EVALUATION OF MEDICATION SAFETY CHALLENGES AND PRESCRIBING ERRORS AMONG HOSPITALIZED PATIENTS IN A SAUDI ARABIAN PRIVATE HOSPITAL

MANSOUR ADAM MAHMOUD

UNIVERSITI SAINS MALAYSIA

2016

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by

MANSOUR ADAM MAHMOUD

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

MARCH 2016

ACKNOWLEDGEMENT

First of all many deepest gratitude goes to the Almighty Allah for the great help, blessing and spiritual guidance for making this work successful. I owe an extreme gratitude to my main supervisor Professor Dr. Mohamed Azmi Ahmad Hassali. He was a brother, a mentor and a great teacher and was always there when I need his guidance. I would also like to express my deepest gratitude to my co-supervisor Dr. Hisham Aljadhey. This work would have not been possible without his continuous support.

I would like to say big thanks to my mother and father for always praying for me and believing in me. I would also like to say thank you for my wife and kids for been understanding and caring. Many thanks are due to my brothers, sisters and all my family members for their continuous encouragement.

A special thank you is due to the National Plan for Science, Technology and Innovation for providing funding for this study. I would also like to thank all faculty, staff and students at the Discipline of Social and Administrative Pharmacy, School of Pharmaceutical Sciences, Universiti Sains Malaysia, for their support during the past few years. Last, but never the least I am grateful to all my friends for their social and moral support. I should never forget to thank my friend Elbaleeq Ballal for been more than just a friend.

"May Allah bless all of you"

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LIST OF ABBREVIATIONS

Adverse Drug Event	ADE
Adverse Drug Reaction	ADR
Arterial Fibrillation	AF
American Society of Hospital Pharmacist	ASHP
Arteriovenous Fistula	AVF
British National Formulary	BNF
Central Board of Accreditation For Health Institutions	CBAHI
Concentrated Electrolyte Solutions	CES
Chronic Kidney Disease	CKD
Chronic Obstructive Disease	COPD
Computerised Physician Order Entry	CPOE
End Stage Renal Disease	ESRD
Intensive Care Unit	ICU
Institute of Healthcare Improvement	IHI
Institute of Medicine	IOM
Institute of Safe Medication Practice	ISMP
Intravenous	IV
Look-Alike Sound-Alike	LASA
Ministry of Health	MOH
Medical Record Number	MRN
National Patient Safety Agency	NPSA
Non-Steroidal Anti-Inflammatory Drug	NSAID
Statistical Package for Social Science	SPSS

United Kingdom	UK
United States	US
United States Pharmacopeia	USP
World Health Organization	WHO

GLOSSARY OF KEY TERMS

Terms	Definition
Medication errors	Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use.
Prescribing errors	A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant reduction in the probability of treatment being timely and effective and/or increase in the risk of harm when compared with generally accepted practice
Prescribing errors without harm	Categories (A-C) in the NCC MERP index
Prescribing errors with potential to cause harm	Category (D) in the NCC MERP index
Prescribing errors with actual harm	Categories (E-I) in the NCC MERP index
Kappa	An agreement measure beyond that agreement expected to occur by chance.
Charlson's Comorbidity Index Weight	Is an index that predicts ten-year mortality for a patient who may have a range of comorbid conditions, such as heart disease, AIDS, or cancer (a total of 22 conditions). Each condition is assigned a score of 1, 2, 3, or 6, depending on the risk of dying associated with each one. Scores are summed to provide a total score to predict mortality.
Incidence	A measure of the probability of occurrence of a given medical condition in a population within a specified period of time.

PENILAIAN CABARAN KESELAMATAN UBAT DAN SALAH PRESKRIPSI DALAM KALANGAN PESAKIT DI SEBUAH HOSPITAL SWASTA DI ARAB SAUDI

ABSTRAK

Keselamatan ubat di hospital di Arab Saudi tidak diteroka sepenuhnya. Walaupun terdapat beberapa kajian yang dijalankan tentang salah preskripsi, namun tiada usaha sepakat tentang definisi salah preskripsi. Justeru, matlamat kajian ini adalah untuk meneroka perspektif profesional penjagaan kesihatan tentang keselamatan ubat, membangun satu definisi tentang salah preskripsi serta menilai insidens salah preskripsi di hospital di Riyadh, Arab Saudi. Kajian ini dijalankan dalam tiga fasa. Fasa pertama, merupakan perbincangan meja bulat dengan profesional penjagaan kesihatan. Fasa kedua, melibatkan proses Delphi dalam kalangan pengamal penjagaan kesihatan dengan para pakar dalam bidang keselamatan ubat dan pengurusan kualiti. Fasa ketiga atau terakhir, merupakan suatu kajian retrospektif yang melibatkan semakan carta perubatan dan arahan pengambilan ubat kepada pesakit pembedahan, pesakit perubatan dan pesakit di unit rawatan rapi (ICU), di hospital swasta, di Riyadh. Keterukan salah preskripsi yang dikenal pasti dinilai oleh pakar perunding (konsultan) melalui penggunaan algoritma NCC MERP (National Coordinating Council for Medication Error Reporting and Prevention). Dapatan kajian fasa pertama mengutarakan tiga tema utama: masalah keselamatan ubat, cabaran terhadap penambahbaikan amalan keselamatan ubat, dan cadangan bagi penambahbaikan keselamatan ubat. Dalam fasa kedua, sejumlah 35

