Factors Associated with Physicians' Actual Use of the Computerised Physician Order Entry System for Prescribing Medicines at Government Hospitals in Saudi Arabia

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Abbreviations

Acronym	Definition
ADE	Adverse Drug Event
AHRQ	The Agency for Healthcare Research and Quality
ANOVA	Analysis of Variance
AUCDS	Actual use of clinical decision support
AUOE	Actual use of order entry
CDS	Clinical Decision Support
CDSS	Clinical Decision Support System
CFA	Confirmatory Factor Analysis
CPOE	Computerized Physician Order Entry
CRS	Computer Reminder System
D&M IS Success Model	The DeLone and McLean Information System Success Model
e-prescribing	Electronic Prescribing
EDPSS	Electronic prescribing decisions support system
EE	Effort Expectancy
EFA	Exploratory Factor Analysis
EHR	Electronic Health Records
EMR	Electronic Medical Records
EMRAM	Electronic Medical Record Adoption Model
EPR	Electronic Patient Record
FC	Facilitating Conditions
GP	General Practitioner
HIS	Health Information System
HIT	Health Information Technology
HITECH	The Health Information Technology for Economic and Clinical Health Act
ICT	Information and Communication Technologies
ICU	Intensive Care Unite
IOM	Institute of Medicine
IQ	Information Quality
IRB	The Institutional Review Board
IT	Information Technology
KFSH&RC	King Faisal Specialist Hospital and Research Center
KMO	Kaiser-Meyer-Olkin test
MESH	The Medical Subject Headings
MMAT	The Mixed Methods Appraisal Tool
MNGHA	Ministry of National Guard - Health Affairs
MOH	Ministry of Health

NGHA	National Guard Health Affaires
NHS	The National Health Service
PCA	Principal Component Analysis
PE	Performance Expectancy
SI	Social Influence
SPSS	Statistical Package for the Social Sciences
SQ	System Quality
SUS	System usability Scale
TAM	The Technology Acceptance Model
TVE	Total Variance Explained
UTAUT	The Unified Theory of Acceptance and Use of Technology
WHO	World Health Organization

Abstract

Background Assuring patient safety and providing high-quality care are the main goals of any healthcare system. Computerised physician order entry (CPOE) systems with clinical decision support (CDS) features are one of the most effective strategies to prevent medication errors and improve the quality of care. The effectiveness of these systems ultimately depends on physicians' utilisation of CPOE systems to their full capacity. However, previous studies suggest that physicians' utilisation of CPOE with CDS remains challenging. Research regarding factors associated with the utilisation of CPOE after its full implementation is limited and poorly investigated. The **objective** of this study is to investigate factors associated with physicians' self-reported actual use of CPOE in government hospitals in the context of Saudi Arabia. More specifically, this research aimed to assess the level of physicians' self-reported actual use of CPOE, in order to identify the factors associated with its use and determine how physicians' demographic characteristics affect that use.

Methods This is a mixed-methods study that uses a questionnaire survey and interviews. The participants were physicians working in two government hospitals in Saudi Arabia. The number of complete surveys analysed was 183, and interviews were conducted with 9 physicians.

Results The utilisation of CPOE in government hospitals in Saudi Arabia was high to moderate. Factors associated with its use were related to the user, the organization, or the technology itself. The degree of association varied between the CPOE tasks, and physicians' characteristics also had an impact on use.

Conclusion The findings of this study will provide healthcare professionals, decision makers, and healthcare information system developers with the necessary knowledge that can help healthcare organizations or practices evaluate the utilisation of an existing CPOE system, implement a health application, or update an existing one. This will enhance physicians' adoption of the systems in practice and, consequently, will lead to improved quality of care.

Declaration

I declare that no portion of the work referred to in the thesis has been submitted in support

of an application for another degree or qualification of this or any other university or other

institute of learning.

Copyright Statement

Publications

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Dedication

To all those I love

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Chapter 1: Introduction

1.1 Patient Safety

Healthcare systems around the world aim to provide good quality of care. One element of achieving good quality care is the practice of patient safety (1). According to the Institute of Medicine (IOM), patient safety is defined as 'the prevention of harm to patients' (1). Patient safety can be accomplished through preventing errors, learning from errors when they happen, and creating a safety culture (1, 2). A safety culture is the collection of healthcare professionals' values, perceptions, and patterns of behaviour that establishes their commitment to proficiency and safety in the healthcare environment (2). Medication error is a main concern in achieving patient safety that mainly occurs during the medication prescription process (3). Medication error refers to any preventable event that might cause harm to the patient (4). Such errors usually happen during one of the three points of medication prescription: prescribing/ordering, dispensing, and administering the medication (4). When a patient is harmed due to a medication error, this is referred to as an adverse drug event (ADE) (4). Medication error is a worldwide issue that adversely affects about 1.3 million people and causes one death every day in the US alone (5). In the US, the yearly cost of treating those affected by medication errors is about $20 billion (6). A recent study in the UK reported that about 237 million medication errors occurred annually during the prescription process (7), and 66 million of these were clinically potentially harmful (7). ADEs caused by medication errors cause 1708 deaths and costs the NHS £98 million per year (7). According to the European Medicine Agency's 2013 report, the incidence of medication errors during the prescription process in primary care is estimated at 7.55%, and within in-patient settings, the rate varies between 0.3% and 9.1%

in Europe (8). In low- and middle-income developing countries, the rates of medication errors is no far than that reported in other advanced countries with less chances of treatment and survival, according to the World Health Organization (WHO) (5). The costs associated with medication errors worldwide represent about 1% of the total global health expenditure and equals about US$ 42 billion each year (5).

Evidence shows that medication errors occur more frequently at the prescribing/ordering point than at the dispensing or administering points (9-11). Errors that occur during prescribing/ordering include prescribing the wrong dose or units, selecting the wrong medication due to similarity or confusion between drug names, wrong administration route, or lack of knowledge about possible interactions/allergies (4, 12, 13). Medication errors not only pose an economic burden to health systems but also contribute to increased rates of mortality and morbidity (13, 14). In one study on a sample of 1103 patient records from three hospitals in Brazil, the rate of ADEs caused by medication errors was 2.3% and the associated mortality rate was 8.5% (15). Further, another study among the elderly population in Taiwan reported that ADEs were highly associated with higher comorbidity and costs (16). In the US, ADEs were responsible for additional spending of US$1803.8 for medical expenses per patient and an average extended hospital stay of 5 days (16). In order to tackle this issue, in 2017, the WHO initiated the third Global Patient Safety Challenge called 'Medication Without Harm'. The goal of this initiative was to decrease preventable medication errors around the world by more than 50% by the year 2022 (5).

As the issue of medication errors had started to become a widespread problem affecting patient safety, in 1999, the IOM release a report called 'To err is human' (17). The report calls for developments in the healthcare systems to prevent medical errors and ensure a

safer environment for patients through the creation of a safer health system (17). The report asserts that medical errors are not solely the responsibility of people who work in the healthcare sector, but rather, it is the system itself that needs to be improved and fixed (17). Prevention of medication errors is essential for ensuring a harmless environment. Accordingly, the 'To err is human' report suggested the introduction of new technologies and an improved understanding of the use of information technology (IT) to reduce medication errors (17).

1.2 Healthcare Information Systems

Healthcare information systems (HISs) refer to electronic systems used in healthcare organizations to process and manage patient data (18). These HISs provide a variety of tools and capabilities that can potentially improve patient safety and quality of care by facilitating the healthcare provider's decision making during the process of treating the patient (19). These tools and capabilities provide access to complete patient data (20). They also allow for the storage and retrieval of patient data, and allow caregivers to communicate, track, report, and evaluate the data (20). Hence, these tools help in reducing errors, enhance an organization's productivity and performance, and improve health outcomes (20). The first calling of HIS was introduced in 1984 in response to the need for hospitals to enhance the quality of care and productivity (21). The shift from a paper-based system to a computer information system occurred in light of the overwhelming amount of patient data that was stored in paper-based systems (21). Paper-based systems require considerable space, time, and effort (21). In a paper-based system, patient files and documents might be easily misplaced or lost (22). This might lead to repeat tests, delayed discharge, or legal complications (22). The shift to a computer information system can

make the storage, processing, and management of patient data easier and more effective (21). Additionally, the use of HISs not only supports healthcare providers but also supports patients and clinical research (21). The Agency for Healthcare Quality (AHRQ) asserts that a main focus of using health technologies for patient safety is to reduce errors that lead to ADEs (19). In this regard, electronic health records (EHRs) and computerised physician order entry (CPOE) with clinical decision support (CDS) features that have been designed to support the prevention of medical errors have been found to be a promising solution.

1.2.1 Electronic Health Records

EHRs are a repository of patient health information that are stored in a legible format, can be communicated confidentially, and are accessible to a limited number of authorized personnel (23). The main purpose of an EHR is to maintain the efficiency and quality of integrated healthcare (23). EHRs can also be referred to by other terms such as electronic medical records (EMRs) and electronic patient records, according to the Organization for Standardization (23). The development of EHRs started between 1972 and 1992, with minimal functions added over time as the technology accelerated (24). In 1992, the IOM announced the need to start using EHRs instead of paper-based records due to an increase in issues related to the use of the paper-based system, as mentioned earlier (24). EHRs include patient data such as billing, demographic data, medical history, medication list, lab tests and results, radiology images, physicians' and nurses' notes, etc. (25). More importantly, todays' EHR systems include specific software with certain functionalities, as described by The Health Information Technology for Economic and Clinical Health Act (HITECH) of 2009 in the US, based on the requirements for the meaningful use of EHRs (26). 'Meaningful use' refers to the use of certain features related to error reduction and

cost effectiveness (26). These features include CPOE with CDS tools that help clinicians capture potential medication errors through alerts and reminders and have been shown to enhance the quality of patient care (25). The comprehensive patient data available in one place, combined with the integrated automated intelligent tools of CPOE and CDS, can help in analysing medical history, prescriptions, and laboratory tests (26). This can help decrease potential medication errors through more coordinated care that is supported by data sharing and immediate accessibility by authorized clinicians (26). Although the shift from paper-based records to electronic records has several advantages, several drawbacks have also been identified. These include the financial cost of the implementation and maintenance of electronic systems, compromised privacy and confidentiality of patient data, and the interruption of physicians' and nurses' workflow (26). Yet, most of the reports on the impact of EHRs show positive results. For example, Campanella et al. (27) conducted one of the largest literature reviews on the effect of using EHRs on patient safety and quality of care reported in 47 studies. The results indicated that there was a 30% increase in adherence to the guidelines, a 54% decrease in medication errors, and reduced documentation time (27). The evidence from this review highlighted the importance of using EHRs.

1.2.2 Computerised Physician Order Entry

One of the most common HIS forms used in hospitals around the world is CPOE (28). CPOE is a promising effective intervention that was originally developed to reduces medication errors and improve patient safety of medication errors (29, 30). CPOE is referred to by several other names such as computerised provider entry, electronic prescribing, or e-prescribing (31). According to the Centers for Medicare and Medicaid

Services, CPOE is defined as 'the provider's use of computer assistance to directly enter medication orders from a computer or mobile device. The order is also documented or captured in a digital, structured, and computable format for use in improving safety and organization' performance (32). CPOE can enhance patient safety by reducing medication errors through eliminating mistakes caused by illegible handwriting; further, safeguard functionalities (such as a CDS system [CDSS]) built into CPOE can capture potential ADEs through linkage with EHRs (33).

Despite the IOM's 1999 report 'To err human' that emphasized on the escalating issue of medication errors and the importance of CPOE technology as a preventative strategy to achieve patient safety, very few hospitals in the US adopted CPOE at the time (34). The low tendency toward the adoption of CPOE was mainly due to the financial costs of implementing the system, staff resistance to technology, and shortage of technical infrastructure (34). However, in 2009, the HITECH Act in the USA allocated US$19.2 billion in funds for promoting CPOE adoption in light of the favourable impact of CPOE as a safety measure for reducing medication errors (35). With the HITECH Act promoting CPOE adoption, the percentage of hospitals in the US that have implemented CPOE has rapidly increased (36). Data from the AHRQ showed that 84% of non-federal acute-care hospitals (rural hospitals with less than 25 beds) had implemented an EHR system that included CPOE by the end of 2015 (36).

The implementation and use of CPOE systems linked with CDS features has been found to be associated with a reduction in medication errors (37). CDSS is a software that aims to help the healthcare provider make a clinical decision at the point of care where the patients' information is matched to a computerised clinical knowledge base (38). Studies

have demonstrated the potential of CPOE with CDS features with regard to the reduction of medication errors. In a systematic review of 10 studies on the effect of implementing and using CPOE on ADEs caused by medication errors in inpatient and ambulatory practices (39), the use of CPOE with CDS was associated with a statistically significant decrease in ADEs in five (50.0%) of the studies. Four studies indicated a non- significant reduction in ADEs, and one did not report any change in ADEs (39).

Another recent study on three acute-care hospitals assessed the rate of prescription errors before and after implementation of CPOE (40). At each site, approximately 4000 prescriptions were reviewed before CPOE and 6 months after CPOE implementation (40). The number of opportunities for error and the number of errors that occurred were collated, and the error rates were then calculated and compared between the pre- and post-CPOE periods (40). Across the three sites, for prescriptions for which opportunities for error were identified, the error rate was found to reduce significantly after CPOE implementation, from 5.0% to 4.0% (P < 0.001) (40). Similarly, CPOE was found to be effective in reducing ADEs and medication errors in a review of 16 studies related to different hospital settings (41). The review indicated that there was an over 50% decrease in ADEs among these studies (41). Although empirical evidence from the literature suggests that implementing and using CPOE has the potential to reduce errors that affect the quality of care, issues with the use of CPOE have also been reported by users (e.g. physicians and nurses). These issues included the extra workload (related to entering more information, justifying a treatment, and responding to alerts), resistance to the newly introduced electronic system and preference for the paper-based system, and physicians' perceived threat to their autonomy (as they are usually the decision makers) (42). Alerts, recommendations, and suggestions

by the CDSS were perceived as a challenge to physicians' independent decision-making ability (42). So far, the effects and capabilities of CPOE with CDS features have been explained. The following section will discuss CDS and alerts further.

1.2.3 Clinical Decision Support System

CDSS is 'a software that is designed to directly support healthcare professionals when making clinical decisions related to patients' conditions in which patients' characteristics are matched to a computerised clinical knowledge base' (Sim et al., 2001, p. 528) (38). CDSS is often integrated with the EHR system. It includes functions and tools that help clinicians in decision making (43). It has a variety of functions and tools such as diagnostic support, alerts and reminders, clinical guidelines, order sets, patient data reports and dashboards, documentation templates, and clinical workflow tools (43).

CDS functions integrated within CPOE have shown effectiveness in reducing medication errors (44). These CDS functions provide computerised alerts that work as a drug safety safeguard tool (44). The functions can capture errors during the ordering session related to drug–drug interactions, drug allergy, dosing guidance, or duplication of therapies (44). When any of these errors are detected, the system notifies the CPOE user through a pop-up alert, for example, if the ordered medication interacts with another medication the patient is on; if the patient is allergic to a certain medication; or if an incorrect dose, route, or frequency of administration is prescribed (29). These alerts known as drug–drug interaction alerts, drug allergy alerts, and dosing alerts (45). These types of alerts are among the most frequently disseminated decision support alerts that have been reported to contribute to preventing medication errors and, hence, improved patient safety (45).

Although CDS alerts are designed to eliminate errors and improve patient safety, physicians' decisions in terms of dealing with these alerts can affect their outcomes (45). A major common decision issue related to CDS alerts is physicians' perceived loss of autonomy (42). As described earlier, physicians might perceive these computerised alerts as a threat of their experience or as 'being told what to do' (42). A second issue related to CDSS use is alert fatigue (42). Alert fatigue refers to the mental reaction to an excessive number of alerts received by the clinician (42). An excessive number of alerts leads to alert override (45). The reasons cited for this attitude toward alerts are clinical irrelevance of the alerts or their repetitive appearance, known patient tolerance for a drug, or documented clinician intention to monitor the patient (45, 46). Mitigation strategies to overcome these issues, as suggested by previous studies, include providing physicians with further training and tailoring the alerts according to clinical severity and relevancy (44, 46).

Thus, CPOE with CDS features can reduce medication errors and medical costs, and improve organizational efficiency (47). To achieve these benefits of using CPOE for medication prescription and help it reach its full potential for any healthcare organization, effective use of CPOE by individual clinicians is important (48).

1.2.4 CPOE Systems in the Context of this Research

In this research, the use of CPOE was investigated at two sites that use different information systems. One site uses Cerner Millennium, which offers a simple, intuitive visual interface with functionality that allows physicians to view clinical data, complete orders, and optimise clinician documentation in the form of one powerful solution (49). It includes a physician-centric ordering application that works in conjunction with Cerner Millennium's robust data repository, viewer, clinical documentation tools, and CDS tool. Physicians

view results and existing orders; place orders; and modify, renew, and co-sign orders. Physicians can modify an order, and the history of the order is retained without the need for additional steps. Its time-saving features include pre-built order sets and sentences (49). The other site uses the BESTCare system, which is an all-in-one system that integrates the outpatient department, inpatient department, intensive care unit, emergency room, and operating room units (50). BESTCare consists of three major applications, an information infrastructure, and channel domains (50). It has various applications, such as EMR, CPOE, and CDSS (50). BESTCare promotes the 'smart hospital' approach by providing electronic exchange of clinical documents and electronic services to support decision-making among healthcare providers for patient-centred care (50). It also provides educational tools for physicians, trainees, and patients (50).

Figure 1.1 presents a diagram depicting the workflow of the CPOE system for medication ordering.
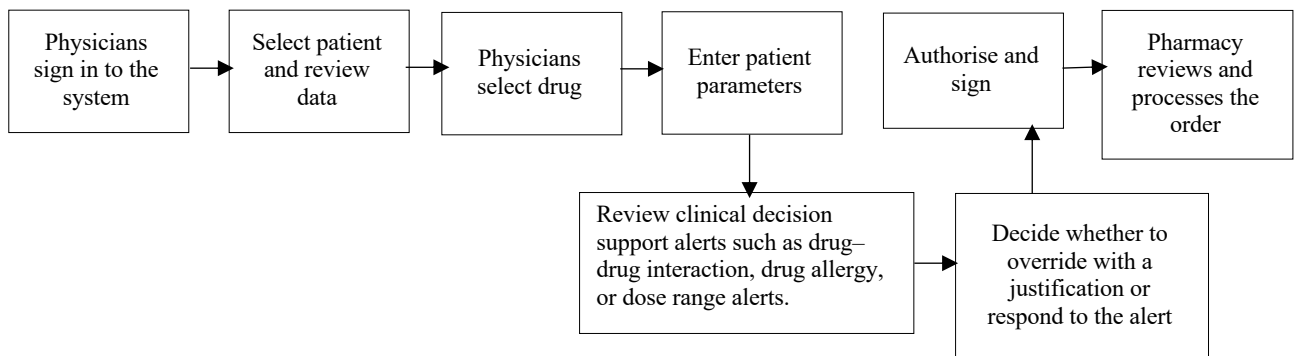
Figure 1.1 Workflow of the CPOE System for Medication Prescription

1.3 CPOE on a Global Scale

Many countries around the world have implemented CPOE within their healthcare practices (51, 52). Implementation refers to the time between deciding to introduce a new system and the activities involved in this decision by the hospital, which includes installing and configuring the new solution and training staff on how it works, up to the point at

which the system is ready for use (53). In the US, Canada, and Europe, CPOE has been available across hospitals for more than 20 years (51). In 2002, a survey conducted among hospitals in the US to assess the availability of CPOE among hospitals showed that CPOE was available for use in only 9.6% of hospitals (6000 hospitals) (54). Another study conducted in 2009 examined the availability of CPOE in seven industrial countries (51). The findings of the study indicated that the CPOE implementation process was slow in all the countries because of the large amount of funds required to install and integrate it with the hospital system (51). The decision to implement CPOE in the first place usually starts at the organizational level, where the decision is affected by the high cost of installing a CPOE system (55). That is, the high cost may hinder many healthcare organizations from installing such a system within their practice (55). In accordance with these findings, Aarts and Koppel (51) also reported that the adoption rate of these systems was low. Adoption starts with the user becoming aware of the new technology integrated with their workflow, and ends with the user embracing the technology and making full use of it (56). Aarts and Koppel's (51) findings showed that CPOE was adopted by 15% of hospitals in the US, 2% of hospitals in the UK, and 20% of hospitals in the Netherlands; however, very few hospitals in Germany, France, and Australia had adopted the system. The reasons for the low rates of adoption were similar in all the countries and mainly included the poor integration of CPOE with other systems in the hospital, physicians' resistance to the new technology, the poor design of the interference that made it difficult for physicians to perform tasks, and excessive alerts from the CDSS (55). In later years, other studies showed that the adoption rate had increased in some of these developed countries. For example, in the US, a study on the relevance of CPOE use in outpatient clinics (36) showed that

between 2014 and 2016, the overall use of CPOE increased from 58% to 67% among ambulatory practices (36). In the UK, an investigation was conducted to evaluate the status of NHS trusts in an implementation plan for e-prescribing medication in 2013 (57). Out of 55 NHS trusts that were assessed, 30 (55%) were planning to implement or were in the process of implementing a system, 11 (20%) were currently implementing a system, 10 (18%) had already implemented a system, and 4 (7%) had no current plans for implementing an e-prescribing system (57).

In some developing countries, despite the availability of several types of computerised health systems, such as EMRs, CDSS, CPOE, and telemedicine, these systems are not properly used due to the limited resources available to develop these systems and the lack of research about the reasons for the low rates of acceptance and use (52). Overall, research on the availability of CPOE in hospitals in different contexts around the world suggests that the implementation and adoption of a system after it has been introduced appear to be low (51, 52, 58).

1.4 Saudi Arabia—An Overview
1.4.1 Profile of Saudi Arabia

The Kingdom of Saudi Arabia is located in southwestern Asia (59). It has a population of over 34,000,000 and an area of around 2,000,000 square kilometres (60, 61). In Saudi Arabia, executive authority is held by councils of ministries (62). Each ministry is responsible for the executive and administrative matters of the country's main sectors such as defence, finance, health, and education, and these sectors are administered through numerous separate agencies (62). Saudi Arabia's administrative structure includes 13 administrative provinces/regions (63): Tabuk, Al Jawf, Northern Border province, Al Madinah, Ha'il province, Makkah, Qassim, Riyadh, Eastern province, Jazan, Asser, and

Albaha (Figure 1.2) (63). Each of these regions has a number of governates and centres under them.

Figure 1.2 Map of Saudi Arabia (64)

1.4.2 Structure of the Healthcare System in Saudi Arabia

Healthcare services in Saudi Arabia are delivered through three leading sectors: the Ministry of Health (MOH) hospitals and primary care centres, governmental healthcare institutions, and private hospitals (65). The MOH provides 60% of the services and 20% is managed by other governments entities, while the remaining healthcare facilities are owned by the private sector (65) (Figure 1.3).
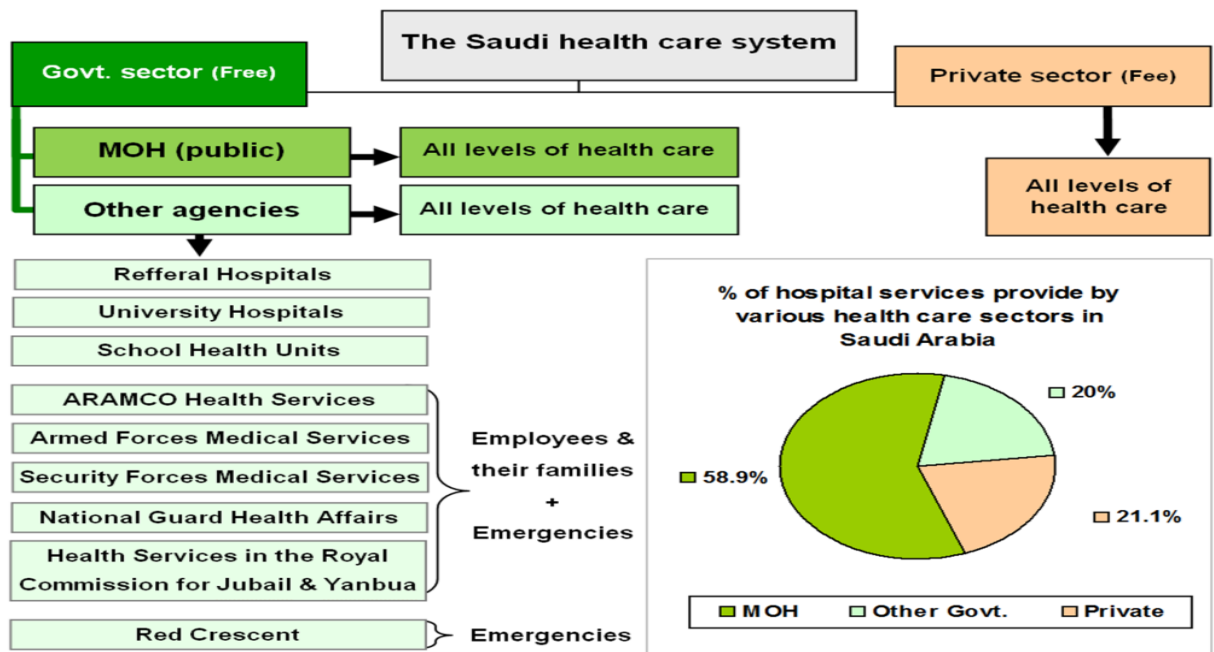
Figure 1.3 Structure of the Saudi Arabian Healthcare System (66)

MOH hospitals and the primary healthcare centres are public healthcare facilities that provide free services for the general public (65) that include preventive, therapeutic, and rehabilitative services (65). MOH facilities cover all regions of Saudi Arabia (65). Governmental healthcare organizations that are managed under other entities include healthcare facilities managed by other ministries and serve a certain segment of Saudi citizens (67). Due to the considerable budgets provided by its ministers, these are highly qualified facilities that are usually equipped with more advanced technologies and resources (67). A couple of examples of government healthcare facilities include the Medical Services Department of the Ministry of Defence and Aviation, which serves Saudi military personnel (67), and the National Guard Health Affairs (NGHA), which is managed by the Ministry of National Guard and serves national guard personnel and their families (67). In addition, university hospitals are educational hospitals associated with medical

schools that are managed by the Ministry of Higher Education and serve students and faculty members and their families (67).

