow and a numerical rating of the medication process performance. An open-ended question was also included to capture other relevant insights that may not have been covered in the questionnaire.

4.5 Data Analysis
The data analysis sought to achieve the following aims:

1. To describe the general profile of all the participants who responded to the survey.

2. To establish the reliability of the scales used in the survey.

3. To establish if there are significant differences between the responses of males and females with respect to the use of technologies and information flow in the medication management process in Australian acute care facilities.

4. To describe the responses of the participants to the questions relating to the use of technology in medication management at their hospitals and the information flow.

5. To evaluate how information flow impacts on the information and medication process integration in Australian acute care facilities.

6. To determine which information flow path enhances or weakens the information and medication management process integration in Australian acute care facilities

7. To test for the association between the use of health information technologies and information flow in the medication management process in Australian acute care facilities.

8. To describe the responses related to information flow questions and the associations among the questions as they relate to the medication management system

A test of normality and reliability of the responses and scales respectively was initially carried out to verify the distribution and consistency of the data collected. Following this analysis, other statistical analysis was then carried out, including frequency counts, descriptive and correlation statistic, and multivariate analysis. To identify and assess more complex relationships, a hierarchical linear regression, logistic regression and multiple regression modelling was used (McQuitty, 2018).

Analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 24 application. The SPSS software has been identified to be robust in terms of its ability to run both basic and advanced statistics, its unique tables and bootstrapping features(Ozgur, Kleckner, & Li, 2015).

Medication Management Process Model

This study has suggested that the process comprises of six key phases which are: Assessment, prescribing, transmission, dispensing, administration, and monitoring and evaluation. These phases have been discussed in the literature review (2.3.2.2). This study also suggests that the primary type of information flow model within the medication management process is sequential. This is consistent with the task-based workflow model for the process which is sequential in its operations. Tasks are executed after each other with varying levels of

dependencies. Although other types such as deferred, parallel, wheel, one-to-many, many-to-many, and also M-1-M do occur, however because each phases depends on information from the previous phase, the sequential will be the most frequently occurring (Oberweis, 2005). This workflow and information flow model isgiven below in Figure 4.3A and B.

Figure 4.3A: Proposed Medication Management Process Model

Figure 4.3A represents a proposed high-level workflow model of the medication management process. There are six phases suggested to follow a linear pattern with the assessment as the initial step. This is followed by the prescription, transmission, dispensing, administration and the monitoring phase**.**
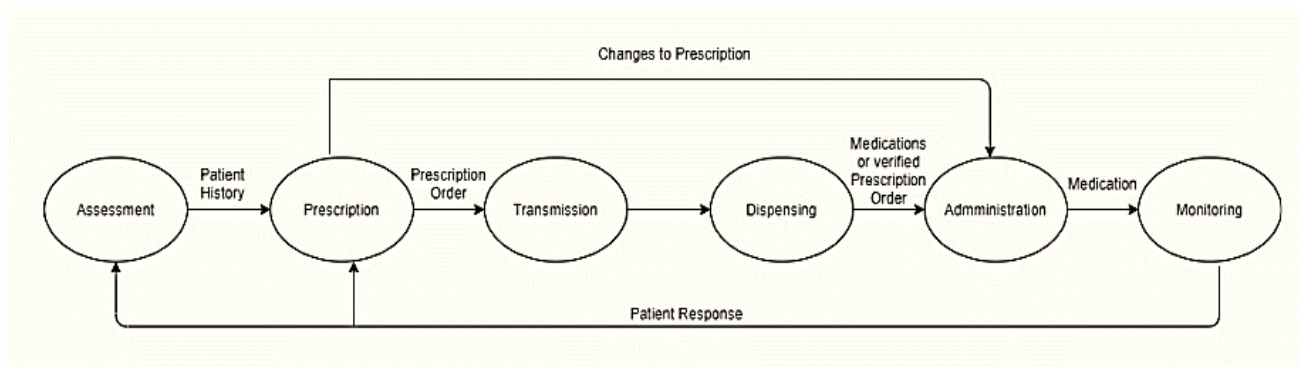
Figure 4.3B: Proposed Medication Management Information Flow Model

Figure 4.3B represents a proposed high-level Information Flow model of the medication management process. There are six phases suggested to follow a linear pattern with the assessment as the initial phase. This is followed by the prescription, transmission, dispensing, administration and the monitoring phase**.** However, information can flow back to either assessment, prescription or both phases and subsequently flow through the process.

Test of Normality

Ghasemi & Zahediasl (2012), have suggested using a visual inspection of a frequency distribution table or graph to determine whether a data set conforms to a normal distribution (i.e, Gaussian distribution or normality), however, this method of testing for normality has been considered unreliable (Oztuna, Elhan, & Tuccar, 2006). Instead, various statistical tests have been used to more accurately determine normality which includes: "Kolmogorov-Smirnov (K-

S) test, Lilliefors corrected K-S test, Shapiro-Wilk test, Anderson-Darling test, Cramer-von Mises test, D'Agostino skewness test, Anscombe-Glynn kurtosis test, D'Agostino-Pearson omnibus test, and the Jarque-Bera test" (Ghasemi & Zahediasl, 2012, p. 487). Among these tests, the Shapiro-Wilk is most appropriate for assessing normality in this study because of the sample size (Ghasemi & Zahediasl, 2012; Thode, 2002).

The Shapiro-Wilk tests assesses correlation between normal scores and given data (Ghasemi & Zahediasl, 2012, p. 491). It also identifies power, which is a common measure in normality for testing values (Thode, 2002).

Prior to conducting statistical analysis, the Shapiro-Wilk test was used to determine the normality of the variables at alpha = 0.05. To test for normality, a hypothesis is used. This is given as:

$$H_0 \quad \textit{Data is normally distributed}$$

$$H_A \quad \textit{Data is not normally distributed}$$

Thus, when significance value is greater than 0.05, data is normally distributed, null hypothesis is not rejected as there is insufficient evidence to do so, and less than indicates a deviation where alternative hypothesis will be accepted (Ghasemi & Zahediasl, 2012).

Variable Scoring

To ensure the responses from the survey could be quantitatively analysed, a normal scoring method was employed as suggested by Agresti (2010). The normal scoring assigns values which are exactly or approximately equidistant based on the normal distribution. Thus, these values are based on ranking and are matched in a way that would be similar to an original set of data based on data values obtained from a normal distribution (Agresti, 2010).

Therefore, each of the five points on the Likert scale used in the survey was change to values 1-5. All statistical analysis was conducted with the numerical scores.

Reliability Analysis

The reliability test is primarily used to measure consistency of an instrument. The reliability of an instrument is related to its validity, thus, a reliable instrument is deemed to have validity (Tavakol & Dennick, 2011; Cronbach, 1951). The reliability of an instrument can be measured using Cronbach's Alpha. It has a wide acceptance and the results are expressed as numbers between 0 and 1.

To assess consistency coefficients in our survey tool, the scale items were subjected to reliability tests utilizing the Cronbach Alpha. An alpha value of 0.7 or above indicates reliability and internal consistency of the survey tools (Reynaldo & Santos, 1999).

Frequency Distribution and Descriptive Statistics

The frequency distribution is an organised representation of the number of participants in a tabular or graphical format using a scale of measurement (Manikandan, 2011). It presents a quick overview of the distribution of the data and helps the researcher to determine whether there is skewness in the data (Manikandan, 2011).

The frequency distributions (counts and percentages) were tabulated for all responses that are categorical. The trends were summarized and tabulated. Furthermore, the skewness of the distributions was recorded where applicable. Summary descriptive statistics (e.g. Means, Medians or Modes) were reported where appropriate.

Multivariate Analysis

The multivariate analysis techniques used for this project includes; independent sample t-test, Pearson's chi-square test, hierarchical linear regression, and multiple linear regression.

An independent sample t-test is a useful test that compares mean responses of two groups that are not dependent on each other (Kim, 2015). An independent sample t-test was used to compare the mean responses of males and females to the use of technologies and information flow in the medication management process in Australian acute care facilities. This test was done to assess if there were differences in gender responses and assist in identifying any gender bias. The test is an inferential test that uses a null and alternative hypothesis. The hypothesis are given as:

Table 4.1: Hypothesis for Independent T-test

H_0: u1 = u2 (population means are equal)
H_A: u1 ≠ u2 (population means are not equal)

Alpha value of 0.05 was used in this test. A significance value greater than 0.05, data is normally distributed, null hypothesis is not rejected as there is insufficient evidence to do so, and less than indicates a deviation where alternative hypothesis will be accepted. The assumptions for a t- test requires a dependent variable (continuous or discrete) and independent

categorical variables (usually two groups). Other assumptions are normality and homogeneity of variance which was sourced from our results (Kim T. K., 2015).

The primary research question for this study was answered using a multimethod analysis approach. Morse (2003), described this approach as using different methods of the same generic type (qualitative or quantitative) to understand a phenomenon. Using a single approach may produce limited understanding on the level of association between the information flow principles and information integration. The multimethod approach has been reported to increase the likelihood of obtaining extensive results and increases confidence in an analysis (Morse, 2003). Thus, this research used the Pearson's chi-square test and Cramer's V to test for association and hierarchical regression to test the extent the independent variables affect the dependent variable. These methods have been selected for the purpose of comparison and to address limitations of each test.

From literature, we identified several chi-square tests which include: Yates chi-square test (which is used for continuity correction), Maxwell-Stuarts chi-square test (used for correlated proportions), Cochran-Mantel–Haenszel chi-square test (which compares odd ratios with 2-by-2 tables) and the Karl Pearson chi-square test (which evaluates independence and associations) (McDonald, 2014; Franke, Ho, & Christie, 2012). As highlighted, each of them can be applied for different analysis though they all rely on the chi-square as a reference distribution. For this study, our goal is to evaluate the associations between the constructs that represent the principles of information flow and the information integration within the medication management process. Thus, the relevant chi-square test for our analysis is the Karl Pearson Chi-square test commonly known as the Pearson chi-square test.

The Pearson chi-square test is a quantitative measure that assesses independence and associations between two categorical variables. It is useful in evaluating the goodness of fit in a sample distribution (Franke, Ho, & Christie, 2012). It has been described as a useful tool for researchers particularly when non-parametric tests are involved (McHugh, 2013). It is represented with the Greek notation χ^2. Applying the Pearson's chi-square test in data analysis has a number of advantages which include its robustness which is a function of the data distribution that can work with it, the ease of computing, and flexibility in its application to two or multiple group studies. The reported limitations arise from its sample size requirements and the tendency to produce a low Cramer V correlation value even in cases correlation is more

significant (McHugh, 2013). The application of the Pearson's chi-square test requires assumptions for the test to be met. Rana and Singhal (2015), highlighted these assumptions as:

- Data for the test is drawn randomly from the population.

- The sample size is larger than 50 which is the set minimum sample size for the test. Applying the test to a smaller sample may result in a Type II error (where a null hypothesis is accepted whereas it is false).

- Variables to be tested must be mutually exclusive. This means that the variables cannot be counted twice between each category and can only appear in one category.

McHugh (2013), also adds the following assumptions to the test:

- There should be 2 variables which are categorical and data could be nominal. It could also be ordinal in a few cases and in cases where interval or ratio have been converted to ordinal data they can also be used.

- The data in the cells should represent frequencies, cases or counts and not percentages or other presentations of data.

The Pearson's chi-square test utilises hypothesis tests. The logic of hypothesis testing was advanced by Karl Pearson in 1900 (Rana & Singhal, 2015). Hypothesis testing draws inferences about parameters and populations from statistics and samples. Probabilistic methods are used to make decisions in uniformity. The hypothesis is tested using statistical significance from a sample data to determine the validity of the hypothesis. A null and alternative hypothesis are used in hypothesis testing. The null hypothesis is denoted as H_0 and it bears specific details about a parameter in the population while the alternative hypothesis denoted as H_A or H_1 provides a more general statement about the parameter (Pugh & Molinaro, 2016). Berman and Wang (2017), described the alternative hypothesis as " logical opposite of the alternate hypothesis".

For this research, the null and alternative hypothesis was used to test the association between each of the principles and information integration (organisation). The principles that were tested are the information flow principles which are: Timeliness, accessibility, transparency and granularity.

The four hypotheses used in the Pearson's Chi-square test are presented in Table 4.2. Each hypothesis has a null stating no association between the information flow principle and integration and the alternative states the presence of an association

Table 4.2: Hypothesis for Pearson's Chi-square test

Hypothesis 1 H0: No association between timeliness and information integration HA: Association exists between timeliness and information integration
Hypothesis 2 H0: No association between accessibility and information integration HA: Association exists between accessibility and information integration
Hypothesis 3 H0: No association between transparency and information integration HA: Association exists between transparency and information integration
Hypothesis 4 H0: No association between granularity and information integration HA: Association exists between granularity and information integration

The conditions for the test was checked before analysis. Our sample size was above 50, our variables are mutually exclusive, and we have both categorical and discrete data. The associations will be determined and the choice on whether to accept or reject the null hypothesis will apply. The results from this analysis will be compared to the results from the hierarchical regression analysis which will further validate the contributory principles to the information integration and inadvertently the process integration.

The Cramers V test is a statistical strength used for correlation measures. While the Pearson's Chi-Square test determines the significance of an association, the Cramers V test assesses the strength of the association (McHugh, 2013). It is designed to measure the size of the effect calculated by Pearson's ChiSquare. Generally interpreted between 0.00 and 1.00. With 1.00 as the perfectly strong association and values closer to 0.00 as weak relationships. The test is useful with multi-categorical variables (variables with 3 or more categories) particularly nominal or ordinal measures, however, it can used with dichotomous variables (Gau, 2018). For this research, the variables are categorical with ordinal measures, therefore it meets the required conditions. The hypothesis test for the Cramer's V test is given as;

Table 4.3: Hypothesis for Cramer's V test

H_0: There is no association between the information flow principles and information integration.

H_A: There is some association between the information flow principles and information integration

Regression modelling is a statistical technique that determines strength of a relationship between one or more independent variables and a dependent variable. The relationship could either be positive or negative (Tabachnick & Fidell, 2007). Hierarchical linear regression is an advanced regression technique that has been used across a number of fields including social work, health, education and business. Its use across these fields is related to its gradual development which has also given the technique different names. Some of these names include: Mixed-linear, multi-level, mixed-effects, random-effects, complex-covariance, random-coefficient (regression) and components-modelling. All these different terms refer to the hierarchical linear regression technique (Weisberg, 2005; Woltman, Feldstain, MacKay, & Rocchi, 2012)

The hierarchical regression explains the statistical variance in the dependent variable when variables of interest are added to the regression model. In performing the hierarchical linear regression, a number of linear regression analysis was performed in a forward step-wise manner and the extent to which the predicting variable(s) uniquely accounts for changes in the dependent variable was assessed. Three parameters were used to select the appropriate model in the hierarchical regression analysis. These parameters are the fit of model, ANOVA (Analysis of Variance) and the Standard Coefficients. The fit of model will be used to observe the changes in the coefficient of determination (R^2). The R^2 explained the variability between the information flow principle and information integration (Kim, 2016). Our primary interest was to determine if these changes were statistically significant at alpha = 0.05 and confirm if there are improvements in R^2. The ANOVA determined the overall significance of the models. It utilises the F- test statistic at alpha = 0.05 to assess whether the information flow principles can explain changes in the information organisation. Two hypotheses were used for ANOVA.