orang pakar ikut serta dalam kajian ini, dan daripada jumlah tersebut, 31(88.5%) memberi respons dalam pusingan pertama. Dalam pusingan kedua, hanya 24 (68.5%) daripada mereka memberi respons. Mereka menerima definisi salah preskripsi. Berdasarkan jenis salah preskripsi, mereka bersetujua memasukkan 34 senario, 5 senario, dan 3 senario bergantung pada situasi klinikal individu. Dalam kajian fasa ketiga, sejumlah 691 salah preskripsi dikenal pasti daripada fail 2,033 orang pesakit. Insidens salah preskripsi adalah 3.6 (95% CI, 3.3 - 3.9) per 100 preskripsi, 33.9 (95% CI, 31.5 - 36.6) per 100 kemasukan dan 76.5 (95% CI, 70.9 - 82.3) per 1000 hari pesakit. Jenis salah preskripsi yang dikenal pasti paling biasa terjadi adalah salah dos (127; 18.4%) dengan 74 lebih-dos dan 53 kurang-dos. Antibiotik (230; 33.3%) adalah kelas drug paling biasa yang terlibat dengan salah preskripsi. Daripada salah preskripsi yang dikenal pasti, 20 (2.9%) adalah salah prekripsi yang benar, 330(47.8%) salah prekripsi yang berpotensi dan 341(49.3%) salah preskripsi yang tidak memudaratkan. Terdapat beberapa cabaran dalam konteks keselamatan ubat di Arab Saudi dan salah preskripsi adalah perkara biasa. Cadangan atau saranan utama bagi penambahbaikan keselamatan ubat termasuk penggunaan teknologi, penilaian kemahiran pendidiikan yang berterusan, penyelidikan dan sokongan yang bersungguh-sungguh daripada, badan akreditasi hospital negara.

EVALUATION OF MEDICATION SAFETY CHALLENGES AND PRESCRIBING ERRORS AMONG HOSPITALIZED PATIENTS IN A SAUDI ARABIAN PRIVATE HOSPITAL

ABSTRACT

Medication safety in Saudi hospitals has not been explored extensively. Although few studies have investigated prescribing errors, no attempts were made to develop a consensus definition of prescribing errors. Therefore, the aim of this study was to explore healthcare professionals' perspectives about medication safety, develop a definition of prescribing errors and assess the incidence of prescribing errors in a private hospital in Riyadh, Saudi Arabia. The study was conducted in three phases. Phase one was an exploratory round-table discussion with healthcare professionals'. The second phase involved Delphi process among healthcare practitioners' with expertise in medication safety and quality management. The last phase was a retrospective study involving review of medical charts and medication orders of patients' admitted to surgical, medical and intensive care unit (ICU) of a private hospital in Riyadh, Saudi Arabia during four month. The severity of the identified errors was assessed by two consultants using the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) algorithm. Phase one study revealed three main themes; medication safety problems, challenges to improve medication safety practices, and suggestions for improvement of medication safety. In phase two study a total of 35 experts accepted to participate in the study, of whom 31 (88.5%) responded in the first round. In the second round only

24 (68.5%) of them responded. Consensus was reached to accept the definition of prescribing errors. Regarding the types of prescribing errors, consensus was reached to include 34 scenarios, to exclude 5 scenarios and to include 3 scenarios depending on the individual clinical situation. In phase three study a total of 691 prescribing errors were identified in 2,033 patients' files. The incidence of prescribing errors was 3.6 (95% CI, 3.3 - 3.9) per 100 prescriptions, 33.9 (95% CI, 31.5 - 36.6) per 100 admissions and 76.5 (95% CI, 70.9 - 82.3) per 1000 patients days. The most commonly identified prescribing errors type was dosing errors (127; 18.4%) with 74 overdoses and 53 under doses. Antibiotic (230; 33.3%) was the most common drug class involved with prescribing errors. Out of the identified prescribing errors 20 (2.9%) were judged to be actual, 330(47.8%) potential and 341(49.3%) prescribing errors with no harm. There are several challenges to medication safety in Saudi Arabia and prescribing errors is very common. Key recommendations to improve medication safety included, use of technology, continuous education competency assessment, rigorous research and support from national hospital accreditation bodies.