1.4.3 E-Health in Saudi Arabia

As a major provider of free healthcare services to the public in Saudi Arabia, the MOH is working on implementing a highly ambitious program to achieve its vision for e-health, which is to provide a safe, efficient health system based on patient-cantered care delivered according to set standards and supported by e-health (68). E-health refers to the delivery of healthcare services through the use of information and communication technologies such as EHRs, HISs, remote monitoring and consultation services (e.g. telehealth, telemedicine, and telecare), and health data analytics (69). In 2008, the MOH allocated over 4 billion Saudi riyals (US$1.07 billion) to the development of e-health programs in order to increase the level of maturity of information technologies in healthcare organizations around Saudi Arabia (70). This program includes the transition from paper-based systems to EHR systems (70). In line with this, in 2011, the MOH announced the aim of the national e-health strategy to transform healthcare provision into an electronic system by building a central national database for EHRs to provide secure communication links with all MOH hospitals and primary healthcare centres (71). The plan is to achieve the aim of shifting to an e-health system in two phases of five years each (68).

Among the different e-healthcare applications, the adoption of EHRs by healthcare organizations in Saudi Arabia has been increasing rapidly. For example, in 2014, a study in Riyadh (the capital of Saudi Arabia) involving 22 hospitals (public and private) aimed to assess the level of implementation of EHR systems (72). The study reported that 11 hospitals had implemented fully functioning EHR systems and 8 hospitals were in the

implementation phase (in progress), while 3 had not yet implemented the system (72). According to a later study (2018) on 15 public hospitals in the Eastern region, 7 hospitals had fully implemented an EHR system, 7 were in the implementation process, and 1 did not have a system yet (73). Studies on EHR prevalence in Saudi Arabia have reported that even though the progress of implementation can be considered favourable, there are challenges that are delaying faster implementation, such as resistance to use, lack of awareness about the benefits of the systems, more training for support staff, extra workload on physicians and nurses, lack of sufficient training, and low computer literacy (72, 74).

Although 40% of MOH hospitals (274 hospitals) currently have EHR systems, primary healthcare centres still rely on paper-based records and are transitioning towards the adoption of IT (75). All other governmental hospitals under government entities have EHR solutions within all their facilities (75). The CPOE system was introduced to hospitals in Saudi Arabia about 15 years ago (76). It was implemented and adopted in two major government hospitals that represented about 1% of hospitals at the time (76). The main challenges that explain the low implementation at the time were the high cost of implementation, lack of well-trained staff, and lack of technical infrastructure (76). However, since then, the adoption rate has accelerated among government hospitals (77-81). Most of these government facilities use a CPOE system in conjunction with CDSS features (74). There are no specific data about the number of governmental hospitals or a complete list of hospitals that have a CPOE system with CDS features within their information systems. Nonetheless, here is a list of government and MOH public hospitals that are currently using CPOE with CDS features according to the available literature.

Table 1.1 Government and MOH Hospitals using CPOE with CDS in Saudi Arabia

Hospital Name	Sector	Beds	City	References
King Abdulaziz Medical City, Riyadh	National Guard Health Affairs	1501	Riyadh	(78, 82)
King Abdulaziz Medical City, Jeddah	National Guard Health Affairs	751	Jeddah	(78, 83)
King Faisal Specialist Hospital and Research Center (KFSH&RC)	Referral Hospital	536	Jeddah	(84, 85)
King Faisal Specialist Hospital and Research Center (KFSH&RC)	Referral Hospital	1589	Riyadh	(85)
Security Forces Hospital	Medical Services of the Saudi Ministry of Interior	295	Makkah	(86)
Prince Sultan Military Medical City	Armed Forces Medical Services (Ministry of Defense and Aviation)	1192	Riyadh	(87)
King Fahd Hospital of the University (KFHU)	University Hospital	381	Khobar	(88)
Dammam Central Hospital (DCH)	MOH	380	Dammam	(88)
King Fahd Specialist Hospital in Dammam (KFSH-D)	MOH	630	Dammam	(88)
King Saud Medical Complex (KSMC)	MOH	1500	Riyadh	(77)
King Fahad Medical City Hospital (KFMCH)	MOH	1200	Riyadh	(81, 89)
King Khaled Eye Specialist Hospital	MOH	250	Riyadh	(90)

1.4.4 Issues in Saudi Arabia's Healthcare System

According to the 2019 report of the Institute for Health Metrics and Evaluation, cardiovascular diseases, strokes, depressive disorders, chronic kidney disease, and diabetes were identified as the major causes of death in Saudi Arabia (91). The rapid growth of the Saudi population at an annual rate of 2.52% and the costly treatments for these diseases, in particular, is creating an economic burden for the Saudi government (92). This is only one of the many challenges that the Saudi healthcare system is facing currently, with the other

issues being shortage of healthcare professionals and lack of a unified national HIS (92, 93). In addition, issues related to medication errors and patient safety cannot be excluded. The overall prevalence of medication errors in Saudi Arabia is not clear, but studies have indicated that it is an issue in the Saudi healthcare system. One study reported that among 10 primary healthcare centres (including 5 public and 5 private centres), medication errors account for 18.7% of all reported errors (94). Further, out of 5299 prescriptions, prescribing errors were found in 990 (94). In a recent review that evaluated the medication error rate among hospitals in Saudi Arabia, the results estimated a prescription error rate of 40.2% out of the total number of reported medication errors (95). The study stated that computerising the medication process system in hospital settings could help reduce the incidence of prescription errors (95). In an observational study involving data about medication errors reported by the General Department of Pharmaceutical Care of the MOH, across 265 government hospital and primary care centres, a total of 71322 medication errors were reported between March 2018 and June 2019 (96). About 84.8% of the errors were detected in the prescription stage, which was followed by the transcribing (5.8%) and dispensing (5.7%) stages. A total of 4,182 (5.8%) errors reached the patient (96). These errors were attributed to work overload and lack of experience (96). The study recommended that CPOE with CDS features be adopted as a strategy to prevent errors (96). In 2010, a meeting was conducted to explore the factors associated with medication errors; this meeting included 65 physicians, pharmacists, nurses, academics, and nurses from different hospitals and community pharmacies in Saudi Arabia (97). The discussion revealed that communication issues between healthcare facilities and the lack of CPOE were the main reasons for medication errors (97). In particular, there was an emphasis on

the use of CPOE as a major contributor to preventing these issues (97). In light of these challenges, it was necessary to use prevention strategies such as CPOE and CDS, which are known to be the most effective strategies for reducing errors (29). Hence, in response to the issue of medication errors a number of healthcare organisations have started integrating CPOE into their systems.

1.4.5 CPOE Use in Saudi Arabia

In consideration of the aim of this study, the literature on factors related to the actual use of CPOE in the Saudi Arabia healthcare setting will be discussed. Most studies discussing the use of CPOE have only focused on certain topics related to CPOE within healthcare practice. For example, five studies assessed the impact of CPOE on medication errors and patient safety (79, 98-101), and three studies discussed CPOE alerts.

Khalifa and Zabani (84) studied the issue of alert fatigue and suggested strategies to reduce it by minimising alerts. In addition, Yossef and Alharthi (102) studied the effectiveness of the drug alert system in CPOE in reducing the prescription of medications that are contraindicated in patients with chronic kidney disease. Further, Alsaidan (103) assessed alert handling practices in terms of the rate of overridden alerts and the appropriateness of alert displays. Mominah et al. (89) discussed the impact of using CPOE on pharmaceutical department workflow. One study reported factors that contribute to the identification of drug prescription errors during the dispensing processes (104). Almutairi et al. (81) evaluated the implementation status of some CDSS features implemented along with CPOE at three different hospitals.

Four studies focused on the users' perspectives about CPOE, as follows. Saddik and Almansour (105) investigated nurses' views about the features of a newly introduced

CPOE system, and Saddik and Alfirdan (80) assessed physicians' satisfaction with a newly introduced CPOE. Barakah and Alwakeel (77) assessed the rate of acceptance of CPOE among physicians after 1 year of use, while Altuwaijri et al. (78) assessed the experience of the organization during the CPOE installation process in terms of making a decision about expanding it to all departments of the hospital. Although these four studies discussed the user in relation to CPOE, they only provided a partial evaluation of the topic, as all of them were conducted during the implementation stage or shortly after implementation. The timing of the study, which is shortly after the implementation of CPOE, reflects the perceptions of users who are still learning about the system, and the factors affecting their use may change with experience and time. Further, these studies were conducted a while ago (prior to 2015). There is no doubt that new developments and advances have occurred in the technologies that were used in the past, and physicians have also been exposed to new training methods and strategies.

In the context of the current study, CPOE has been in use for years. While the utilisation of the CPOE system has been studied in many different contexts and from different perspectives, the factors associated with the actual use of CPOE for prescribing medications in the context of Saudi Arabia are poorly investigated. The initial literature review indicated that there is no empirical research on the factors associated with physicians' actual use of CPOE in government hospitals in Saudi Arabia. It is known that CPOE is available at hospitals in Saudi Arabia, and post-implementation assessments considering the users' perspective were undertaken shortly after its implementation in two studies only. However, there is no evidence that any study has investigated factors associated with the actual use of CPOE after years of routine use, particularly the level of

utilisation of the three drug safety alerts (drug–drug interaction alerts, drug allergy alerts, and dose alerts). Exploratory studies conducted shortly after implementation may reflect factors that are different from those reported after several years of utilisation. Early adopters of a newly introduced systems may show hesitation and resistance towards its use, as they would be in the learning process (106). Their experience in the beginning would reflect a different perspective from that of someone who has used it for longer periods (106).

1.5 Actual Use of CPOE as Reported in the Literature

In general, most of the existing literature and studies on the use of healthcare technologies within healthcare practices focus more on assessing factors that affect the intention to use the technologies, a not-yet-available system (pre-installation stage), or the acceptance of a newly introduced system. There are not enough studies on the actual usage of CPOE (a system that has been routinely used for years) and the factors related to its usage (107). A review of the literature showed that there were a very limited number of reviews with a focus on CPOE for prescription (31, 48, 108, 109). The evidence from these reviews shed light on the factors affecting healthcare providers during the ***implementation and adoption phases***, rather than the factors affecting the ***actual use*** of CPOE. Actual use is defined as a behaviour that can be measured through indicators, such as an individual's frequency or duration of usage (110). The term 'system usage' consists of three fundamental components: the subject using the system (user), the system itself, and the task to be accomplished through the system (111). In this study, actual use refers to usage of the system as measured through physicians' self-reported frequency of use. The actual usage

of a system occurs after the system has been implemented and fully adopted and embraced by the user (112).

Van Dort et al. (48) discussed medication-related CDS after it was fully implemented; however, their paper included evidence only from qualitative studies. Additionally, there was no indication that the actual usage, as defined here, was the main focus of their review. Farre et al. (108) discussed various types of users' or stakeholders' perceptions about CPOE during the implementation, adoption, or usage phases. The review also only included qualitative studies (108). Each of the phases was associated with different influential factors. According to Gagnon et al. (31), user perception tended to change between the different phases of implementation of e-prescription systems

Gagnon et al. (31) discussed the barriers and facilitators associated with the implementation of CPOE in primary care centres as reported by various healthcare professionals, e.g. physicians, nurses, and pharmacists. Kruse and Goetz (109) also studied the barriers to the implementation and adoption of CPOE, but their study focussed on the US healthcare system only.

The current research focused entirely on physicians as users and the factors that were likely to affect their usage, as professionals from different disciplines might be affected by different factors in their decision to use CPOE for prescribing medication. The aforementioned reviews produced evidence about factors that affect the use of these systems based on the different perspectives of different types of users and certain contexts; their focus was not on actual usage but, rather, on the earlier stages of implementation and adoption. Additionally, most of the studies included in these reviews were conducted in industrialised western countries (e.g. the US, the UK, Sweden, the Netherlands, Australia,

and Canada), and only one study was conducted in a developing country. Their findings shows that there is a huge gap in the evidence found in prior reviews on the factors associated with the actual usage of CPOE for prescribing medication, especially in developing countries (52). The studies identified within the context of Saudi Arabia fail to provide information about the factors associated with actual usage after a long period of CPOE use. A review of the literature showed a few studies that specifically discuss factors associated with the actual use of CPOE. This led to the following research question: What are the factors associated with physicians' actual use of CPOE in government hospitals in Saudi Arabia? Before answering this question, it is necessary to summarise the research problem.

1.6 The Research Problem

CPOE systems with CDS alerts have resulted in a significant reduction in medication errors. The main motivation for CPOE usage is the potential it has to eliminate certain elements of human error and, thus, improve the process of care (17). However, the success of CPOE is not guaranteed upon its implementation only. Ensuring that CPOE systems are being used to their full capacity is critical for obtaining their maximum benefits. Despite the body of evidence informing the prevalence and availability of CPOE and the potential benefits of using CPOE for medication prescription in healthcare practices (47, 113-116), cases from around the world have shown that the actual utilisation of CPOE systems is associated with certain factors that make CPOE use challenging for physicians (117-121). This affects physicians' performance and, consequently, patient safety and quality of care. Thus, this research aims to investigate the factors associated with physicians' use of CPOE

and the significance of the association in the context of government hospitals in Saudi Arabia.

Based on the previous discussions about the issue of medication errors and how the implementation and usage of CPOE can reduce these errors and, hence, enhance patient safety and quality of care, the next section is an overview on technology use and acceptance theories.

1.7 Theories on Technology Acceptance and Use

The literature contains many theories that can explain the acceptance and usage of technology in the workplace. The following sections present theories that the literature indicated to be the most relevant and appropriate for use when assessing the use of technology in healthcare (122-124).

1.7.1 The Technology Acceptance Model

The technology acceptance model (TAM) is a technology acceptance theory that can explain and predict behaviour in terms of the use and acceptance of ITs (125). It consists of two main determinants of user behaviour: perceived usefulness and perceived ease of use (Figure 1.4) (126). Perceived usefulness is the extent to which the user believes that using a system would enhance their job performance (126), while perceived ease of use is the extent to which a user believes that using a certain technology is free of effort (126). TAM can explain 40% of user behaviour, according to Venkatesh and Davis (127). However, TAM has been criticised for its limited explanatory power (128). In order to improve it, an extension of TAM was introduced by Venkatesh and Davis (127) that includes two collections of constructs: social influence (image, subject norms, and voluntariness) and cognitive constructs (result demonstrability, job relevance, and output

quality). Venkatesh and Bala (129) introduced TAM 3, which is a combination of TAM

and TAM 2 and includes antecedents that explain the perceived ease of use.
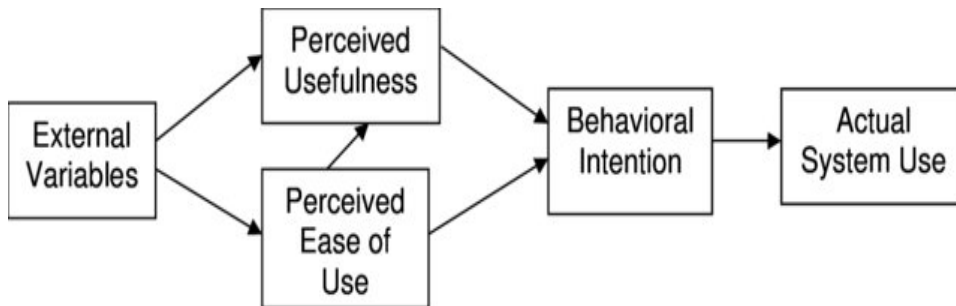
Figure 1.4 Technology Acceptance Model (125)

1.7.2 The Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a unified model

that can explain and predict an individual's intention to use and actual use of technology

(130). It consists of four key constructs, namely, performance expectancy, effort

expectancy, social influence, and facilitating conditions (131), and four moderators, i.e.

age, gender, experience, and voluntariness (Figure 1.5). Performance expectancy refers to

a user's perception that using a certain system will improve his/her job performance (131).

Effort expectancy refers to the user's belief that using the system is effortless (131). Social

influence refers to user's perception of the importance of the opinions of others (co-

workers/supervisors) about whether he/she should or should not use the system (131).

Facilitating conditions refer to recourses, facilities, and infrastructure that help physicians

in utilising the system (131). The UTAUT model was developed by combining eight of the

most influential technology acceptance theories; this gives UTAUT a level of

comprehensiveness that is not achievable with any of the other models alone (131).

Venkatesh et al. (131) demonstrated that the UTAUT model can explain 70% of user

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behaviour and usage; this means that the model has more explanatory power than any other

proposed model.
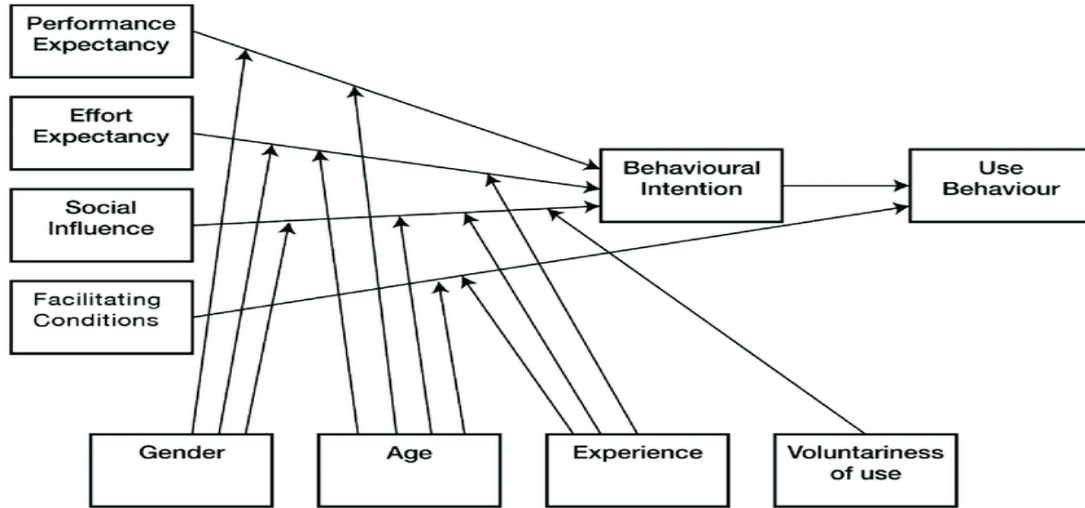
Figure 1. 5 The Unified Theory of Acceptance and Use of Technology (131)

1.7.3 The DeLone and Mclean Information Systems Success Model

The DeLone and Mclean Information Systems (D&M IS) success model is used to assess

and understand the success of any information system and its impact on the individual and

the organisation (132). It consists of six dimensions: system quality, information quality,

service quality, intention to use/use, user satisfaction, and net benefits (132) (Figure 1.6).

System quality refers to the quality of the system's capabilities such as functionality,

reliability, flexibility, data quality, portability, integration, adaptability response time, and

usability (132). Information quality refers to the quality of information (the output) the

system provides in terms of accuracy, timeliness, completeness, relevance, and consistency

(132). Service quality refers to the quality of the IT support/IT department provided to

users (132). Intention to use/use measures the degree to which the system is being utilised

(132). User satisfaction is used to measure the satisfaction of the user and net benefits,

which represent the overall value of the usage to the stakeholders (132).

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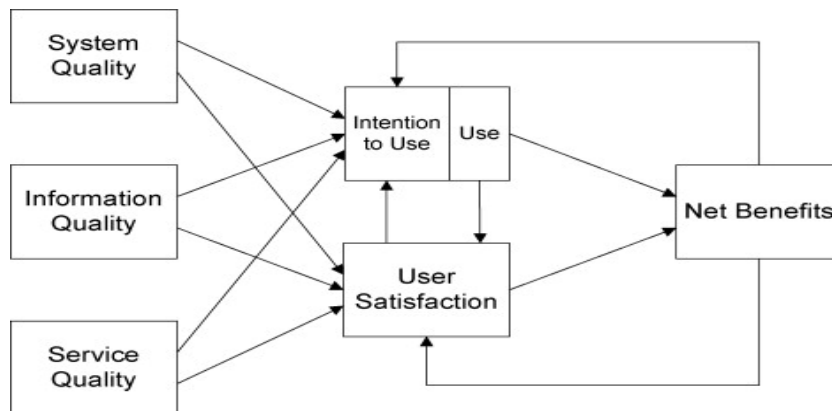
Figure 1.6 The D&M IS Success Model (132)

1.8 Rationale

Measuring the acceptance of a newly introduced system or the acceptance of a future implementation is usually done through assessing users' intention to use (133). However, when a study seeks to explain users' utilisation of a fully implemented available system for use, actual use refers to the action to be measured (123, 134). The CPOE system in the context of this study has been in use for many years. It is a fully implemented CPOE system in the sense that it has all the main CPOE functions and CDS drug safety alerts. Users of the system are fully aware of it and are already trained in its use. Further, it has been integrated with their workflow, and its use is mandatory. It has frequent users and, thus, actual use is the appropriate action to measure. The problem here is that although CPOE has been available for some time and has been fully adopted by physicians, the literature reports that issues and challenges remain with the utilisation of CPOE. These limitations prevent users from gaining full value of the system and fulfilling the aims of using the CPOE system.

These issues are mainly related to the user, the organization, or the system itself. For example, one of most significant issues with the use of CPOE is alert overrides. A study that assessed physicians' responses to drug safety alerts in CPOE found that of 307 alerts assessed, 246 (80%) were judged to have been displayed appropriately and 244 (79%) were overridden appropriately. The override rate calculated was higher than the rates reported in the international literature (102). Other than override, alert fatigue, the complexity of the software, system malfunction, and time constrains are also examples of reported issues that have implications for physicians' use of CPOE (135, 136). As the usage of CPOE is mandatory for physicians in almost all healthcare contexts, the physicians' performance, physician–patient communication, and the overall process of the delivery of healthcare can be affected. Hartwick and Barki (137) asserted that in settings where using a system is mandatory, users still have control over the level or extent of use based on their personal judgments (e.g. attitude and intention) and that the reported variance in their usage behaviour qualifies measures of use as a valid dependent variable for information systems research. Thus, it is worth asking the question 'Which factors are associated with physicians' actual use of CPOE?' A wide range of studies have discussed factors related to CPOE use. However, most of these studied are limited to the pre-implementation phase, the post-implementation phase, or the initial stage of adoption rather than actual use after long-term interaction with CPOE. Hence, it is necessary to measure the actual use of CPOE to explain the factors associated with its use.

CPOE is an IT, and these technologies are dynamic in nature in terms of development, impact, and their usage under complex organizational settings (138). Such systems are exposed to developments, upgrades, maintenance, and long periods of use (138). As the

maturity of the CPOE system changes over time, it is important to seek a full understanding of the factors associated with the system that affect its usage. Additionally, the goals and views of the users and organization are subject to change over time, so it is important to conduct studies on the actual use of the systems. That is, the actual use of physicians needs to be evaluated at different points of time and not just shortly after implementation or in the pre-implementation stage. Assessing physicians' actual use of CPOE would provide complete insight into the drivers of its utilisation and the factors that affect that usage; that is, it would provide insight into whether the system is being utilised to its optimal level and whether its maximum benefits and main goals (patient safety and quality of care) are being achieved.

This research focuses on investigating factors related to the use of CPOE in terms of the order entry task of medication prescription including laboratory tests in conjunction with CDS features for medication safety in government hospitals in Saudi Arabia.

Government hospitals embraced CPOE with CDS several years ago, so these hospitals are technologically mature. The scope of this research can be extended to other healthcare settings that use a CPOE system for prescribing with CDS features related to medication safety, but not to healthcare settings that do not have the system yet or have CPOE with no CDS features.

1.9 Research Questions, Aim, and Objectives

To achieve the key aim of this research, the following research questions were formulated:

Q1. What are the factors associated with physicians' self-reported actual use of CPOE in government hospitals in Saudi Arabia?

Q2. What is the level of utilisation of CPOE tasks?

Q3. Is there an association between physicians' characteristics, namely, position, age, gender, and years of experience, and the level of utilisation of CPOE?

Q4. How significant is the association between the identified factors and the self-reported actual use of CPOE for prescribing?

To answer the above research questions, five objectives were developed. These objectives are as follows:

Objective 1. To perform a systematic literature review on factors associated with the actual use of CPOE for prescription. This will be performed in order to identify factors associated with the actual use of CPOE for prescribing medicines among physicians.

Objective 2. Develop a survey questionnaire to evaluate physicians' levels of self-reported actual use of CPOE for prescribing medication and the factors associated with it.

Objective 3. Statistically examine the correlation between the identified factors and the self-reported actual use of CPOE for prescribing medication.

Objective 4. Statistically examine the association between physicians' characteristics (namely, position, age, gender, and years of experience) and the use of CDS tasks.

Objective 5. Conduct interviews and observations to further investigate physicians' perspectives on factors associated with the use of CPOE for prescribing medication.

This thesis consisted of seven chapters. The content of each chapter is summarised below:

- *Chapter 1—Introduction:* Chapter 1 discusses HISs in relation to patient safety, the context of this research (which is Saudi Arabia), and the literature concerning the actual use of CPOE. It also outlines the research problem, theories that explain the

use of information systems, and the rationale of this research. Lastly, it summarises the research aim and objectives and the overall structure of this research.