Table 4.4 states the null hypothesis asserts no relationship, and the alternative hypothesis indicates a relationship

Table 4.4: Hypothesis for ANOVA

H_0: The independent variables cannot explain the dependent variable

H_A: The independent variables can explain the dependent variable

If the p-value is greater than alpha = 0.05, the null hypothesis (H_0) will not be rejected because, there is insufficient evidence to do so, therefore no further tests are conducted. However, if the p-value is less than the value of alpha, the null hypothesis is rejected and the alternative hypothesis is accepted, further testing can proceed (Faraway, 2002). The assumptions of normality, sample independence and equality of variance were checked and met before commencement of analysis (Berman & Wang, 2017).

The third phase was the hierarchical modelling with information flow principles entered in a forward step-wise manner and tested against the information integration. The model was interpreted with level of significance of each standard coefficient at alpha = 0.05. For this research, the constructs were added to the model in the order given in Table 4.5 below. The hierarchical order was adopted based on the hierarchy of the information flow principles as suggested by Berente, et al., (2009).

Table 4.5: Hierarchical Regression Model Order

Model	Variables
Model 1	DV (Information Integration) – IV (Timeliness)
Model 2	DV (Information Integration) – IV (Timeliness, Accessibility)
Model 3	DV (Information Integration) – IV (Timeliness, Accessibility, Transparency)
Model 4	DV (Information Integration) – IV (Timeliness, Accessibility, Transparency, and Granularity)

Two of the principles (transparency and timeliness) had only one question to assess the principle. This was done to avoid ambiguity and vagueness since the constructs were not latent and easily measurable. Gilliam and Voss (2010), suggested the use of formalized language in measuring non-latent constructs to ensure clarity of responses.

The hypothesis test for the linear regression is given as:

Table 4.6: Hypothesis for Linear Regression

H_0: All independent variables are equal to zero cannot explain the dependent variable
H_A: At least one independent variables is not equal to zero.

To answer the first sub-question in this research, exploratory data analysis (EDA) was used. This data analysis technique emphasizes an objective approach to data analysis (Yu, 2017). The primary goal in the exploratory data analysis was to draw out the preferred information flow path from the perspectives of the healthcare professionals. Two techniques (boxplot and stem and leaf plot) were used to interpret the data. These techniques have been found to be useful in cases were the sample size is not large (McGill et al., 1978).

To answer the second sub-question in this research, hierarchical and multiple linear regression were utilised to gain insights into the drivers that influence the usage of the technologies and how the use of specific technologies at hospitals can impact on information integration and process integration respectively. The model adopted by this study to assess the drivers impacting on the usage is the TAM model suggested by Davis (1989). This model represents the second iteration of the model and it evaluates the perceived usefulness, perceived ease of use and a general attitude towards using a technology (rating) (Berkowsky et al., 2018). For this study, the model assessed factors that influenced the adoption of technologies in medication management process. The independent variables were inputted into the model to measure the constructs of usefulness and ease of use against the rating of the technology. The findings from this model suggested the level of technology adoption in the process and factors that contributed to this.
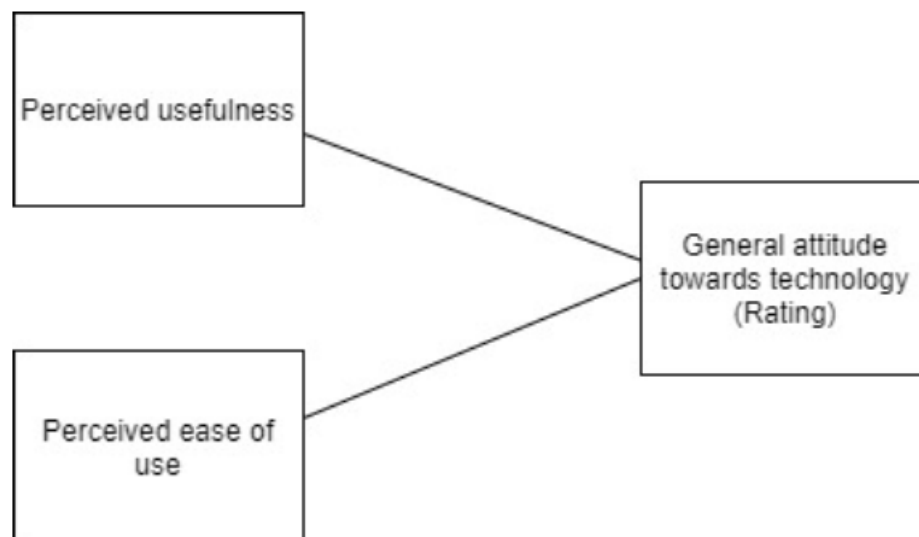
Figure 4.4: Technology Acceptance Model

Adapted from Davis (1989)

In the multiple regression, the independent variable are the ratings of CPOE, COW, EMRT, and Other Technologies against the information integration. The independent variables were selected for inclusion into the multiple regression model using an enter method and a 0.05 criterion of statistical significance. Missing values in the variables were replaced by respective variable means. The assumptions of multiple regression including linearity, homoscedasticity, independence and normality were considered and met for all models (Table 5.2, Appendix Table 4) (Berman & Wang, 2017).

4.6 Research Considerations

To ensure the reproducibility of this study, adjustments were made across different phases of this research. This section discusses these adjustments and considerations. Three key areas were identified; (1) Questionnaire design (2) Sampling and (3) Data analysis.

The questionnaire was aligned to guidelines provided by Wolf et al., (2016). Additionally, a pilot was also conducted with five nurses to assess possible challenges related to ease of completeness and question ambiguities. Feedback received related to question ambiguities and necessary modifications were made. Furthermore, to minimise bias, questions were neutrally worded, and anonymity was assured. Administering the survey through a web platform (Survey Monkey) was to minimise researchers influence on respondents.

The research adopted convenience sampling design. To ensure representativeness, several mails were sent out directly to healthcare professionals, through health managers and through professional bodies. Administering surveys through diverse channels improves representativeness of the sample (Jenn, 2006). To improve research reliability, statistical power tests (Appendix Table 5, 6, and 7) were conducted for the three major statistical tests in this study (Independent T-test, Pearson's Correlation, Hierarchical Linear Regression). From these tests, minimum sample size required for each test was determined.

In the same vein, prior to each of these data analysis assumptions for each test was checked and met before proceeding with the tests. For the Independent T-Test and Pearson's correlation test, the condition of normality was checked (Table 5.2) and linearity were met before analysis. Similarly, the conditions of normality (Table 5.2) and multicollinearity (Appendix Table 4) were checked and met for the hierarchical linear regression. For ANOVA, the assumptions of normality (Table 5.2), equivalence of variance (Appendix Table 4) and independence (Table 5.4.1 and 5.4.2) were checked and met. In addition, the margin of error (Appendix Figure 1)

was calculated from the survey platform (SurveyMonkey) and this was taken into consideration while discussing the results.

4.7 **Ethical Consideration**

Ethical issues that could impede the research were taken into consideration before data collection commenced. Five ethical issues were identified as risks in conducting this research. The ethical issues include: Participant informed consent, use of coercion or deception to recruit participants, confidentiality, anonymity and communicating of results to participants (Yip et al., 2016). These risks are classified as low risks according to The University of Notre Dame Australia's low-risk application procedure (v. 2017). In recognition of these issues, ethics approval was sought from the Human Research Ethics Committee at The University of Notre Dame, Australia. The study was assessed and approved as low risk to participants in 2017 (#015087S).

Chapter 5   Demography

Reports have suggested that participant demography and gender differences in responses can affect the overall response pattern in a study thereby limiting the ability to draw appropriate conclusions (Sifers, Puddy, Warren, & Roberts, 2002). To ensure this is properly addressed, this chapter will present participants' response to general and demographic questions in the survey. The responses have been analysed and displayed as frequency distribution tables. Other results presented in this chapter includes tests of normality, reliability analysis and a sample t-test to determine if there are differences in responses between male and female participants are also shown. Furthermore, the medication workflow configuration will be determined to be used as in other aspects of this research.

5.1   Participants' Demography

This research adopted a population-based survey to limit response bias (Morrison, Lee, Gruenewald, & Marzell, 2015). Biases may occur in cases where specific institutions are used, however, using the general health practitioner population would manage this limitation. The population-based survey also enhances the representativeness of the data, and may serve as a basis for further cohort studies.

The professional background of the participants indicated that a majority of them are doctors (n=48, 54.5%). Other professions represented were nurses (n = 24, 27.3%), pharmacists (n = 14, 15.9%), and nursing students (n = 2, 2.3%) (Table 5.1). A significant number of the participants were females making up 72.7% of the participants (n=64). Although, the practicing experience among the participants was represented in all three groups in the survey (0-3 years, 4-7 years, and 8 years or more), participants mostly had 8 years or more experience (n = 39, 44.3%). This was followed by 0 – 3 years (n=32, 36.4%), and then 4 – 7 years' experience (n = 17, 19.3%). Of the 88 participants in this study, all except one indicated that they were working in public hospitals (n=87, 98.9%).

Table 5.1: Participants' Demography

Item	Frequency	Percent
Profession		
o Doctor	48	54.5
o Nurse	24	27.3
o Pharmacist	14	15.9
o Nursing student	2	2.3
Gender		
o Female	64	72.7
o Male	24	27.3
Length of Practice		
o 0 - 3 Years	32	36.4
o 4 – 7 Years	17	19.3
o 8 years of more	39	44.3
Type of Health Facility		
o Private	1	1.1
o Public	87	98.9

5.2   Normality

A Shapiro-Wilk test of normality was conducted to determine if the five scale scores resulted in the data being normally distributed (Table 5.2). The results indicate that the five scale scores produced a normally distributed population since most level of significance $p > 0.05$, except CPOE which had $p < 0.05$. Visual inspection suggested normality, however, this will be taken into consideration in further tests.

Table 5.2: Test of normality

	Shapiro-Wilk		
	Statistic	df	Sig.
CPOE	0.892	34	0.003
COW	0.964	21	0.594
EMRT	0.890	9	0.198
Other Technologies	0.905	11	0.214
Information Flow	0.985	64	0.624

5.3   Reliability Analysis

To assess whether the survey questions are reliable and internally valid, Cronbach's alpha was measured. Table 5.3 highlights the reliability coefficients of all scales used in the survey. Since

all variables resulted in Cronbach's alpha values greater than 0.7 alpha value they are deemed fit (reliable) to be used in further analysis.

Table 5.3: Reliability analysis (Cronbach's alpha)

Scale	Number of Items (N)	Cronbach's Alpha
CPOE	6	.844
ADC	6	NA[1]
COW	6	.831
EMRT	6	.889
Others	6	.895
Information Flow	20	.809

[1] Cannot be computed as only one participant indicated that ADC is used at their hospital

5.4 Comparison between Male and Female Responses

The independent sample t-test was carried out to determine whether there was any statistically significant difference in the responses between males and females in this study. The results of the independent sample t-test are shown in Table 5.4.1 and Table 5.4.2. The results indicate that there were no significant differences between male and female responses to the technology or the information flow questions except for the questions assessing whether there are guidelines in medication history retrieval and the clarity of prescriptions throughout the process which were both statistically significant at $p < 0.05$.

Table 5.4.1: Comparison between male and female responses (Technology)

Gender		N	Mean	SD	Sig.
CPOE Score	Male	7	3.76	0.34	0.534
	Female	27	3.63	0.73	
COW Score	Male	6	3.50	0.39	0.315
	Female	15	3.23	0.78	
EMRT Score	Male	4	3.57	0.33	0.181
	Female	5	2.86	0.96	
Other Technologies Score	Male	4	3.50	0.54	0.186
	Female	7	2.74	1.21	

Table 5.4.2: Comparison between male and female responses (Information Flow)

	Gender	N	Mean	SD	Sig.
Face to face communication is used additionally to explain and clarify prescriptions	Male	19	3.89	0.809	0.456
	Female	51	3.73	0.850	
Telephone calls are used additionally to explain and clarify prescriptions	Male	19	3.74	1.098	0.320
	Female	51	3.47	0.946	
Information given about the patient medication history at assessment is enough to commence treatment	Male	19	3.32	1.057	0.097
	Female	51	2.86	0.980	
There are guidelines for medication history retrieval used at the point of first contact	Male	19	2.89	1.197	0.028
	Female	51	3.49	0.903	.
Clinical Decision Systems are used to aid diagnosis and prescriptions	Male	19	3.53	1.219	0.871
	Female	51	3.57	0.855	
Clinical Decision Systems are always up to date	Male	19	2.79	1.134	0.104
	Female	51	3.20	0.825	
Prescriptions are verified and dispensed by pharmacists before medication administration	Male	19	3.37	1.012	0.426
	Female	51	3.14	1.096	
Pharmacists have adequate information about patient's medication history	Male	19	3.32	0.582	0.861
	Female	51	3.35	0.844	
Pharmacists review medication charts regularly	Male	19	3.05	1.026	0.117
	Female	51	3.49	1.027	
Medications are checked and verified by professionals and patients respectively before administration	Male	19	3.68	0.885	0.774
	Female	51	3.61	1.021	
Nurses have adequate information about patient's medical history when administering	Male	19	2.63	1.116	0.099
	Female	51	3.12	1.070	
Prescriptions are clear and easy to comprehend	Male	19	3.53	1.172	0.048
	Female	51	3.92	0.483	
Changes to prescriptions are communicated to all parties	Male	19	3.32	1.204	0.480
	Female	51	3.12	0.973	

Test results are communicated to all parties	Male	19	3.00	1.202
	Female	51	3.10	0.964

0.725

Information about patient and medication is easily retrieved	Male	19	3.26	1.046
	Female	51	3.39	0.850

0.598

Inadequate information leads to medication errors	Male	19	3.26	0.991
	Female	51	3.33	0.816

0.764

Inadequate information sharing leads to medication errors	Male	19	3.84	1.167
	Female	51	4.18	0.713

0.151

Introduction of technology has improved information flow	Male	19	4.05	1.224
	Female	51	4.08	0.717

0.913

Introduction of technology has reduced medication errors	Male	19	3.21	.976
	Female	51	3.57	0.900

0.153

Information about patient and medication is properly organised	Male	19	3.16	1.068
	Female	51	3.41	0.804

0.288

Information about patients and their medication\s is received and retrieved in a timely manner	Male	19	2.58	0.769
	Female	51	2.96	0.894

0.104

5.5 **Discussion**

5.5.1 **Demographic effect of responses**

Doctors and nurses constituted 81.8% of the respondents (Table 5.1), of which doctors represented 54.5% of participants and nurses 27.3% in this study. Although this is dissimilar to the health workforce population and distribution where doctors constitute about 18.5% of the population of selected health professions (Australian Institute of Health and Welfare, 2018). This response rate is similar to past studies on healthcare service research (Cook, Dickinson, & Eccles, 2009). In a meta-analysis of 350 studies over a 10-year period, Cook et al. (2009) found that doctors were the most likely to participate in research surveys and made 55-60% of all studies, followed by nurses at approximately 20%. The study also revealed that responses to surveys were generally very low in the industry and is declining. Notably, countries like USA, UK, Canada, Australia and New Zealand were more likely to show lower response rates compared to other countries around the world (Cook et al., 2009). Therefore, the participation rate in this research with only 88 participants even though more than 1000 potential participants

were contacted to partake in the study is similar to industry trends. The country of focus - Australia, may also explain the low response.