CHAPTER 1: GENERAL INTRODUCTION

1.1 Background

In the last few decades, patient safety has become a global issue and has therefore been a focus of attention for both healthcare professionals and researchers (Kohn , Corrigan, & Donaldson, 1999). Despite healthcare practitioners' efforts to provide safe and effective care, several studies have identified harms resulting from unintended medication errors. These vary in severity from minor to major, or even the death of the patient (Aljadhey, Mahmoud, Mayet, Alshaikh, Ahmed et al., 2013b; Bates, Cullen, Laird, Petersen, Small et al., 1995; Classen, Pestotnik, Evans, Lloyd JF, & JP., 1997). The Institute of Medicine (IOM) has reported that at least 1.5 million Americans are injured by medication errors every year (Institute of Medicine, 2006). Medication errors also impose an economic burden on both patients and healthcare providers. The cost of medication errors in the United States (US) was estimated at 20 billion dollars (IMS Institute for Healthcare Informatics, 2013). The overall cost of adverse drug events (ADEs) in the US was reported as approximately 5.6 million dollars per year, and the cost of preventable ADEs resulting from medication errors was reported at 2.8 million dollars per year (Bates, Spell, Cullen, Burdick, Laird et al., 1997). Using these figures, it was estimated that the direct cost of ADEs to acute care hospitals in the US was 4 billion dollars and the cost of preventable ADEs due to medication errors was 2 billion dollars per year. The cost of preventable ADEs in community hospitals in the US was 3,511 dollars (Hug, Keohane, Seger, Yoon, & Bates, 2012). Preventable ADEs are also associated with increased length of hospital stay (Classen et al., 1997; Hug et al., 2012).

Medication errors can occur at any stage of the medication use process (prescribing, dispensing, transcribing, administering and monitoring). A growing body of

literature, however, reports that medication errors, especially those causing preventable ADEs, most commonly occur in the prescribing stage (Aljadhey et al., 2013b; Bates et al., 1995; Morimoto, Sakuma, Matsui, Kuramoto, Toshiro et al., 2011). According to a recent systematic review of 65 studies published from 1985-2007, mostly from the US or the Unite Kingdom (UK), prescribing errors occur in 7% of medication orders, 2% of patient days and 5% of hospital admissions (Lewis, Dornan, Taylor, Tully, Wass et al., 2009).

There is a lack of studies about medication safety issues in the Middle East (Alsulami, Conroy, & Choonara, 2013). Although Saudi Arabia is the third most common country in the Middle East to investigate medication errors (Alsulami et al., 2013), exploratory studies enquiring about the current situation of medication safety in Saudi hospitals is lacking. Particularly little is known about the incidence of prescribing errors in hospitalised patients in Saudi Arabia. Therefore, this study aims to explore the challenges to medication safety from the perspective of healthcare professionals in Saudi Arabia and assess the incidence of prescribing errors in hospitalised patients using a validated definition.

1.2 Study justifications

Medication safety in Saudi hospitals has not been explored extensively. Some attempts have been made to explore healthcare professionals' experiences about medication errors and medication errors reporting (Tobaiqy & Stewart, 2013). Few studies were also conducted to investigate the implementation of certain standards and good practice, such as creating a culture of safety (Alahmadi, 2010), basic medication safety practices (Aljadhey, Alhusan, Alburikan, Adam, Murray et al.,

2013a), the use of prohibited abbreviations (Alshaikh, Mayet, Adam, Ahmed, & Aljadhey, 2013a) and incidents reporting at hospital level (Arabi, Alamry, Al Owais, Al-Dorzi, Noushad et al., 2012). As far as can be established, however, no qualitative studies have been made to explore healthcare professionals' views on the subject. Exploratory studies are therefore needed to gain insights into the current practice of medication safety from the perspective of healthcare professionals. This will help healthcare authorities to design interventions to improve medication safety.

Previous studies of prescribing errors in Saudi Arabia have used different definitions, and to date there have been no attempts to develop an agreed definition. This variability in definitions used makes it necessary to develop a validated definition to assess the prevalence and incidence of prescribing errors in Saudi Arabia. Predefined scenarios and a definition of what is and is not a prescribing error serve as a guide for researchers who wish to investigate this area (B. Dean, Barber, & Schachter, 2000). The definition also affects the number and types of errors discovered and allow comparisons between studies using the same definition. A definition and scenarios developed by Dean and colleagues in the United Kingdom (UK) have been widely used in other studies (Lewis et al., 2009). It is not clear, however, whether the definition is valid used in a different country, such as Saudi Arabia, because the healthcare system, and education and training of individual healthcare professionals may be very different.

Numerous international studies have been conducted to establish the incidence of prescribing errors in hospitalised patients (Lewis et al., 2009). However, compared to western countries, few studies were conducted in the Middle East (Alsulami et al.,

2013). In Saudi Arabia, the majority of the studies that investigated prescribing errors were conducted in the primary care settings (Alsulami et al., 2013; Khoja, Neyaz, Qureshi, Magzoub, Haycox et al., 2011; Neyaz Y, Qureshi NA, Khoja T, Magzoub MA, Haycox A et al., 2011) with few to date in hospital settings (Al-Dhawailie, 2011; Al-Jeraisy, Alanazi, & Abolfotouh, 2011; Dibbi, Alabrashy, Hussain, Fatani, & Karima, 2006). These studies have not used a standard definition of prescribing errors. A study using a valid definition of prescribing errors is needed to estimate the incidence of prescribing errors.