- *Chapter 2—Systematic Review:* This chapter presents a systematic review of the evidence on the actual use of CPOE. It explains the methods used for reviewing the literature, presents the results, and discusses the review findings with a critical analysis. In this way, it identifies the gap in studies related to the actual usage of CPOE that this research seeks to fill.

- *Chapter 3—Research Methodology:* This chapter introduces the methodological approaches used to conduct this research study. Information provided in this chapter includes the research philosophy, the research approach, the research design, population and sampling, the data collection tools and procedures, the data analysis technique, and finally, ethical considerations.

- *Chapter 4—Quantitative Results:* This chapter explains the results of the quantitative data. It includes a descriptive statistic of the participants' characteristics, the actual usage tasks, a descriptive statistic of all the study's variables, and the correlation between these variables and the self-reported actual use of CPOE.

- *Chapter 5—Qualitative Results:* This chapter discusses the findings of the qualitative approach. It summarises the themes that emerged from physicians' perceptions about the usage of CPOE through a thematic analysis approach.

- *Chapter 6—Discussion:* This chapter presents the interpretation of the results obtained from the findings of the survey and the interviews in conjunction with the existing literature. The research limitations and future work are also discussed.

- *Chapter 7—Conclusion:* This chapter presents the conclusions drawn from all the results. This includes a summary of the key findings and the research's recommendations and contributions.

Chapter 2: Systematic Review

2.1 Introduction

This chapter presents the systematic literature review performed for this research. This review was published in March 2021 (See Appendix A). The aim of this review was to identify factors associates with the actual use of CPOE for prescribing among physicians and the knowledge gap related to the topic of this research. The chapter starts with the theoretical grounding used in this research study. Followed by describing the detailed process of the methods, results, and the discussion. The final section is a summary of this chapter.

2.2 Selection of Theoretical Grounding

Based on scoping review on factors related to the use of healthcare technologies the UTAUT model and D&M IS Success model were selected to explain physicians' actual use of the CPOE for medication prescribing. The integration of the two theories provides a comprehensive understanding of the CPOE usage compared with what would be acquired using either model alone. Various researchers have acknowledged the necessity for an interdisciplinary framework when examining the use of information systems. The integration between the UTAUT and the D&M IS Success model have been empirically validated in many research contexts. For example, Cheng et al.(139) examined customers' perceptions of internet banking through an integration between UTUAT constructs and the IS model. Handayani et al.(140) developed an integrative model to study user acceptance of a HIS. Talukder et al. (141) studied different types of employee acceptance of an open government data system in Bangladesh. Sambasivan et al. (142) also used both models to determine the factors that influence the usage of a G2B system (e-government system) by various ministries in the Government of Malaysia. The great value behind combining these

two models is that it enables the examination of factors external to the system (UTAUT) and factors internal to the system (IS Success) that affect system usage. The examples of previous applications of integrating both models across various contexts indicates a greater cognitive understanding of system usage behaviour in each of those contexts (139-142). Each of these models can provide an explanation of the actual use experience from different perspectives. The UTAUT provides a framework of users' perceptions and views, whereas the D&M IS Success model provides a framework for the technological aspect of a system's functions that may influence the use (131, 132). The UTAUT was a more holistic model than TAM, as it overcame TAM's limitation by including 2 other predictors (social influence and facilitating conditions) that covers all aspects of the individual behaviour towards usage. Unlike TAM that has focus on two predictors only. Additionally, the UTAUT considered moderators of the users' characteristics (e.g. age and gender) that also has an effect on the use that are not a part of TAM's predictors. The comprehensiveness of UTAUT gives it more explanatory power than TAM. For example, Ling et al. (143) wanted to investigate the actual determinants of computer usage among school teachers in Malaysia using a technology model. They reviewed and compered between UTAUT and TAM to decide which of these models would serves better their study's objective (143). Their findings showed that UTAUT was a better application than TAM as it can help them in predicting the determinants for usage (143). UTAUT origins was to be employed in many contexts such as business, health, banking, accounting, media, and education while TAM was mainly design to business and commercial contexts with limited application to educational settings (143). UTAUT can predict up to 70% of the usage behaviour, while TAM can explain 40% (143). UTAUT consists of 4 constructs and moderators that may

predict the usage behaviour while TAM consist of two (143). Therefore, they chose UTAUT. In another study to measure bank employees intensity of internet usage and estimate the most significant factor to adopt or not adopt, they compered between TAM and UTAUT in measuring usage (144). Results of discriminant analysis of both models showed that UTAUT predicted the usage intensity by 81.5%, whereas TAM was 71%. UTAUT showed a higher prediction power in measuring the intensity of internet usage more than TAM (144).

Although UTAUT provides an meaningful explanation into the use of technology and how might certain factors affect that behaviour (145), a limitation of the UTAUT model is that it fails give a sufficient consideration for the technical attributes of the system itself (e.g. functionality, interoperability, integration) with other systems that may be associates with the actual use. This shortcoming of UTAUT was acknowledged by Ammenwerth (146). Considering the shortcomings of UTAUT, this present study integrated D&M IS Success model. The D&M IS Success model would explain the complex technical side of the CPOE given that the CPOE is a type of a software that consists of many functions and features that help physicians with their clinical decisions. It is often integrated with other systems within the health organisation, such as the EHR. That makes the CPOE complex interventions functioning in complex healthcare systems, and as such, are challenging to design, implement, and evaluate (147). Hence, CPOE exposed to internal-technical system errors, as any technology is. This enhances the relevance of the D&M IS Success model. The combination of the UTAUT and the D&M IS Success model is complementary and can provide a complete theoretical grounding for assessing the factors associated with

CPOE actual use and thus, offer greater explanatory power. Figure 2.1 presents a combined

model of UTAUT, and the D&M IS Success model.
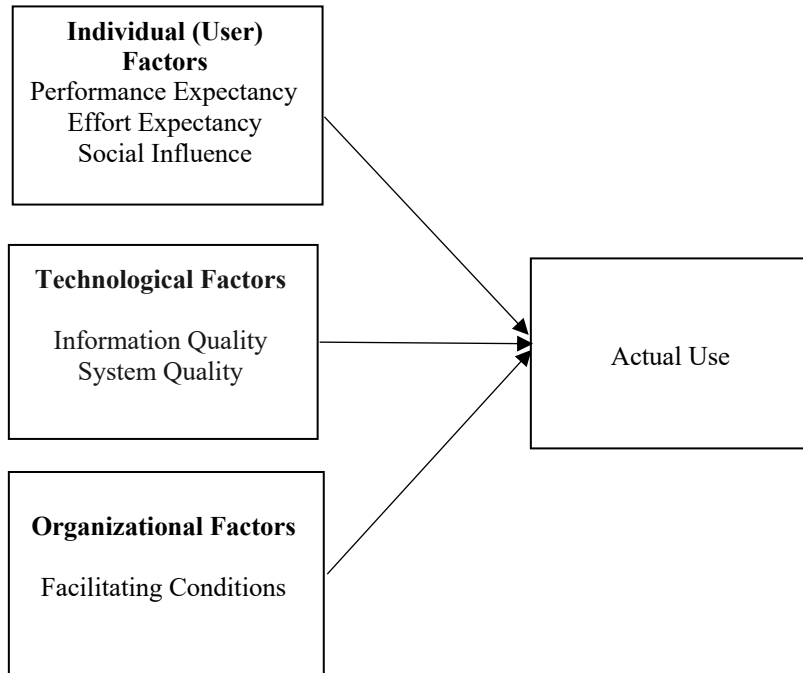
Figure 2.1 Combined Model of UTAUT and the D&M IS Success model.

The following section presents the systematic literature search that was performed to

identify the factors associates with the actual use of CPOE by physicians.

2.3 Methods

2.3.1 Search Strategy

This literature search was based on the PRISMA (Preferred Reporting Items for Systematic

Reviews and Meta-analyses) guidelines (148). PRISMA is a set of instructions on how to

report literature reviews, or evaluating an intervention (149). The literature search started

with searching the following databases from September 2019 to December 2019: PubMed,

Embase, Ovid MEDLINE, and CINAHL. The search was performed without any

restrictions on dates; however, it was limited to English language papers. Reference lists

in the identified reviews and included studies were checked also to retrieve relevant papers.

Medical subject headings (MeSH terms) related to CPOE retrieved from PubMed and keywords from the relevant research literature were combined (Table 2.1).

Table 2.1 MeSH Terms and Keywords used in the Searches of PubMed, EMBASE, Ovid Medline, and CINAHL.

Group A: names of the system	Group B: usage	Group C: factors
1.Medication alert systems 2.Computerised provider order entry 3.Computerised physician order entry 4.CPOE 5.Electronic prescription 6.Prescription decision support system 7.Computerised prescriber order entry 8.Pharmaceutical decision-support systems 9.Pharmacy information system 10.1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	1.Use 2.Actual usage 3.System use 4.Utilisation 5.Acceptance 6.Adoption 7.Usage 8.1 or 2 or 3 or 4 or 5 or 6 or 7	1.Factors 2.Determinants 3.1 or 2

The final search strategy (A10, B8, and C3) was applied to all 4 databases. A draft of the search strategies used in three of the databases is presented in Appendix B.

2.3.2 Eligibility Criteria

For the retrieved studies to be eligible to include in this literature review, the studies consisted of the following inclusion criteria. Studies were peer-reviewed research reports written in English, with the stated aim of exploring, investigating, or assessing factors that related the use of medication-related CPOE systems as the target intervention. The population of interest was physicians, with the included studies reporting the results of physicians only or papers in which physicians' responses were reported separately. The included studies also had to be conducted in clinical settings, that is, inpatient and outpatient departments of hospitals, health care centres, primary care centres, and polyclinics. Quantitative, qualitative, and mixed methods designs were considered eligible for inclusion. Studies were excluded if the CPOE system had not been implemented at the

time of this study or if the study assessed factors affecting intention to use the CPOE system rather than on its actual use. Papers with a population of nurses, pharmacists, information technology (IT) personnel, managers, or patients and those with interventions that were not strictly CPOE, were excluded from the review. Studies that were conducted in nonclinical settings (e.g. retail pharmacies, community pharmacies, nursing homes) were excluded from this review.

2.3.3 Selection Process

The titles and abstracts of all papers retrieved from the search using the inclusion criteria were screened by the researcher. Then the full-text articles of all potentially relevant studies were assessed independently by all 3 authors (the student, and both supervisors) for eligibility. A calibration exercise was conducted to cross-check the results obtained by the authors. All disagreements were resolved through discussion. The details of the exclusion criteria are shown in Figure 2.2.

```
Identification

    Articles identified through databases
    searching

    PubMed (n = 67)
    CINAHL (n = 84)
    EMBASE (n = 208)
    Medline (Ovid Medliner) (n = 113)
    Citations Screening (n = 9)
                    │
                    ▼
    Results Combined (n = 481)

Screening
                    │
                    ▼
    Records after duplicates removed
    (n = 479)
                    │
                    ▼
    Records screened
    (n = 479)                          Main reasons for exclusion:
                    │                   • Referring to other
                    ▼                     computerized systems.
                                        • Irrelevant aim.
Eligibility                             • Non healthcare settings
    Records excluded                      (e.g. retail pharmacies).
    (n = 460) - - - - - - - - - - - →   • Assessing implementation
                    │                     stage or intentions to use
                    ▼                     but not actual usage.
                                        • Investigating reasons of
                                          delayed adoption
                                          /implementation of HIT/
                                          rate of errors.

    Full-text articles assessed for     Full-text articles excluded, with
    eligibility                         reasons (n=8).
    (n = 19) - - - - - - - - - - - - →   • Physicians responses were
                    │                       not reported separately
                    ▼                       (n=3).
Included                                • Not CPOE and not
                                          physician population (n
                                          =2)
    Studies included in review          • Different population
    (n=11)                                (nurses) (n=1).
                                        • Not CPOE (n=2).
```

Figure 2.2 Flow Diagram of the Selection Process for the Included Articles

2.3.4 Data Collection Process and Data Items

For each article, a data extraction was performed by the researcher. These data included names of the authors, publication year, country, objective, study design, data collection method, type of intervention, setting, population and sample, factors associated with CPOE use, how actual use was assessed, and the duration of the system's use in the healthcare setting.

2.3.5 Risk of Bias of the Included Studies (Quality Assessment)

The Mixed Methods Appraisal Tool (MMAT) was used to assess the quality of the included studies (150). The MMAT is a comprehensive tool designed to evaluate reviews, including quantitative, qualitative, and mixed methods studies (150). Included studies were independently appraised by the researcher and the supervisors. The researcher reviewed all the studies, and each of the 2 supervisors reviewed half of the studies. Any disagreements were resolved through discussion. MMAT does not recommend assigning a single score based on the assessment (150). However, in this review a specific metric derived from a previous study was used (151) to rate the quality of each of the studies justifying the reasons for the final inclusions and exclusions. Studies were classified as high, medium, or low quality, depending on the number of criteria that were met. A study was considered high quality if all 5 MMAT criteria were met, medium if 3 or 4 criteria were met, and low when a study met 1 or 2 criteria (151).

2.3.6 Data Synthesis

Narrative synthesis was used to summarize the evidence from the included studies. Narrative synthesis is appropriate when a review includes both qualitative and quantitative findings (152).

2.4 Results

2.4.1 Study Selection

The electronic database search retrieved 67 records from PubMed, 84 from CINAHL, 208 from Embase, 113 from Ovid MEDLINE, and 9 from the reference lists of the included studies. After duplicates were removed, the titles and abstracts of the remaining 479 studies were assessed for eligibility. Of these, 460 studies were excluded because they were ineligible, and 19 articles were selected for in-depth analyses. A total of 11 studies were included in the final review. The study selection process and reasons for exclusion are shown in Figure 2.2.

2.4.2 Characteristics of the Included Studies

Table 2.2. summarizes the characteristics of the included studies (80, 153-162). The 11 studies included in the review were from different regions of the world: 4 are from the United States (153, 155, 160, 161), 3 are from Sweden (154, 157, 158), 1 is from the Netherlands (156), 1 from Saudi Arabia (80), 1 from Australia (159), and 1 from Singapore (162). Of the total number of studies, 4 used qualitative methods (interviews) (153, 155, 157, 159), 6 used quantitative methods (surveys or questionnaires) (80, 154, 158, 160, 162), and 1 used a mixed methods approach (156). Among the 11 included studies, the factors associated with the use of CPOE for medication prescribing were mainly related to technical, organizational, or individual characteristics. All the included studies were conducted in either a hospital or a primary care centre. Seven studies were conducted in a hospital setting (80, 153, 155, 157, 159-161), 2 in a hospital and a primary care centre (154, 158), 1 in a primary care centre (156), and another in a group of polyclinics (162).

Table 2.2 Characteristics of the Included Studies

Author/Year	Country	Objective	Study Design/Data Collection Methods	Intervention	Setting	Population/Sample Size	Factors Associated with Usage	Actual Usage Reporting	Duration of System Usage at the Time of the Study
Abramsom et al, 2016 (153)	US	To evaluate how physicians' perceptions and experiences with prescribing evolved after prolonged system use	Qualitative/Semi-structured interviews	Electronic prescribing system	Hospital-based adult internal medicine outpatient clinic	13 Physicians (only 11 were interviewed).	• Efficiency and usability • Effects on safety • Training • Alert fatigue • Shortcut features would either be too difficult to customize and time consuming	Not applicable[a]	For 2 years
Hellström et al, 2009 (154)	Sweden	To assess experienced e-prescribers' attitudes toward e-prescribing for suggesting improvement	Quantitative/Survey	EHR[b] systems with integrated electronic prescribing modules	Primary care centres & hospitals (primary care, internal medicine, orthopaedics, and general surgery)	431 Physicians (180/431 – 42%)	• Ease of use • Clarity of information display	Number of E-Prescriptions per day (self-reported)	15% of the respondents had used an electronic system for two months to one year, and 85% for more than one year
Holden, 2010 (155)	US	To describe physicians' beliefs about the use of EMR[c] and CPOE[d] for inpatient and outpatient care, to identify what factors shaping information technology usage	Qualitative/Semi-structured interviews	EMR and CPOE	2 Hospitals (inpatient/outpatients)	20 Physicians	• Performance outcomes • Productivity and efficiency outcomes • Behavioural beliefs • Financial, organizational factors • Normative beliefs • Moral normative beliefs • Hardware and software barriers • Environmental barriers • Insufficient time to use the system or to learn to use it • Availability of training and technical support facilitated use	Not applicable	Hospital 1: provided data on the first few weeks of using CPOE Hospital 2: about 7 months
Martens et al., 2008 (156)	The Netherlands	To evaluate the feasibility and acceptability of a CRS[e] to improve prescribing behaviour and to investigate the strengths and weaknesses of a reminder system	Mixed methods Quantitative/Questionnaire Qualitative/Semi-structured interviews	CRS	Primary care practice	53 Physicians 2 Project leaders 1 Technical consultant	• Stability and speed of the CRS • Instructiveness and shortness of the reminders, • User-friendliness • Layout • Support from the help desk. • Technical problems that caused delay during prescribing	Mean number of reminders per GP[f] per month per 1000 enlisted patients through (system logs)	Halfway through the intervention year
Omar, 2016 (157)	Sweden	To study paediatrician's attitude towards EPDSS[g] and to investigate factors affecting user acceptance using a technology acceptance model	Qualitative/Semi-structured interviews	Electronic prescribing decision support system	Hospital paediatric department	7 Physicians	• Perceived usefulness • Perceived ease of use	Not applicable	2 to 4 years
Rahimi et al., 2009 (158)	Sweden	To observe factors associated with the adoption of a CPOE system for inter-organizational and intra-organizational care	Quantitative/Survey	CPOE	Primary healthcare centres and hospitals	741 Physicians (176/741 physicians - 23.8%)	• Relative advantage • Compatibility • Complexity	Number of entered orders in the CPOE system	After 1 year

Study	Country	Aim	Method/Design	System	Setting	Participants	Factors/Barriers	Observation	Timing
		using the diffusion of innovation theory			using the system in Östergötland County	200 Nurses (134/200 nurses - 67.0%)		in a normal day (self-reported)	
Saddik & Al-Fridan, 2012 (80)	Saudi Arabia	To measure the satisfaction of physicians toward CPOE and explore the factors associated with satisfaction	Quantitative/Questionnaire	CPOE	Hospital (all units)	101 Physicians (81/101 – 80%)	• Ratings of impact on patient care and quality, speed, clarity, and reliability • Characteristics related to locating items on the clarity of correcting mistakes • Ease of use. • Availability of technical support, reference materials, and the usefulness of error messages • Locating items in the system • Retrieval of radiology data	Not applicable	Shortly after implementation (Not clear how shortly)
Santucci et al, 2016 (159)	Australia	To determine whether physicians in ICU[h] use and perceive hospital-wide CDS[i] useful for integration with an electronic prescribing system	Qualitative/Observation and interviews	Electronic prescribing system	Hospital - 12-bed general/neuro-logical intensive care unit	20 Physicians	• Customization of pre-written orders for the ICU context • Alerts/alarm fatigue • Unawareness that the reference viewer tool was available • Insufficient training	Through shadowing 20 doctors	4 Months (The study reported that at the time of the study, June–September 2014, the electronic prescribing system was in use in all wards of the hospital, including the ICU
Schectman et al., 2005 (160)	US	To understand whether physicians' computer experience and attitudes or other barriers were related with the actual adoption of an expert prescription system	Quantitative/System's logs and survey	Prescription expert system	Academic internal medicine residency training clinic	94 Physicians (84/94 - 89%)	• System efficiency • Effect on quality	-System utilization rate: the number of electronic prescriptions written by each physician during the study period (system logs) -self reported survey.	6 months post-implementation
Shriner & Webber, 2014 (161)	US	To explore residents' perceptions and attitudes toward implementation of CPOE CDS prior to implementation and at 6 months and 12 months post-implementation	Quantitative pre-implementation and post implementation survey	CPOE	Paediatric hospital	146 Physicians 43.8% (n=64) of residents responded to the pre-CPOE survey 37.6% (n=55) responded to the 6-month post-CPOE survey 43.2% (n=63) responded to the 12-month survey.	• Time constrains (at both 6- and 12-months assessment). • The degree of EMR implementation; support staff availability • Hardware availability	Not applicable	After 6 months then after 12 months

Tan et al., 2009 (162)	Singapore	To assess users' satisfaction and factors associated with satisfaction toward the electronic prescription system	Quantitative/Questionnaire	CPOE	Polyclinics	118 Doctors 61 Pharmacy staff	• Computer skills • Functionality (detection of prescribing errors and the ability to receive alerts for drug-interactions and drug-allergies) • Processing (entering orders) and system speed • Training and ongoing support • Effect on productivity	Not applicable	After 3 months

[a]Not applicable: not a part of this study
[b]EHR: Electronic health record
[c]EMR: Electronic medical records
[d]CPOE: Computerised physicians' order entry
[e]CRS: Computer reminder system
[f]GP: General practitioner
[g]EPDSS: Electronic prescribing decisions support system
[h]ICU: Intensive care unit
[I]CDS: Computerised decision support

2.4.3 Quality of the Included Studies

Table 2.3 summarizes the results of the quality assessment of the included studies (80, 153-162). Of the total number of studies, 3 (all qualitative) were rated as high quality because they met all 5 MMAT criteria (153, 155, 157). Of the total number of studies, 5 (all quantitative) were rated as medium quality, as they met 3 or 4 of the MMAT criteria (80, 154, 158, 160, 162), and 3 studies were evaluated as having low quality because they met either 1 or none of the MMAT criteria. Of these, 1 was a quantitative study (161), 1 study used a mixed methods design (156), and 1 was a qualitative study (159). These studies were not excluded from the final synthesis based on their quality because of the exploratory nature of the review.

2.4.5 Synthesis of the Results

The identified factors that were associated with physicians' actual use of CPOE for medication prescribing are presented in Table 2.4. These factors were organized according to the definitions of the constructs from the UTAUT (131) and constructs from the D&M IS Success model (132) as illustrated in the next section. The results of the included studies were grouped and synthesized under 3 categories: individual, organizational, and technological factors.

Individual

The individual factors were defined based on Venkatesh et al. (2003) definitions of performance expectancy, effort expectancy, and social influence (131). Definitions of performance expectancy was based on concepts from 5 different technology acceptance theories (131). These definitions mainly reflecting how the noticed outcomes of using a certain system are related to the user behaviour (131). When the user perceived the system

as beneficial to the quality of their work, the effectiveness, productivity and valued outcomes it will affect his/her behaviour of utilising the system (131). While the effort perceived either as easiness (or difficulty) associated with the utilisation of the system might affects the user in terms of the time and effort spent doing his/her tasks (131), hence that would impact the overall tendency of usage and the performance in general. Social influence refers to how the user's behaviour toward the system usage might be affected by the way other people at work would views them if they are using the system (131). Since these definitions covers mainly the individual perceived effects on their job out of the system usage, it primarily reflects factors that related to the individuals who are using the system, hence these perceptions are to be considered individual related factors.

Table 2.3 Quality Assessment of the Included Studies Using the MMAT (2018) [a]

References in Alphabetical Order	1.[b] Qualitative					4. Quantitative Descriptive					5. Mixed Methods					Quality of the Study
	1.1[c]	1.2	1.3	1.4	1.5	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4	5.5	
Abramsom et al, 2016 (153)	Yes	Yes	Yes	Yes	Yes											High
Hellström et al, 2009 (154)						Yes	Yes	No	No	Yes						Medium
Holden 2010 (155)	Yes	Yes	Yes	Yes	Yes											High
Martens et al., 2008 (156)	Yes	Can't Tell	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No	No	Low
Omar, 2016 [d] (157)	Yes	Yes	Yes	Yes	Yes											High
Rahimi et al., 2009 (158)						Yes	Yes	Yes	No	Yes						Medium
Saddik & Al- Fridan, 2012 (80)						Yes	Yes	Can't Tell	Yes	Yes						Medium
Santucci et al., 2016 (159)	Can't Tell	Can't Tell	Yes	No	Can't Tell											Low
Schectman et al., 2005 (160)						Yes	Yes	Can't Tell	Yes	Yes						Medium
Shriner & Webber, 2014 (161)						No	No	No	No	Yes						Low
Tan et al., 2009 (162)						Yes	Yes	Yes	No	Yes						Medium

aMMAT: Mixed Methods Appraisal Tool
b1., 4., 5.: Sections of the MMAT used to evaluate the qualitative, quantitative and mixed–methods studies, respectively
c1.1-5.5: Items in each of the MMAT sections used to evaluate the qualitative, quantitative and mixed-methods studies
d Due to the high relevance of this paper, we used the primary source, and not the article that was identified through the systematic search, as we were reporting it in this review. the primary source:
https://pdfs.semanticscholar.org/d7c6/40411a6bc8f7f2ef3d504bee91b2208893e8.pdf

Organizational

 The organizational factors were defined as the facilitating conditions as described in the UTAUT, to be the existence of the resources the organization provide to facilitate the use of the system (131).

Technological

The technological factors were defined in accordance with D&M IS success model definitions of system quality and information quality (132) only, as most of the identified technological factors were mainly related either to the quality of the retrieved information, or the quality of the system itself. System quality refers to the quality of the system's capabilities such as functionality, reliability, flexibility, data quality, portability, integration, adaptability response time and usability (132). While information quality refers to the quality of the information the system is giving in terms of accuracy, timeliness, completeness, relevance, and consistency (132).