Studies in survey research have also pointed out that the nature of survey topics are likely to affect response rates in online surveys. Fan and Yen (2010), suggested that topics which are considered sensitive or non-sensitive or which may be related to concerns, attitudes or facts may likely affect response rates. Their study further affirmed that the salience of a topic significantly influences both mail and web survey response rates. For this study, the topic was non-sensitive though may have been abstract to healthcare professionals because it did not have robust medical language which may have impacted the response rates. However, making it a population-based survey should eliminate possible limitations in this regard.

Trends in this study about the experience of participants aligns with past studies. Results from this research indicated that 63.6% of the participants had 4 or more years of practice while the remaining 36.4% had 0 – 3 years of work experience (Table 5.1). Previous studies have equally indicated that more experienced workers are more likely to participate in health research surveys (de Vries et al., 2013; Brasaite et al., 2016; Opnegorth et al., 2018). Our results also indicate that more females (73%) participated in the study than their male counterparts (27%) (Table 5.1). This result supports the gender distribution among health workers in Australia as reported by Australian Institute of Health and Welfare (2016), where 90% of nurses were females and the 54% of medical practitioners were also female. It has also been reported by Smith (2008), that women were more likely to participate in surveys than men. Thus, the higher participation rates by women in this research aligns with the trends Australian health workers' distribution and previous similar studies.

Studies by Taylor and Dahal (2017) and Alazmi et al. (2011), have suggested that gender differences in survey responses may have potential effect on the outcome of a research study. To determine if there were gender- different-responses in this study, an independent sample t-test was conducted ($p < 0.05$) across the technology related and information flow related questions (Tables 5.4.1 and 5.4.2). Prior to the test, the results of the Shapiro Wilk's test of normality (pg.104) was reviewed and satisfied required condition to proceed with the test. The majority of responses did not show any statistical difference across the two domains except for responses relating to information flow in the medication process which were related to guidelines for medication history retrieval used at the point of first contact and that prescriptions are clear and easy to comprehend throughout the medication process respectively. For these two areas, our null hypothesis which indicates that population means are equal will

not be rejected, because there is insufficient evidence to do so. Therefore, the findings indicate that gender differences may exist among health practitioners while seeking guidelines.

To explain possible reasons for this gender variability, we will examine some parameters in our result. The first of these questions expands on the question related to the construct on accessibility while the second question represents an aspect of granularity of information. The aspect relating to guidelines had a mean response of 2.89 among men while women had a mean response rate of 3.49 which indicates that men were less aware of guidelines that could guide information accessibility within the assessment phase (Appendix 1 – Table 2). Medication safety standards instituted by the Australian Commission on Safety and Quality in Health Care (2019) which is a part of the National Safety and Quality Health Services Standards (2019) which documents the expected requirements of care a consumer expects from a health service organisation in Australia. The best possible medication history (BPMH) is a part of the Medication Reconciliation Process which supports and feeds the medication management process. The standard emphasises the collection of BPMH as soon as possible for patients that will be admitted in hospital. It also recommends that the collected information should be available to all clinicians that will be involved in managing the patient. This standard seeks to capture all the medicines taken by the patient prior to admission. It also seeks to determine known allergies, previous adverse drug reactions, previously and currently used medicines and to assess patient's disposition to medicines. Verification of these medicines can be done using the patient's My Health Record or the patient's file in cases of manual records (Australian Commission on Safety and Quality in Health Care , 2017). The differences in level of awareness of men compared to women on these standards as indicated by these results may arise from the information seeking behaviour between the genders. According to Haldera et al. (2010), women tend to have a higher purposive information seeking behaviour than men in their study among students. Hsieh and Wu (2015, p. 204), also affirmed this and further explained that females were not just concerned about the overt information available but they were also interested in the "information diagnosticity", a phenomenon that indicates a more purposive and cautious searching pattern. Thus, the result to the question which was meant to assess their use of recommended standards may have portrayed the information seeking behaviour in both male and female and suggests that men may not be as aware of these standards as much as the females. This suggests a gap in an information flow paradigm based on gender differences. A study by Arcand and Nantel (2012), also propose that gender differences may be associated with differences in perceived clarity and information processing

in men and women. According to the article, a selectivity model was used in information processing, men and women were observed to adopt different strategies in processing information. In the model, it was suggested that when men process information they seek self-relevant information, thus, making judgements empirically, however, women explore information comprehensively paying attention to different dimensions of the information. Meyers-Levy & Sternthal (1991), have equally suggested that these differences emanate from the different psychological dispositions between men and women. Yong (2006), also observed that in situations where demands of tasks were moderate and subjects had adequate time to review, gender differences in managing the situations were apparent.

The identified gap from the independent sample T -Test to 2 of the questions highlighted above may not constitute a significant difference in responses for the overall study but this finding will be taken into consideration as other results are discussed in subsequent chapters.

Chapter 6 Information Flow and Information Integration

This chapter will elaborate on the results and discussion relating to the first research question in this study. As indicated in Chapter 1 of this thesis, the primary research question for this study seeks to evaluate how the principles of information flow (timeliness, accessibility, transparency and granularity) impact the integration of the process under study from the perspective of healthcare practitioners. It is expressed as "To what extent is the medication management process integration in Australian acute care facilities impacted by information flow principles?". The results presented to answer this question include the Pearson's chi-square test, the Cramer's V values, and the models representing the steps in the hierarchical regression. The objectives for these tests were twofold. Firstly, to determine the significance of associations (Pearson's chi-square test and Cramer's V values) and secondly, the extent of impact on integration (hierarchical regression). Subsequently, the findings were discussed in the light of the research question and hypothesis postulated relating to the question.

6.1 Research Question 1

To what extent is the medication management process integration in Australian acute care facilities aligned with information flow principles?

The steps to answer this research question will be depicted here -

6.1.1 Medication Management Process Workflow

The participants were asked to outline the steps in the order 1 to 6 used in medication management at their facility. They were required to match medication management tasks to the numbers. The mode (most frequently allocated number) to each task is presented in Table 6.2. Not all participants matched a task to a number and these are presented as missing values.

Table 6.1: Medication Management Process Workflow

	N		Mode
	Valid	Missing	
Assessment	81	7	1
Prescribing	81	7	2
Transmission	69	19	3
Dispensing	82	6	4
Medication Administration	82	6	5
Monitoring and Evaluation	81	7	6

Figure 6.1A: Most used medication management workflow configuration

Figure 6.1B: Second most used medication management workflow configuration

Figure 6.1C: Third most used medication management workflow configuration

Results from the responses of participants are presented to determine the workflow process models of the medication management process. Three most common workflows selected by participants indicate that majority of participants (81.2 %, n=56) alluded to the first workflow configuration (Figure 5.1A), while 11.6% and 7.2% of participants (n = 8, n = 5) suggested the other workflow configuration (Figures 5.1B and C) respectively. Nineteen participants did not completely match the tasks to the ordered steps.

To determine if there was association between information integration and 1) timeliness, 2) accessibility, 3) transparency and, 4) granularity, we used the Pearson's chi-squared test. As shown in Table 6.2, there was a statistically significant association between information integration and constructs measuring transparency, granularity and one of the constructs in accessibility ($p < 0.05$) but not timeliness and the first construct in accessibility ($p > 0.05$).

Table 6.2: Pearson's Chi – Square Tests for Information Flow Principles

	Asymptotic Significance (2-sided)
Timeliness	
Information about patients and their medication\s is received and retrieved in a timely manner	.695
Accessibility	
Information given about the patient medication history is enough to commence treatment	.151
Information about patient and medication is easily retrieved	.000
Transparency	
Pharmacists have adequate information about patient's medication history when verifying prescriptions	.000
Nurses have adequate information about patient's medical history when administering	.000
Granularity	
Prescriptions are clear and easy to comprehend throughout the medication process	.000

To determine the strength of the associations between information integration and 1) timeliness, 2) accessibility, 3) transparency and, 4) granularity, we used the Cramer's V values. As shown in Table 6.3, the results show a moderate strength of association (0.463, 0.363, 0.353 and 0.384) between information integration and constructs measuring transparency, granularity and one of the constructs in accessibility. These constructs had level of significance ($p < 0.05$). However, constructs with ($p > 0.05$) timeliness and the first construct in accessibility are not considered for strength of association because they are statistically insignificant.

Table 6.3: Cramer's V for Information Flow Principles

	Value	Approximate Significance
Timeliness		
Information about patients and their medication\s is received and retrieved in a timely manner	.192	.695
Accessibility		
Information given about the patient medication history is enough to commence treatment	.515	.151
Information about patient and medication is easily retrieved	.463	.000
Transparency		
Pharmacists have adequate information about patient's medication history when verifying prescriptions	.363	.000
Nurses have adequate information about patient's medical history when administering	.353	.000
Granularity		
Prescriptions are clear and easy to comprehend throughout the medication process	.384	.000

The hierarchical multiple regression was carried out in four stages. The dependent variable (DV) was information integration and the independent variables were constructs assessing 1)

timeliness, 2) accessibility, 3) transparency and, 4) granularity. The test was carried out at a level of significance – 0.05. The order for entering the variables is given as:

- o Model 1: DV (Information Integration) – IV (Timeliness)
- o Model 2: DV (Information Integration) – IV (Timeliness, Accessibility)
- o Model 3: DV (Information Integration) – IV (Timeliness, Accessibility, Transparency)
- o Model 4: DV (Information Integration) – IV (Timeliness, Accessibility, Transparency, and Granularity)

Table 6.4, shows the ANOVA which tested each model to determine if the addition of the independent variables explained a variation in the dependent variable. The models 2, 3, and 4 had significance ($p < 0.05$) indicating that these models are statistically significant while model 1 ($p > 0.05$) is not.

Table 6.4: ANOVA of information flow principles against information integration

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.194	1	.194	.219	.641[b]
	Residual	70.127	79	.888		
	Total	70.321	80			
2	Regression	11.636	3	3.879	5.089	.003[c]
	Residual	58.685	77	.762		
	Total	70.321	80			
3	Regression	16.003	5	3.201	4.419	.001[d]
	Residual	54.318	75	.724		
	Total	70.321	80			
4	Regression	16.963	6	2.827	3.921	.002[e]
	Residual	53.358	74	.721		
	Total	70.321	80			

Table 6.5 shows the regression table highlighting the standard coefficients and p- values. The standard coefficients indicate the extent to which the independent variable can predict the dependent variable. The p-values highlight a statistical significance if $p < 0.05$. There are 4 models in our table. In Model 1, the independent variable was not statistically significant ($p > 0.05$). In Model 2, the two constructs measuring accessibility were significant ($p < 0.05$), while the timeliness construct was not. In Model 3, the 2 constructs measuring accessibility were significant ($p < 0.05$), while the timeliness and transparency were not. In Model 4, one construct measuring accessibility was significant ($p < 0.05$), while the timeliness, transparency, granularity and one of the accessibility constructs were not.

Table 6.5: Coefficients of information flow principles against information integration

Model		Unstandardized Coefficients B	Sig.
1	(Constant)	3.188	.000
	Information is timely	.056	.641
2	(Constant)	2.878	.000
	Information is timely	-.017	.883
	Information is enough to commence treatment	-.287	.013
	Information is easily retrieved	.412	.000
3	(Constant)	2.303	.000
	Information is timely	-.020	.864
	Information is enough to commence treatment	-.291	.010
	Information is easily retrieved	.267	.036
	Adequate information pharmacist	.198	.124
	Adequate information nurses	.145	.165
4	(Constant)	1.981	.005
	Information is timely	-.006	.960
	Information is enough to commence treatment	-.281	.013
	Information is easily retrieved	.192	.177
	Adequate information pharmacist	.186	.148
	Adequate information nurses	.124	.241
	Prescriptions are and easy to comprehend	.160	.252
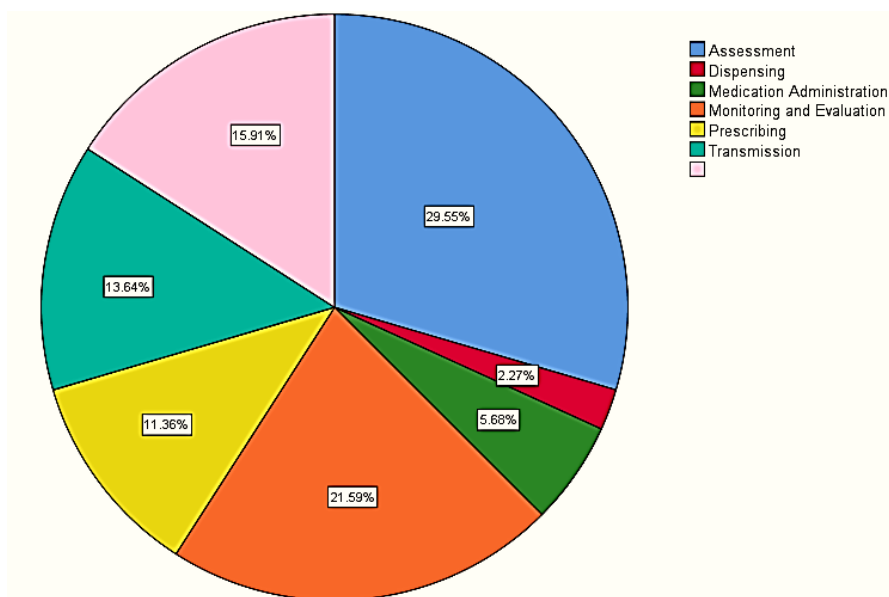
Figure 6.2: Participants' Response on Phases with Poor information sharing

Results for this question was analysed and expressed as percentages of total participants. Each slice in different colours represent the percentage of participants that indicated a phase as having poor information sharing. The top three phases which had poor information sharing were Assessment (29.55%), Monitoring and Evaluation (21.59%), and Transmission (13.64%). The pink coloured slice (15.91%) represents prescription phase.
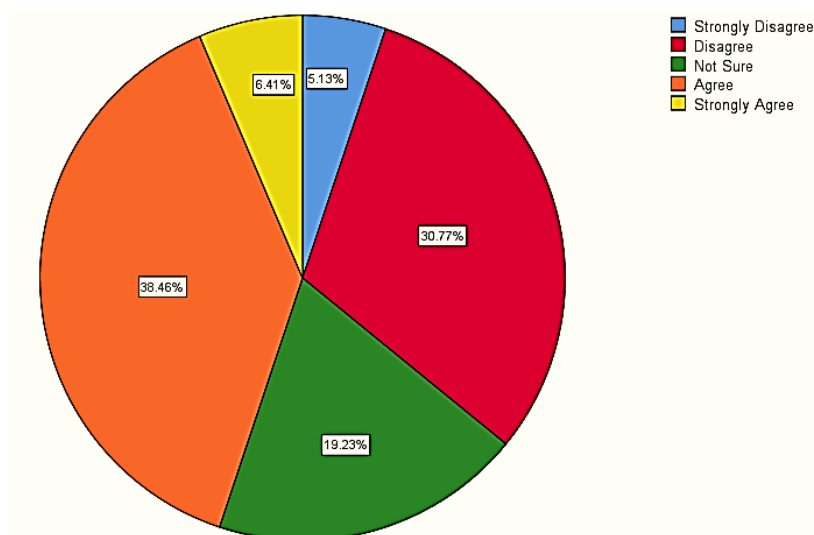
Figure 6.3: Participant Response on communicating changes to prescriptions to all parties involved in medication management

Results for this question was analysed and expressed as percentages of total responses. Each slice in different colours represent the percentage responses of participants to the question. 44.87% were in the affirmative (38.46% agreed and 6.41% strongly agreed). 19.23% of participants were not sure while 30.77% and 5.13% disagreed and strongly disagreed respectively.
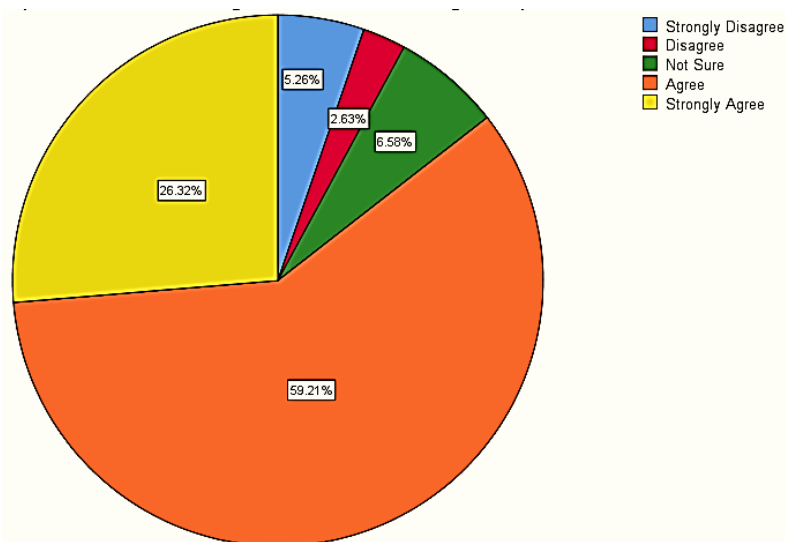
Figure 6.4: Participant responses on inadequate information sharing leading to medication errors
This result represents the distribution in percentages of responses to the question. Each slice in different colours represent these percentages. To determine if inadequate information sharing led to medication errors, 85.53% were in the affirmative (59.21% agreed and 26.32% strongly agreed). 6.58% of participants were not sure while 2.63% and 5.26% disagreed and strongly disagreed respectively.