1.3 General study objectives

- To explore healthcare professionals perspectives about the challenges to medication safety practice in Saudi Arabian hospitals.
- To develop a consensus on the definition of prescribing errors to be used in the assessment of prescribing errors among hospitalised patients in Saudi Arabia.
- To assess the incidence and severity of prescribing errors.

1.4 Thesis overview

This thesis consists of seven chapters, covering introduction, method, results and discussion. Chapter two, the literature review, discusses medication safety. It also contains a detailed and up-to-date discussion of published studies on incidence, prevalence, severity, and causes of, and risk factors associated with, prescribing errors. Chapter three discusses the methodology, and in particular, possible methodological approaches to achieve the objectives. Chapter four describes the qualitative part of the study. It includes an in-depth analysis of a round-table

discussion about medication safety challenges with healthcare professionals in Saudi Arabia. Chapter five includes the result of a Delphi study involving practitioners with a special interest in medication safety and quality of healthcare. It validates the definition of prescribing errors and the scenarios for use in Saudi Arabia. Chapter six is the quantitative part of the study and includes the epidemiology of prescribing errors. It provides data on incidence, types, severity, medication involved and factors associated with prescribing errors. Chapter seven provides an overall conclusion, recommendations and limitations from the thesis findings.

CHAPTER 2: LITERATURE REVIEW

2.1 The healthcare system in Saudi Arabia

Saudi Arabia is located in southwest Asia and covers an area of 2.250 million square kilometres (The Saudi Ministry of External Affairs, 2013) with a population of 30,770,375 in 2014 (Central Department of Statistics & Information, 2014). Saudi citizens make up 67.9% of the total population; 50.2% are male and 49.8% are female. Saudi Arabia is among the richest countries in the Middle East. According to the 2014 Human Development Report from the United Nations, Saudi Arabia was ranked 34 out of 187 countries, with a Human Development Index of 0.83, which is considered very high (Human Development Report, 2014). It is generally agreed to be the world's largest oil producer and exporter and possesses one-fifth of the world's oil reserves (U.S. Energy Information Administration, 2013).

The government expenditure on the Ministry of Health (MOH) has increased from 6.2% of the total government budget in 2009 (Central Department of Statistics & Information, 2009) to 6.6% in 2013 (Ministry of Health, 2013). The total number of hospitals in the country increased from 408 in 2009 to 445 in 2013 and the number of beds increased from 55,932 in 2009 to 64,777 in 2013 (Ministry of Health, 2013). The main government organisations that provide healthcare services are the MOH hospitals, primary healthcare centres, other government hospitals and private hospitals. The MOH is the major provider of healthcare services and has 268 hospitals with 38,970 beds, followed by the private sector with 136 (30.6%) hospitals and 14,310 beds. Other government hospitals include 39 (9.6%) hospitals with 10,822 (19.3%) beds (Ministry of Health, 2013). In total, 39 (9.6%) hospitals and 11,497 beds are provided by other government organisation, including the National Guard, Armed Forces, security forces, teaching hospitals and Health Services in the

Royal Commission for Jubail and Yanbu (Ministry of Health, 2013). The majority of these hospitals deliver services to employees and their dependents. All services in government hospitals are provided free of charge; private hospitals charge for services.

Private hospitals are the second main provider of healthcare in Saudi Arabia (Ministry of Health, 2013). The number of private hospitals increased from 125 hospitals in 2009 to 136 in 2013 (Ministry of Health, 2013). In 2013 the highest percentage of private hospitals was present in Jeddah (24.2%) followed by Riyadh (23.5%) (Ministry of Health, 2013). However, the highest number of hospital beds were present in Riyadh (30.5% of the total number of hospital beds) followed by Jeddah (21.2% of the total number of hospital beds).

The quality of healthcare institutions in Saudi Arabia is monitored by the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI), the official body authorised to award quality accreditation to healthcare institutions in Saudi Arabia. As part of their initiatives to deliver safe care and keep up-to-date with international standards, some Saudi hospitals, including government non-MOH and some big private hospitals have sought accreditation from national and international bodies. Some of the top hospitals in the country have sought Canadian accreditation, which provides an external healthcare quality peer review process for national and international hospitals.

The safety of drugs, food and medical and diagnostic devices in Saudi Arabia are monitored by the Saudi Food and Drug Authority (SFDA), established in 2003

(Saudi Food & Drug Authority, 2013). It covers three main sectors, food, drugs and medical devices. It is also responsible for developing clear policy and procedures for the use of drugs and monitoring the implementation of these policies.