Table 2.4 Factors Associated with Physicians Actual use of the CPOE

Theme	Construct	Factor	Frequency	Reference
Individual Factors	**Performance Expectancy** Perception that using CPOE will improve the physician's job performance (131)	Perceived usefulness	1	(157)
		Relative advantage	1	(158)
		Effect on quality of care and/or patient outcomes	3	(80, 155, 160)
		Effects on productivity	2	(155, 162)
		Effects on safety	1	(153)
		Performance outcomes	1	(155)
	Effort Expectancy Belief that the CPOE is easy to use (131)	Ease of use	3	(80, 154, 157)
		User-friendliness	1	(156)
		Difficult to use	2	(153, 155)
		Complexity	1	(158)
	Social Influence Perceived importance of others' (e.g. leaders, colleagues) opinions that the physician should or	External normative beliefs	1	(155)

		should not use the system (131)		
Organizational Factors	**Facilitating Conditions** Available resources, facilities, and infrastructure that facilitates using CPOE (131)	Training	4	(153, 155, 159, 162)
		Availability of technical support	4	(80, 155, 156, 161)
		Compatibility	1	(158)
		Computer skills	1	(162)
		Time constraints	3	(153, 155, 161)
		Availability of hardware	2	(155, 161)
		Lack of awareness of the availability of certain features	1	(159)
		Management support	1	(155)
		User involvement	1	(155)
Technological Factors	**Information Quality** Relevance, accuracy, comprehensiveness, understandability, prevalence, timeliness, and usability of the outputs/content (132)	Usefulness of error messages	1	(80)
		Clarity and brevity of the reminders	1	(156)
		Confidentiality, privacy, and security of patients' records	1	(155)
	System Quality Reliability, availability, usability, functionality, flexibility, integration, and response time of the system (132)	Clarity	2	(80, 154)
		Layout	1	(156)
		Technical problems causing delays during prescribing	1	(156)
		System's speed	3	(80, 156, 162)
		Software barriers	1	(155)
		Reliability	1	(80)
		Customization to individual departments	2	(155, 159)
		Functionality of the tools in the system	1	(162)
		Locating items on the system	1	(80)
		Retrieval of radiology data	1	(80)
		Usability	1	(153)
		System's efficiency	2	(153, 160)
		Availability of reference materials	1	(80)
		Alert fatigue	2	(153, 159)

A total of 11 individual factors were identified (See Table 2.4). The most cited factors were the effect on the quality of patient care (160 ,155 ,80) and ease of use (80, 154, 157). Physicians perceived that using CPOE enhanced patient care. In one study (160) the features of the CPOE system were associated with better quality of patient care by providing easy and direct access to patient records and reminders and alerts for physicians, which led to a reduction in duplicate tests and expediting the ordering process. While physicians agreed that their satisfaction with the system was greater because it was easy to use, which led to their usage of the system (80, 154, 157), other studies reported limited use of CPOE by physicians because they found it difficult to use and complex in terms of navigating, accessing, and finding information (153, 155, 158).

Nine organizational factors were identified that affected the use of CPOE (See Table 2.4). Training (153, 155, 159, 162) availability of technical support (such as a help desk) (80, 155, 156, 161), and time constraints (153, 155, 161) were the most cited factors. Training issues reported by physicians included either the need for retraining because of new features (153) or lack of training (159). The availability of technical support means the physicians need to have IT staff accessible to help them in case of any technical issues while using the CPOE system (80, 155, 161) or the extent of the physician's awareness that there is a designated help desk to assist them (156). The timing of the reporting of these factors in the included studies suggests that the factors related to the organization were critical for the usage of the CPOE system by physicians, regardless of whether the physicians recently began using the system or have been using it for a longer time. For example, studies that reported training (153, 155, 159, 162), were conducted at different time points after the implementation of CPOE. One study conducted its assessment after 2

years of CPOE usage (153), while 3 other studies investigated the factors affecting usage after only months of use (155, 159, 162). Technical support availability was reported in studies after weeks (80, 155, 156) and after 1 year of usage (161).

Time constraints were the second most cited factor associated with the usage (153, 155, 161) The complexity of CPOE (153), its slowness (155), and physicians' unfamiliarity with its features (161) were reasons why it was so time-consuming for physicians to use it.

Evidence from 8 of the included studies (80, 153-156, 159, 160, 162) indicated that the technological factors related to CPOE were the most relevant to the use by physicians. A total of 17 factors were reported (Table 2.4). The system's efficiency was the most cited factor (80, 156, 162), specifically the quick prescribing process (156), fast data retrieval, response time (80), and the system's speed, in terms of entering patient data (162). Furthermore, studies that reported the system's speed as a significant factor in its use by physicians were conducted shortly after the implementation phase, that is, halfway through the intervention year (about 6 months later), shortly after implementation (not clear), and 3 months after implementation. This finding suggests that because the system was newly implemented, the processing speed was significant for physicians' performance of tasks.

The findings indicate that ease of use, the effect of using CPOE on quality of care, training, availability of technical support, time, and the system's speed were the most associated with the use of CPOE for medication prescribing among all the studies.

2.5 Discussion

Principal Findings and Comparisons with other Works

CPOE for medication prescribing can serve physicians as a tool to enhance patient quality of care. However, this has not led to a rapid uptake of the system by health organizations

and clinicians to use it (48, 55). A key factor in the slow adoption of CPOE by health care organizations is attributed to the costs associated with installing the system and the costs of sustaining it (55) as referred to in Sections 1.2.2 and 1.3. Despite many years of implementation of CPOE for medication prescription, development, and research, the issue of low adoption post implementation remains. This study focuses on the usage of the user—the physician—after the system has been implemented.

Factors that were related to the individuals (physicians), organization, and technological aspects of CPOE that associated with the actual use of CPOE by physicians for medication prescribing were identified, rather than intention to use a CPOE system. The findings of this study are consistent with those of Van Dort et al (48) and Gagnon et al (31). Nevertheless, these reviews identified other factors that were not found in this study. Resistance to use was reported in both reviews (31, 48) as a factor that negatively affected the usage of the system by physicians for medication prescribing. CDS systems embedded in the CPOE system for medication prescribing were examined in Van Dort et al (48). As CDS systems are known to offer suggestions and recommendations, user resistance was present as the physicians reported concerns that the information presented might not be reliable (48). In addition to resistance to using CPOE, Gagnon et al (31) described how the system could negatively affect the patient-clinician relationship and identified financial issues as another associated factor, neither of which was detected in this study. This inconsistency might be because of the focus of this study on the actual use of CPOE after the system had been installed and used and resistance is no longer an issue.

This study showed that technological factors related to the system were the most frequently reported factors that affects the physician usage of the CPOE system for medication

prescribing. This finding is consistent with the results reported by Gagnon et al (31). As their findings suggest, technical and design concerns were the most frequently identified factors limiting the system's use (31). One of the principal findings of the review is that among the 3 main themes, 5 factors were cited most frequently (any factor cited 3 or more times was considered frequently cited), indicating that it was significant in the physicians' decisions about using the CPOE system. Quality of care, ease of use, training, availability of technical support, time constraints, and system speed were key factors in the use of CPOE by physicians. A similar pattern of results has been reported in an extensive body of literature (31, 48, 163, 164). One unexpected finding was that the effect of alert fatigue, as a factor in the use of CPOE, was identified in only 2 studies (153, 159). Alert fatigue is the receipt of a massive amount of reminders or warnings that cost time and effort and is eventually ignored (165). This finding contradicts the observation that alert fatigue has previously been found to be associated with the usage of CPOE for medication prescribing. In their review, Gagnon et al. (31) showed that alert fatigue was associated with the use of an electronic prescription system in 5 studies. In addition, Van Dort et al. (48) showed that too many irrelevant alerts were related to the uptake of medication-related CDS systems in 10 studies.

In these 2 studies (153, 159), alert fatigue affected physicians' use. In the first study (153), physicians' perception of the alerts was that after transitioning to a more advanced new system, the alerts were more sensitive than those of the older system. In the second study (159), the ratings of the alerts were higher when the study's setting was an intensive care unit (ICU), compared with their ratings by other departments in the hospital. All factors identified in this study are similar to those of other reviews related to the implementation

(31), adoption (163), or acceptance (164) of CPOE. However, a factor not discussed in previous CPOE for e-prescription studies and detected in this study was customization of the CPOE system's features for medication prescribing to each department. Customize refers to tailoring the features of a CPOE system to the preferences and needs of a specific department. For example, ICU physicians reported that some alerts were irrelevant to ICU patients and more suitable for other departments in the hospital (159). This finding is in line with that reported in the review by Li et al (166), who suggested the importance of customization of the system's features according to different specialties and emphasized its significance for the provider's workflow.

Constructs from the UTAUT (131) and D&M IS Success model (132) were used to organise the identified factors to provide a better understanding of what each factor means to the user and how it may be associated with physicians' attitudes toward the actual use of the CPOE for medication prescribing. All the factors reported in the included literature in this study were aligned with the constructs of the UTAUT (131) and D&M IS Success model (132). The examination of factors using these 2 models provides a useful framework for this systematic review. Two of the constructs (system quality and information quality) from the D&M IS Success model were found to be highly relevant, as the most frequently reported factors were the technological ones (132). These factors were mainly related to the quality of the system or information. Both models have been extensively used in research related to health care technology assessment (167, 168).

Limitations and Strengths

The limitations of this literature review research should be acknowledged. First, only 4 databases were searched. Although these databases are the most relevant for health care

publications, there is a possibility that relevant studies could have been missed. Second, the first step of the database search—checking every single title and abstract—was performed by a single author (the researcher). However, it is believed that this does not affect the quality of the review process as the results of the selection and screening were revised in regular meetings with the other reviewers (supervisory team) who are experts in the field and no issues were raised by them during the review process. In addition, all the assessment steps for article eligibility were conducted by all 3 authors (the researcher and the supervisors) in parallel. Any disputes between all the reviewers were systematically discussed to ensure consistency. Third, the fact that the search resulted in only 11 articles was acknowledged as that could be viewed as a small sample for a system that has been in use for a number of years. However, this study focused on the medication ordering aspect of the CPOE and did not evaluate the CPOE as a whole system. In addition, the focus was on physicians as the target population and studies that indicated that the system is being actually used and not the intention to use (installation phase or implementation phase).

The strength of the performed systematic literature review lies in the presentation of 4 elements that were absent from previous attempts to synthesize primary research on this topic: (1) it evaluated research that used major study designs (quantitative, qualitative, and mixed methods); (2) it drew on the perspectives of physicians only; and (3) it included research on the period of actual usage of CPOE for e-prescribing in particular (while the physicians were using the system in later stages) and not the intention to use. (4) Factors that are unique to the physician's actual usage were explained using a framework that consists of a combination of 2 theoretical approaches.

To the best of our knowledge, no previous systematic reviews have explored specific factors associated with physicians' actual usage of CPOE or e-prescriptions considering these elements.

2.6 Summary

The literature review suggests that an individual's, technical, and organizational factors are all associated to the usage of CPOE by physicians. Although most of the identified factors were similar to those reported in previous reviews related to CPOE, the results of this work have allowed the identification of an additional factor that was not discussed in earlier reviews, namely, the preference of physicians to customize the CPOE system to the needs of the medical department. In addition, as much as there are issues at the organizational level during the implementation process, it was important to focus on the individual physicians after the implementation is completed.

The review also highlighted that only a limited number of studies have empirically documented the factors that associates with physicians' use of electronic prescribing systems, with the majority of reported studies were studies that have been conducted with in healthcare practices in industrial and advanced countries where 10 of them were from developed countries, and 1 from a developing country (Saudi Arabia). It highlighted a gap in the literature regarding factors that are associated with the actual use concerning physicians in Saudi Arabia.

Updated Systematic Review:

To maximize the currency of the systemic review, an updated search was performed to retrieve new studies that have been added since the last time the search was done. The same search strategy mentioned in Section 2.3.1 was used, but with a limitation on the dates starting from 2020 to 2022. The eligibility criteria in Section 2.3.2 were used for the newly retrieved studies. A total of 56 articles were identified through database searching. The titles and abstracts of all the papers retrieved from the search were screened based on the inclusion criteria. Five new studies emerged, and their full-text articles were assessed for eligibility (169-173). Three studies (169-171) assessed physicians' perceptions of different types of e-prescribing interventions before the implementation of the intervention. This was described as 'evaluating user intention to use' by these studies. Jung et al (169) study was an investigation on factors related only to user expectations and support from the hospital for the introduction a new medication-related CDS in a Korean hospital. Catho et al (170) aimed at gaining an in-depth understanding of the determinants of adherence to antimicrobial prescription guidelines and CDSS adoption in three European hospitals. Ghaznavi et al (171) investigated the attitudes of clinical staff toward the CPOE system before the implementation of CPOE in an Iranian hospital. The focus of these studies was intention to use rather than actual use. As discussed in Section 1.5, these two concepts differ in terms of user behaviour and factors that affect use. The objectives of the other two studies of Wei et al and Rodríguez et al (172, 173) were not relevant to the objective of this study. Wei et al (172) aim was to examine residents' subjective mental workload when they entered prescriptions in a CPOE system, and Rodríguez et al (173) describes the benefits of implementing a CPOE system in a practice. Since these studies investigated

physicians' intention to use a system that has not been fully implemented or used yet, the phases they examined are different from actual utilisation as defined in the current research. Further, the topics investigated by two of these studies were irrelevant to the topic of investigation of the current research. None of these newly emerged studies met the eligibility criteria of this systematic review, and therefore, none of the five articles were suitable for an updated systematic review.

The next chapter explains and justifies the research methodologies used to investigate the factors associated with physicians' use of CPOE in governmental hospitals in Saudi Arabia.

Chapter 3: Research Methodology

3.1 Introduction

In the two previous chapters, the research background, context, research questions and objectives, and evidence from the literature review were presented. As the review indicated that there is a lack of studies evaluating physicians' use of CPOE during the actual use stage—after full implementation and during the usage stage—and limited research in developing countries, the aim of this study was to investigate the factors associated with physicians' self-reported actual use of CPOE for prescribing medication in government hospitals in Saudi Arabia. This chapter discusses the methodological approaches, data collection strategies, and data analyses conducted to achieve this research's aim. Following this, the chapter discusses the population, the data analysis methods for each approach, and the ethical considerations.

3.2 Research Philosophy

Research philosophy is the development of knowledge in a particular field through a system of beliefs and assumptions (174). Levin (175) describes it as the researcher's beliefs of the way in which the data about a phenomenon shall be collected, analysed, and used. Saunders et al. (174) identified four major research philosophies: positivism, interpretivism, realism, and pragmatism.

Positivism is the belief that reality is stable, and that facts shall be described independently and objectively by a natural and detached researcher (174). In a positivist approach, the researcher maintains an objective stance (174). Positivism usually deals with deductive approaches and quantitative data that can be statistically analysed, and uses existing theories to develop hypotheses (174). Interpretivism implies that the researcher gives the

data subjective meaning, and that these meanings have multiple interpretations rather than one truth that can be determined through a measurement (176). Interpretivism requires that social phenomena be grasped through the participants' perceptions of the topic under study (176). The aim of the interpretivist paradigm is to explore and understand the subjective meaning of social worlds and contexts (177). Interpretivism deals with inductive methods that involve qualitative analysis and investigations such as interviews (177). Realism implies that the reality of things or a phenomena is as just as it appears and shall be perceived objectively, independently of what the human mind thinks (174). Realism focuses on a historical analysis of pre-existing structures (177). Pragmaticism argues that the adoption of a particular philosophy depends mostly on the research question (174), as one method might be more appropriate than another method to answer certain research questions (174). According to this philosophy, the use of a mixed-method approach (quantitative and qualitative) is highly appropriate in the same study (174). According to Creswell (176), researchers are free to choose procedures, approaches, and techniques for their research that best meet their objectives. The flexibility of this philosophy allows the researcher to achieve a better understanding of the outcomes by using more than one approach (174).

This research adopts the pragmatist philosophy in order to achieve its aim by applying a mix of positivist and interpretivist perspectives (174). Since pragmatism supports the use of qualitative and quantitative methods, it was seen as the best way to answer the research question and address the research problem comprehensively. This research is exploratory in nature. Positivism will allow the researcher to apply quantifiable measures that can help answer the research question (174). This will produce facts that can be interpreted

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objectively. The interpretivist approach will allow the researcher to interpret real human experiences through qualitative techniques (174); thus, the researcher's subjective interpretation of the participants' statements will make a new contribution to the field.

The ability to integrate qualitative and quantitative methods in the pragmatist approach will help this research gain a wider and richer understanding of the research problem. This understanding shall be through the experiences of real people who work in the environment where this research problem exists and through measurable facts and figures. This will provide fair conclusions about the prospects and challenges related to the research problem. Pragmatism focuses on practical solutions as a contribution, rather than abstract distinctions (174). This knowledge will help in shaping the lessons and recommendations this research will generate as future solutions for CPOE stakeholders in the context of CPOE implementation and utilisation in Saudi Arabia. Thus, pragmatism was found to be suitable for this research, as it has a bigger focus on problem solving and practicality than the other research philosophies.

3.3 Research Approach

Two main research approaches that can be adopted for conducting studies (178): the deductive approach and the inductive approach (178). The deductive approach starts with a theory that is mostly informed by reviewing previous literatures, and this is followed by a strategy to test the theory (177). In contrast, the inductive approach starts with the observation and collection of data to seek and find patterns and then draw conclusions from these findings in order to devolve a theory (177). Deductive reasoning is known as a 'top-down' approach, as the researcher starts with assessing a proposition or hypothesis related to an existing theory and then testing that thorough the collected data (178). Inductive

reasoning is usually referred to as a 'bottom-up' approach, as the researcher starts with observation and data collection to build up conclusions or theories (178). In this research, deductive reasoning was found to be the most appropriate approach, as the previous literature was reviewed to identify theories and concepts that could be investigated in the context of this study using theory-based data collection strategies, as illustrated in Section 2.2 of Chapter 2.

3.4 Research Design

Research design refers to 'the plan of action that links the philosophical assumptions to specific methods' (Creswell et al., 2007, p. 4) (179). Methods refers to a set of procedures, techniques, and tools used to collect and analyse the data (179). There are three main designs that are usually used in research: quantitative, qualitative, and mixed methods (176). Quantitative designs aim to collect numerical data that can be measured statistically through an instrument such as a survey or an experiment (176). Quantitative design is used to test theories, identify variables, explain relationships between variables, or observe and measure data (176). Qualitative design aims to collect non-numerical data from participants through techniques such as interviews or focus groups, in order to explore and understand human insights about a certain phenomenon (176).

Mixed-methods design refers to the integration of quantitative and qualitative data collection and analysis to study the research topic (176). The aim of using mixed methods is to gain a better understanding of the research problem than with the use of a single method (176). There are three dominant mixed-method models (176): convergent parallel mixed methods, explanatory sequential mixed methods, and exploratory mixed methods (176). In convergent parallel mixed methods, the researcher collects both quantitative data

and qualitative data at the same time to present a comprehensive analysis of the research topic (176). Then, the researcher merges the results of both analyses in an interpretation of the final findings (176). The main purpose of this design is 'to obtain different but complementary data on the same topic' (Morse, 1991, p. 122) (180). The researcher may use this design to compare and contrast, validate, confirm, corroborate, or expand the quantitative results with qualitative findings (179).

An explanatory sequential mixed-method design is one in which the researcher starts with collecting and analysing quantitative data first, and then elaborates further the results of the quantitative analysis using qualitative research (176). This approach aims to explain the results of the quantitative data, for example, by explaining a significant, non-significant, or interesting result in the quantitative data (179). In contrast, in the exploratory sequential mixed-methods approach (176), the researcher starts with collecting and analysing qualitative data first and then uses qualitative analysis to develop or inform the other method (176). For example, a researcher may create an instrument or identify variables that need to be assessed in a follow-up quantitative study (176).

A convergent mixed methods design was adopted for this research, in which qualitative and quantitative data were collected in parallel, analysed separately, and then merged (176) (Figure 3.1).
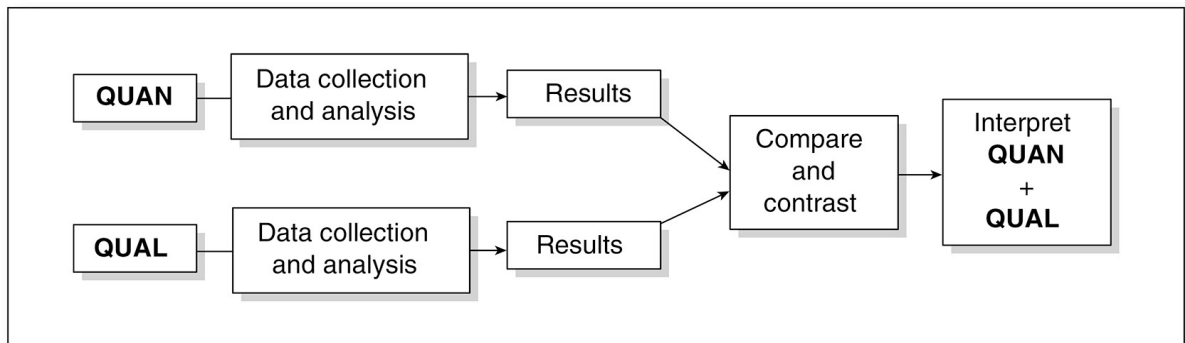
Figure 3.1 Convergent Parallel Design (181)

This design helps to provide either different or complementary results in order to best understand the research problem. The quantitative results might not cover all aspects of the research issues, but these issues may be easily explored during interviews. In addition, combining results from different types of sources (quantitative and qualitative) was considered to enable a cohesive analysis of the research problem.

Pragmatism is the underlying approach of this research, as its basis is the belief that complementary, and hence mixed methods, research consists of quantitative and qualitative approaches that can be integrated in order to overcome the limitations within each approach (182). The integration of the two sets of quantitative and qualitative data and procedures can be applied to three points of the research: the study design level, the methods level, and the interpretation and reporting level (183).

Integration at the study design level involves combining two methods of data collection and procedures in one of the main study designs, which could be explanatory sequential, exploratory sequential, or convergent, as illustrated above (183). Method-level integration means connecting, building, merging, or embedding one data collection tool or procedure with another data collection tool (183). While the integration of the results of two different types of data sets at the interpretation and reporting level can be considered to be challenging, the literature suggests techniques which help in cohesive integration (184), such as narrative integration, data transformation integration, and joint display integration (184).

- **Narrative integration** refers to describing the quantitative results and the qualitative results in a narrative style (183). This can be presented in different forms: the researcher can describe both sets of findings in a theme-by-theme or

concept-by-concept way under one section of the report, describe the quantitative findings and the qualitative findings in the same report but under two different sections, or present a staged integration of the findings in the form of multistage mixed research, where each type of result is reported and published separately from the other types (183).

- **Data transformation** involves converting one type of data set to another type of data set (183). For example, a researcher can convert qualitative results into numerical form and then integrate that with the quantitative results (183). This can be accomplished by assigning the qualitative verbatim data certain codes and counting the frequency of each code (183).

- **Joint display** refers to the organization of quantitative and qualitative results in a figure, a table, a chart, or a matrix to give the results more visual meaning (183, 185).

For this research, the quantitative data and qualitative data were narratively interpreted separately in different sections (Chapter 4 and Chapter 5) and then significant results were displayed in a table for comparison. Creswell and Plano Clark (184) argue that when converging two different data sets with different sample sizes, researchers should think about the consequence, as sample size is a part of the design goal, considering that quantitative and qualitative data are usually collected for different purposes (generalization vs. in-depth description, respectively). Since the sample size in this research notably varies between the quantitative design and the qualitative design, with generalization being the goal of the quantitative data collection and in-depth discerption being the goal of the

qualitative methods, narrative integration was appropriate. The steps in the convergent study design and integration of the results of this research are illustrated in Figure 3.2.

Step 1	•Collect the quantitative data: using a questionnaire survey •AND •Collect the qualitative data: using interviews
Step 2	•Analyze the quantitative data: using statistical tests/SPSS •AND •Analyze the qualitative data: using thematic analysis
Step 3	•Interpret quantitative results •AND •Interpret qualitative results
Step 4	•Compare quantitative significant statistical results with qualitative findings to validate or expand quantitative results with qualitative data using joint display (table).
Step5	•Interpret the merged results in the discussion section narratively topic-by-topic •Discuss to what extent and in what ways results from the two types of data converge, diverge, relate to each other, and/or produce a more complete understanding.

Figure 3.2 Steps of the Convergent Design Process of this Research (as informed by Creswell and Plano Clark, 2006, p. 79) (184)

3.5 Data Collection Methods

Quantitative data collection methods consist of surveys (questionnaires) and experiments (176). Qualitative data collection methods consist of observation, interviews, and collection of audio or visual material (176). For the survey in this research, interviews and observation were selected as the data collection methods.

3.5.1 Survey Questionnaire (Quantitative Data Collection)

A survey is a data collection tool for carrying out survey research (186). Creswell (176) stated that the purpose of a survey is to provide an explanation of the populations' attitudes and opinions through quantifiable measures and conclusions generalized by studying a

sample of the population. Surveys can be in several forms in terms of the collection of data, which can be obtained through mail, telephone, face-to-face interviews, internet (online) platforms, or group administration (187). This research used an online survey to collect the quantitative data. Surveys were seen as the most appropriate quantitative approach for the following reasons:

- *The ability to measure human attitude*s: surveys are considered to be an appropriate tool for measuring human attitudes, trends, and perspectives, according to Creswell (176). Using a survey in this research to collect quantitative data regarding physicians' self-reported actual use of CPOE allowed the researcher to answer the following questions:

- What is the level of utilisation of CPOE tasks?

- Is there is an association between physicians' characteristics, namely, position, age, gender, and years of experience, and the level of utilisation of CPOE?

- How significant is the association between the identified factors and the self-reported actual use of CPOE for prescribing?

- To what extent is the significance between the identified factors and the self-report actual use of CPOE for prescribing?

- *Relevance to the context of this research:* Surveys are a widely used tool in studies of a descriptive nature, including both exploratory and explanatory studies (188). It is the most appropriate for studies in which individuals (humans) are the units of research (188). What distinguishes surveys from other tools is that surveys can capture intangible human data such as behaviours, attitude, and perceptions (188).