6.1.2 Rating of the Medication Management Process
Participants were asked to rate the medication management process at their facility on a scale of 1 – 5 with 1 as the lowest and 5 as the highest. Mean rating was given as 3.39 with a standard deviation of 0.839. Median and mode was given as 3 and 75% of participants gave a rating of 3 and above.

Table 6.6: Participant responses on rating of the medication process.

N	Valid - 83
	Missing - 5
Mean	3.39
Median	3.00
Mode	3
Std. Deviation	.839
Variance	.703
Range	4
Minimum	1
Maximum	5
Sum	281
Percentiles	3.00
25	3.00
50	4.00
75	

6.2 **Discussion on Research Question 1**

From our results, three types of medication management process models were given (Figure 6.1A, 6.2A, and 6.3A). 84.2% of the participants highlighted that the phases in the medication management process are: Assessment, prescribing, transmission, dispensing, administration, and monitoring and evaluation. The remaining 15.8% of participants suggested the other to process model configuration (Figures 6.2B and 6.2C). Determining the workflow of a process is fundamental in understanding how the information flows in the process. Unertl et al. (2009), outlines an interconnection between a process workflow and information flow. The study also highlights that different hospitals have different workflows, thus, identifying the most commonly used workflow is important to this research and would help to determine gaps in information flow principles.

From these workflow models, it is apparent that the primary difference is the positioning of transmission within the process. Transmission has been reported as an under studied area in studies related to medication management (Agency for Healthcare Research and Quality, 2011). For example, a workflow model proposed by Kitson et al. (2013), did not include the transmission phase at all. The phase is alternatively referred to as order communication (Hughes & Blegen, 2008). The most reported model identified in this study (Figure 6.1) is similar to the models by Bell (2004), Friedman et al. (2009), and Agency for Healthcare Research and Quality (2011). However, these medication management models did not include the assessment phase in their workflows. This may have occurred because previously developed models focussed mostly on outpatient settings with limited studies into acute care workflows. The assessment phase is a fundamental part of the process in acute care and is particularly referenced in the medication reconciliation process. In a study by Holbrook et al. (2016), where observation was used in evaluating 3 academic acute teaching hospitals in Canada to develop a process map for the medication management process, the phase was described as medication information gathering phase before admission. According to Holbrook et al. (2016), the process is usually carried out from the triage in the emergency department to determine the Best Possible Medication History (BPMH) and the time used ranges between 1– 5 min each on each occasion. Variable methods and sources were used (e.g., patient, other source such as the Electronic Health Record (EHR)) to get the BPMH (Holbrook, et al., 2016). Kitson et al. (2013), further described the assessment phase as the phase to determine the need for medication in the Medication Communication Framework. According to the framework, it

is the phase where the nurses or doctors listen to the complaints of the patient and determine the next line of action to undertake.

The Pearson's chi-square test assessed the existence of associations between information integration and 1) timeliness, 2) accessibility, 3) transparency and, 4) granularity (Table 6.2). The results indicate that two of the constructs (timely retrieval of patient and medication information and adequacy of information to commence treatment) were not statistically significant with p-values > 0.05 (p = 0.695 and 0.151 respectively), therefore these constructs had no associations with information integration. One of the constructs assessed timeliness and the other assessed accessibility. Therefore, the null hypothesis (H_0) or theses constructs will be accepted and alternative hypothesis rejected. The other constructs (information about patient and medication is easily retrieved, pharmacists have adequate information about patient's medication history when verifying prescriptions, nurses have adequate information about patient's medical history when administering and prescriptions are clear and easy to comprehend throughout the medication process) were statistically significant with $p < 0.05$ (p = 0.000, 0.000, 0.000 and 0.000 respectively) indicating that associations exist with information integration. These constructs represent transparency, granularity and one of accessibility. Thus, the null hypothesis (H_0) relating to these constructs are rejected and the alternative hypothesis (H_A) accepted. In the subsequent test (hierarchical regression), a further test to validate the existence of any relationship was conducted. Results from the Cramer's V sought to determine the degree of association between the variables. The 2 constructs that were statistically not significant in the Pearson's chi-square tests had statistically insignificant Cramer's V values. The other constructs had values of 0.463, 0.363, 0.353 and 0.384 respectively. These values are statistically comparable and indicate a moderate degree of association with information integration. However, the construct assessing information retrieval had a slightly higher association value (0.463) compared to other constructs, thereby suggesting a slightly stronger association with information integration. The construct seeks to assess accessibility of information in the process. From our results, we assert that there is a moderate positive relationship between the ease in retrieving patient and medication information and organisation of information in the medication management process. The other constructs relating to pharmacists having adequate information about patient's medication history when verifying prescriptions, nurses having adequate information about patient's medical history when administering, and prescriptions are clear and easy to comprehend throughout the medication process have a comparable strength of association. The subsequent

hierarchical regression analysis highlighted the extent of impact of the principles on the process.

The correlation coefficients of each independent variable used in the analysis were tested for strong associations with each other, and showed no multicollinearity among the independent variables representing each construct or principle. Data from the ANOVA (Table 6.5), using a showed that, three of the models (2,3, and 4) were statistically significant $p < 0.05$ ($p = 0.003$, 0.001 and 0.002 respectively). However, Model 1, was not statistically significant $p > 0.05$ ($p = 0.641$), and was therefore not considered. The F-Statistic change from the Model 1 to Model 2 was statistically significant $p < 0.05$ ($p = 0.001$) and The R-Square change from the Model 1 to Model 2 (0.163) while R-square change in Models 2 to 3, and 3 to 4 was given as 0.062 and 0.14 respectively. Thus, we can deduce that addition of other independent variables did not significantly impact the explained variation in the model. Therefore, we state that Model 2 better explains the impact of the constructs on the dependent variable. Two constructs were used in model 2 (timeliness and accessibility). The construct on timeliness was not statistically significant $p > 0.05$ ($p = 0.883$) while accessibility constructs were significant $p < 0.05$ ($p = 0.013$ and 0.000 respectively). Thus, the independent variables in Model 2 measuring accessibility better explain changes to information integration. We can therefore express our updated mathematically as:

Information integration = 2.878 + -0.287 (Information to commence treatment) + 0.412 (Information is easily retrieved) + S.E

Results from the standard coefficients in Model 2 (Table 6.5) and our formula indicate that when information about patient medication history is not accessed at the point of assessment, it can explain a 28.7% (+/- 10) decrease in the organisation of information about patient and medication in the medication management process holding other factors constant and from the second construct, it can be interpreted as the ease in retrieving information about patient and medication across the whole process can explain a 41.2% (+/-10) increase in the organisation of information about patient and medication in the medication management process holding other factors constant.

The challenge of accessibility has been highlighted in reports and articles over the last decade. In our review of literature in Chapter 2, Ash et al., (2004) highlighted the challenge of retrieving information thus, affecting the coordination of information flow in patient-care information systems. In another large public hospital in Victoria, Australia, Lederman and Parkes (2005)

reported that one of the major reasons the deployment of an electronic management system failed was information inaccessibility. To overcome the need to manually retrieve patients' information, Iglesias et al. (2009), developed an algorithm to extract dosage and frequency of prescribed medicines from 923 patient reports. Some of the reasons that presented challenges in extracting information were related to inaccessibility issues for the algorithm. Issues like error of misspelling drug names and other typological which made it difficult for the algorithm to identify specific drugs. Keenan et al (2013), also identified accessibility as a challenge among nurses. Efforts to retrieve information accounted for up to 37% (+/- 10) of the nurses' time. A local health district strategic ICT report in New South Wales (NSW) equally emphasised access as an enabling theme that will ensure that ICT can improve health outcome delivery across the health network. The report affirmed that most of the health staff who were interviewed required access to technologies that will enable them access electronic medical records. Though the staff affirmed that there is a rich repository of clinical information available on the intranet, the limitation of access makes it difficult to utilise such information. Staff have had to use their personal devices on some occasions to transmit clinically related information (South Western Sydney Local Health District, 2015). Physicians have also emphasized that there was a need for more accessible information to be made available in situations where clinicians' time is limited, such as in emergency surgery (Thornhill, Potter, Nakarada-Kordic, & Reay, 2017). Berente et al. (2009), affirmed that accessibility of information is a significant factor for coordination of activities within a given process. According to Berente et al. (2009), although inputting data is significant for documentation, however, finding and obtaining information is vital for continuity within a process. Furthermore, Bergkvist et al. (2009) while studying discharge summaries, referred to accessibility as how readily information can be used to carry out activities and pointed out that it is a function of the source, content usability and interactivity of the channel.

To conceptualise information sources in an acute care facility, Marshall, West and Aitken (2011), observed that among nurses, information was frequently gathered from other people rather than information systems, as they were considered more useful and readily accessible when seeking for information in a clinical setting. Formal documentation sources were considered less accessible, primarily because trying to access this source was deemed time consuming. Participants in the study believed that when faced with uncertainties in a clinical situation, obtaining information verbally from colleagues was quicker for responding to clinical presentations. However, the challenge observed with accessing information in this way was

that the information retrieved is not documented or updated thus, propagating the issue of having an unreliable information system and increasing the likelihood of clinical and medication errors. Past studies have reported that information accessibility is directly related to information sharing. For example, it is reported that intelligent information sharing improves access to relevant information necessary to complete tasks (Hwang, Mollen, Kellom, Dougherty, & Noonan, 2017). Furthermore, information sharing was identified as a consequence of accessibility. It enables information to be viewed as a resource that is in a central repository and enables access to information from a single input (Aubert, Vandenbosch, & Mignerat, 2003). According to Wong et al. (2015), information sharing is a fundamental precursor to integration it was identified as a critical part of integration in an architecture describing processes and in system development (Hägglund, 2009). Information sharing and process integration are closely intertwined with high degrees of complexities. Whenever processes are to be integrated the sharing of information will be a part of it in some way or the other. Thus, we can say that integration and information sharing are inextricably interrelated (Scholl & Klischewski, 2007; Scholl, Kubicek, Cimander, & Klischewsk, 2012). From these findings, and results from our study, we hypothesize that improving information sharing has a direct relationship on improving information accessibility and this will explain an improvement in process integration.

In our study, 85.52% of participants (Figure 6.4) affirmed that inadequate information sharing leads to medication errors occurring within the process. This result supports findings by Hermon and Williams (2013), which suggested that sharing information among healthcare providers improves acquiring information regarding patients. Hägglund (2009), in a study of patients care in homecare also affirmed that in clinical settings information needs to be viewed as shared objects. According to Hägglund (2009), information that needs to be shared includes patient care plan, prescription or medication records. More recently, studies by Kariotis and Harris (2019), also supports this finding. In their study, general medical practitioners and psychologists affirmed that information sharing was a challenge in medication management. The study also revealed that there was little to no communication received in cases where changes were made to medication regimen. This further affirms the findings in this research where 35.9% of participants disagreed and another 19.2% were not sure that changes to prescriptions were communicated to all parties within the medication management process (Figure 6.4). Similarly, a report by Roughead et al. (2017), identified major discrepancies between documented and actual medications patients were taking. Indeed, studies have

consistently reported that clinicians would like to alert other clinicians about changes and updates to patients' medications plans but such a system is not currently available (Kariotis & Harris, 2019). The introduction of the My Health Record may soon address some of these gaps.

This study sought to sought to understand which phase/s in the medication management process had poor information sharing (Figure 6.2). The results revealed 29.55% of the respondents highlighted the assessment phase and 21.58% the monitoring and evaluation phase. The other phases: Prescribing 15.91%, transmission 13,64%, dispensing 2.27%, medication administration 5.68%. This result points out that healthcare practitioners perceived there are information sharing gaps across the medication management process. The results used the phases (assessment, prescribing, transmission, dispensing, medication administration and monitoring and evaluation phase) deduced as the workflow model from this research to further understand where the gaps are prominent. The highest percentage of gaps in information sharing (assessment 35%, and monitoring and evaluation 26%) are positioned at the beginning and end of the model. Bell et al. (2004), points out that information may flow back into the process when changes are made to medication regimen during the monitoring and evaluation phase. Therefore, we suggest that in cases where changes are made, accessing the current treatment or medication plan may not be occurring as required and this impacts on the organisation of information about the medication and patient.

Taken together our data suggests that the challenge in accessibility in the medication management process in participants' acute care facilities may be due to inadequate or poor information sharing. This perceived poor information sharing may arise from a failure to communicate changes to prescriptions to all parties involved in medication management process. The poor information sharing is reported to occur predominantly in the assessment and monitoring and evaluation phases. This aligns with the statistical significance of the accessibility construct where inability to access information about patient medication history at the point of assessment can explain a decrease in the information integration by 28.7%. It should be emphasised that though other principles are valid for the information flow within the process, however, they may not adequately explain the information integration within the process. Future work can be carried out with a larger sample to validate these findings and possibly understand why this problem occurs through interviews.

Chapter 7 Information Channel and Information Flow

This chapter highlights results and discussion that relate to the first sub-question in this research. As indicated in Chapter 1, the first sub-question is given as "Which information flow pathway/channel enhances or weakens the medication management process integration in Australian acute care facilities?" The chapter is organised in two parts. The first part presents results from the exploratory analysis which sought to determine the information channel that contributes to the information flow and how the information flow pathway or channel positively or negatively contributes to the medication process integration. The results to address this question is presented as frequency distribution tables, boxplot and stem and leaf plot. The second part presents the discussion of results and drawing inferences.

7.1 Research Sub-question 1

Which information flow pathway/channel enhances or weakens the medication management process integration in Australian acute care facilities?