In March 2009, the SFDA launched the Saudi Pharmacovigilance Centre and joined the World Health Organization (WHO) International Drug Monitoring Program (Olsson, 2009). The Saudi Pharmacovigilance Centre created the Saudi Adverse Events Reporting System (SAERS) to receive reports from healthcare professionals, the pharmaceutical industry and the general public on adverse drug reactions (ADRs), quality problems, unexpected lack of efficacy and drug poisoning. (Alshammari, Al-Kathiri, Le Louet, & Aljadhey, 2015).

2.2 Defining medication errors

According to a recent systematic review covering definition and characteristics of medication errors, there are at least 26 different generic definitions of medication errors (Lisby, Nielsen, Brock, & Mainz, 2010). Perhaps the most comprehensive definition is that given by the National Coordinating Council for Medication Errors Reporting and Prevention (NCC MERP), which defined medication errors as "Any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use."(National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP), 2014).

More narrowly the National Patient Safety Agency (NPSA) defined Medication errors as any errors in the medication use processes (prescribing, dispensing, administering, transcribing and monitoring) (National Patient Safety Agency, 2007).

2.3 Defining medication errors in the prescribing stage

Medication errors that occur during prescribing stage is called prescribing errors. Any definition of prescribing errors should consider the main elements of the prescribing process; for example the choice of medicine should be appropriate to the patient and the condition (Aronson J.K, 2004). The prescribing process should minimise harm and consider the balance between harm and benefit (Aronson J. K, 2006). Several definitions of prescribing errors have been reported in the literature (Lewis et al., 2009). Prescribing/ordering of drugs includes a decision making component and a technical component. Errors can occur in both parts of this process. For example, one definition is an error in the process of prescribing medication that leads to or has the potential to lead to patient harm (Aronson J. K, 2009). Dean and colleagues (2000) used a two-stage Delphi method with healthcare professionals (physician, pharmacists and nurses) having a special interest in medication errors and risk management, to develop an operational definition, concluding that "A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective or (2) increase in the risk of harm when compared with generally accepted practice". In this definition the word "unintentional" was used to exclude the risk of harm from malicious acts (Avery, Barber, Ghaleb, Dean, Armstrong et al., 2012). The statement "compared with

generally accepted practice" was included because the preventability of the prescribing error depends on the generally accepted practice. The word "significant" was used to include only clinically meaningful prescribing errors and cognitive errors with adverse consequences, and to ensure that the findings would be relevant and worthy (Avery et al., 2012). This definition was accompanied by 27 scenarios that should be included as prescribing errors, eight that should be excluded and seven where judgment depends on the individual clinical situation (Appendix A). These scenarios provide some clarity on potentially controversial cases to help decide on the inclusion and exclusion of prescribing errors. This definition is widely accepted (Lewis et al., 2009) and has been used in several studies (Avery, Ghaleb, Barber, Dean, Armstrong et al., 2013; Dean, Reynolds, Shebl, Burnett, & Jacklin, 2011; Keers, Williams, Vattakatuchery, Brown, Miller et al., 2014; Ryan, Ross, Davey, Duncan, Francis et al., 2014; Seden, Kirkham, Kennedy, Lloyd, James et al., 2013).

Other definition of prescribing errors was given by the American Society of Hospital Pharmacist (ASHP). The ASHP defined prescribing errors as "incorrect drug selection (based on indications, contraindications, known allergies, existing drug therapy, and other factors), dose, dosage form, quantity, route, concentration, rate of administration, or instructions for use of a drug product ordered or authorised by physician (or other legitimate prescriber); illegible prescriptions or medication orders that lead to errors that reach the patient" (American Society of Hospital Pharmacists, 1993). Agalu et al. (2011) defined prescribing errors as deviation from standard practices (as indicated in national standard treatment guidelines, textbooks, handbooks, and software) excluding dosage form errors, illegible hand writing, and failure to authenticate the prescription with signature and/or date. Dale et al. (2003)

defined prescribing errors as an error which caused an adverse drug event (ADE) (ADE; an injury resulting from medical intervention related to a drug) or was judged to represent a potential ADE (an error that has the capacity to cause injury but fails to do so either by chance or because it is intercepted). The Pharmaceutical Care Network Europe (Pharmaceutical Care Network Europe , 2010) classification of drug related problems was also used by few studies (Glanzmann et al., 2015). This classification consists of drug selection (the cause of the MPE can be related to the selection of the drug, i.e. no indication for drug, inappropriate combination of drugs (interactions), indication for drug treatment not noticed and too many drugs prescribed for indication), drug formulation (the cause of the MPE is related to the selection of the drug formulation), dose selection (the cause of the MPE can be related to the selection of the dosage schedule), treatment duration (the cause of the MPE is related to the duration of therapy), drug use process (the cause of the MPE can be related on the way the patient gets the drug administered), or other problems (Pharmaceutical Care Network Europe , 2010).