- *Generalization:* Generalization refers to the extent to which research findings for a sample of a population are applicable to a larger population on other research sites (174). Survey results can be generalized from a specific sample of the population to the whole original population (176, 187). Hence, data collected from the survey on factors associated with physicians' use of CPOE in a sample of government hospitals can possibly be generalized to all physicians in all government hospitals in Saudi Arabia.

- *Online distribution of the survey:* Distributing the survey through a link to collect the data provides access to a wider population (189). The survey link can be posted and circulated easily (189). Online surveys are less costly than mail, phone, or interview surveys (187). They can also help the researcher reach thousands of individuals with common characteristics in a short amount of time, even if they are separated by great geographic distances (190). For the participants, it is convenient and will guarantee the respondents' anonymity (189). While online surveys can facilitate data collection, it might be challenging when it comes to those who have no internet access.

3.5.1.1 Survey Instrumentation

An online survey was developed to investigate the factors associated with physicians' actual use of CPOE in government hospitals in Saudi Arabia. Creswell (176) pointed out that a researcher can design an instrument, modify an existing one, combine more than one instrument, or use an already existing one. According to the literature, there are various scales and questionnaires for evaluating the use of information systems. The System Usability Scale (SUS) has been used extensively in various contexts to assess systems and

applications, including software, mobile devices, and websites (191). The SUS is a ten-item questionnaire administered to users for measuring the usability of a system (191). Although SUS has been validated in healthcare studies (192), it was not deemed to be suitable for this research. The SUS items mostly focus on the usability and learnability of a system and fall short when it comes to elements related to system functions. Since the identified factors to be investigated in this study included technologic and organizational factors too, it was necessary to use a more comprehensive measure. In addition, SUS statements alternate between positive and negative statements (Figure 3.3), and this may cause confusion for participants (191). This alternating presentation can, therefore, result in an extreme response bias. Hence, SUS was not considered for this study.

No.	Original Item
1	I think that I would like to use this system.
2	I found the system unnecessarily complex.
3	I thought the system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found the various functions in the system were well integrated.
6	I thought there was too much inconsistency in this system.
7	I would imagine that most people would learn to use this system very quickly.
8	I found the system very cumbersome to use.
9	I felt very confident using the system.
10	I needed to learn a lot of things before I could get going with this system.

Figure 3.3 SUS Items (193)

The following section provides details about the survey tool used to collect the participants' responses. This includes the development of the survey and its translation and piloting. The steps followed in developing this research's survey were adapted from Moore and Benbasat's (194) instrument development guide, according to which the creation of an instrument occurs in three stages: item creation, scale development, and instrument testing.

Stage 1: Item Creation

Item creation refers to the formation of a group of items to measure each construct (194). The survey consists of a total of seven constructs: actual use (the dependent variable) and six constructs (independent variables) that were based on the framework illustrated in Table 2.4 in Chapter 2. The survey questions were designed based on the identified factors from the systematic literature review (Table 2.4). Each of these factors is represented by a construct from either the UTAUT or the D&M IS success model. Questions related to factors under performance expectancy, effort expectancy, social influence, and facilitating conditions were all adapted from Venkatesh's UTAUT questionnaire items (131), while questions related to information quality and system quality were adapted from validated studies of the D&M IS Success model. Table 3.1 indicates the source for each of the questions. For any factor that is not specifically covered by any of the items, an extensive review of the previous literature was conducted to explore items from existing scales that could be used to measure those factors. For example, 'training' is a facilitating condition; however, Venkatesh did not have a specific item to measure training in his questionnaire. Measurement items were carefully selected and adapted from previous studies in such cases. The questionnaire items were slightly modified to fit the context of this study (e.g. the word 'system' was replaced with the phrase 'CPOE for medication prescription'). Table 3.1 shows the survey measurement items and the references used to inform those items.

Table 3.1 Survey Measurement Items

Construct	Items	Reference
Actual Use of Order Entry Tasks	• AUOE1. Order medications. • AUOE2. Order laboratory requests.	The main ordering functions of any CPOE system.

Actual Use of CDSS Tasks*	- AUCDS1. Carefully read the drug interaction alerts that I receive. - AUCDS2. Provide reasons for drug interaction alerts that I decide to override. - AUCDS3. Drug interaction alerts presented to me during order entry change my prescribing decisions. - AUCDS4. Carefully read the drug allergy alerts that I receive. - AUCDS5. Provide reasons for drug allergy alerts that I decide to override. - AUCDS6. Drug allergy alerts presented to me during order entry change my prescribing decisions. - AUCDS7. Carefully read the dose range alerts that I receive. - AUCDS8. Provide reasons for dose range alerts that I decide to override. - AUCDS9. Dose range alerts presented to me during order entry change my prescribing decisions. *Only CDS1, CDS2, and CDS3 were selected from reference (13), while CDS4 to CDS9 are not in (13). They were developed using the same wording as the first three items, but 'drug interaction alert' was changed to allergy alerts and dose alerts.	(195)

Construct	Items	Reference
Performance Expectancy	- PE1. I find the CPOE for medication prescribing useful in my job. - PE2. Using the CPOE medication prespring in my job enables me to accomplish tasks more quickly. - PE3. Using the CPOE medication prescribing improves the quality of output of job.	(131) (196)
Effort Expectancy	- EE1. My interaction with the CPOE for prescribing is clear and understandable. - EE2. It is easy to get the CPOE for prescribing to do what I want it to do. - EE3. I find the CPOE for medication prescribing easy to use.	(131)

Social Influence	• SI1. My supervisors/leaders influence my use of CPOE for medication prescribing. • SI2. My colleagues influence my use of CPOE for medication prescribing . • SI3. Patients influence my use of CPOE for medication prescribing.	(131)
Facilitating Conditions	• FC1. I have the technological resources necessary (e.g. PC/laptop/tablet) to use CPOE for medication prescribing. • FC2. The CPOE system for medication prescribing that I'm using is compatible with other systems (for example, for using EHR, I can open other links and windows at the same time) that I'm using in the hospital. • FC3. Technical support from a specific person or group (IT staff/help desk) is available for assistance when problems are encountered when using CPOE for medication prescribing. • FC4. There was enough time for me to familiarize myself with the CPOE system for medication prescribing. • FC5. The training I received was relevant to how to use the CPOE system for medication prescribing. • FC6. The management team provided me with enough support and encouragement to use CPOE for medication prescribing.	(131) (197) (198) (199)
Information Quality	• IQ1. Information provided by the CPOE for medication prescribing is relevant to my work. • IQ2. Information I get from the CPOE for medication prescribing is accurate. • IQ3. Information on the CPOE screen is easy to understand.	(198)
System Quality	• SQ1. The layout of the CPOE for medication prescribing is well-organised. • SQ2. Any error during prescribing/ordering is quickly corrected. • SQ3. The CPOE for medication prescribing response time is acceptable (not slow). • SQ4. The CPOE for medication prescribing can be accessed using different devices. • SQ5. It is easy to find information (about the patient, medications, etc.) when using CPOE for medication prescribing.	(139) (198) (200) (141)

	• SQ6. The CPOE for medication prescribing features contains timely updates that meets my needs. • SQ7. I can easily retrieve information from the CPOE for medication prescribing.	

To capture participants' responses to the measurement items, a 5-point Likert scale was used (201). A 5-point Likert scale is a measurement scale designed to capture individuals' opinions and attitudes that influence how they feel about an issue (201). The 'actual use' items aim to measure participants' level of utilisation of several tasks. For each task, the participants were asked to select the answer that best represented their level of utilisation. Therefore, the scale ranges between 'always' to 'never was used'. The other construct items measure the level of agreement for a number of statements, with the scale ranging between 'strongly agree' and 'strongly disagree'. Table 3.2 indicates the Likert scale items and their codes.

Table 3.2. Likert Scale Item Coding

Likert scale item (for actual use)	Code	Likert scale items (for all other constructs)	Code
Never	1	Strongly disagree	1
Rarely	2	Disagree	2
Some of the time	3	Neutral	3
Most of the time	4	Agree	4
Always	5	Strongly agree	5

Stage 2: Scale Development

After the needed items to measure each construct were grouped, scales were developed. The goal of this stage (stage 2) is to review the developed scale (194). Reviewing the developed scale can be achieved through content validity (194). Content validity refers to the degree to which a scale's items are relevant and representative of the construct it intends to measure (174). To make sure that the scale's content is valid, the researcher reviewed

literature related to the topic under study and, also, consulted with experts (174). Consequently, apart from the systematic literature review for this study, an extensive review of the literature was conducted and the appropriate scale measurements were selected accordingly. Five experts were asked to assess the content of the survey in terms of its format, clarity, relevancy, consistency, and appropriateness (202). These experts included three academics (a professor of health informatics, a researcher in public health from the UK, and an assistant professor in computer science from Saudi Arabia) and two physicians from Saudi Arabia (a consultant pulmonologist and an internal medicine resident). A web link to the survey questions was sent to the experts, and they were asked to assess the content. The content included a cover page explaining the purpose of the study and the questions. Using a weblink for content assessment was considered convenient and useful for keeping a record of their comments.

The experts' comments were mostly about some of the wordings and paraphrasing suggestions for some questions to make them understandable for the reader. Some wordings were replaced with more appropriate terms. For example, for question EE1, 'My interaction with the CPOE for medication prescribing is clear and understandable', a reviewer (a physician) suggested that either 'clear' or 'understandable' be used, and not both, in the same question, as both words have the same meaning. Alternatively, if both words were necessary, it was suggested that two separate questions be framed. Other comments were related to spelling or wording replacement. The survey was modified accordingly.

After the content had been validated, the survey was translated into the Arabic language, as Arabic is the first language in Saudi Arabia. Although all the responding physicians

were fluent in English, it was important to make sure that there was an Arabic version of the survey to avoid any non-responses due to language barriers. Translation of a survey from one language to another requires a qualified translator who is an expert in both languages (203).

The translation of this research's survey from English to Arabic was done by an independent certified translator. The translator was a bi-lingual who were an expert in both languages. After the survey content had been reviewed, assessed, and validated by experts, it was ready for testing.

Stage 3: Instrument Testing

At this stage, the survey is tested before the final distribution (194). This stage is typically called the pilot test (194). The aim of the pilot test is to make sure that the surveys' questions are understandable for the researcher and, also, to assess the reliability of the questions (174). For this research, the pilot test was done in two stages. In the first pilot test, the survey was sent to a convenience sample of 7 physicians. The aim of this first testing stage was to assess the feasibility of the survey in terms of its format, clarity, language, length, time spent responding, appropriateness, or clarification of any ambiguity. Respondents were also asked to comment in case there were any issues that required further refinement. After reviewing the results of the first stage, the second stage of piloting was conducted. In the second-stage pilot test, the survey was sent to 18 physicians. The aim of the second pilot was to confirm the reliability of the survey's constructs (194). Hill (204) suggested that 10 to 30 participants for pilot survey research is appropriate to ensure the statistical power of the statistical tests. The reliability and validity of the survey are discussed in Section 3.9.2.

3.5.1.2 Survey Sections

The survey consisted of four sections:

Part 1: A cover page that includes the title of the study, the purpose of the study, an explanation of anonymity, the contact information of the researcher, the supervisory team, and the university, in case the participant has any enquiry. This is followed by a consent statement.

Part 2: This consists of demographic questions to inform the characteristics of the user, such as age range, gender, years of experience, area of speciality, etc. One of the aims of this study was to assess the existence of any relationship between the demographic characteristics and actual use. Thus, it was important to collect demographic data.

Part 3: This part consists of 11 statements about the level of utilisation of the CPOE tasks. These statements are used to measure the actual use of CPOE.

Part 4: This part includes 25 statements to measure 6 constructs that represent factors illustrated through the systematic literature search (107). For each construct, the participants were asked to select the answer that best represented their level of agreement. The survey and the translated version are provided in Appendix C and Appendix D respectively.

3.5.2 Interviews and Observation (Qualitative Data Collection)

The purpose of using interviews is to explore individuals' perceptions, motivations, and experiences related to the topic under study (205). Interviews have been shown to provide a richer understanding of the problem than when a quantitative approach alone is used, and it is the most recommended tool for obtaining further details from an individual in order to understand the research problem (205). There are three types of interviews: structured,

unstructured, and semi-structured (205). In structured interviews, participants are asked pre-determined questions in the same order, and no follow-up questions are asked to elaborate on a topic (205). This type of interview is manageable and can be achieved in a timely manner; however, it is not useful when an in-depth explanation is necessary (205). In contrast, in unstructured interviews, the questions are not prepared in advanced (205). The researcher asks participants questions spontaneously, and there is no clear organization of the interview (205). This type of interview can be time consuming; however, it is useful when in-depth elaboration is needed (205). In semi-structured interviews, participants are asked a number of pre-determined open-ended questions (206). The researcher uses a well-defined interview guide that consists of the questions or the topic that they wish to explore during the interview (206). As the researcher can ask follow-up questions, this type of interview motivates the participant to elaborate on and explain their response further (206). The flexibility of this type of interview helps the researcher uncover new areas about the phenomena under study by encouraging participants to elaborate further about their perceptions, views, and experiences (207).

This research used semi-structured interviews to collect qualitative data. Interviews were considered as the most appropriate qualitative approach for the following reasons. Using interviews helps achieve objective 6 of this research, which is to investigate further the perspectives of physicians on factors associated with their use of CPOE for medication prescription. Further, conducting interviews is the most appropriate approach to obtain the needed information about their views and opinions, as it provides physicians with an opportunity to elaborate in depth about their perspectives. This space of elaboration during the interviews might reveal other factors that were not captured from the literature search

or covered by the survey alone. Semi-structured interviews can be challenging, as answering the open-ended questions might take longer than expected, and participants might go off topic. However, follow-up questions are used to keep participants within the topic of the question.

Qualitative observation refers to the process of watching and listening to the people under study at the research site (208). It requires the researcher to make field notes on the behaviour and activities of individuals at the research site (176). Observations can produce highly accurate data as the researcher himself/herself is directly recording the target population in their natural setting and not relying on other's reflection or judgment to record that behaviour (209). Additionally, it can help to overcome the discrepancy between what people say and what they actually do, as the research targets behave in the desired natural manner and do not trying to represent themselves based on the influence of what the researcher wants to hear (208).

3.5.2.1 Interview Protocol

Interview protocol is a document that the interviewer uses as a guide to the questions and topics the researcher wants to cover (176). It consists of a heading with the research study title; the coded name of the interviewee; the date, time, and duration of the interview; instructions for the interviewer to follow; the interview questions; and a final thank-you statement to acknowledge the time the interviewee spent on the interview (176). In this research, a protocol was developed and used as a guide for conducting the interviews. In the process of developing an interview protocol, protocol pilot testing is an important step a researcher needs to take in order to ensure the feasibility, relevance, and appropriateness

of the protocol questions (210). Pilot testing can be achieved through expert assessment or/and real interviews with potential participants (210). Pilot testing helps refine the questions and shed light on anything that is not clear or seems irrelevant; it also gives the researcher insight into how much time an interview might take (210). For this research interview protocol, two pilot interviews were conducted to make sure the questions were relevant and clear. A pilot interview was conducted with a graduate student, and a second interview was conducted with a physician (See Appendix E).

3.6 Population and Recruitment

The population of a study refers to an entire group of people, objects, or events that share common characteristics (211). For this study, the target population was physicians who work at government hospitals and use CPOE with the entire set of CDS features for prescribing medication in Saudi Arabia. Government hospitals can be distinguished from private hospitals in Saudi Arabia in several ways. Government hospitals are equipped with their own research centres, and this allows for more reliable and credible empirical studies. Some examples of such hospitals are King Faisal Specialist Hospital and Research Centre (212), King Abdul-Aziz Medical City (213), and King Abdallah Medical City (214). According to the MOH Statistical Year Book for 2020 (Chapter 2), all government hospitals have over 500 physicians from a variety of medical specialties (215). This feature will improve the chances of obtaining sufficient responses in this study. Moreover, large budgets are allocated for governmental hospitals; this allows them to have much more advanced CPOE systems than private sector hospitals (67).

Geographically, governmental hospitals are widely speared among all 13 regions of Saudi Arabia (216) (refer to Figure 1.2, Chapter 1). There are about 47 hospitals under

government entities that provide healthcare services across all regions of Saudi Arabia (216, 217). This allows for the findings of this research to be generalized. Due to the limitations in terms of time, resources, accessibility, and locations, two settings were selected to conduct this research study. These will be referred to as hospital A and hospital B during this study, for the purpose of confidentiality. Hospital A is a tertiary referral hospital. It provides a wide range of medical services through its oncology, transplant, paediatric, obstetrics and gynaecology, neurology, cardiology, emergency surgery, and radiology departments, and pain clinic. It has a capacity of 500 beds and has about 329,642 outpatient visits and about 10,483 inpatients annually. The CPOE system has been in practice for 12 years at this site. Hospital B is a specialist hospital, which apart from providing medical services, is mostly known for treating critical cases through a series of medical centres, including a cardiology centre, a bone marrow transplant centre, and a burns unit. It has a capacity of 751 beds and has about 22,000 inpatient and around 435,000 outpatient visits annually. The information system at this site has been in use for 9 years.

The reasons for choosing these two sites are as follows. First, both settings have reached Electronic Medical Record Adoption Model (EMRAM) stage 6 and stage 7 (83, 85). EMRAM is a framework to assess how effectively a healthcare facility is using their information system (218).

This model has 8 stages for ranking the facility (0–7); each stage indicates a certain level of achievement through the adoption of the model (218). Stage 6 means that the healthcare organization has used the technology effectively in medication administration and blood works; the EMR has been implemented and integrated with CPOE, laboratories, and pharmacy; and a full decision support system is present (218). Stage 7 means that the use

of the system has reached a point where the hospital no longer uses paper charts for reporting or clinical data analysis, clinical information about patients is being shared even with non-associated health centres, and physicians' documentation with CPOE as a closed-loop process (that is, solely system processing with no human interaction) has reached 95% (218). Appendix F illustrates the capabilities that define each stage in detail. Based on these capabilities, the two settings were mature enough to fit the inclusion criteria of this research and its objective.

The second reason for choosing the two hospitals was that both settings have their own research centre, and both have over 500 physicians who work on all specialties. Third, both settings have branches in the two most populated and largest regions in Saudi Arabia (219, 220)—Riyadh (8,660,885 million) and Makkah (9,033,491 million)—according to the General Authority of Statistics' report of 2019 (221). This geographical distribution of branches in the most important areas may enhance the representativeness of the selected sample. The similar characteristics of these two settings, such as the user type (physician), gender balance, all variations of medical specialties, similar CPOE and full CDS features for medication prescription, and geographical distribution, made these settings appropriate research sites to meet this study's objectives.

3.7 Data Collection Procedures

3.7.1 Surveys

An invitation email was sent to all physicians through the medical director's office in each setting. The email included a cover letter consisting of an introduction to the study, confidentiality and anonymity considerations, time needed to finish the survey, the researcher's contact information, and the survey weblink. The survey weblink was

provided through Select Survey. Select Survey is an online survey tool that was approved by the University of Manchester at the time of data collection. The online survey was available from July 2020 till October 2020. A weekly reminder was sent for following up in order to try and increase the response rate.

3.7.2 Interviews and Observation

In the same invitation email, participants were asked if they would like to participate in an interview as part of the study. Physicians who agreed sent an email to the researcher to arrange for the interview. Before the interview was conducted, the researcher sent an information sheet that included a consent form for the participant to read and sign (See Appendix G). The information sheet included an introduction about the study, the terms of confidentiality, the structure of the interview, how much time it would take, and the researcher's contact information. The second page included a consent form with permission to audio record the interview. Once the participant read the information sheet and signed the consent form, the researcher and the participant started the process of arranging the interview.

For interviews, a purposive selection approach was used (176). Purposeful selection means selecting individuals who are especially informative about a phenomenon of interest (174). Creswell (176) asserted that in qualitative research, purposeful selection of participants or sites serves the researcher's needs the best in terms of understanding the research problem. Physicians were selected according to the number of years of experience, knowledge, and availability. Availability and readiness to participate are important considerations when recruiting in qualitative research (222).

In qualitative research, there is no specific answer to how many participants is enough for a sample (176). However, the literature provides some guidelines about this. For example, Saunders and Townsend (223) recommended 4 to 12 participants in the case of a homogenous population and 12 to 30 participants in the case of a heterogeneous population. Homogeneous means that the subjects of a population are mostly alike, while heterogeneous means that the subjects of the population are not similar to each other (174). Creswell (176) suggested different numbers of participants for different qualitative designs. He noted that 4 to 5 participants are sufficient for case studies (176). Since the research sites and population sample of this research are homogenous, and the study was conducted over two sites, 5 to 10 participants were anticipated to be sufficient to conduct interviews for this research.

The interviews were originally planned in the participants' settings where they worked (176). However, due to the outbreak of the COVID-19 pandemic (224), at the time of data collection, it was difficult to meet physicians within their settings. Therefore, all the interviews were conducted by the researcher via online meeting tools (e.g. Cisco WebEx Meetings and Zoom). At the beginning of each interview, the researcher started by introducing herself and the study objectives. The participant was informed about the terms of confidentiality, the structure of the interview, and how much time it would take. In addition, participants were reminded that it was a voluntary study and they could withdraw at any time, and that the interview would be audio-recorded. All interviews were audio-recorded, and notes were taken during interviews in order to have a backup source in case there were any technical errors with the recordings. All the interviews were conducted in English, as all the physicians spoke fluent English. The interviews were completely

anonymous, and no personal information was mentioned or collected. A code name was assigned to each participant and used where applicable, and the information collected was anonymised. At the end of the interview, the researcher thanked the participant and asked if they had any queries. Once the interview was completed, the transcription of each interview was conducted immediately.

Observation of physicians was not possible at the time of data collection due to restrictions on healthcare facilities posed by the COVID-19 pandemic in March 2020. Hence, this part of the research was cancelled.

3.8 Ethical Considerations

This research study followed the ethical guidelines for conducting research studies of the University of Manchester. Participant's personal information was kept anonymous and confidential during the study. To maintain participants' confidentiality during the research and ensure anonymity of the data, any information related to either the participants or their organizations was not included. Two separate informed consent forms were provided to the participants—one for the questionnaire and the other for the interview. Both consent forms explained the objective of the study and provided all other information the participants might need (see Appendices C & G). According to the University of Manchester Research Governance Policy, working with professional employees is classified as being exempt from ethical review. Since this study's population comprises physicians (professionals) who are expressing their perceptions, this study did not require ethical approval from the University of Manchester's ethical committee. However, approval letters from the institutional review board of each setting were obtained to obtain permission for conducting this research (See Appendix H).

3.9 Data Analysis

In the previous sections, the overall research design, data collection strategies, and data collection processes were explained. In this section, the data analysis methods used to analyse the quantitative and qualitative data are illustrated.

3.9.1 Quantitative Data

This section describes the tests used to analyse the quantitative data and justifies these choices. Before the analyses were conducted, the data were prepared. Survey data were exported from the survey tool provider (Select Survey) to a spreadsheet. The data were then coded into numerical codes that were entered in another spreadsheet.

Coded data were checked for any errors, such as numbers that do not make sense: for example, for a response scored on a scale of 1 to 5, any number other than 1, 2, 3, 4, or 5 was considered an error. Additionally, data were screened to make sure that there were no missing answers or odd response patterns (174). Lastly, the prepared codes were entered into the Statistical Package for the Social Sciences (SPSS) software for analysis.

Because this study's survey has several scales with a different number of items for each scale (refer to Table 3.1), a scoring system was used (see Figure 3.4) (225). This scoring system was used to convert the 5-point scale from 1 to 5 into 0 to 100. The 5-point scale was reset to start at 0 by subtracting 1 from the response options and then multiplying it by 25 (the desired maximum of 100 divided by the subtracted, unstretched maximum of 4) (225). It is important to have a common scale in order to have a general standardized analysis across all scales (225).

5-point	1	2	3	4	5
101-point	0.0	25.0	50.0	75.0	100.0

Figure 3.4 Scoring System (225)

3.9.2 Reliability and Validity of the Survey

In the process of evaluating survey-based research, reliability and validity are two essential elements to be considered by researchers (194). Reliability refers to the consistency of the scale's results over time (226). This consistency can be measured through internal consistency tests (226).

Reliability means that there is consistency between different items of the same construct (226). Examining the internal consistency of a scale requires the researcher to calculate Cronbach's alpha coefficient for each scale measuring a certain construct (226). Cronbach's alpha coefficient is the most popular method of testing for internal consistency (227). It is a calculated number that provides an indication of the internal consistency of a scale and ranges between 0 and 1 (226).

Hulin et al. (228) proposed that alpha values ranging between 0.60 and 0.70 indicate an acceptable level of reliability, while alpha values of 0.80 and above indicate very good reliability. To measure the reliability of this research's survey, an internal consistency test was conducted using Cronbach's alpha coefficient. SPSS was used for this test as well as for all quantitative analyses in this research (229). Validity is examined after data collection, as illustrated in detail below.

Validity refers to the extent to which a data collection tool is measuring what it should be measuring (174). To test the validity of the survey, face validity, content validity, and construct validity were examined (174). Table 3.3 illustrates the procedures of validation performed for the survey.