The steps to answer this question is presented below:

7.2 Information Flow Channels

To determine which information flow channels were used in participants' facility, a frequency distribution was used to present responses from participants. Three types of information flow channels were assessed – 1) electronic, 2) hybrid (electronic and paper), and 3) paper. From the responses presented in Table 7.1, 90.9% (n = 80) of participants responded to the question while 9.1% (n=8) provided no responses. The responses further indicated that 35.2% (n = 31) used electronic, 28.4% use paper (n = 25), while 27.3% (n = 24) use hybrid.

Table 7.1: Information channels used in medication order transmission in participants' facilities

	Frequency	Percent
No Response	8	9.1
Electronic	31	35.2
Hybrid (Paper and Electronic)	24	27.3
Paper	25	28.4
Total	88	100.0

Based on responses in Table 7.1 from participants who used hybrid channel (n = 24) in their facilities, this table (Table 7.2) presents findings on which of the medication management phases used - 1) electronic, 2) hybrid, or 3) paper. The results presented in Table 7.2 indicate that across the medication management phases, electronic (mean = 53% (+/- 10)) was used more, while hybrid (mean = 32.5% (+/- 10)) was the secondly most used and paper (mean = 12.5%(+/- 10)) was the least used. The responses also reveal that the prescribing phase was the only phase that did not have only paper used.

Table 7.2: Information channels used in medication management phases among participants using hybrid channel.

	Medication Management Phases					
	Assessment	**Prescribing**	**Transmission**	**Dispensing**	**Administration**	**Monitoring and Evaluation**
Electronic	41.7	54.2	54.2	50	54.2	66.7
Hybrid (Paper and Electronic)	20.8	45.8	29.2	41.7	29.2	29.2
Paper	37.5	-	12.5	8.3	12.5	4.2
No Response	-	-	4.2	-	4.2	-
Total	100	100	100	100	100	100
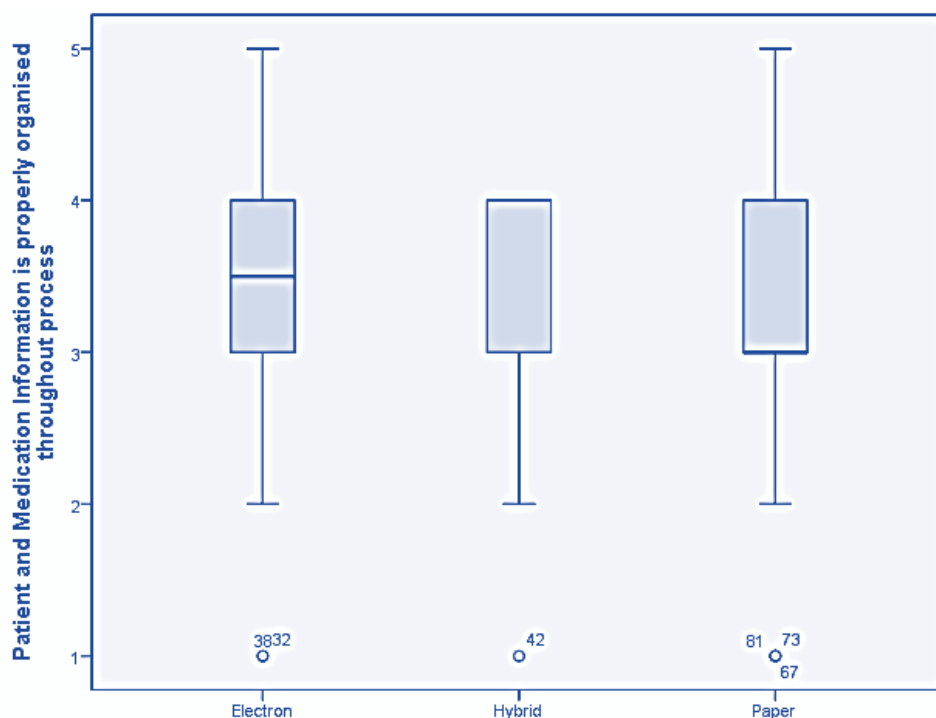
Figure 7.1: Comparing medication management information integration and information flow channel/path

Results presented in this figure represents the responses of participants to the relationship between each information flow channel (electronic, hybrid and paper) and information integration. The responses were ranked from 1 – 5, representing our Likert scale responses (strongly disagree, disagree, not sure, agree and strongly agree). Comparison of the three channels indicate they have similar spread (Q1 to Q3) between 3 and 4. The highest observation for electronic and paper is similar (= 5), while hybrid (= 4) was different. The lower observations across the three channels are similar (= 3) and they all had outliers (=< 1) with electronic having 2, hybrid having 1 and paper having 3. The top whiskers for electronic and paper are similar, indicating similar trends, however differences abound at the median response with electronic slightly above (3.5) the paper (3), indicating the electronic tends towards more information integration than paper.

7.3   Information flow channel and information integration

Table 7.8A, 7.8B and 7.8C presents the details of the relationship between each information flow channel (electronic, hybrid and paper) and information integration. The tables expand on the results presented in Figure 7.1. Table7.8A presents the results for electronic channel and indicates that stem 3 and 4 had similar responses (where n represents the total count of responses relating to each stem) (n = 14) while stem 5 was (n = 3), stem 2 (n = 2) and the low extremes was (n = 2). In the same vein, Table 7.8B presents results for the hybrid with stem 4

having the highest responses (n = 15), followed by stem 3 (n = 5), and then stem 2 and the lowest extreme (n = 2, n = 1) respectively. Table 7.8C presents results from the paper channel and shows that stem 3 had the highest (n = 12), and then stem 4 (n = 8). Stem 5 and stem 1had similar responses (n = 1) while the lowest extreme was (n = 3).

Table 7.8A: Stem-and-Leaf plot ccomparing medication management information integration and electronic channel/path

Stem	Leaf
Extremes	(=<1.0)
2	0
3	00000000000000
4	00000000000000
5	000

Stem width: 1

Each leaf: 1 case(s)

Table 7.8B: Stem-and-Leaf plot comparing medication management information integration and hybrid channel/path

Stem	Leaf
Extremes	(=<1.0)
2	00
3	00000
4	00000000000000

Stem width: 1

Each leaf: 1 case(s)

Table 7.8C: Stem-and-Leaf Plot comparing medication management information integration and paper channel/path

Stem	Leaf
Extremes	(=<1.0)
2	0
3	000000000000
4	00000000
5	0

Stem width: 1

Each leaf: 1 case(s)

7.4 Discussion on Research Sub-Question 1

Information channels plays an important role in the dissemination of information. This chapter sought to determine the information channel/s that positively or negatively impact on the medication management information process integration. The results have highlighted channels used in the participants' facilities, the results from Table 7.1 indicated that electronic (n = 31, 35.2% (+/- 10)), paper (n = 25, 28.4% (+/- 10)) and hybrid (paper and electronic both) (n = 24, 27.3% (+/- 10)) are used across the facilities participants work. We also understand that among the facilities that use the hybrid channel (n = 24), electronic medium is more prominently used (mean = 53% (+/- 10)) across all phases within the medication management process.

Though our data shows that electronic information channels are the most common when compared with paper-only and a hybrid of paper and electronic, however, paper-only and hybrid modes of communications makes up almost 65% (Table 7.1). Importantly, this data highlights that paper-based activities are still prevalent within the medication management process. This affirms Leslie (2010), where findings from his study indicated that there are still a number of hospital processes that still utilize paper. According to Leslie (2010), utilizing paper in processes like the medication management presents a susceptibility to error. His findings also supported previous studies which highlighted problems of poor legibility, lack of standardisation of drug dosing and frequency in paper-based medication processes which were

highlighted in our review of literature (Velo & Minuz, 2009; Grossman, Cross, Boukus, & Cohen, 2012).

Drawing from other industries, we know that the extent of collaboration and information integration is related to the information channel used in information flow for organisations (Sillanpää & Sillanpää, 2013). From our results (Figure 7.1) indicate that 50% (+/- 10)of respondents among the participants in the paper arm were either not sure or disagreed that the paper-based channel was ensuring that the medication process was properly integrated. Compared to any of the arms, they had 3 outliers that strongly disagreed that the channel was supporting the integration of information in the process. These results can be compared with a study by Middleton et al. (2009), where they compared using electronic channels and paper-based channels to assess the implication of these two channels on the process workflow in radiotherapy for cancer patients. Findings from that study indicated that there was a 50% reduction in workload in the paperless history check and 70% reduction in identifying image trend analysis using the paperless channel. In another study by Aziz et al. (2015), where they compared the use of computerised physician order entry (CPOE) against paper-based ordering of medications in chemotherapy, there was a significant reduction in medication errors (0.26% - CPOE, and 2.4% - paper) and a significant improvement in the process in terms of timeliness and cost. Thus, using paper-based activities throughout the process may not ensure adequate information flow and this may not positively impact the process integration in medication management.

From our analysis of the hybrid channel (Table 7.8B), 65% (+/- 10) of the respondents indicated that the medication and patient information was more integrated in the process. This result differs to other Australian studies that have investigated the use of the hybrid medication management systems. In a 2015 study by Elliot, Lee and Hussainy, assessing hybrid medication systems used in a residential aged care facility in Victoria, where assessment and prescribing phase were paper-based and transmission was electronic. Additionally, dispensing activity was carried out off-site and utilized manual procedures, while monitoring and evaluation used both electronic and paper with the paper serving as back-up. Results from the assessments identified a number of risks associated with the hybrid mode. The hybrid medium had a high prevalence of discrepancies predisposing the process to medication administration errors affecting up to 24% of residents within the facility. The most common discrepancies were related to omission of a medication or addition of an extra medication. The results from this study was also similar to a study conducted by the Australian Commission on Safety and Quality in Healthcare. Their

findings from the use of hybrid medication management systems across residential aged care facilities revealed that there were significant discrepancies in the process ranging from different versions of medication charts, loss of information between the paper and the electronic, inability to access updated information after normal work hours and lack of consolidation of patient and medication history. The results from these studies differ from the perception of the healthcare workers who participated in this research. Perhaps, the difference in research approach may account for these differences, because the other two studies retrospectively looked through the medication charts, prescriptions and administration whereas our study looked at the process from the lens of the actors in the process; the healthcare workers. However, a report in Norway that with assessed the medical system as the country embarked on adoption of electronic health systems nationally argues that "electronic flow in health care services both rests upon and interferes with other forms of information and information flow; that it requires a lot of work and also creates new work" (Moser, 2004, p. 5). The author argues that, introduction of technology in healthcare may not adequately enhance the flow of information because information practices across the different department involved in healthcare processes are heterogeneous. The author further argues against the use of only paper-based systems because the papers observed from the project consisted of so many different formats and qualities. Thus, the report suggested that the combination of electronic and paper may be more appropriate within the hospital given the complexities around the information required for each process. In another study by Akhu-Zaheya et al. (2017), which was carried out in Jordan to compare nurses' documentation when it is paper-based or electronic. The study used three indicators (content, process and structure) to measure the quality of each channel. Patient records from two hospitals (acute care) were used for the study and findings revealed that the structure and process of electronic health records were better than paper-based health records, however, content and quantity were better for paper-based health records. From our study, in cases were electronic channel was used, the boxplot figure and stem and leaf results reveal that 50% (+/- 10) of participants were either not sure or disagreed that the patient and medication information were properly organised or integrated across the process. In cases where paper was used, 65% (+/- 10) of participants were either not sure or disagreed that the patient and medication information were properly organised or integrated across the process.

Drawing from the report of Moser (2004) and Akhu-Zekya et al. (2017), as well as the results from this study, this research reasons that an adoption of a homogeneous channel for

information flow may leave out vital information in healthcare, considering the structure and current practices that operate within the system. It can also be argued that most research that has evaluated or assessed these two channels are usually retrospective and documents like prescriptions or health records as samples were analysed and/or audited to report findings however, retrospective studies have limitations of inadequate measurement of key parameters and possible introduction of bias (Sedgwick, 2014). However, our study and Moser (2004), has evaluated the use of these channels from a people's (and user's) perspective which is critical to the use of any system. Thus, the perspective of healthcare professionals which posits that hybrid channel/path hybrid channel has a more significant impact on the medication management information integration than the other channels (electronic and paper) aligns with the report by Moser (2004).

Chapter 8   Technology and Information Flow

In this chapter, the results and discussion of the second research sub-question are presented. The second research sub-question sought to evaluate the extent health information technologies enhanced or weakened the information flow in the medication management process in Australian acute care facilities. The chapter has been organised in two parts. The first part presents results using frequency distribution tables and charts. Subsequently, regression tables are presented. The results highlight the impact on technologies used in the medication management process against the process information integration. The level of adoption of these technologies have also been assessed to understand the factors that facilitate the use or drawbacks of the technologies. These two paradigms have been evaluated from the perspective of the users who are healthcare professionals that have participated in this study. The second part discusses the results and inferences are drawn to answer this research's second sub-question.

8.1   Research sub-question 2

To what extent have health information technologies enhanced or weakened the information flow in the medication management process in Australian acute care facilities?

To address this second research sub-question, we present the following results:

8.2   Technology Use

To put a context on the adoption and extent of impact technologies have on the information integration, the participants were required to assess their abilities on their use of technology (Table 8.1). From our results, most of the participants described themselves as good to advanced users of technology (n=84, 95.5), however, we also had occasional users (n = 3, 3.4%) and a non-user (n = 1, 1.1%). Among all participants, the good users were more (n = 47, 53.4%), and the second highest were the average users (n = 21, 23.9%) while advanced users (n = 16, 18.2%) followed.

Table 8.1: Participants' perception on their ability to use technology.

	Frequency	Percentage
Non User	1	1.1
Occasional User	3	3.4
Average User	21	23.9
Good User	47	53.4
Advanced User	16	18.2
Total	88	100.0

To determine if technologies were used in participants' facilities (Table 8.2), participants were required to answer yes or no. Majority of the responses indicated that technology is used in their facility (n=73, 83% (+/- 10)), the other participants (n = 15, 17% (+/- 10)) indicated that no technology was in use in their hospitals.

Table 8.2: Technologies used in Participants' Facilities

	Frequency	Percent
No	15	17.0
Yes	73	83.0
Total	88	100.0
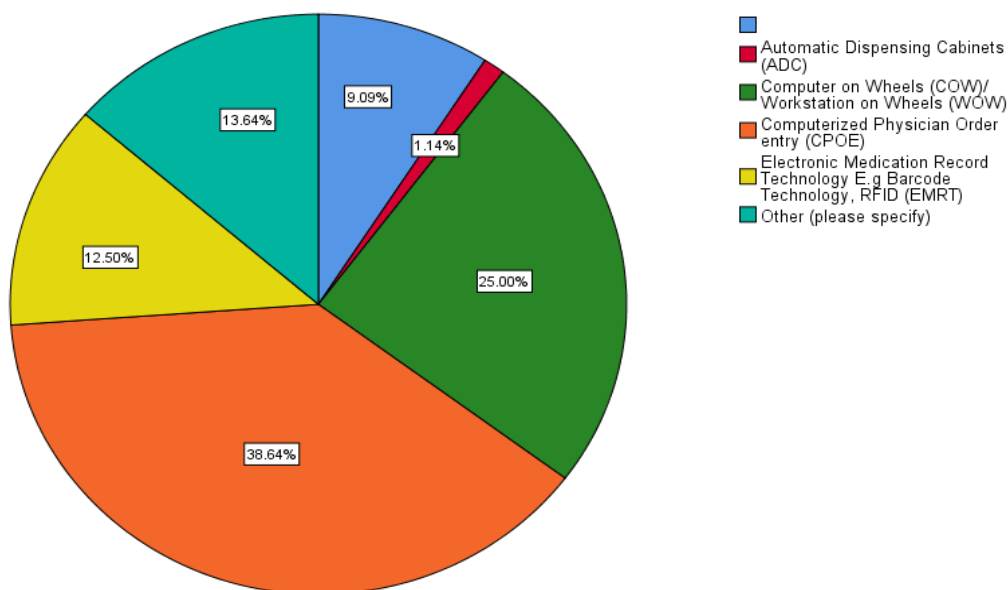
Figure 8.1: Technologies used in participants' facilities

Fig 8.1 presents results that highlights the types of technologies used in the participants' facilities. The top three responses were Computerized Physician Order entry (CPOE) (38.64%), Computer on Wheels (COW)/ Workstation on Wheels (WOW) (25%), and Electronic Medication Record Technology e.g. Barcode Technology, RFID (EMRT) (12.5%). Automatic Dispensing Cabinets (ADC) (1.14%) were also mentioned and Other Technologies (13.64%). Examples of other technologies mentioned is MedChart. The blue slice (9.09) refers to participants who provided no responses.