Studies investigating prescribing errors in Saudi Arabia have not used a standard definition of prescribing errors. For example Al-Dhawailie (2011) categorised prescribing errors as "wrong patient, wrong drug, wrong dose, wrong strength, wrong frequency, wrong drug combination, and unclear written medication orders or inpatient drug charts". Another Saudi study defined prescribing errors as "an incorrect or inappropriate drug selection (based on indications, contraindications and other factors), dose, route, rate of administration, or frequency. A prescription error also included illegible handwriting, an incomplete order (missing the dose, route, or frequency), incompatibility, incorrect instructions for

using the drug product, and the use of non-standard nomenclature or abbreviations that requires further interpretation." (Al-Jeraisy et al., 2011). Both studies provided different definitions of prescribing errors. These differences in definitions led to some inconsistencies. For example, an incomplete medication order was considered as a prescribing error by one study (Al-Jeraisy et al., 2011) and not by the other study (Al-Dhawailie, 2011).

In this thesis The definition of Dean et al (2000) was used because it is the most comprehensive definition available. It provides scenarios of prescribing errors (Appendix A) which are very easy to follow and help to classify the types of prescribing errors. In addition this definition was widely used by many studies to investigate the incidence of prescribing errors worldwide (Lewis et al., 2009).

2.4 Defining Adverse Drug Events

An Adverse drug events (ADE) is defined as injury resulting from medical intervention related to a drug (Bates et al., 1995; National Patient Safety Agency, 2007). ADEs can be potential or actual. Potential ADEs, also known as 'near misses', are incidents that did not cause harm but had the potential to do so (National Patient Safety Agency, 2007). Actual ADEs involve harm caused by medication and include both ADRs and medication errors (Figure 2.1). An ADR is defined by the WHO as "A response to a drug which is noxious and unintended, and which occurs at doses normally used in man for the prophylaxis, diagnosis, or therapy of disease, or for the modifications of physiological function" (World Health Organization, 2002).

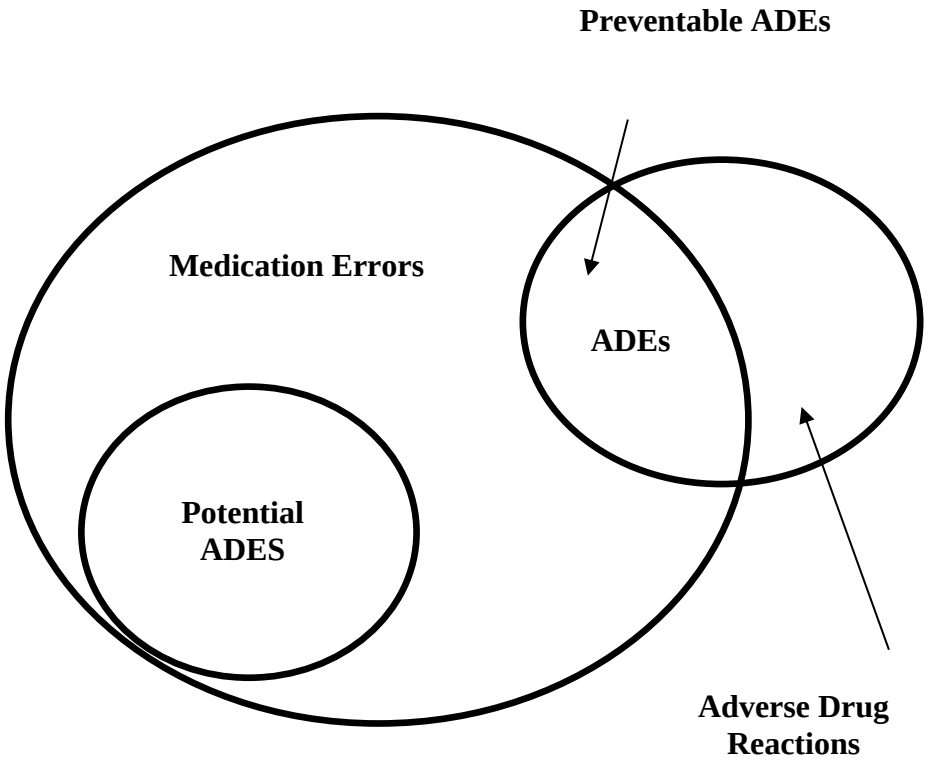

Figure 2.1: Relationship between Medication Errors, ADEs and ADRs (Morimoto, Gandhi, Seger, Hsieh, & Bates, 2004)

An ADE can be preventable or non-preventable. Preventable ADEs happen because of medication errors and result in patient harm (Bates et al., 1995; National Patient Safety Agency, 2007). Examples of preventable ADEs include prescribing a medication to a patient with a known allergy to that medication and prescribing the correct medication by the wrong route of administration (National Patient Safety Agency, 2007). Non-preventable ADEs are harms not caused by medication errors. An example of non-preventable ADEs includes a side effect to a medication that was prescribed to the patient for the first time (National Patient Safety Agency, 2007). The relationship between medication errors, ADEs and ADRs are illustrated in figure

2.1 (Bates et al., 1995; Morimoto et al., 2004; National Patient Safety Agency, 2007). This thesis focuses on medication errors in the prescribing stage of medication use process and their severity.