Table 3.3 Validation Tests Performed for the Survey

Validity Test	Definition	How it was established

Face Validity	Face validity means the subjective judgment of the survey's questions as appearing clear, rational, and relevant (230). To establish face validity, a test taker can be asked to evaluate the survey (231).	- The pilot test
Content Validity	Content validity refers to the degree to which a scale's items are relevant and representative of the construct it intends to measure (174). It can be established by exhaustive literature review and expert feedback (174).	- In-depth literature review - Consultation with experts
Construct Validity	Construct validity means the extent to which the survey or scale items or questions actually measure the construct it claims to measure (174). Construct validity can be assessed through factor analysis (232). Factor analysis is a statistical procedure used to evaluate the relationship between a group of variables that are measured through questions, and its aim is also to condense a set of items into a smaller set of clear and definable items for each construct (232). There are two major factor analysis tests: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is used to test the relationship between variables, while CFA is used to test a theory or hypothesis (232).	- Factor analysis using principal component analysis (PCA) - Factor loadings - Total variance explained (TVE %)

Content validity was evaluated as explained earlier in stage 2 (scale development), and face validity was examined through the first pilot test with 7 physicians, as explained in stage 3 (instrument testing) in Section 3.5.1.1 of this chapter. Construct validity was measured through factor analysis using principal component analysis (PCA) (232). PCA is a statistical extraction method that is most commonly used for exploratory factor analysis (232). The aim of using PCA is to determine the minimum number of values required to represent the maximum variance within the data set (233). To determine this, PCA uses a method called factor loading (233). Factor loadings are values that express the correlation of each variable (item) to the underlying factor (construct) (233). Loading indicates the degree of association between the variables and the factor and ranges between -1.0 and +1.0 (233). High loadings indicate a representative item of the construct (233). Hair et al.

(233) proposed that loadings of ±0.30 to ±0.40 can be considered important, and loadings of +0.50 or greater can be considered to be very significant.

Before factor analysis is conducted, the sample needs to be assessed to determine its adequacy for factor analysis (232, 233).

Field (234) and William et al. (232) suggested the Kaiser-Meyer-Olkin test (KMO) and Bartlett's sphericity test (233) to assess sample appropriateness for factor analysis (232, 234). KMO is a statistical test used to measure whether the sample of data is appropriate for factor analysis (232). KMO values ranges between 0 and 1, with values of 0.50 or higher considered suitable for factor analysis (235). Bartlett's sphericity test is a statistical test to determine the correlation between variables (233). Statistical significance ($p < 50$) indicated by Bartlett's test suggests that the correlation between variables is sufficient (233). In general, a KMO value above 0.50 and a significance level of $p < 0.05$ with Bartlett's sphericity test are considered acceptable (235). To assess sample adequacy, data from 183 responses were run through SPSS. Each scale was assessed separately.

Beside factor loadings, total variance explained (TVE) was considered for each scale. TVE is a percentage which indicates that the items explain a specified amount of variance (233). The use of TVE as a criterion has been a debatable subject in the literature. No specific threshold for TVE has been set (233). While Pett et al. (236) and Pallant (237) suggested that 50% of total variance is acceptable, Hair et al.(233) argued that it is common to consider 50% to 60% of the total variance as satisfactory when the study involves assessing an individual behaviour for which the information available is often less precise. Anderson (238) argued that in studies involving humans, a variance of just over 49% is explainable.

3.9.3 Results for Reliability and Validity of the Surveys' Scales

Table 3.4 represents the results of the reliability tests of the pilot study for 18 responses. The alpha values indicated that all the scales had acceptable alpha values. The alpha values ranged from 0.65 to 0.93, so they exceed the recommended value of 0.60. Based on these results, all the scales were deemed to be reliable.

Table 3.4 Reliability of the Survey's Scale Items

Scale	Abbreviation	Number of Items	Cronbach's Alpha
Actual Use Order Entry	AUOE	2	0.75
Actuals Use CDS	AUCDS	9	0.93
Performance Expectancy	PE	3	0.65
Effort Expectancy	EE	3	0.83
Social Influence	SI	3	0.82
Facilitating Conditions	FC	6	0.78
Information Quality	IQ	3	0.76
System Quality	SQ	7	0.86

With respect to the validity of the scale, the KMO values and Bartlett's values for each scale met the criteria illustrated in Section 3.9.2. The KMO values for all the scales were above 0.50, and Bartlett's tests indicated significance too. The results indicated that the sample was appropriate for factor analysis. Accordingly, factor analysis using PCA was conducted to assess the performance expectancy, effort expectancy, social influence, facilitating conditions, information quality, and system quality scales. All the items' loadings for each scale were above the acceptable range proposed by Hair et al. (233). This indicates that all the items within each of the scales are representative of the construct they were intended to measure. The actual use scale is a multidimensional scale that consists of order entry tasks and CDS tasks for three different types of medication prescription alerts. Factor analysis was not conducted for this scale, as reducing the number of items would affect the reliability of the scale and, hence, affect the scale content.

The TVE values for performance expectancy, effort expectancy, social influence, and information quality were over 50%. For the facilitating conditions scale and system quality scale, TVE was 49.28% and 49.26% respectively. Given that this study is on the evaluation of the use of information systems in healthcare settings through assessing human behaviour in terms of the use, and that it is not uncommon to have low variance in such cases, the loadings for all items on all scales were within the acceptable range. In this regard, all the TVE values were considered to be satisfactory. Thus, all the items on all the scales are representative of each construct. Table 3.5 illustrates all the values from the validation process.

Table 3.5 Construct Validity Tests

Construct	Kaiser-Meyer-Olkin test (KMO)	Bartlett's Test of Sphericity	Items	Factor Loading	TVE%
Performance Expectancy	0.67	0.00	PE1	0.847	70.23%
			PE2	0.783	
			PE3	0.881	
Effort Expectancy	0.67	0.00	EE1	0.846	68.82%
			EE2	0.774	
			EE2	0.866	
Social Influence	0.67	0.00	SI1	0.900	73.72%
			SI2	0.900	
			SI3	0.769	
Facilitating Conditions	0.75	0.00	FC1	0.440	49.28%
			FC2	0.635	
			FC3	0.665	
			FC4	0.807	
			FC5	0.808	
			FC6	0.783	
Information Quality	0.69	0.00	IQ1	0.872	70.69%
			IQ2	0.835	
			IQ3	0.819	
System Quality	0.85	0.00	SQ1	0.795	49.26%
			SQ2	0.751	
			SQ3	0.637	
			SQ4	0.361	

SQ5	0.765	
SQ6	0.730	
SQ7	0.774	

3.9.4 Statistical Data Analysis

The following are the statistical tests that were used to analyse the quantitative data.

Table 3.6 Quantitative Data Analysis Tests

Statistical Test	Definition	Objective
Descriptive Statistics	A descriptive statistic is used to describe and compare the data set numerically (174). It can be used to calculate the most frequent value of the data (mode), the mid-point value after the data are ranked (median), the average of a set of data (mean), and the standard deviation, which is the extent to which values differ from the mean (174).	To evaluate physicians' self-reported levels of actual use, to determine the frequencies and percentages of the participants' characteristics, as well as all the variables.
Chi-Square	A chi-square test is a statistical test that is used to determine how likely two variables are of being associated (174). A chi-square test is used to produce a p-value. This p-value informs whether the association between the variables is significant or not (174).	To explain the association between the physicians' characteristics, namely, position, age, gender, and years of experience, and the level utilisation of CPOE.
Pearson's Correlation Coefficient	Pearson's correlation coefficient is a statistical test used to assess the linear association between two continuous variables (174). It provides information about the strengths of the correlation, as well as the direction of the linear association (174). It is represented by r (174). The value of r ranges between -1 and 1. An r value of -1indicates a perfect negative relationship, and an r value of 1 indicates a positive relationship. An r value of 0 means that the variables are perfectly independent and there is no relationship (174) (See Figure 3.4). To determine whether the correlation is significant or not, the p-value is compared to the significance level, which is usually 5.0 (174). If the p-value is equal to or less than 5.00, then the correlation is statistically significant (174). If the p value is greater than 5.0, then the correlation is not statistically significant (174).	To determine the correlation between the independent factors of the performance expectancy, effort expectancy, social influence, facilitating conditions, information quality, and system quality scales, and the dependent variable, which is the actual use of CPOE.

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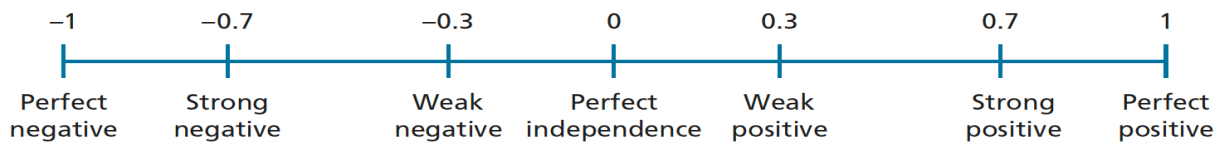
Figure 3.5 Values of the Correlation Coefficient

3.9.5 Qualitative Data

Qualitative data analysis techniques can be divided into three categories: methods that explain and analyse participants' insights such as content and thematic analysis (239), methods that focus on generating a theory known as grounded theory (239), and socio-linguistic analysis that explains the use and meaning of language, for example, discourse and conversation analysis (239). Due to the exploratory objective of this research, and since it is an investigation of participants' views and opinions, a thematic analysis approach was used to analyse the qualitative data (240). Braun and Clarke (241) and King (242) recommended thematic analysis for assessing the views and opinions of various research participants and providing unexpected findings.

Thematic analysis is a technique researchers apply to identify, analyse, organise, and interpret meanings within the qualitative data set (241). This approach was chosen as it facilitates the observation of similarities and differences in large sets of data (241). This approach also helps the researcher to produce well-structured reports (241). This can help in linking the data of the interview transcripts and making sense of them. The thematic analysis approach applied in this research was informed by Braun and Clarke's six-step guide for qualitative analysis (241), as shown in Table 3.7.

Table 3. 7 Braun and Clarke's (2006) Six-Step Thematic Analysis Guide (241)

Phase	Description of the Process
1. Familiarizing yourself with your data	- transcribing data - reading and re-reading the data

	• noting down initial ideas
2. Generating initial codes	• coding interesting features of the data in a systematic fashion across the entire data set • collating data relevant to each code
3. Searching for themes	• collating codes into potential themes • gathering all data relevant to each potential theme
4. Reviewing themes	• checking if the themes work in relation to the coded extracts and the entire data set • generating a thematic 'map' of the analysis
5. Defining and naming themes	• ongoing analysis to refine the specifics of each theme • generating clear definitions and names for each theme
6. Producing the report	• producing a scholarly report of the analysis

Based on the abovementioned six-step guide for thematic analysis, the following analysis process was conducted:

Phase 1—Data Familiarization: The researcher had the opportunity to familiarize herself with the data during the transcribing process. The recordings of the interviews had to be replayed several times to make sure the transcripts were accurate. During the process, any reflective potential code or theme was identified.

Phase 2—Generating initial codes: After the researcher familiarized herself with the data and read through it repeatedly, she started coding the data by noting similar patterns and sorting them into groups. Coding means to assign a label or a descriptive word to a set of data that shows a similar pattern to provide a meaningful understanding of this set of data (241). The codes were generated by highlighting the data that show specific patterns in different colours, with each colour representing a certain code (See Appendix I).

Phase 3—Searching for themes: After a list of codes was produced, the researcher started assembling those codes under potential main themes.

Phase 4—Reviewing themes: This step involves refining the themes. The researcher reviewed carefully the codes listed under each theme and made sure that they were coherent and formed a rational pattern. The initiated themes seemed coherent with the list of codes. A thematic map was generated accordingly (See Appendix J).

Phase 5—Defining and naming themes: At this step, the researcher explained what each theme means and what it captures by giving each one a comprehensive definition that fits with the overall story of the research. The definition for each theme is presented in Table 3.8.

Phase 6—Producing the report: At this step, the researcher started reporting the thematic analysis by describing the findings in a clear and logical manner. The report was supported by direct quotations from the participants that are related to the themes, in order to enhance the trustworthiness of the themes.

3.9.6 Thematic Framework

The theoretical basis of explaining physicians' views about the factors associated with their self-reported actual use of CPOE was drawn from the concepts of the UTAUT (131) and the D&M IS success models (132), as illustrated in Table 2.4, Chapter 2. In accordance with these theoretical definitions, the following framework was used to explain physicians' perceptions (Table 3.8).

Table 3.8 Thematic Framework used to Categorise Physicians' Perceptions

Theme (Category)	Definition of the Theme
Individual	Aspects related to the physicians' perceived effects on their performance by using CPOE for medication prescription. These include effects on job performance, quality of work,

(Performance Expectancy) (Effort Expectancy) (Social Influence)	productivity, effectiveness, outcomes, ease of use, and perceptions of important others' view of them when using the system (131).
Organizational (Facilitating conditions)	These include physicians' perceptions about the resources (facilitating conditions) provided by the organization that facilitate physicians' utilisation of CPOE, such as the technical infrastructure, personnel, circumstances, and environment (131).
Technological (System quality) (Information Quality)	These include perceptions related to the technical aspects of CPOE in terms of system quality (e.g. availability, reliability, functionality, flexibility, usability, integration, and response time) and information quality (e.g. accuracy, timeliness, completeness, relevance, consistency, and content) (132).

3.9.7 Trustworthiness of the Analysis

Trustworthiness refers to the validation process of the qualitative findings in terms of confidence in the data, interpretation, and methods used to ensure the quality of a study (243). The purpose of assessing the trustworthiness of the data, according to Lincoln and Guba (244), is to ensure that 'the findings are worth paying attention to' (p. 290). Lincoln and Guba (244) proposed the following criteria to assess the trustworthiness of the qualitative data:

I. **Credibility:** Credibility refers to representing reliable information that reflects participants' original views (244). To establish this credibility, prolonged engagement, triangulation, peer debriefing, and member checking may be employed (244). For this research, prolonged engagement was achieved through spending sufficient time with the participants during long interviews. Triangulation means using multiple research approaches to enhance the qualitative findings (245). In this study, two data sources were used to collect the data, and were cross-checked for ensuring the credibility of the results. Peer debriefing involves having an expert who knows a great deal about the substantive area of the method of qualitative

analysis and assesses the findings (244). The results of this research were assessed for validity by a member of the supervisory team who is an expert in qualitative research. Member checking involves getting feedback on the interpretation of findings from the participants from whom the data were originally obtained (244). In the current study, interpretations of data were sent to participants to obtain their feedback and to confirm the rigor of these findings.

II. **Transferability**: Transferability means the applicability of the results to other contexts or other settings (244). This can be achieved through a thick description of the research process and the participants, in order to enable the reader to assess whether your findings are transferable to their own setting (244). In this research, a thick description was provided earlier in this chapter.

III. **Dependability**: Dependability refers to the consistency of the findings, and these findings can be repeated over time (244). Dependability can be confirmed through an audit trail (244), which is defined as the researcher's provision of evidence on decisions made during the research process, sampling, research approaches, management of data, and the development of the findings (244). This research fulfilled this criterion through the audit trail provided in the detailed explanation of the methods in this chapter.

IV. **Confirmability:** Confirmability demonstrates that the explanation of the findings are clearly drawn from the raw data obtained from participants and are not based on the researchers' perceptions (244). Confirmability can be established through audit trail, as explained earlier. In addition, direct quotations from each

participants' statement are included to demonstrate how the findings are based on evidence rather than the researcher's preconceptions (240).

3.10 Summary

This chapter described the philosophy, approaches, and the overall design that was appropriate to achieve this research's objectives. It explained the selected data collection tools, how each were developed, and the rationale behind these selections. In addition, the study population was defined, and the sampling procedures for the surveys and the interviews were illustrated. A detailed process depicting how each set of data were collected and the data analysis approaches for both sets were provided. The next two chapters present the results and analysis of the quantitative data and the qualitative data.

Chapter 4: Quantitative Results

4.1 Introduction

In the previous chapter. both quantitative and qualitive data approaches, collection tools, and procedures were explained and justified. This chapter presents the results of the analysis of the quantitative data. This includes a descriptive statistic of the participants' characteristics, the level of actual usage of tasks, and the study variables (constructs). This is followed by an explanation of the associations between the actual usage of tasks and the physicians' characteristics, namely, position, gender, age, and years of experience, and finally, the correlation between the factors and the self-reported actual use of CPOE.

Quantitative data were obtained through an online survey. A total of 459 physicians initially started the survey, and 183 were completed and returned. Out of the initial 459 surveys, 60% were partially completed and, therefore, excluded from the data analysis. Therefore, the response rate was 40%. The non-respondents (60%) comprised those who only opened the survey link and did not provide any answers and those who dropped out later in the middle of the survey. The majority of those who dropped out in the middle of the survey were consultants. The data from 183 completed surveys were processed in SPSS for analysis.

4.2 Characteristics of Participants

A total of 183 physicians completed the survey. This sample included reasonably experienced physicians and was composed of 42.6% consultants, 39.9% residents, and 17.5% assistant physicians. There were more males than females (64.5% vs. 35.5%). The difference between the number of male and female participants can be explained by the greater number of male physicians than female physicians in the total population that was targeted for the survey. With regard to age distribution, 34.4% of the respondents were

between the age of 20 and 29 years, which represents the biggest age group; 25% were between 30–39 years and 40–49 years; and only 14.8% were over 50 years old. Further, 44.8% of the respondent were working in setting A, while 55.2% were in setting B. The participants differed with regard to their years of experience: 41% had more than 10 years of experience, 13% had between 5 to 10 years of experience, 25.1% had 2 to 5 years of experience, and 20.8% had less than 2 years of experience. With regard to their skill in using technology/devices, 32.2% and 55.2% of the physicians rated themselves as excellent and good respectively. This indicates that more than half of the participants know how to use the computer devices in their settings. Most of the participants (42%) had been using CPOE for 2–5 years only, while only 8% of the participants had been using CPOE for more than 10 years. The respondents were from different medical specialties: 16.4% were from the paediatric department, while 14.2% were from the internal medicine department. The rest were distributed among all the other medical departments. This variation in medical specialities helped to inform different views about COPE use. Table 4.1 and Figures 4.1 to 4.8 summarise the characteristics of the physicians.

Table 4.1 Characteristics of Physicians

Demographics		**n**	**%**
Total		183	100.0
Position	Consultant	78	42.6
	Resident	73	39.9
	Assistant Physician	32	17.5
Gender	Male	118	64.5
	Female	65	35.5
Age	20–29 years	63	34.4
	30–39 years	47	25.7
	40–49 years	46	25.1
	50 years and above	27	14.8
Setting	A	82	44.8
	B	101	55.2
Years of experience	Less than 2 years	38	20.8
	Between 2 and 5 years	46	25.1

	Between 5 and 10 years	24	13.1
	More than 10 years	75	41.0
Generally, how do you rate yourself in using computer/technology devices at work (computer skills)?	Poor	2	1.1
	Average	21	11.5
	Good	101	55.2
	Excellent	59	32.2
For how many years have you been using CPOE?	Less than 2 Years	47	25.7
	2 to 5 Years	77	42.1
	5 to 10 Years	45	24.6
	More than 10 Years	14	7.7
Department	Internal Medicine	26	14.2
	Family Medicine	16	8.7
	General Surgery	15	8.2
	Emergency	9	4.9
	Obstetrics and Gynaecology	16	8.7
	Paediatrics	30	16.4
	Neurology	10	5.5
	Cardiology	8	4.4
	E.N.T (Ear, Nose, and Throat)	3	1.6
	Orthopaedics	6	3.3
	Anaesthesiology	6	3.3
	Cardiac Surgery	1	0.5
	Dentistry	4	2.2
	Dermatology	4	2.2
	Diagnostic radiology	1	0.5
	Haematology Oncology	1	0.5
	Oncology	13	7.1
	Ophthalmology	3	1.6
	Paediatric Cardiology	1	0.5
	Plastic Surgery	1	0.5
	Psychiatry	3	1.6
	Urology	5	2.7
	Vascular	1	0.5
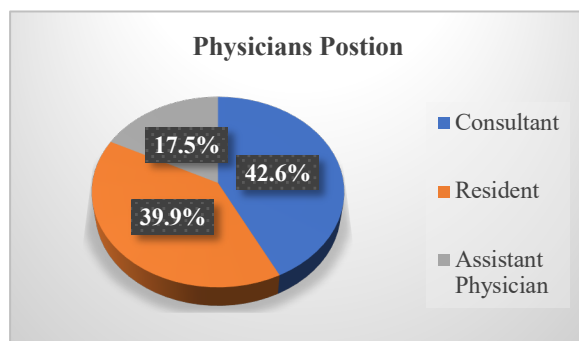
Figure 4.1 Positions
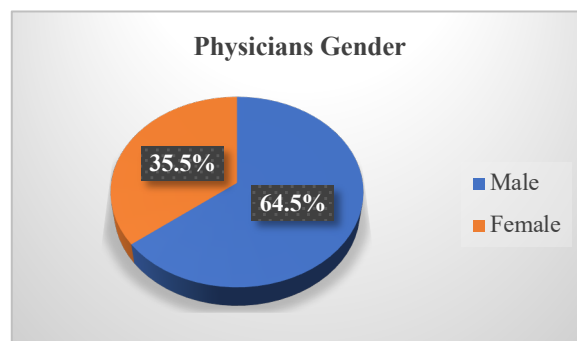
Figure 4.2 Gender
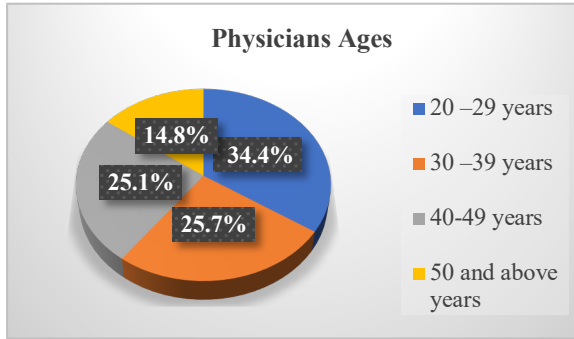
Figure 4.3 Age
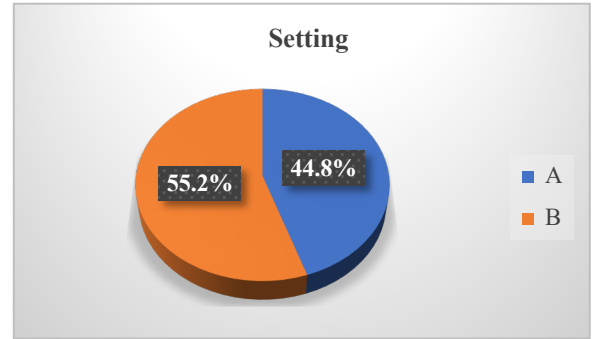
Figure 4.4 Settings
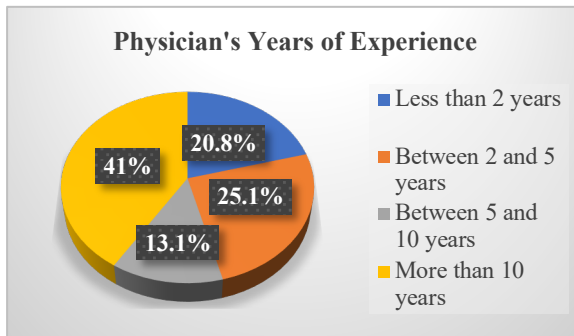
Figure 4.5 Years of Experience
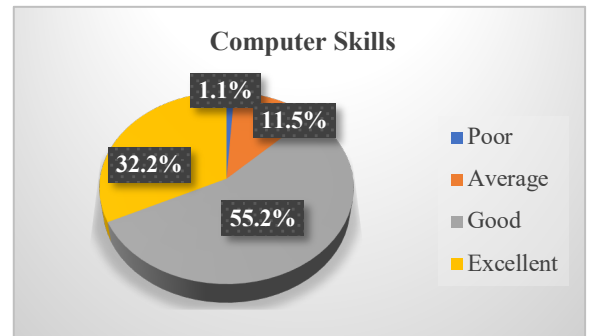
Figure 4.6 Computer Skills
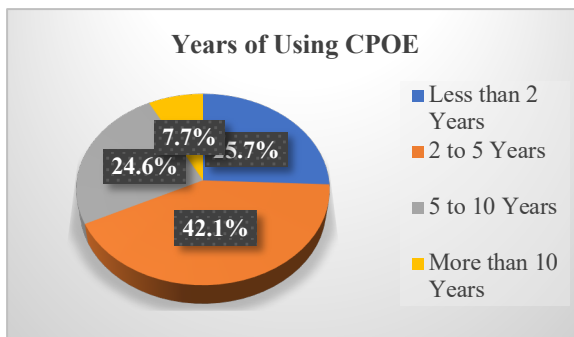
Figure 4.7 Usage of CPOE
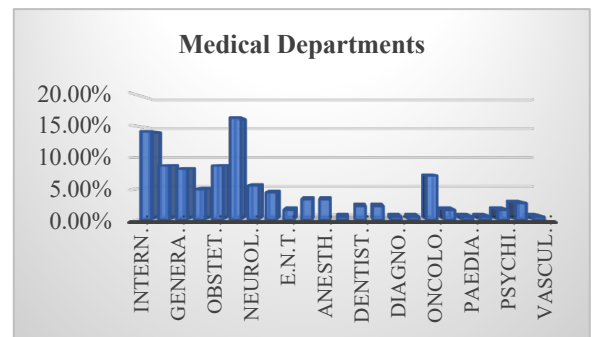
Figure 4.8 Departments

4.3 Level of Physicians' Actual Usage of CPOE

To understand the level of self-reported use of CPOE tasks, physicians were asked to select the answer that best represented their level of use (frequency) on a 5-point Likert scale. The results showed that the level of self-reported actual use of order entry tasks (ordering medications and lab requests) had a higher mean score than all the other CDS tasks.

The mean scores for ordering medications and lab requests were 4.70 and 4.69 respectively. It is possible that their scores are high because these tasks are mandatory for prescribing medication (See Table 4.2). For self-reported actual use of CDSS tasks, the mean scores range between 3.12 and 4.36 (See Table 4.2). There are three CDSS tasks under each type of alert: carefully read the (type of alert) that I receive, provide reasons for (type of alert) that I decide to override, and change my decision related to medication prescription based on (alert type) presented to me during order entry. The alert types are drug interaction alerts, allergy alerts, and dose range alerts. The results show that there was a significant difference between the level of use for each of the alert types. Drug allergy alerts were the most significant, as they were reported by physicians to be the most used, with a mean score of 4.36, 4.09, and 3.99 for the three tasks carefully read the drug allergy alerts that I receive, provide reasons for drug allergy alerts that I decide to override, and Drug allergy alerts presented to me during order entry change my prescribing decisions respectively. Dose range alerts were the second most commonly used, and drug interaction alerts were the least significant, with the least mean scores for the level of utilisation (See Table 4.2).