Table 8.3: Duration of technology use

Participants were required to indicate how long their facilities had been using the technologies (Table 8.3). The table refers to the technologies identified in Figure 8.1 and highlights the length of use in participants' facilities. The table presents the frequency counts in each category (number of years). Responses indicate that most technologies were introduced between 0 – 3 years (CPOE, (n = 34), ADC, (n = 1), COW, (n = 15), Others, (n = 11)). This represents 82% of total responses. Some other participants indicated that they had used computer on wheels (COW) for 4-7 years (n = 3) and for 7 years and more (n=4). Similarly, one participant had used other technologies (Medchart) for 7 years and more.

Technologies in Use	Missing	0-3 years	4-7 years	More than 7 years	Total
No response	8	0	0	0	8
Automatic Dispensing Cabinets (ADC)	0	1	0	0	1
Computer on Wheels (COW)/ Workstation on Wheels (WOW)	0	15	3	4	22
Computerized Physician Order entry (CPOE)	0	34	0	0	34
Electronic Medication Record Technology e.g. Barcode Technology, RFID (EMRT)	0	11	0	0	11
Other (please specify)	0	11	0	1	12
Total	8	72	3	5	88
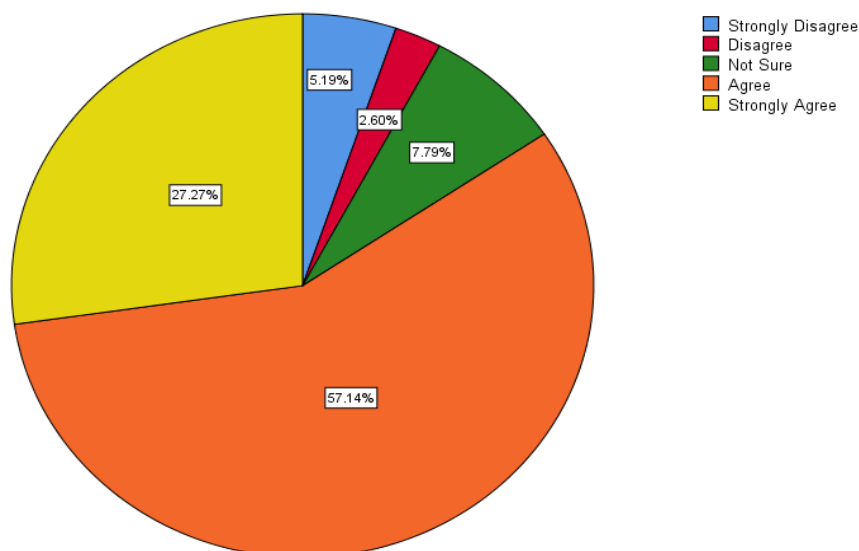
Figure 8.2: Benefit of introduction of technology on information flow

Figure 8.2 highlights the results from the responses of participants on whether the introduction of technology had improved information flow in the medication management process to t. Most of the participants (84.41%) affirmed technology had benefited information flow. Some were not sure (7.79%) while the others disagreed (7.79%) with the question.
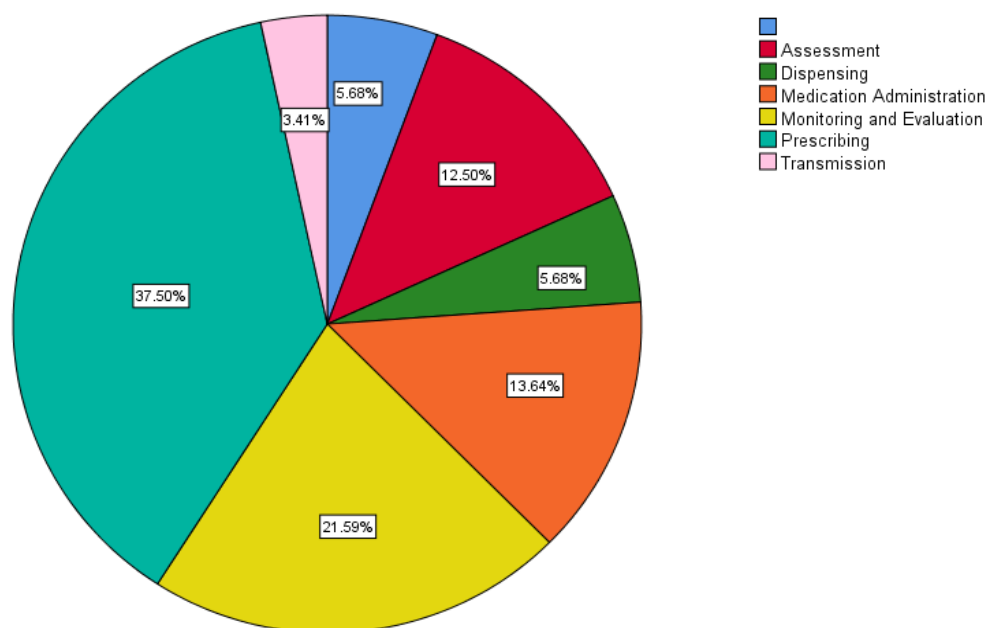
Figure 8.3: Phases that will benefit from introducing technology

Figure 8.3 shows results from the responses of participants to on what other medication management phases will benefit from the use of technology in their facilities. Prescribing phase had the highest number of responses (37.50%) followed by monitoring and evaluation (21.59%). The other phases medication administration (13.64%), assessment (12.5%),

dispensing (5.68%) and transmission (3.41%) were also mentioned. The blue slice (5.68%) represents participants that did not respond.

Participants were asked to rate the technology using scores 1 to 5, with 5 as the highest and 1 as the lowest score. Descriptive statistics of the response are reported (Table 8.4). The mean ratings across the technologies were similar (CPOE = 3.66, COW = 3.31, EMRT = 3.17, and Other technologies = 3.17). CPOE was the only technology that had maximum rating (5) and this is reflected in its mean (3.66) which was the highest.

Table 8.4: Rating of the technologies used in participants' facilities

	N	Minimum	Maximum	Mean	Std. Deviation
CPOE Score	34	1.00	5.00	3.66	0.67
COW Score	22	2.00	4.00	3.31	0.69
EMRT Score	11	2.00	4.00	3.17	0.80
Other Technologies Score	12	1.00	4.00	3.02	1.05

Table 8.5A: Hierarchical models of Computer on Wheels (COW) attributes against rating

A hierarchical linear regression was used to understand the factors that impact the use of these technologies used in the medication management process. Only 2 of the technologies (COW and CPOE) could be analysed because of the number of respondents. The hierarchical regression in Tables 8.5A (COW) and 8.5B (CPOE) analyse the attributes of these technologies using the Technology Acceptance Model (TAM) which was adopted as the framework for this evaluation. The attributes training and ease of use were statistically significant ($p < 0.05$) in Model 2 (Table 8.5A) and that model was significant ($p = 0.001$). For CPOE (Table 8.5B), Model 4 was significant ($p = 0.000$) and the attributes referring to improve timeliness ($p = 0.007$) and reduces medication errors ($p = 0.000$) were statistically significant. The model is also statistically significant ($p = 0.000$).

Model		Unstandardized Coefficients B	Sig.
1	(Constant)	2.016	.005
	Training	.423	.047
2	(Constant)	-1.191	.317
	Training	.547	.005
	Ease of use	.805	.006
3	(Constant)	-1.767	.102
	Training	.211	.291
	Ease of use	.554	.035
	Reduced medication error	.774	.016

Table 8.5B: Hierarchical models of Computerized Physician Order Entry (CPOE) attributes against rating

Model		Unstandardized Coefficients B	Sig.
1	(Constant)	3.223	.000
	Training	.239	.162
2	(Constant)	2.249	.001
	Training	.092	.586
	Ease of use	.379	.025
3	(Constant)	1.184	.020
	Training	-.010	.930
	Ease of use	.062	.610
	Reduced medication error	.718	.000
4	(Constant)	.955	.036
	Training	.050	.633
	Ease of use	-.101	.410
	Reduced medication error	.642	.000
	Timeliness	.269	.007

Table 8.6: Regression model of technology scores and information integration

A multiple linear regression model was further developed with the organisation of information about patient and medication in the medication management process (information integration) as the dependent variable and the ratings of CPOE, COW, EMRT, and Other Technologies as the independent variables (Table 8.6) to determine if the perceived efficiency of the technogies impacted information integration. The independent variables of COW Score, EMRT Score, and Other Technologies Score were not statistically significant ($p > 0.05$). Only CPOE score was statistically significant ($p = 0.005$). The CPOE score had a positive coefficient (0.286) and only the CPOE coefficient will be considered because it is significant.

Model	Unstandardized Coefficients		Sig.
	B	Std. Error	
(Constant)	1.442	.827	.085
CPOE Score	.286	.098	.005
COW Score	-.045	.122	.713
EMRT Score	.218	.165	.192
Other Technologies Score	.120	.113	.293
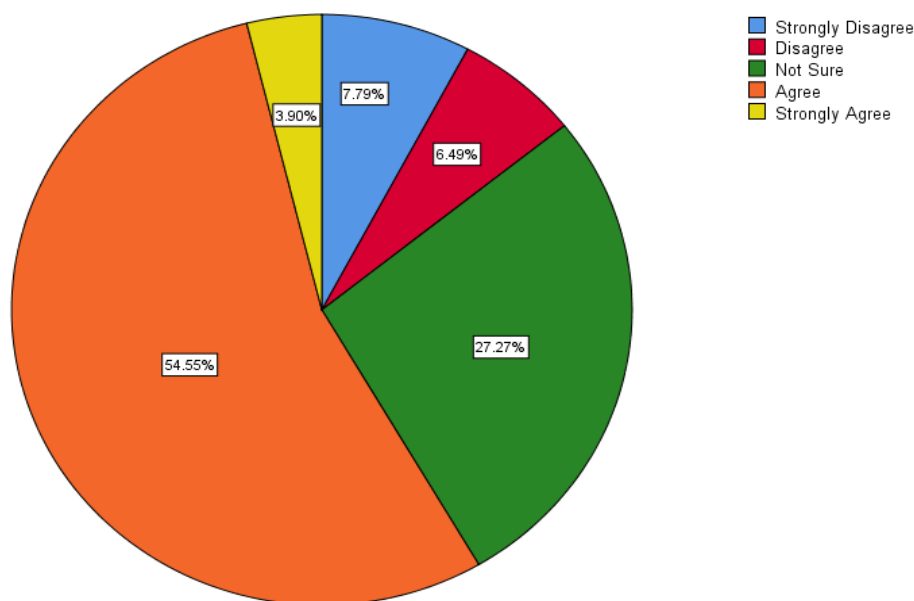
Figure 8.4: Introduction of technology has reduced medication errors in the medication process

Figure 8.4 represents the responses of participants to the question seeking to determine if introduction of technology had reduced medication errors. The responses that were in the affirmative were agreed (54.55%) and strongly agreed (3.9%). Some others disagreed (6.49%) and strongly disagreed (7.79%) while the others were not sure (27.27%).

8.3 Discussion on Research Question 1.3

Our results (Table 8.1) indicates that only one participant (1.1%), identified as a non-user of technology. While this response represents an outlier in this study, however, Walker and Johnson (2006), suggested reasons why people may use or reject technology. Some of the reasons include: Person's capacity to use the technology, anxiety, user-friendliness of the technology and perceived benefits they may receive. Further investigation revealed that the participant who had this response had 8 or more years work experience and this may mean the participant may be an older worker. Schulz et al. (2015), and Alanazi et al. (2018) have affirmed that older health workers had reluctance to use health technologies because it required more time to get used to the technology or the fear of making a mistake which could lead to significant errors. In another study by Heywood (2014), the findings highlighted that older professionals who had been used to older technologies had reservations in adopting new technologies that were more advanced. While we may not be able to confirm reasons for not engaging with technology, it can be assumed that one or a combination of reasons highlighted by Walker and Johnson (2006), Schulz et al. (2015), Alanazi et al. (2018) and Heywood (2014),

may explain the reasons for non-engagement. However, further studies can be undertaken and this will be included in our concluding chapter.

Although 99% (+/- 10) of participants (Table 8.1) indicated that they are regular technology users, yet electronic channel/path was not the most preferred information flow channel/path in chapter 7 (paper was still prevalent). This represents a paradox, a mismatch in user capability and system capabilities. From a health system perspective, Schofield, Shaw and Pascoe (2019), pointed out that Australian health system has made advances with technology implementation across many healthcare processes, however, major gaps still exists, current implementations are not coordinated and systems are not interoperable. Similarly, a report by Price Waterhouse Coopers, in 2016 indicated that Australia and New Zealand lags behind in digitizing healthcare compared to countries like the United States of America (USA). USA was reported to have 1414 digital hospitals as at 2015, while Australia and New Zealand had only one. This report considered digital hospitals as hospitals that had eliminated the use of paper across the processes within the hospital. Findings from the Price Water Coopers supports results from our study which highlighted that technology is used in 83% of the hospitals, other participants worked and 17% reported no technology was used at their healthcare facility. However, it is important to note that indicating technology use may not indicate that their facilities are completely digital. This is equally apparent from the results in our study (Table 7.1) were 30% of participants indicated that hybrid (electronic and paper) channel was used within the medication management process in their facility. Based on these findings, we assert that the technology adoption in the Australian health system is lagging behind the technology competence of the professionals who practice in the system.

Furthermore, results from our study has giving us insight into the technologies used in the medication management process in our participants' facilities (Figure 8.1). The most commonly used technology in the facilities was the CPOE (38.64%), which aligns with Baysari et al. (2018), where it was pointed out that there is a global wide adoption of CPOE across hospitals to facilitate safety in the use of medications. This may equally account for why this was the most commonly identified technology among the participants. Other technologies that were identified include COW or WOW (25%). Cuda (2013), also indicated that 87% of hospitals in the USA had WOWs at their points of care and this suggests why it was the second most commonly used technology reported by our participants in Australian acute care facilities. The EMRT was the third most commonly used technology (12.5%) (+/- 10) in participant's facilities. While studies have highlighted the benefit of EMRT technology, particularly the

barcode scanners (Poon, et al., 2010; Bainbridge & Askew, 2017), its use in Australia has been mostly within the pharmacy department for inventory management. It is important to point out that only 15.9% of our participants were pharmacists (Table 5.1) suggesting why it may not have been technology of choice in our study. Similarly, the ADC (1.1%) may have that level of response because it is gradually been phased out and replaced with the COWs and WOWs (Australian Commission on Safety and Quality in Health Care , 2017). With regards to the other technologies, participants were required to identify which other technologies were used within their facilities, however, only one (1) of the participants mentioned Medchart while the other participants did not indicate which technologies were in use. Therefore, it may be difficult to discuss further on other technologies used.