2.5 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

2.5.1 Introduction

Literature search were conducted for studies investigating the prevalence, incidence and types of prescribing errors in hospital inpatients. Searches were conducted for articles published in English language only. Studies investigating prescribing errors involving specific medication or medication classes and those investigating the incidence of one type of prescribing errors (example, dosing errors) were excluded. Table 2.1 shows studies investigating the incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia.

2.5.2 Countries

The majority of the studies were conducted in the UK (Abdel-Qader, Harper, Cantrill, & Tully, 2010; Ashcroft, Lewis, Tully, Farragher, Taylor et al., 2015; Basey, Krska, Kennedy, & Mackridge, 2014; B. Dean, O'Grady, Paschalides, Utley, Gallivan et al., 2007; B. Dean et al., 2011; Ghaleb, Barber, Franklin, & Wong, 2010; Keers et al., 2014; Mandal & Fraser, 2005; Ridley, Booth, & Thompson, 2004; Seden et al., 2013; Shulman, Singer, Goldstone, & Bellingan, 2005; Tully & Buchan, 2009) and US (Bobb, Gleason, Husch, Feinglass, Yarnold et al., 2004; Cimino, Kirschbaum, Brodsky, & Shaha, 2004; Echeta, Moffett, Checchia, Benton, Klouda et al., 2014; Grasso, Genest, Jordan, & Bates, 2003; Hendey, Barth, & Soliz, 2005;

Sard, Walsh, Doros, Hannon, Moschetti et al., 2008; Taylor, Selbst, & Shah, 2005). Other countries included Canada (Forster et al., 2004), France (Caruba, Colombet, Gillaizeau, Bruni, Korb et al., 2010), Scotland (Ryan et al., 2014), Japan (Morimoto et al., 2011), the Netherland (Van Den Bemt et al., 2009) and Switzerland (Glanzmann et al.., 2015).

2.5.3 Study Design

The study design of the reviewed studies were either prospective or retrospective. Prospective studies were more most common compared to retrospective studies (Table 2.1). Either medical chart review or prescription review or both were conducted in majority of the studies. Data were most commonly collected by pharmacists or nurses.

2.5.4 Setting

Studies were most commonly carried out in teaching hospitals (Bacic Vrca, Becirevic-Lacan, Bozikov, & Birus, 2005a; Bobb et al., 2004; Caruba et al., 2010; Colpaert, Claus, Somers, Vandewoude, Robays et al., 2006; B. Dean et al., 2007; B. Dean et al., 2011; Forster, Halil, & Tierney, 2004; Lisby, Nielsen, & Mainz, 2005; Ridley et al., 2004; Shulman et al., 2005; P. M. L. A. Van Den Bemt, Zaal, Egberts, Lenderink, Kosterink et al., 2009). Few studies were conducted in specialized hospitals (Glanzman et al., 2015; Ghaleb et al., 2010; Mandal & Fraser 2005; Grasso et al., 2003). One study was a multinational study conducted in Newzealand and Australia (Barton, Futtermenger, Gaddi, Kang, Rivers et al. 2012). Few studies were also conducted in multiple hospitals (Seden et al., 2013; Dean et al., 2011; Ryan et al., 2014; Marimoto et al., 2011; Cimino et al., 2004; Ghaleb et al., 2010).

2.5.5 Incidence of prescribing errors

The incidence of prescribing errors in Europe, US, Canada and Australia ranged from (0.9% to 94%). The rate of prescribing errors was reported per number of admissions, patient-days and number of medication orders. The lowest incidence (0.9%) was reported by a prospective study conducted in seven medical wards of a teaching hospital in France (Caruba et al., 2010). The highest incidence (94%) was reported by a prospective study conducted in three sites in Australia and one in New Zealand (Barton et al., 2012).

2.5.6 Type of prescribing errors

Omission of the required drug therapy including omission of medications on admission, on rewriting of prescriptions and on discharge (Ashcroft et al., 2015; Seden et al., 2013; Taylor et al., 2005; Keers et al. 2014; Dean et al., 2011; Ryan et al., 2014; Basey et al., 2014) and dosing errors (overdosing, undersosing and dose selection) (Ashcroft et al., 2015; Bobb et al. 2004; Seden et al., 2013; Colpaert et al., 2006; Glanzmann, Frey, Meier, & Vonbach, 2015; Hendey et al., 2005; Basey et al., 2014) were the most frequently reported types of prescribing errors. Other prescribing errors included incomplete prescription such as missing the dose/frequency of medication and wrong frequency of medications administration were common types of prescribing errors. Prescribing errors such as wrong infusion rates and use of abbreviation were the least commonly identified errors (Table 2.1).