Table 4.2 Physicians' Actual Usage of CPOE

	Actual Use	Mean	SD
Actual Use of Order Entry Tasks	Order medications.	4.70	0.7
	Order laboratory requests.	4.69	0.7
Actual Use of CDS Tasks	Carefully read the drug interaction alerts that I receive.	3.59	1.0
	Provide reasons for drug interaction alerts that I decide to override.	3.58	1.2
	Drug interaction alerts presented to me during order entry change my prescribing decisions.	3.12	1.1
	Carefully read the drug allergy alerts that I receive.	4.36	0.9
	Provide reasons for drug allergy alerts that I decide to override.	4.09	1.1
	Drug allergy alerts presented to me during order entry change my prescribing decisions.	3.99	1.1

	Carefully read the dose range alerts that I receive.	3.99	1.0
	Provide reasons for dose ranges that I decide to override.	3.87	1.1
	Dose range alerts presented to me during order entry change my prescribing decisions.	3.54	1.1

4.4 Association between Physicians' Demographic Characteristics and the Actual Use of Tasks

To explain the association between physicians' demographic characteristics, namely, position, gender, age, and years of experience, and the self-reported actual use of each task, a chi-square test was conducted. Significant relationships were found between these demographic characteristics and self-reported actual use of several tasks (See Table 4.3). The associations for each of the characteristics are reported in the following section.

Table 4.3 Association between Physicians' Demographic Characteristics and the Actual Use of Tasks

Actual Use of Tasks	Position	Gender	Age	Years of Experience
Order medications.	0.056	0.016[a]	0.067	0.040 [a]
Order laboratory requests.	0.057	0.203	0.219	0.138
Carefully read the drug interaction alerts that I receive.	0.159	0.029[a]	0.668	0.646
Provide reasons for drug interaction alerts that I decide to override.	0.060	0.003[a]	0.162	0.124
Drug interaction alerts presented to me during order entry change my prescribing decisions.	0.335	0.983	0.616	0.191
Carefully read the drug allergy alerts that I receive.	0.597	0.222	0.400	0.244
Provide reasons for drug allergy alerts that I decide to override.	0.366	0.278	0.490	0.199
Drug allergy alerts presented to me during order entry change my prescribing decisions.	0.512	0.952	0.996	0.788
Carefully read the dose range alerts that I receive.	0.005[a]	0.814	0.061	0.009[a]
Provide reasons for dose range alerts that I decide to override.	0.353	0.549	0.683	0.206
Dose range alerts presented to me during order entry change my prescribing decisions.	0.071	0.683	0.921	0.599

[a]-significant using the chi-square test at a p level of <0.05

The Likert scale for self- reporting the level of actual use (never, rarely, some of the time, most of the time, and always) was collapsed into three categories to facilitate the analysis: never/rarely, some of the time, and most of the time/always.

4.4.1 Position

The physician's position was mainly related to the level of the physician's education and experience. The sample of this study consisted of three categories of physicians: consultants, residents, and assistant physicians. Consultants have more education and experience than assistant physicians and residents. The analysis revealed that among the 11 CPOE tasks, the use of the 'carefully read the dose range alerts' task was significantly associated with physician's position. Consultants (46.5%) were more likely to read the dose range alerts carefully than residents (46.5% vs. 36%; $p = 0.005$) and assistant physicians (46.5% vs. 17.5%, $p = 0.005$), and residents were the least likely to carefully read the dose range alerts (Table 4.4).

Table 4.4 Physicians' Position and Actual Use of Tasks

Carefully read the dose range alerts that I receive				
Physician's Position	Never/Rarely (n = 19)	Some times (n = 33)	Most of the time/always (n = 131)	**p-value**
Consultant	3 (15.8%)	14 (42.4%)	61 (46.5%)	0.005*
Resident	12 (63.1%)	14 (42.4%)	47 (36%)	
Assistant Physician	4 (21%)	5 (15.2%)	23 (17.5%)	

*Significant using the chi-square test at a p value of <0.05

4.4.2 Gender

Figure 4.2 shows the percentages of each gender in the total sample. Male physicians represented 64% of the total population, while female physicians represented 35%. The relative difference in the number of male and female physicians is because the number of male physicians was higher than the number of female physicians in the original target

population. Chi-square analysis showed that physicians' gender was significantly associated with three of the actual use tasks: 'order medications' ($p = 0.016$), 'carefully read the drug interaction alerts that I receive' ($p = 0.029$), and 'provide reasons for drug interaction alerts that I decide to override' ($p = 0.003$). Male physicians were less likely to use these tasks than female physicians: 'order medications' (90% vs. 98.5%, $p = 0.016$), 'carefully read the drug interaction alerts that I receive' (50% vs. 53.8%, $p = 0.029$), and 'provide reasons for drug interaction alerts that I decide to override' (47.4% vs. 63%, $p = 0.003$) (Table 4.5).

Table 4.5 Physicians' Gender and Actual Use of Tasks

	Order medications				Carefully read the drug interaction alerts that I receive				Provide reasons for drug interaction alerts that I decide to override			
Physicians' Gender	Never/ Rarely	Some times	Most of the time/Always	*p-value*	Never/ Rarely	Some times	Most of the time/Always	*p-value*	Never/ Rarely	Some times	Most of the time/Always	*p-value*
Male (n = 118)	6 (5.8%)	5 (4.2%)	107 (90%)	0.016*	18 (15.2%)	41(34.7%)	59 (50%)	0.029*	29 (24.5%)	33 (28%)	56 (47.4%)	0.003*
Female (n = 65)	0	1 (1.5%)	64 (98.5%)		9 (13.8%)	21(32.3%)	35 (53.8%)		7 (10.8%)	17 (26.1%)	41(63%)	

*Significant using the chi-square test at a p value of <0.05

4.4.3 Age

Although the participating physicians were from different age groups, there was no significant association between the physicians' age and the actual use of any of the tasks. All physicians from all age groups had similar responses to all the actual use tasks.

4.4.4 Years of Experience

With regard to the number of years of experience, the analysis showed that the number of years of experience was significantly associated with two of the actual use tasks: 'order medications' and 'carefully read the dose range alerts that I receive'. Those who had 10 or more years of experience were the most likely (32.7%) to use the order medications task

than those from all other categories. In contrast, those who had 5 to 10 years of experience were the least likely to use the order medications task (13.4%) (Table 4.6).

Number of years of experience was also associated with the use of the 'carefully read the dose range alerts that I receive' task ($p = 0.009$). An increase in the use of this task was found among physicians with the most experience: that is, its rate of usage was 42.7% among physicians with more than 10 years of experience. In contrast, physicians with 5 to 10 years of experience were the least likely to use this task (14.5%, $p = 0.009$) (Table 4.6).

Table 4.6 Physicians' Years of Experience and Actual Use of Tasks

Order medications			
Physicians' years of experience	Never/Rarely (n = 6)	Some times (n = 6)	Most of the time/Always (n = 171)	***p*-value**
Less than 2 years	0 (0%)	1 (16.7%)	37 (21.6%)	0.040*
Between 2 and 5 years	0 (0%)	0 (0%)	46 (27%)	
Between 5 and 10 years	0 (0%)	1(16.7%)	23 (13.4%)	
More than 10 years	6 (100%)	4 (66.6%)	56 (32.7%)	
Carefully read the dose range alerts that I receive			
Physicians' years of experience	Never/Rarely (n = 19)	Some of the time (n = 33)	Most of the time/Always (n = 131)	***p*-value**
Less than 2 years	6 (31.5%)	6 (18.2%)	26 (19.8%)	0.009*
Between 2 and 5 years	7 (36.8%)	9 (27.2%)	30 (23%)	
Between 5 and 10 years	3 (15.7%)	2 (6.1%)	19 (14.5%)	
More than 10 years	3 (15.7%)	16 (48.4%)	56 (42.7%)	

*Significant using the chi-square test at a *p* level of <0.05

The analysis of the association between physicians' characteristics (position, gender, age, and years of experience) and the actual use of tasks showed that the actual use of 4 of the 11 tasks significancy varied according to the physicians' characteristics, as shown below:

Task	Physician Characteristics Significantly Associated with the Level of Use
• **Order medications**	Gender, years of experience
• **Carefully read the drug interaction alerts that I receive**	Gender
• **Provide reasons for drug interaction alerts that I decide to override**	Gender
• **Carefully read the dose range alerts that I receive**	Position, years of experience

4.5 Descriptive Statistics of Constructs

Table 4.7 presents the descriptive statistics for each of the study variables. The dependent variable is actual use, and the independent variables are performance expectancy, effort expectancy, facilitating conditions, social influence, information quality, and system quality. The number of items for each variable, mean, and standard deviation scores were determined. For each variable, the participants were asked to score a number of items on a 5-point Likert scale to indicate their level of agreement about statements related to the use of CPOE. The average score for the independent variables ranged between 60.66 and 85.93 out of 100. This result suggests that physicians had a positive perception of most of these constructs as factors associated with the actual usage of CPOE for prescribing medication. However, social influence had the least mean score, which indicates that social influence is not highly associated with physicians' use of CPOE for prescribing medication. The score for the self-reported actual use of order entry tasks (92.42 out of 100) suggested that because ordering tasks through CPOE is mandatory, the mean score is relatively high. The score for the self-reported actual use of CDS tasks (69.83 out of 100) indicates that these tasks were moderately used by physicians, as these tasks can be ignored, or overridden (See Figure 4.7).

Table 4.7 Descriptive Statistics for Each Construct

Construct	Items	Mean	SD
Actual Use of Order Entry	2	92.42	15.8
Actual use of CDSS	9	69.83	17.9
Performance Expectancy	3	85.93	16.6
Effort Expectancy	3	80.78	14.6
Information Quality	3	78.96	16.0
Facilitating Conditions	6	73.98	16.7
System Quality	7	73.53	14.8
Social Influence	3	60.66	22.6
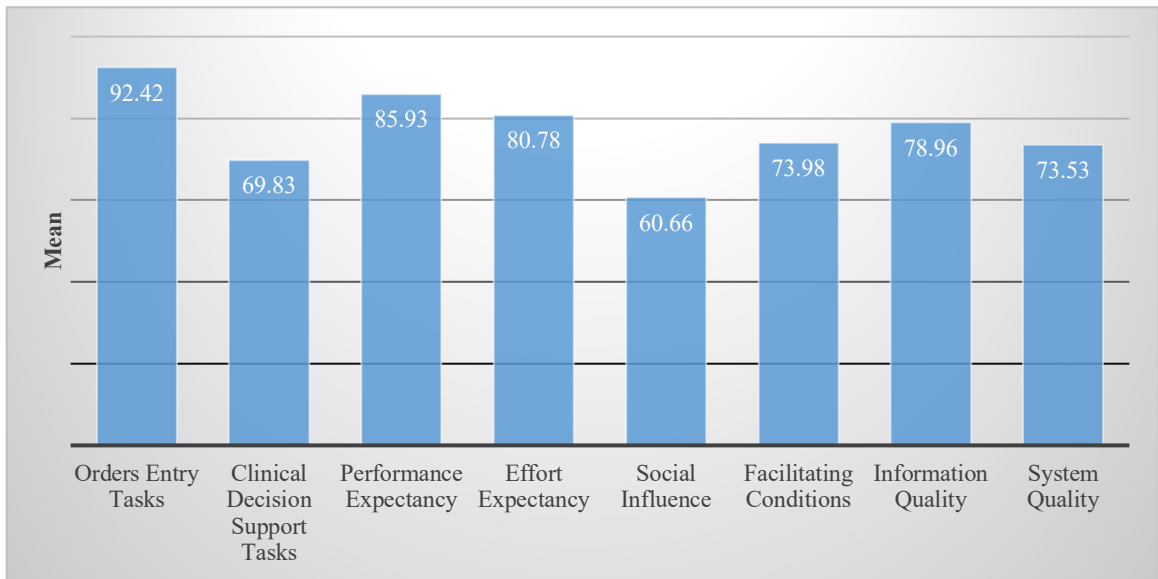
Figure 4.9 Mean Scores of all Variables

4.6 Correlations between Independent Variables (Factors) and Dependent Variable (Actual Use)

Pearson correlation coefficient was calculated to assess the correlation of the independent variables (factors) performance expectancy, effort expectancy, information quality, facilitating conditions, system quality, and social influence with the dependent variable actual use.

Actual Use of Order Entry Tasks

Order entry tasks consist of ordering medications and ordering lab requests. The results of the correlation analysis are shown in Table 4.8. There was a statistically significant positive relationship between performance expectancy, effort expectancy, facilitating conditions, and the actual use of order entry tasks. Effort expectancy had the strongest correlation with actual use of order entry tasks ($r = 0.233$, $p = 0.002$); the correlation was stronger than that of performance expectancy and facilitating conditions. The less effort and more ease associated with the medication order entry process, the more likely were physicians to report high use of these features. Performance expectancy showed the second strongest correlation with the use of order entry tasks ($r = 0.180$, $p = 0.15$). The more aware physicians were that using CPOE for order entry tasks improved their job performance, the more likely they were to use it. Facilitating conditions showed the third strongest correlation with the actual use of order entry tasks ($r = 0.160$, $p = 0.030$). The results indicate that the availability of facilitating conditions to physicians increases their likelihood of using the order entry tasks. In contrast, social influence ($r = 0.027$, $p = 0.716$), information quality ($r = 0.85$, $p = 0.250$), and system quality ($r = 0.066$, $p = 0.373$) all had a positive, but not significant, correlation with the actual use of order entry tasks.

Actual Use of Clinical Decision Support Tasks

The actual use of CDS tasks consists of 9 features (see Table 4.3). Analysis of correlations between the factors and the actual use of CDS tasks showed that performance expectancy, effort expectancy, facilitating conditions, information quality, and system quality all had a significant positive correlation with the actual use of CDS. System quality showed the strongest correlation with the actual use of CDS tasks ($r = 0.386$, $p = 0.001$). Information quality showed the second strongest correlation ($r = 0.359$, $p = 0.001$), and facilitating

conditions showed the third strongest correlation ($r = 0.350$, $p = 0.001$). They were followed by performance expectancy ($r = 0.287$, $p = 0.001$) and effort expectancy ($r = 0.226$, $p = 0.002$). These findings indicate that the more aware physicians are that using the CPOE CDS tasks can enhance their performance, that effortless facilitating conditions are available, and that the information provided by the system is of high quality and is trustworthy, the more likely they are to actually use CPOE.

Social influence did not have a significant correlation with either task. Similar to the finding for actual use of order entry tasks, social influence ($r = 0.126$, $p = 0.089$) did not have a statistically significant relationship with physicians' actual use of CPOE CDS tasks.

Table 4.8 Correlations between Independent Variables and the Dependent Variable

Dependent Variable		Performance Expectancy	Effort Expectancy	Social Influence	Facilitating Conditions	Information Quality	System Quality
Actual Use of Orders Entry Tasks	r	0.180*	0.233**	0.027	0.160*	0.085	0.066
	p-value	0.015	0.002	0.716	0.030	0.250	0.373
Actual Use of Clinical Decision Support Tasks	r	0.287**	0.226**	0.126	0.350**	0.359**	0.386**
	p-value	<0.001	0.002	0.089	<0.001	<0.001	<0.001

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

4.7 Summary

In this chapter, an analysis of the quantitative data obtained from the surveys was provided. Data from the 183 completed surveys revealed the following findings:

- Drug allergy alerts were more frequently used than other alerts.

- A physician's position, gender, and years of experience have an impact on the actual use of tasks. Consultants and the most experienced physicians were more likely to consider dose range alerts, and females were more likely to use the drug interaction alerts than males.

- Performance expectancy showed the most significant association with the actual use of CPOE tasks, while social influence showed the least significant association.

- The correlation between the factors and actual use of tasks varies between order entry tasks and CDS tasks. Effort expectancy showed the most significant correlation with the order entry and order lab requests tasks, while system quality showed the most significant correlation with the CDS tasks. Social influence did not appear to have any significant association with CPOE use.

The next chapter provides the analysis of the qualitative data.

Chapter 5: Qualitative Results

5.1 Introduction

This chapter presents the qualitative results from the semi-structured interviews with 9 physicians. The interviews consisted of five questions. The first two were general questions designed to explore physicians' views on the benefits and challenges of using CPOE. The rest of the questions were related to individual/personal, technical, and organizational factors that might be associated with the physician's self-reported use of the system. These questions were based on the findings of the systematic literature review (Section 2.4.5). As described in Section 3.9.6, these findings were analysed using a thematic analysis approach. The chapter starts with a description of the interviewees' profile, and then explains the key findings of the qualitative data analysis, including the identified codes, the thematic analysis of these codes, and the interpretation of each theme. These findings are supported by direct quotes from the interviewees. Each quote is accompanied by a unique respondent ID number that is followed by a number which refers to the line numbers in the interview transcripts where the quote was located. The objective of these interviews was to investigate physicians' perspectives of factors associated with the self-reported actual use of CPOE for prescribing medication.

5.2 Interviewees' Profile

Nine physicians were interviewed. The sample included a mix of male, female, senior, and junior physicians; the purpose was to obtain different points of view about the phenomena under investigation. Of the interviewees, seven were consultants and two were residents, and four were female and five were male. The residents' ages ranged between 20 and 29 years, while all the consultants were over 30 years old. The majority of the consultants had

more than 10 years of experience, while the residents had 2 to 5 years of experience. The participants were from different departments, with their self-rated computer skills were 'good' and 'excellent'. The average interview time was 30 min. The interviewees' characteristics are listed in Table 5.1.

Table 5.1 Interviewees' Profile

Coded Name	Position	Gender	Age (years)	Setting	Years of Experience	Department	Skill Rating for Computers/Technology Devices at Work	Number of Years of Experience with CPOE for Medication Prescription
A1	Consultant	Female	30–39	A	More than 10 years	Dermatology	Good	2–5 years
A2	Consultant	Male	Over 50	A	More than 10 years	Paediatric cardiology	Excellent	More than 10 years
A3	Consultant	Female	40–49	A	Between 5 and 10 years	Nephrology	Excellent	5–10 years
A4	Resident	Male	20–29	A	2–5 years	Internal Medicine	Good	2–5 years
B1	Resident	Male	20–29	B	2–5 years	Internal Medicine	Good	2–5 years
B2	Consultant	Female	40–49	B	More than 10 years	Paediatric dentistry	Good	5–10 years
B3	Consultant	Male	Over 50	B	More than 10 years	Neonatologists	Good	2–5 years
B4	Resident	Female	20–29	B	2–5 years	Internal Medicine	Good	2–5 years
B5	Consultant	Male	40–49	B	More than 10 years	Neurologist	Good	Less than 2 years

5.3 Coding and Thematic Analysis

A total of 28 codes were identified by physicians as factors that were associated with the use of CPOE for prescribing medication. Table 5.2 presents a list of these codes.

Table 5.2 List of Codes

SN	Factor	Participants
1	Enhances quality	B2, B3
2	Effect on patient safety	A2, A4, B1, B2, B3, B5
3	Usefulness of alerts	A1, B1, B2, B4
4	Access to patient history	A3, B1, B4
5	Usefulness of dose functions	B1, B2

6	Usefulness of renewal reminders	B3
7	Relative advantage	A2, A4, B3
8	Time saving	B2, B4
9	Ease of use	A1, A3, B1, B2, B3, B4, B5
10	Complexity	A2, A3, A4
11	Organised	B4
12	Reliability	A2, B5
13	Response time	A1, A2, B1
14	Too many alerts	A3, A4, B2, B3, B5
15	Integration	A1
16	Interoperability	A2
17	Information reliability	A1, B2, B3
18	Standardisation	A1, B1, B3, B4
19	Updated status of medications availability	B3
20	Accessibility to on-spot IT support staff	A2,B1,B2,B3,B5
21	Reliable network infrastructure	A3,B2,B3,B4
22	Availability of adequate devices	A1, B4
23	Training	A1, A2, A4, B2, B5
24	Time constrains	A1, B2
25	Accessibility to remote ordering	B2, B3, B4
26	Suitable work environment	A3
27	Ownership of the CPOE system	B3
28	Unified ordering system across the branches	B3

These codes were then categorised according to the thematic framework illustrated in Table 3.6, Chapter 3. Table 5.3 presents the categorisation of these factors mapped under the three main themes.

Table 5.3 Categorisation of the Factors Associated with Physicians' Actual Use Mapped under Three Themes

THEME	CODE	REFEREES	EXAMPLES OF REPRESENTATIVE QUOTATIONS
INDIVIDUAL	*Effects on Performance*		
	• Enhances quality	B2, B3	'I told you it's very helpful because it makes me focus.' (B2)
	• Effect on patient safety	A2, A4, B1, B2, B3, B5	'It increases the effectiveness of the prescription safety, that is number 1.' (B2)
	• Usefulness of alerts	A1, B1, B2, B4	'The second thing this is the alert system for the allergies in the computerised system is very useful.' (B1) 'Alerts helps me a lot to reduce errors, especially the allergy alerts. If I forgot that this patient is allergic to a certain medication, it tells me.' (B4)
	• Access to patient history	A3, B1, B4	'If we want to go back to the history of the patient it's easy to access it.' (A3) 'If the patient was using any previous medication, I can search in the patient history.' (B1)
	• Usefulness of dose functions	B1, B2	'Then I can adjust the dosage according to the age of the child specially because I'm a paediatric dentist so the dosage is different than the adult, so I can use the formulation or calculation and the computer will calculate quickly for me not like when I do it by hand.' (B2) 'One of the nice things sometimes, specially in the electrolytes replacement [a substance used when a patient has a continued vomiting or diarrhoea] it gives me: "if the level of serum phosphate from 0.5 to 0.6 the replacement amount should be like 20 mml equivalent." This is a good thing it gave us dosing.' (B1)
	• Renewal reminders	B3	'Because I work in intensive care so there is a time period, so I have to renew the medication, so automatically the system will remind me.' (B3)
	• Relative advantages	A2, A4, B3	'It is very legible because it computerises its very clear.' (B3) 'There are many layers of protection in the CPOE rather than the handwriting system.' (B3)
	• Time saving	B2, B4	'It's better for me as a physician because it saves time as I just write the first 3 letters of the medication name so the full list of medication that have the same 3 letters will appear with different dosage and different formulation so I can select easily and quickly.' (B2)
	Effort Expectancy		

	• Ease of use	A1, A3, B1, B2, B3, B4, B5	'The system is user friendly, it's not that difficult.' (A1) 'If I want to renew, it gives me options if I would like to use the same dose, so I don't have to rewrite it again, even if I had to write it will be very clear and easy, it not a hassle.' (B3)
	• Complexity	A2, A3, A4	'It's more complicated than what I think. I think the system has to be simplified.' (A2)
TECHNOLOGICAL	*System Quality*		
	• Organised	B4	'It's very organised, I know that these certain medications are there and documented in a certain place.' (B4)
	• Reliability	A2, B5	'In general, its good, the system we have is reliable, the response time is immediately, whatever you write pharmacy will immediately see it.' (A2)
	• Response time	A1, A2, B1	'however sometime there is delay in response, when I click send, I have to wait if the order went through or not.' (B1) 'In general, its good, the system we have is reliable, the response time is immediately, whatever you write pharmacy will immediately see it.' (A2)
	• Too many alerts	A3, A4, B2, B3, B5	'So we get some alerts in the system whenever we order the medication that may interact, may have some interaction, may have some rare interaction….We get that alerts so we have to justify. We get a lot of alerts that we already know about, so that thing is somehow cumbersome.' (A3) 'Contradiction alerts I usually ignore it. It causes me boring I prefer to have as a layer of protection out safety.' (B3)
	• Integration	A1	'The alerts system is not very dermatology friendly…So maybe it needs to be more integrated system based.' (A1)
	• Interoperability	A2	'The challenge is that until now I did not see an ideal comprised system. For example, here in our hospital what we see as a physician is different than what the pharmacist sees in his computer.' (A2)
	Information Quality		
	• Information reliability	A1, B2, B3	'It helps with the dosing, with the intervals, with the timing. It makes sure that everything you are giving is correct.' (A1)
	• Standardisation	A1, B1, B3, B4	'Sometime, that the same medication has many orders in different form. So sometimes I got confused which one to give the patient. This is one of the challenges.' (B1)

			'Especially if there are several forms of insulin or there are mixed types of insulin, when you click on… you got 5 or 6 forms, by mistakes sometimes you click in one of them instead of the other, this is what sometimes happened.' (B1)
	• Updated status of medication availability	B3	'The other challenge we might face when we wrote multiple medications, the system does not show if this is an old medication, or this medication is discontinued, if it discontinued it should be removed from the screen, however the system still shows it.' (B3)
ORGANIZATIONAL	*Facilitating Conditions*		
	• Accessibility to on-spot IT support staff	A2,B1,B2,B3,B5	'The IT support is very important, they are very supportive, they have 24 hours coverage and they are local on spot.' (B3) 'If it's really an IT issue, we have to call the IT department, and not all the time they are available on spot. Now everything is solved by mirroring your computer, but to get that person who can mirror your computer is not always simple.' (A2)
	• Reliable network infrastructure	A3,B2,B3,B4	'However, if the system went down, everything stops.' (B4)
	• Availability of adequate devices	A1, B4	'We do not have many devices. The number resident is much more than the number of devices. Sometimes it delays me to find a device to order my medications.' (B4)
	• Training	A1, A2, A4, B2, B5	'We had enough training, and the real training you get from your colleagues.' (A2) 'Honestly, we did not have enough training. It was only one session in the first week. It was only like one extensive training from 9 am to 3 pm, and they teach you about the system with so much detailed that you cannot grasp all the concepts.' (A4)
	• Time constrains	A1, B2	'But at the same time, it increases the time. The challenge is the time, it needs time and training.' (B2)
	• Accessibility to remote ordering	B2, B3, B4	'Ordering from home is not available unless I asked for it. But because my specialty is mostly in intensive care, I don't prefer that I'd rather to be inform of the patient.' (B3)
	• Suitable work environment	A3	'Actually, we have an excellent support in terms of spacing, environment, confidentiality, privacy we have all of that. I don't have any problem with the organisation. Everything is available and I don't have any issues.' (A3)
	• Ownership of the CPOE system	B3	'And the important thing in my organization, they outsource the program and then they bought the system, so they owned the system, so they invest in it. And the good thing also the continuous development of the system, every time there is additions. So, if the organization doesn't support it, it will fail.' (B3)