Part of the objectives of this research was to understand the factors that influence a general positive attitude towards technologies in the process. Only 2 of the technologies (CPOE and COW) in this study were eligible to be investigated. The other technologies (EMRT, ADC and other technologies) could not be assessed because they did not have adequate responses in the study (Figure 8.1). From the hierarchical model for COW (Table 8.5), model 2 was the most statistically significant model (p-value of 0.001) and the constructs that were significant was training (p = 0.005) when combined with ease of use (p = 0.006). The training construct was significant and aligned with the works of Czaja and Sharit (2013), and Cotton et al. (2016). These studies emphasised that adequate training is a factor for improving technology adoption. Thus, the significance of these variables can be interpreted as adequate training before introduction of COW can explain an increase in general attitude towards COW by 54.7% and ease of use of COW can explain an increase in general attitude towards COW by 80.5% holding other factors constant. In the hierarchical model for CPOE (Table 8.6), model 4 was the most statistically significant model (p-value 0.007; R^2 = 0.737). The R^2 represents the degree to which the variation (73.7%) in attitude towards the technology is explained by training and ease of use. In the model 4, the construct highlighting the ability of the technology to reduced medication error was statistically significant (p = 0.000) and the construct that improved timeliness was statistically significant (p0.007). These factors are interpreted as, the ability of the CPOE to reduce medication error can explain an increase in general attitude towards CPOE by 64.2% (+/- 10) and the ability of the CPOE to improve timeliness in the medication process can explain an increase in general attitude towards CPOE by 26.9% (+/- 10) holding other factors constant. From these highlighted results, it is apparent that different factors contribute to adoption of different technologies. In the case of COW, its perceived ease of use and training

were the significant drivers towards its adoption while CPOE had perceived usefulness was the driver. These differences may arise because of the essential features of these technologies that have been promoted over time. For example, the COW has been promoted for improving collaboration and bringing technology to bedside (Balgrosky, 2015), while the CPOE has been promoted for reducing medication errors (Kaushal, Shojania, & Bates, 2003; Ammenwerth, Schnell-Inderst, Machan, & et al, 2008; Nuckols, Smith-Spangler, Morton, & et al, 2014; Kruse & Goetz, 2015). The significance of the CPOE results supports previous studies like the one by Phichitchaisopa and Naenna (2013), where performance expectancy of technologies in healthcare was found to be significantly correlated to behavioural intention. Performance expectancy is explained as the capabilities of the information technology and behavioural intention is described as a belief that a certain behaviour makes a positive or negative contribution to use of that technology (Phichitchaisopa & Naenna, 2013). Thus, the ability or inability of the CPOE to perform its core functions will influence its positive or negative contributions to the medication process. In another related study, Chang et al. (2007), found out that in Taiwan the performance expectancy had a significant effect on behavioural intention than effort expectancy (measure of ease of use). In our research, 58.4% (+/- 10) of respondents (Fig 8.4) affirmed that introduction of technology has reduced medication errors and this aligns with the performance expectancy of the technology as highlighted by Chang et al. (2007), and this suggests that there will be a positive disposition among participants to use technology.

Our results further indicate that 84.41% of participants affirmed that technology improved information flow. This affirms Kaipia (2009),'s suggestion that investing in information technology ensures real time availability of information which represents a seamless flow of information. This was presented in the light of supply chains which is highly sensitive to information flow, however, we can draw lessons for the medication process. To determine which of the technologies had a significant impact on the information process integration within the medication management process, three of the technologies (CPOE, COW/WOW and EMRT) were used in the analysis. These technologies were selected based on the number of responses (CPOE, n = 34, COW/WOW, n = 22, EMRT, n = 11) they had from our survey. ADC could not be used because it had only one response and the other technologies were also not used because these technologies could not be identified. The attributes of the technologies and ratings were tested against the organisation of information about patient and medication in the medication management process as the dependent variable (Table 8.6).

CPOE was the technology that was statistically significant ($p = 0.005$) in predicting the information integration in the regression tests carried out. CPOE is usually used in the prescription phase and medication orders are generated and transferred to nurse and pharmacists using this application. Studies evaluating CPOE has primarily focussed on its capabilities to reduce medication errors with limited studies evaluating its impact on information flow. However, a Netherlands study by Niazkhani (2008), while evaluating the effect of the technology on inter-professional collaboration affirmed that CPOE improved information flow and required a workflow reorganisation when introduced. However, Niazkhani (2010), when reviewing CPOE and its impact on medication process emphasised that in facilities where a hybrid model was used in medication processes, fragmented information may exist, thereby, affecting the flow or integration of information.

From our analysis, we propose that technology enhances information flow and CPOE has a more significant effect on information integration in the medication management compared to the other technologies (COW, EMRT and ADC). We also infer that adoption of different technologies used in medication management are based on different factors which may be a result of the positioning of the technologies in the minds of participants.

Chapter 9 Conclusion and Recommendation

This chapter will highlight the conclusions resulting from the findings of this research which has sought to evaluate information flow in Australian acute care facilities. The research has assessed this flow from the perspectives of the professionals who participate in the process. The conclusions that will be highlighted are based on the objectives, research questions and findings from this research. Drawing from these conclusions, recommendations will be presented and explained.

9.1 Research Overview

This research was an analytical, explorative and quantitative study. The research adopted a positivist paradigm which is guided by the cause and effect (causality) belief. It focussed on numeric measures to evaluate this relationship. The research design was an analytical and cross-sectional design to ensure that the findings are broadly relevant to current situation within the healthcare system. Data for this research was collected using an online, self-administered survey which collected information regarding information flow and the technologies used by participants in the medication management process. The questions adopted in the survey were based on areas noted as important in literature (Agency for Healthcare Research and Quality, 2011; Bell, Cretin, Marken, & Landman, 2004; Berente, Vandenbosch, & Aubert, 2009; Clinical Excellence Commission, 2011). These areas include demography, technologies, information channel/paths and information flow in medication management.

Throughout the course of this research we have sought to investigate the medication management process in Australian acute care facilities. Our area of focus has been the information flow within the process to seek for how improvements can be made in this domain of the process. To this end, we have developed research questions which has served as a guide all through this research. There was a primary research question and two sub-questions which will assist in drawing conclusions.

9.2 Research Question

To what extent is the medication management process information integration in Australian acute care facilities aligned with information flow principles?

To answer this question, this research sought to achieve some objectives. The objectives were to identify which information principle/s impact the information flow integration in the medication management process and to identify current gaps in medication management

process information flows. The research equally sought to analyse how these gaps impact the integration of the medication management process in acute health settings.

Research Question Result Summary

In our review of literature, we hypothesized a high-level process model for the medication management process. From our research, 81.2% (+/- 10) (Figure 5.1A) of participants validated the model, therefore we propose that the medication management process comprises of the phases – assessment, prescribing, transmission, dispensing, administration, and monitoring and evaluation in a linear manner.

In this research, we assessed information integration in the medication management using the Pearson's Chi-Square test (Table 6.1) and assessed the strength of the associations using Cramer's V values (Table 6.2). Findings from this research revealed that the principle of timeliness was not statistically significantly associated with information integration (Table 6.2). However, principles evaluating transparency and granularity were moderately associated (Table 6.2), and one of the constructs evaluating accessibility was also moderately associated with information integration. The medication management process phases hypothesized earlier in this research was validated by participants, with 88% (+/- 10) of participants affirming the model. A further test using hierarchical linear regression was used to determine which of the principles explained the information integration and to what extent it could (Table 6.4). The principle of accessibility was the significant principle in explaining an increase or decrease in information integration in the medication management process (Table 6.4). We also determined that accessibility is directly related to information sharing and 88% of the participants affirmed that inadequate information sharing led to medication errors (Figure 6.3). The results also identified the assessment and monitoring and evaluation phases as having the highest challenges with information sharing. Similarly, 44.87% (+/- 10) of our participants affirmed that the changes to medication plans were are not adequately shared across the process, thus, predisposing the process to errors.

Drawing from these highlighted findings we can draw inferences to answer our primary research question. Results from this study infers that the principle of accessibility explains the information integration more than other principles in the medication management process in the acute care facilities in participants work in. In the light of the 2 tests conducted, the construct of accessibility referring to information retrieval was statistically significant, thus, we propose that information retrieval in the medication management process is a significant

accessibility principle that explains information integration. We equally affirm that other principles are moderately associated with information integration, thus, attention need to be paid to these principles.

9.3 Research Sub-question 1

Which information flow pathway/channel enhances or weakens the medication management process information integration in Australian acute care facilities?

As part of our research into the information flows of the medication process, we sought to identify which information flow channel supports information flow integration across the medication management process.

Research Sub-question 1 Result Summary

Findings from the research affirmed that three types of channels (Electronic, Paper and Hybrid) are still currently used across Australian acute care facilities to transmit patient and medication information across the medication management process. Further results also indicated that the electronic model was widely used across the process (Table 7.1 and Table 7.2). However, the hybrid model of transmission was preferred among participants to support information integration (65%, Table 7.8B).

We therefore infer based on responses from our participants,

9.4 Research Sub-question 2

To what extent have health information technologies enhanced or weakened the information flow in the medication management process in Australian acute care facilities?

Furthermore, our research sought to evaluate the technologies used in the medication process and understand the level of adoption and how it impacts on information flow and information integration.

Research Sub-question 2 Result Summary

Our findings have revealed that acute care facilities in Australia are currently using technologies, however, 17% (+/- 10) of participants indicated that no technologies were in use in their medication management process (Table 7.2). 84.41% (+/- 10) of our participants affirmed that introduction of technology has improved information flow in the medication process. The commonly used technologies across participants' facilities were CPOE (38.64%) (+/- 10) and COW (25%) (+/- 10) (Figure 8.1). A hierarchical linear regression was used to

assess the adoption of the two commonly used technologies, perceived ease of use and adequate training were the factors that were related to the use of COW, while perceived usefulness was the factor related to use of CPOE. Among the technologies evaluated for the medication process, only CPOE was found to be statistically significant ($p < 0.05$) in explaining an increase in information integration.

From these findings, we can state that technologies enhance the information flow in the medication management in Australian acute care facilities. We also state that among comparative technologies, CPOE can explain the information integration within the medication management process.

9.5 Implications and Contributions

Findings in this study has identified the construct of accessibility relating to information retrieval as a significant information flow principle in information integration in the medication management process in acute care facilities where our participants work. Thus, the ability to retrieve information across all the phases in the process will improve the integration of information and the process in itself. A study by Black and Sahama, (2017), which sought to co-create value using digital ecosystems in a patient's journey through the healthcare system had similar findings. According to Black and Sahama, (2017), the current architecture in Australian healthcare system collects and stores data in a central repository. However, it was suggested that a 'searchable information model' should be adopted. The suggested model makes information accessible to authorised users thus, enabling a 'Single Source of Truth' (SSOT) information flow across the care continuum for the patient. This will improve continuity, accessibility, timeliness and accuracy of information and the clinical care process efficiency. From this research we can equally infer that when information is adequately shared across the process, it will be accessible and eventually result in improved integration. Inadequate information sharing has been identified as a challenge in the medication information flow and it is directly related to accessibility and linked to medication errors. The phases of assessment and monitoring and evaluation were identified to have poor information sharing and these phases are critical because they lie at the beginning and end of the process, respectively. These phases may lead into a new medication management process (assessment), lead back to an existing one (monitoring), or indicate an end to an in-patient medication process (monitoring).

The challenge of accessibility to information in Australian healthcare has been widely acknowledged and was also mentioned in the media as a means of improving productivity

within the industry (Ho, 2012). The study also deduced that women were more disposed to seeking relevant information in the assessment phase (pg. 111). This finding suggests that gender differences may also be a contributory factor to existing gaps in accessibility in the assessment phase. Men were less aware of standards integral to the process and this gap may present differences in process outcomes.

A major outcome of information integration is reducing the incidences of medication errors within the process. Across the literature reviewed in this study, gaps in information flow and its management have been identified as a precursor to the many contributory factors that predisposes healthcare professionals to medication errors. This study suggests that improving retrieval and sharing of information will improve information flow considerably and inadvertently reduce medication errors in Australian acute care facilities. For example, our study highlighted that information flow includes sending and receiving information from machine to machine, machine to person and person to person. Ensuring that information is easily retrieved from/for the patient at the point of assessment and easy retrieval and sharing information via clinical information systems will minimise factors predisposing the process to medication errors particularly those arising from patient, team, electronic task and environmental. Therefore, strategies to improve information retrieval would significantly impact on information flow, process integration and eventually a reduction in medication errors.

Findings from this study also affirms the benefit of viewing the medication management process from a system perspective. In this study, we focused on the process and the dynamics across the process rather than isolating the different phases to investigate. The system view assisted in identifying gaps across the high-level process model, and opportunities that can enhance the efficiency and effectiveness of the process.

From our data, we understand that paper-based communication is still widely used and that the hybrid (electronic and paper) channel is the preferred channel among respondents we assert that a homogeneous channel (of electronic only) may not be beneficial for the medication management process integration at this stage in Australian acute care facilities. Therefore, the hybrid channel, which improves on paper channel limitations, is preferred until a more significant permeation of technology occurs across facilities. While several studies have posited that an adoption of technology in healthcare will improve data collection and accessibility, care must be taken not to introduce newer gaps such as fragmented information challenges from use of technology (Baysari & Raban, 2019), as results suggest that hybrid

transmission is beneficial to information and process integration at this stage. These findings also suggests that the level of technology-adoption maturity across participants' facilities may be assessed as level three based on the Strategic Alignment Maturity Model Alignment Levels as proposed by Luftman, (2000). This level points out that alignment of business processes, technology and users are evolving (Naidoo, 2011; Luftman, 2000). This may also explain why the hybrid channel is perceived to promote information integrity in the process.

Furthermore, our results, which highlighted that one participant was a non-user of technology and 17% of participants indicating technologies were not used in their facilities further accentuate that healthcare facilities are still evolving. Among the technologies evaluated in the medication management process, the CPOE was identified to enhance information integration across the process and participants indicated that it reduced the incidences of medication errors.

Our study anticipates that findings highlighted will serve as a framework that will guide interventions that can be introduced across the medication management process. The process has been characterized with medication errors as reported in Chapter 2, and findings like the ones presented from this study contributes to giving insights that may help in the error reduction. Participants in this research have confidence in the process based on their rating (mean = 3.69) (Table 6.6), and we believe that insights gained from this study gives insight to aspects of the process that can be improved which may eventually improve the outcomes of the process and perception of healthcare professionals.