2.5.7 Medications associated with prescribing errors

The most common medication class associated with prescribing errors was antibiotics (Bobb et al., 2004; Colpaert et al., 2006), but some studies did not report the medication class.

Table 2.1 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

Setting	Study design	Duration of the Study	Population	Sample	Rate of prescribing errors reported	Types of prescribing errors	Medication classes involved	Reference
UK (20 National health service hospitals)	Prospective study	Seven days	Patients admitted to the 20 hospitals during the study period.	26,019 patients and 124,260 medication orders	8.8% (10,986 of the 124,260 medication orders)	Omission (28.5%), under-dosage (10.9 %), over-dosage (8.4 %), strength/dose missing (7.6%) and administration times incorrect/ Missing (6.6%)	Cardiovascular, central nervous system, respiratory, endocrine, and gastrointestinal drugs (73.1 %)	Ashcroft et al. (2015)
US (Teaching hospital)	Prospective study	One week	Inpatients and emergency department admissions	17808 medication orders.	6.2% (1111 errors of the 17808 medication orders)	Of 342 clinically significant errors, 39 % were dosing errors, 20 % wrong frequency and 9.4% nomenclature errors	Anti-infectives (37%), cardiovascular drugs (12.3%), opoid analgesics (7.6%) and vitamins/ Electrolytes (3.8%)	Bobb et al. (2004)

Table 2.1 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

Setting	Study design	Duration of the Study	Population	Sample	Rate of prescribing errors reported	Types of prescribing errors	Medication classes involved	Reference
Canada (Teaching hospital)	Prospective study	One month	General medical ward	543 patient-days	23.9 per 1000 patient-days (13error occurred during the 543 patient-days)	NR	Reported for all ADEs	Forster et al. (2004)
France (7 medical wards of a teaching hospital)	Prospective study	18 days	Seven medical wards	204 patients with 12 533 medication orders	0.9% (117 errors of the 12 533 medication orders)	Inappropriate choice of drugs (56.4%), omission (20.5%) and drug-drug interaction (13.7%)	NR	Caruba et al. (2010)

NR= Not Reported

Table 2.1 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

Setting	Study design	Duration of the Study	Population	Sample	Rate of prescribing errors reported	Types of prescribing errors	Medication classes involved	Reference
North West UK (teaching hospitals, district hospitals and specialist hospitals s for paediatrics, women and mental health)	Prospective study	Three weeks	Nine hospitals	4238 prescriptions	71% (3011 errors in the 4238 prescriptions)	Omission (26.9%), writing errors (20.7%), dosing errors (20.6%)	NR	Seden et al. (2013)
North West UK (National Health Service (NHS) mental health hospitals in the North West of England.)	Prospective study	10 days	Three mental health hospitals	4427 prescriptions	6.3% (281 of the 4227 prescriptions)	Omission (12.5%), incorrect or missing admission times/frequency (11.7%) and missing strength or doses (10.4%)	NR	Keers et al. (2014)

NR= Not Reported

Table 2.1 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

Setting	Study design	Duration of the Study	Population	Sample	Rate of prescribing errors reported	Types of prescribing errors	Medication classes involved	Reference
UK (two teaching and one non-teaching hospital)	Prospective study	Two weeks in each ward	Patients admitted to medical and surgical wards	6605 medication orders and 1771 patient days.	15.5% (1025 prescribing errors were identified in the 6605 medication orders) 58% (1025 prescribing errors were identified during the 1771 patient days)	Omission, inappropriate dose, Incomplete prescription.	NR	Dean et al. (2011)
Scotland (eight hospitals)	Prospective study	28 weeks	Adult medical, surgical, acute and long stay patients	4710 patient charts and 44,726 prescribed medicines	36% (1700 of the 4710 prescription charts)	Omission (28.6%), incomplete prescription (15.7%), sub therapeutic dose (7.8%) and incorrect dose (7.1%)	NR	Ryan et al. (2014)

Table 2.1 Incidence, prevalence, types and medications associated with prescribing errors in Europe, US, Canada and Australia

Setting	Study design	Duration of the Study	Population	Sample	Rate of prescribing errors reported	Types of prescribing errors	Medication classes involved	Reference
Belgium (ICU of a teaching hospital)	Prospective study	Five weeks	ICU	1224 prescriptions and 80 patient-days.	27% (331 errors of the 1224 prescriptions)	Dosing error (48%), wrong infusion rate (18%), wrong frequency (9%).	Antibiotics (23.5%), cardiovascular medications (23%), sedatives (19.8%)	Colpaert et al. (2006)
Denmark (Teaching hospital)	Prospective study	Four months	Patients admitted to medical and surgical ward	433 medication orders	38.6% (167 of the 433 medication orders)	Drug formulation (37.9%), omission of route (34.7%) and wrong treatment time (10%)	NR	Lisby et al. (2005)

NR= Not Reported