9.6 Recommendation and Future Direction

The findings from this study has attempted to provide insight into how information within the medication management process can be more integrated using information principles. Based on these findings, we suggest further research could investigate barriers to information accessibility within the medication management process in Australian acute care facilities. This study has used a quantitative methodology for evaluation; further studies could utilise a qualitative methodology to build on the findings from this research to gain a broader understanding of underlying issues around accessibility. Furthermore, cohort studies with larger participants and a lower margin of error across different geographical and ecological settings such as different states and regional hospitals can also be explored. Subsequent research into the medication management can also investigate current technology and strategic alignment maturity levels and determine how the process can transit to optimization alignment. A similar approach using the systems framework can also be used across other error-prone

processes like medical errors (encompasses other errors in healthcare other than medications) in Australian healthcare. Additionally, similar investigations can be conducted in developed and developing nations to determine contributory principles to information and process integration and such findings can guide policy makers to develop evidenced-based strategies for improvement.

9.7 **Research Limitations**

Efforts were made to minimise the effect of potential limitations in the course of this research, however, some limitations still exist. These limitations include sample size, fewer categories of health professionals. These limitations are intertwined.

The sample size of 88 participants for this study and only 3 major professionals across the Australian acute care facilities presented a considerable limitation to the generalizability of this study. Although efforts were made to ensure a higher number of participants and broader category of professionals participated in this research through reminders, however response was still low. While there were suggestions that extending the time of the survey (beyond one year) may increase the response, however, no further responses were received while writing up this report. To minimise this effect, two major types of statistical analysis were carried out (Pearson's Chi-Square test and Hierarchical Linear Regression) to answer the primary research question in this study.

It should be emphasised that these highlighted limitations do not undermine the validity of the results presented in this research. Similarly, the insights gained from this study can serve as a guide for further research.

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Appendix

11.1 **Appendix 1: Further Results**

Chapter 5 Further Results

Variable Scoring

Five scale scores were calculated from the various scales. The conceptual and operational definitions of these scores are given in Table 1 below.

<u>Table 1: Conceptual and Operational Definitions of Five Scale Scores</u>

Variable	Conceptual Definition	Operational Definition		
		Number of Items	Computation	Interpretation of Scores
CPOE score	Usefulness of COPE	6	Average of all items	1=Low levels 5=High levels
COW score	Usefulness of COW	6	Average of all items	1=Low levels 5=High levels
EMRT score	Usefulness of EMRT	6	Average of all items	1=Low levels 5=High levels
Other technologies score	Usefulness of Other Technologies	6	Average of all items	1=Low levels 5=High levels
Prescription information flow score	Adequacy of prescription information flow	20	Average of all items	1=Low levels 5=High levels

Table 2: Descriptive statistics for prescription information flow questions

Prescription information flow	Mean	SD
1. Face to face communication is used additionally to explain and clarify prescriptions	3.73	0.90
2. Telephone calls are used additionally to explain and clarify prescriptions	3.46	1.01
3. When a patient is seen in emergency department, information given about the patient medication history is enough to commence treatment	2.90	0.99
4. There are guidelines for medication history retrieval used at the point of first contact	3.19	1.05
5. Clinical Decision Systems are used to aid diagnosis and prescriptions	3.47	1.02
6. Clinical Decision Systems are always up to date	3.03	0.95
7. Prescriptions are verified and dispensed by pharmacists before medication administration	3.20	1.05
8. Pharmacists have adequate information about patient's medication history when verifying prescriptions	3.18	0.83
9. Pharmacists review medication charts regularly	3.34	1.11
10. Medications are checked and verified by professionals and patients respectively before administration	3.58	0.98
11. Nurses have adequate information about patient's medical history when administering	2.92	1.08
12. Prescriptions are clear and easy to comprehend throughout the medication process	3.78	0.89
13. Changes to prescriptions are communicated to all parties involved in medication management	3.10	1.08

Prescription information flow	Mean	SD
14. Test results are communicated to all parties involved in medication management	3.04	1.06
15. Information about patient and medication is easily retrieved throughout the medication management process	3.24	0.96
16. Inadequate information in the medication management process leads to medication errors	3.22	0.93
17. Inadequate information sharing in the medication management process leads to medication errors	3.99	0.96
18. Introduction of technology has improved information flow in the medication process	3.99	0.97
19. Introduction of technology has reduced medication errors in the medication process	3.40	0.96
20. Information about patient and medication is properly organised throughout the medication management process	3.35	0.95

Table 3: Correlation analysis technologies

	CPOE Score	COW Score	EMRT Score	Other Technologies Score
COW Score	.[a]			
EMRT Score	.[a]	.[a]		
Other Technologies Score	.[a]	.[a]	.[a]	
Prescription Information Flow Score	.586[**]	-.131	.595	.140

**. Correlation is significant at the 0.01 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Table 4: Correlations of information flow principles against information integration

		Prescription_Information_Flow_20	Prescription_Information_Flow_3	Prescription_Information_Flow_15	Prescription_Information_Flow_8	Prescription_Information_Flow_11	Prescription_Information_Flow_21	Prescription_Information_Flow_12
Pearson Correlation	Prescription_Information_Flow_20	1.000	-.142	.299	.309	.297	.053	.319
	Prescription_Information_Flow_3	-.142	1.000	.377	.104	.235	-.315	.192
	Prescription_Information_Flow_15	.299	.377	1.000	.362	.485	-.065	.590
	Prescription_Information_Flow_8	.309	.104	.362	1.000	.393	-.058	.315
	Prescription_Information_Flow_11	.297	.235	.485	.393	1.000	.011	.421
	Prescription_Information_Flow_21	.053	-.315	-.065	-.058	.011	1.000	-.100
	Prescription_Information_Flow_12	.319	.192	.590	.315	.421	-.100	1.000

Table 5: Power Analysis - Independent Sample Means

Power Analysis Table

	N1	N2	Actual Power[b]	Power	Test Assumptions Std. Dev.[c]	Effect Size	Sig.
Test for Mean Difference[a]	83	83	.818	.8	1	1.000	.05

a. Two-sided test.

b. Based on noncentral t-distribution.

c. Group variances are assumed to be equal.

Table 6: Power Analysis - Pearson Correlation

Power Analysis Table

	N	Actual Power[b]	Power	Test Assumptions Null	Alternative	Sig.
Pearson Correlation[a]	97	.812	.800	0	.5	.05

a. One-sided test.

b. Based on Fisher's z-transformation and normal approximation with bias adjustment.

Table 7: Power Analysis - Linear Regression

Power Analysis Table

	N	Actual Power[b]	Predictors Total	Test	Test Assumptions Power	Partial[c]	Sig.
Type III F-test[a]	97	.818	9	2	.8	.6	.05

a. Intercept term is included.

b. Predictors are assumed to be fixed.

c. Multiple partial correlation coefficient.

Table 8: Model fit of information flow principles against information integration

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.406[a]	.165	.144	.868	.165	7.720	2	78	.001
2	.477[b]	.227	.187	.846	.062	3.050	2	76	.053
3	.477[c]	.228	.176	.851	.000	.030	1	75	.864
4	.491[d]	.241	.180	.849	.014	1.331	1	74	.252

Chapter 8 Further Results

Table 9 Model Summary of CPOE Rating

The model summary gives an R-Square of 0.202 This indicates that the model explains 20.2% variability of the response data around its mean.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.449[a]	.202	.174	.686

Table 10: ANOVA of CPOE Rating

The ANOVA model is statistically significant (0.011). Thus, the independent variable (CPOE Rating) can predict the information integration of the medication management process (dependent variable) at a 95% confidence level.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.446	1	3.446	7.320	.011[b]
	Residual	13.651	29	.471		
	Total	17.097	30			

Table 11: Coefficients of CPOE Rating

The CPOE rating is statistically significant (0.011) in predicting the information integration of the medication management process at a 95% confidence level.

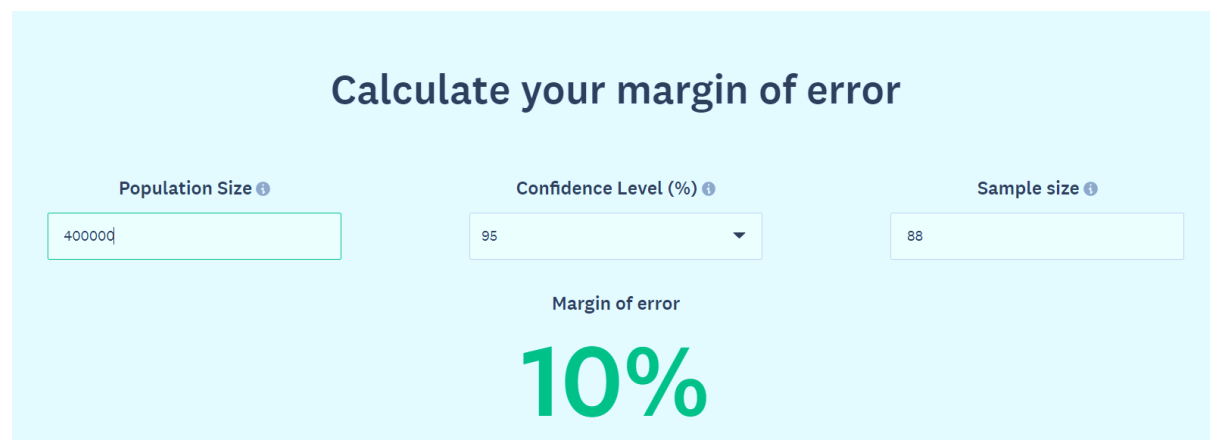| Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.167	.560		3.868	.001
	CPOE_Rating	.388	.144	.449	2.706	.011

Table 12: Model Summary of CPOE Attributes

The model summary gives an R-Square of 0.757. This indicates that the model explains 75.7% variability of the response data around its mean.

R	R Square	Adjusted R Square	Std. Error of the Estimate
.870[a]	.757	.697	.416

Table 13: ANOVA of CPOE Attributes

The ANOVA model is statistically significant (0.000). Thus, the independent variables can predict the information integration of the medication management process (dependent variable) at a 95% confidence level.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.947	6	2.158	12.479	.000[b]
	Residual	4.150	24	.173		
	Total	17.097	30			

Figure 1: Margin of error calculation

Calculate your margin of error

Population Size ℹ
400000

Confidence Level (%) ℹ
95

Sample size ℹ
88

Margin of error
10%

11.2 **Appendix 2: Ethics Approval**

THE UNIVERSITY OF
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23 July 2015

Dr Frank Moisiadis & Mr Seyi Olatunbosun Lagoke
School of Arts & Sciences
The University of Notre Dame Australia
PO Box 944
Broadway NSW 2007

Dear Frank and Seyi,

Reference Number: 015087S

Project Title: "Modelling and simulation of information flow in the medication management process in acute care facilities."

Your response to the conditions imposed by a sub-committee of the university's Human Research Ethics Committee, has been reviewed and assessed as meeting all the requirements as outlined in the *National Statement on Ethical Conduct in Human Research* (2014). I am pleased to advise that ethical clearance has been granted for this proposed study.

All research projects are approved subject to standard conditions of approval. Please read the attached document for details of these conditions.
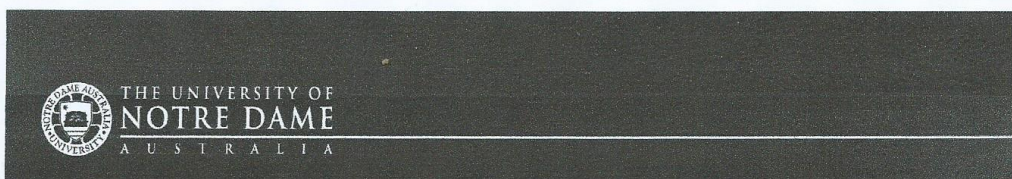
On behalf of the Human Research Ethics Committee, I wish you well with your study.

Yours sincerely,

Dr Natalie Giles
Research Ethics Officer
Research Office

cc: Dr Angus Brook, Acting Dean, School of Arts & Sciences Sydney;
        Dr Ebi Cocodia, SRC Chair, School of Arts & Sciences Sydney.

11.3 **Appendix 3: Participant Information Sheet**

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PARTICIPANT INFORMATION SHEET

PROJECT TITLE: Simulation and Modelling Of Information Flow in the Medication Process in Acute Care Facilities.

CHIEF INVESTIGATOR: Dr. Frank Moisiadis

STUDENT RESEARCHER: Mr. Seyi Lagoke

STUDENT'S DEGREE: Doctor of Philosophy

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
The research project seeks to model the current information flow in medication management process in Acute Health Facilities in Australia, identify the points of disruptions that can potentiate medication errors, suggest improvements to the current models and simulate proposed improved models.

Who is undertaking the project?
This project is being conducted by Mr. Seyi Lagoke and will form the basis for the degree of Doctor of Philosophy at The University of Notre Dame Australia, under the supervision of Dr. Frank Moisiadis.

What will I be asked to do?

You will be asked to complete a survey. The survey intends to evaluate information flow in the medication management process and the technologies used in information flow within the medication process from the perspective of the users (healthcare team members). The first part of the survey has questions about the technologies used in your facilities and the second part has questions about the medication process. In addition to this, an interview would be conducted with heads of units (Nursing Managers, Pharmacy Managers and Medical Directors). These components will capture information on the information flow, the effect of the technologies on the process and Identify where disruptions occur in the information of the medication process.

Participation in this survey is entirely voluntary, and you may withdraw your responses any time prior to completing the surveys. Most questions will simply require you to choose an answer from a list of options. We appreciate that some responses may not be easily recalled, and in such cases we ask that you provide us with what you deem as most appropriate. There is no right or wrong answer.

PARTICIPANT INFORMATION SHEET

Are there any risks associated with participating in this project?

We believe there are no known risks associated with this research study; however, the survey would be completed online and via hard copies and as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by ensuring responses are stored only in university drives.

What are the benefits of the research project?

It is expected that this study will help in improving the medication process in Acute Care Facilities, thereby reducing the incidence of medication errors.

Can I withdraw from the study?

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences. However, it would not be possible to withdraw after the survey has been submitted because the completed surveys are non-identifiable.

Will anyone else know the results of the project?

Information gathered about you will be held in strict confidence. This confidence will only be broken in instances of legal requirements such as court subpoenas, freedom of information requests, or mandated reporting by some professionals. Though completed surveys are non-identifiable, the responses would be stored on the University drive with a password and hard copies of any data collected would be stored in secured filing cabinets in the School of Arts and Sciences at The University of Notre Dame, Australia and locked. This data would be kept for at least a period of five years. The data may be used in future research but you will not be able to be identified.

Results would only be presented in aggregate format and published in health journals and presentations in scientific meetings and conferences

Will I be able to find out the results of the project?

Outcomes of the study will be made available via mails and newsletters and feedback presentation with the collaborating services and organizations.

Who do I contact if I have questions about the project?

For more information, you may contact the researchers at the School of Arts and Sciences, The University of Notre Dame, 140 Broadway, Chippendale NSW 2008, Dr. Frank Moisiadis on (02) 82044103 or Mr. Seyi Lagoke on 0414486742.

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at The University of Notre Dame Australia (approval number #######). If you wish to make a complaint regarding the manner in which this research project is conducted, it should be directed to the Executive Officer of the Human Research Ethics Committee, Research Office, The University of Notre Dame Australia, PO Box 1225 Fremantle WA 6959, phone (08) 9433 0943, research@nd.edu.au

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.
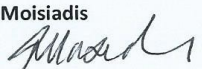
PARTICIPANT INFORMATION SHEET

I want to participate! How do I sign up?
The survey would take approximately twenty (20) minutes to complete. It could be completed online via a web-link that would be mailed to you. Alternatively, you may also wish to complete a paper copy of the survey. This would be sent to you by the student researcher Mr. Seyi Lagoke.

Yours sincerely,

Dr. Frank Moisiadis

Mr. Seyi Lagoke