• Unified ordering system across the branches	B3	'Luckily I'm working in a corporate organization meaning that its huge corporate with multiple branches. The system is unified all over these branches. So, whether if I order them from X or Y it's the same system. This is very important.' (B3)

5.4 Individual

5.4.1 Effect on Performance

Improves Quality

Physicians reported that their CPOE usage improves the quality of care. CPOE capabilities can help ensure that physicians are less worried about potential mistakes; this can increase the quality of the healthcare provided to the patients, as mentioned by some physicians:

> *'It's very helpful because it makes me focus.' (B2: 31)*

> *'It improves it actually [indicating his performance], it improved dramatically. From my brain not to be worried about my handwriting, to be worried about the dosage, to be worried about you know how fast the medication reaches the pharmacy.' (B3: 36–38)*

Effect on Patient Safety

Utilising CPOE for prescribing medications contributes to increased patient safety, as CPOE has safeguard functions (alerts) to inform physicians of potential errors. The legibility of the CPOE system can result in better and safer outcomes, which can lead to better job performance. In this regard, some physicians stated:

> *'It's easier for the pharmacy to know what I ordered so he/she can double check my order in a better way, so it's safer for the patient.' (A2: 17)*

> *'We have high alert medication like warfarin [a drug used to treat blood clots]in the inpatient you need to renew the medication every day. I think this is much safer.' (A4: 22–23)*

'Also, our CPOE generates a bar code. This helps, when you order a medication, the right patient will receive. That making sure that this exact medication will only go to the desired patient. If it went to the wrong patient, the nurse would scan this bar code and that will alarm her that this medication is not for this patient. Less mistakes. Mistakes are so rare.' (B3: 41–43)

Usefulness of Alerts

Usefulness of alerts refers to the physicians' belief that these alerts enhance their job performance. Alerts work as warning messages that pop up on the ordering screen if the prescribed medications contradict each other, if the patient is allergic to a certain medication, or if the prescribed dose needs to be modified. CPOE alerts that popped up when prescribing a medication was indicated to be effective and beneficial for the physicians; this was true for drug contradiction alerts, allergy alerts, and dosage alerts. The interviewed physicians made this clear by the following statements:

'The first thing is the drug interactions, always come up, so it's very important, because we usually forget what they are, and the systems already knows what type of drug interaction they are.' (A1: 3–4)

'But of course, this is good especially if let's say by mistake you wrote the dosage, or overdose, or the patient is taking certain medication and its contradiction the medications that you are prescribing or the patient is allergic to some medication that you forgot about. So it will alarm, it will appear for you so that will remind you for things that you might forget.' (B2: 68–71)

Access to Patient History

Access to patients' comprehensive history was considered to be useful for physicians to effectively carry out their job. The fact that all patient history data and medication information are saved in one place and can be retrieved at any time was associated with the

utilisation of the CPOE prescribing process. This is what the physicians stated in this regard:

> *'If we want to go back to the history of the patient it's easy to access it.' (A3: 3)*

> *'It's accurate, everything is there. If the patient was using any previous medication, I can search in the patient history.' (B1:5–6)*

Usefulness of Dose Functions

The dosing functionalities within the CPOE system were pointed out as being helpful for the physicians in terms of performing effectively. Physicians reported that the ability to adjust the dose of the prescription and dosage suggestions were correlated with their productivity, as illustrated in the quotations below:

> *'Then I can adjust the dosage according to the age of the child specially because I'm a paediatric dentist so the dosage is different than the adult, so I can use the formulation or calculation and the computer will calculate quickly for me not like when I do it by hand.' (B2: 5–8)*

> *'One of the nice things sometimes, especially in the electrolytes replacement [a substance used when a patient has a continued vomiting or diarrhoea], it gives me: "if the level of serum phosphate from 0.5 to 0.6 the replacement amount should be like 20 mml equivalent." This is a good thing it gave us dosing.' (B1: 56–58)*

Renewal Reminders

The usefulness of automatic reminders for the renewal of medications was appreciated by one physician, who considered it as a benefit of using CPOE.

> *'Because I work in intensive care so there is a time period so I have to renew the medication, so automatically the system will remind me.' (B3: 10–11)*

Relative Advantages of Computerised Prescribing

Relative advantage means the extent to which a system is perceived as being more beneficial than the previous one (194). Computerised prescription was considered to be more efficient than handwritten prescription because it helped physicians avoid medication errors, achieve patient safety, and provide readable prescriptions. The physicians indicated that they had gained these relative advantages from using the system:

> *'It does help me in many aspects, first of all its much easier to write prescription in a computerised system rather than a paper. Usually, papers prescription easily got messed. Another thing is that everyone can read what's been typed in the computer.' (A4: 3–5)*

> *'I've been using both ways, I've using the handwriting system, and believe me see mistakes almost daily, but with the CPOE its almost eliminated.' (B3: 15–16)*

Time Saving

The time saved through the ability to find medications fast when searching was perceived as a factor associated with the use of CPOE, as it enhances productivity:

> *'It's better for me as a physician because it saves time as I just write the first 3 letters of the medication name so the full list of medication that have the same 3 letters will appear with different dosage and different formulation so I can select easily and quickly.' (B2: 3–5)*

> *'It's fast, doesn't take much time.' (B4: 3)*

5.4.2 Effort Expectancy

Ease of Use

Ease of use was the most cited factor under the individual factors associated with the actual use of CPOE, according to the participants' views. Ease of use was attributed to the flexibility of the ordering functions, such as searching for medications, renewal of prescription, and not having to go through too many steps when ordering. The usability of these functions was considered to contribute to easy and effective utilisation of the system, especially because some patients visit physicians on a regular basis and are on the same medications. For example, this is what the physicians mentioned:

> *'While ordering again it's easy to copy for example the same medications that the patient was on, rather than writing individual medicine alone, so whenever the patient comes for a refill, we just have to go back to the last prescription, review it and we just highlighted and copy it and paste it.' (A3: 6–8)*

> *'Sometimes I do not recognise the full spelling of the medication name, I just start writing the initials it appeared immediately which is make my life easier in searching for medications.' (B1: 28–29)*

> *'The ease of use, the program has to be intuitive. So, I don't need to jump to many steps to reach ordering medication, that is very important. Once I press a logo or tag, it will take me to the ordering system.' (B3: 47)*

Complexity

Complexity refers to the physicians' perception that CPOE is difficult to understand and work with (131). The physicians agreed that the complexity of CPOE was due to the excess number of clicks needed to complete a single prescription. This process may result in physicians spending more time than needed just for data input for one order, as they stated:

> *'However, is not flexible, the number of clicks that you need to do to finish the order are too many.' (A2: 22)*

'It is not really very user-friendly. As I said we get a lot of alerts, many messages that we have to go through, many steps before we proceed the ordering medication. There are some items or things in the CPOE that we use and makes it a bit inconvenient for the physicians when ordering.' (A3: 24–26)

'The other thing we have to justify the reason for every medication. That is another cumbersome thing.' (A3: 14–16)

5.5 Technological

5.5.1 System Quality

<u>*Organised*</u>

The appropriate placement of information and the ability to find it easily was identified as a factor related to system utilisation, as expressed by one physician:

'It's very organised, I know that these certain medications are there and documented in a certain place' (B4: 11)

<u>*Reliability*</u>

The reliability of the system refers to the system's ability to perform the tasks that it was designed for (246). The reliability of the CPOE system was seen as a factor associated with its use, as stated by the physicians:

'In general, its good, the system we have is reliable, the response time is immediately, whatever you write pharmacy will immediately see it.' (A2: 20–21)

'I think the CPOE is quite reliable, because I'm not technically savvy with the current system.' (B5: 14)

The response time until the order reaches the pharmacy was reported by physicians as a factor that is associated with the utilisation of CPOE. The physicians noted the following points in this regard:

> *'Everything is clear, however sometime there is delay in response, when I click send, I have to wait if the order went through or not.' (B1: 45–46)*

> *'In general, its good, the system we have is reliable, the response time is immediately, whatever you write pharmacy will immediately see it.' (A2: 20–21)*

Too Many Alerts

Although physicians' previous statements showed that all types of alerts were perceived as useful and had an effective impact on their performance and the safety of the patients, the occurrence of a lot of alerts at the same time caused alert fatigue. Alert fatigue is a state of mind that occurs when the physician is exposed to an overwhelming number of alerts, which take up the physician's time and effort. This can lead to critical alerts being overridden (247). For example, the physicians mentioned:

> *'So, we get some alerts in the system whenever we order the medication that may interact, may have some interaction, may have some rare interaction, this is not really [inaudible] with other medication. We get that alert, so we have to justify. We get a lot of alerts that we already know about, so that thing is somehow cumbersome.' (A3: 11–13)*

> *'The alerts system in my opinion is poor in the current CPOE I'm using. There are a lot of alerts so which can cause alerts fatigue.' (B5: 8–9)*

Integration

The need for an integrated alert system that supports all medical specialties was perceived as a factor affecting the utilisation of CPOE. This integration can affect the quality of the prescriptions, as indicated by one physician:

> *'The alerts system is not very dermatology friendly. So, for example, if you are ordering a typical steroid cream and putting for one week it will tell you "No, the minimum is 30 days." But we never use steroid cream for 30 days. So maybe it needs to be more integrated system based.' (A1: 41)*

Interoperability

Interoperability refers to sharing, accessing, using, and integrating data between systems within the organization in an accurate and consistent manner (248). It was pointed out by a physician that the absence of consistency between the ordering system screen and what the pharmacy sees on their screen affects the prescribing process. This causes uncertainty for the physician, and this consequently impacts his/her performance in the delivery of care. This was explained as follows by one physician:

> *'The challenge is that until now I did not see an ideal comprised system. For example, here in our hospital what we see as a physician is different than what the pharmacist sees in his computer. Many times, we see orders that are still active, while when we call the pharmacy, they tell us that this is already prescribed. From our side we know the active order, but we don't know whether its prescribed or not.' (A2: 5–9)*

5.5.2 Information Quality

Information Reliability

Information reliability refers to the testworthiness of the information the CPOE system provides in terms of its relevance, consistency, and accuracy. Knowing that the system being utilised for everyday tasks provides an accurate prescription affects its use, as mentioned by the physicians:

> *'It helps with the dosing, with the intervals, with the timing. It makes sure that everything you are giving is correct.' (A1: 18)*

> *'Other than that, the route of administration, the dosage, the frequency, all the content of the ideal prescription is written, and you cannot bypass it or ignore it.' (B2: 9–10)*

Standardization

Physicians reported standardization as a factor affecting their use of CPOE from two perspectives. First, occasionally, the labelling of the same medication by multiple names causes confusion when the physician is choosing the medication. Some medications have a generic name and a commercial name, so being unfamiliar with names may be a hazard for the patient. The need to have a standardized way of naming the medications was reported as a factor associated with CPOE use. This was described by physicians as follows:

> *'Here in Derma, we have a lot of medications that we use off label. For example, we can use cyclosporine [used in case of organ transplant to avoid rejection] for erythrodermic psoriasis [a very severe skin condition that can be deadly], but sometimes the system will not accept it. It tells you "this is restricted for use for example for Nephrology".' (A1: 11–13)*

'Types of medication are a lot. Each medication has several names and that really make me confused for example, heparin, a medication used to treat blood clots, there are many types of heparin. You have to know which one you need to order. I believe this is the only thing that is really annoying for me.' (B4: 6–8)

The overwhelming amount of medications with different names and forms was perceived as a factor that might affect the safety of the patient. One participant provided the following suggestion to overcome this issue:

'There should be a feature/the system should allow to order the medication with both its generic and trade name. This would improve medication safety in my opinion.' (B5: 27–28)

The second form of standardization, as a factor affecting the use of CPOE, is related to the doses. Some types of medications do not have a standard dosing system that physicians can choose from or refer to. Not having such a standardised dosage was reported as challenging by one of the participants, who managed critical patients. The physician said:

'Another challenge is when writing the medication dosage, if it's not standardized (the dosage) specially in my field "Neonatology" where I deal with very small babies [neonatology is a subspecialty of paediatrics that treat ill or premature babies] many of the doses are not standardized yet, and the challenge we faced that there is no standardized system for the dosage of some of the medication, so the system will accept any dosage I write.' (B3: 24–27)

Updated Status of Medication Availability

A routine check of the availability of medications needs to be conducted regularly, so that whatever shows up on the ordering screen can be matched with what is in the pharmacy.

Accordingly, the accuracy of the information provided to the physician while ordering was seen as a factor affecting physicians' use of CPOE, as indicated by one physician:

> *'The other challenge we might face when we wrote multiple medications, the system does not show if this is an old medication, or this medication is discontinued, if it discontinued it should be removed from the screen, however the system still shows it.' (B3: 28–30)*

5.6 Organizational

5.6.1 Facilitating Conditions

Accessibility to On-Spot IT Support Staff

The provision of on-spot IT staff was noted by physicians as an important factor for their use of the CPOE system. Although all the physicians agreed that IT support personnel are often available, some physicians noted that they are not accessible sometimes. Not being able to reach to IT when needed may affect physicians' workflow, as pointed out by one physician:

> *'We have IT staff and there are available. But sometime things happen at night (system goes down) if it took too long, we do it paperwork.' (B1: 86–87)*

> *'If it's really an IT issue, we have to call the IT department, and not all the time they are available on spot. Now everything is solved by mirroring your computer, but to get that person who can mirror your computer is not always simple.' (A2: 45–46).*

Reliable Network Infrastructure

If the hospital system goes down, communication, activities, and access to patients' records can be suspended for a while. The CPOE prescription system is connected to the hospital's

network, and the entire process of accessing records, communicating, and ordering would stop if the network crashed. Therefore, providing an appropriate grounding network is an important factor for the use of CPOE, as noted in the physicians' comments below:

> *'Of course, whenever we have technical difficulties or delay in the system or slow or downtime of course this is a nightmare whenever we have a downtime, we cannot do our work, our clinic will be interrupted.' (A3: 18–19)*

> *'If the internet is down so all that system is down, so you cannot even write a prescription, you cannot communicate with the pharmacy or anything.' (B2: 44–45)*

Availability of Adequate Devices

Accessibility to a computer device within the ward or the area where the physician is working is important for ordering prescriptions. Therefore, not having access to a device because very few devices are available was reported as a factor affecting the use of CPOE, as it may affect the whole process of delivery of care. This was indicated by the physicians as follows:

> *'I think we need more computers. If I have a resident for example working with me, the resident needs to take what they call a computer on wheels, and there are only 2 or 3 available for all outpatient department.' (A1: 27–29)*

> *'We do not have many devices. The number resident is much more than the number of devices. Sometimes it delays me to find a device to order my medications.' (B4: 24–25)*

Training

Continuous training on the use of the system is necessary to maintain its effective use, in order to achieve the appropriate delivery of care. Accordingly, training was reported to be one of the most significant factors associated with effective use of CPOE. The physicians' views varied, as some indicated that the training they received was sufficient:

> 'They gave us a training in the beginning. The system is user friendly, it's not that difficult.' (A1: 35).

> 'The training, sometimes we don't know where anything is, especially in the start. But as time goes by and with having the "super user," so if we have any problem, we just call him and he will teach us where is the trick, where is the difficulty, where is the problem. So, that gave us a very good support and leaning quickly about the system and how to do our prescription in easy way.' (B2: 20–24)

Some other physicians stated that they had received limited training, and that there was a need for continuous ongoing training to facilitate their utilisation of CPOE:

> 'Honestly, we did not have enough training. It was only one session in the first week. It was only like one extensive training from 9 am to 3 pm, and they teach you about the system with so much detailed that you cannot grasp all the concepts. Most of the people who took the orientation course came out of it with nothing from it. We keep learning by practicing, we keep learning by doing errors or by calling our seniors to teach us how this thing works.' (A4: 34–39)

> 'Challenge is learning the system which new to me. I went through informal training, and it was very poor.' (B5: 5)

Time Constraints

Time constraints was reported as a factor challenging physicians' use of CPOE. Due to the workload demands for most of the physicians, sometimes, the ordering process can result in time loss. This was indicated by some physicians:

'But at the same time, it increases the time. The challenge is the time, it needs time and training.' (B2: 37)

'When I was in the United States, it was very helpful that the nurse could enter the labs along with the physician. I think here unfortunately, the physician has to enter everything e.g. a sick leave, labs, appointments. So maybe if we could delegate, the nurse could enter for example the sick leave, the resident could enter the labs, and the physician could enter the meds then they would help with time.' (A1: 30–33)

Accessibility to Remote Ordering

The absence of remote ordering (accessing the CPOE prescription system remotely when away from the hospital) was cited as a factor affecting the utilisation of CPOE. Being able to do this task while away from the hospital can save physicians' time and effort, as noted in the following comments by physicians:

'The other thing is that the organization did not grant remote access, so I have to be there myself or let someone do it through the phone which is sometimes hectic process.' (B4: 26–27)

'We have the access, but we do not have the configuration that enable us to order medication. I think the issue was patient confidentiality. We were looking to be able to order prescription from home but until now they did not do it.' (B2: 60–62)

Suitable Work Environment

Providing a convenient work environment for physicians was reported to be associated with the use of CPOE. A suitable work environment helps them perform their job competently, as one physician noted:

'Actually, we have an excellent support in terms of spacing, environment, confidentiality, privacy, we have all of that. I don't have any problem with the organisation. Everything is available and I don't have any issues.' (A3: 29–30)

Ownership of the CPOE System

Being a part of a health organization that owns their CPOE system was seen as important for efficient use. Owning the system gives the organization the freedom to make it relevant to the work environment, existing values, and needs that would facilitate its utilisation. This was illustrated by one physician as follows:

'And the important thing in my organization, they outsource the program and then they bought the system. So, they owned the system, so they invest in it, and the good thing also the continuous development of the system. Every time there is additions. So, if the organization doesn't support it, it will fail.' (B3: 76–78)

Unified Ordering System Across Branches

A unified system for medication ordering across the hospital's branches where the participants work was described as important for physicians' actual use of the system, as indicated by one physician:

'Luckily I'm working in a corporate organization meaning that its huge corporate with multiple branches. The system is unified all over these branches. So, whether if I order them from X or Y it's the same system. This is very important.' (B3: 70–72)

5.7 Summary

This chapter presented the qualitative results of nine interviews with physicians. The data from the interviews were analysed using a thematic analysis approach. To facilitate the

analysis, data were categorised under three themes: individual, technical, and organizational.

A number of the reported factors varied across sites. That is, several factors that were reported by physicians at site B were not mentioned by physicians at site A, and vice versa (See Table 5.2). For example, the effect of the quality and usefulness of dose function and renewal reminders was reported by physicians from site B but not by those from site A. These factors were also mentioned by physicians from site A, as they indicated the usefulness of dose functions and effect on quality in the context of other factors such as patient safety and relative advantage. Moreover, physicians from site B indicated the significance of ownership of the CPOE system and a unified ordering system across the branches, while none of the physicians from site A reported this. Yet, according to hospital A's management, they own the system and have a unified system across branches.

A remarkable point of difference between the two sites was related to the complexity of the system and access to remote ordering. Site A physicians reported that complexity and interoperability were factors that affected their use of the system, while none of the site B physicians reported these factors. This difference might be attributable to differences in the processors of the systems, as these systems are not provided by the same vendor. Access to remote ordering is actually available at site A according to management (but was not mentioned during the interviews), while it was not available to everyone at site B for the purpose of protecting patient confidentiality.

The number of reported factors from site B were higher than those from site A. As five physicians were interviewed from site B and four were interviewed from site A, this may

explain why more information was obtained from site B. The main takeaways from this chapter are presented below:

- Out of the 28 reported factors, 5 factors stood out as the ones that were most frequently reported by physicians to be significantly related to the actual use of CPOE.

	Number of Times the Factor was Reported
Ease of use	7
Effect on patient safety	6
Too many alerts	5
Accessibility to on-spot IT support staff	5
Training	5

- Ease of use was the most cited factor that was associated with physicians' utilisation of CPOE, and the effect on patient safety was the second most cited factor by physicians.

- Too many alerts was the most emphasized factor under system quality that was associated with CPOE use.

- Access to on-spot IT support and training were reported as the most significant facilitating conditions associated with physicians' CPOE use.

In the following chapter, both the quantitative and qualitative findings are discussed.

Chapter 6: Discussion

6.1 Introduction

CPOE for prescribing medication has been used in practice in many healthcare contexts around the world. These systems have the potential to enhance patient safety and the quality of care. However, the utilisation of CPOE by physicians is challenging due to factors related to the physicians, the organization (the hospital), or the system itself. In the context of the current study, which is Saudi Arabia, the factors associated with the actual use of CPOE among physicians has been poorly investigated. Thus, the aim of this research was to investigate factors associated with physicians' self-reported actual use of CPOE for prescribing medication in government hospitals in Saudi Arabia. To achieve this aim, four questions were asked: (a) What are the factors associated with physicians' actual use of CPOE in government hospitals in Saudi Arabia? (b) What is the level of utilisation of CPOE tasks? (c) Is there an association between physicians' characteristics, namely, position, age, gender, and years of experience, and the level of utilisation of CPOE? (d) How significant is the association between the identified factors and the self-reported actual use of CPOE for prescribing? These questions were answered through a systematic review, collection of quantitative data (through a survey), collection of qualitative data (through interviews), analysis of both sets of data, and comparison of the results (See Table 6.1). In this chapter, the interpretation of both sets of results will be discussed and explained in conjunction, topic by topic.

Table 6.1 Comparison of the Quantitative and Qualitative Results

Topic	Results from Surveys	Results from Interviews	How results relate
Drug allergy alerts	• Most frequently used according to the mean score for the reported level of usage (Table 4.4)	• Drug allergy alerts were indicated as being important through various statements, for example: - 'Alerts helps me a lot to reduce errors especially the allergy alerts. If forgot that this patient is allergic to a certain medication, it tells me.' - 'The second thing this is the alert system for the allergies in the computerised system is very useful.'	Support
Dose range alerts	• Second most frequently used according to the mean score for the reported level of usage (Table 4.4)	• Dose-related functions were indicted as being useful and important through statements such as: - 'It helps with the dosing, with the intervals, with the timing. It makes sure that everything you are giving is correct.' - 'One of the nice things sometimes, especially in the electrolytes replacement (a substance used when a patient has a continued vomiting or diarrhoea) it gives me "if the level of serum phosphate from 0.5 to 0.6 the replacement amount should be like 20 mml equivalent." This is a good thing it gave us dosing.' - 'Another challenge is when writing the medication dosage, if it's not standardized (the dosage) specially in my field "Neonatology" where I deal with very small babies (neonatology is a subspecialty of paediatrics that treat ill or premature babies). Many of the doses are not standardized yet, and the challenge we faced that there is no standardized system for the dosage of some of the medication, so the system will accept any dosage I write.'	Support
Drug interaction alerts	• Least used according to the mean score for the reported level of usage (Table 4.4)	• Statements from interviews indicated that drug interaction alerts were not considered as important as the other two types of alerts, for example: - 'Contradiction alerts I usually ignore it. It causes me boring I prefer to have as a layer of protection out safety.' - 'So, we get some alerts in the system whenever we order the medication that may interact, may have some interaction, may have some rare interaction, this is not really (inaudible) with other medication. We get that alert, so we have to justify. We get a lot of alerts that we already know about, so that thing is somehow cumbersome.'	Support

Position vs. dose range alerts	• Consultants were more likely to carefully read the dose range alerts than other categories of physicians (Table 4.6).	• Seven of the nine physicians who were interviewed stated the importance of dose alerts/functions: six of them were consultants and one was a resident (Table 5.3).	Support
Gender vs. interaction alerts	• Female physicians were more likely to use interaction alerts than male physicians (Table 4.7).	• One male physician said 'Contradiction alerts I usually ignore it. It causes me boring I prefer to have as a layer of protection out safety.' - In contrast to his view, a female physician stated 'But of course, this is good especially if let's say by mistake you wrote the dosage, or overdose, or the patient is taking certain medication and its contradiction the medications that you are prescribing or the patient is allergic to some medication that you forgot about, so it will alarm, it will appear for you so that will remind you for things that you might forget.' (B2)	Unable to support completely due to the small number of interviewees.
Years of experience vs. use of dose range alerts	• Physicians with more than 10 years of experience were the most likely to use CPOE (Table 4.8).	• Out of the nine physicians interviewed, five had more than 10 years of experience. Three of these five physicians emphasized on dose alerts and their effect on their job (Table 5.3).	Support
Performance expectancy (PE)	• PE showed the closest association with the actual use of CPOE (Table 4.9). • PE had the second strongest correlation with order entry tasks ($r = 0.180$, $p < 0.05$) and the fourth strongest correlation with CDS tasks ($r = 0.287$, $p = 0.001$) (Table 4.10). Both correlations were significant at a p level of 0.01.	• All nine interviewees reported factors affecting their performance via 23 different statements (see Table 5.2/SN1–8 and Table 5.3) that emphasize the significance of PE for their use of the CPOE system.	Support
Effort expectancy (EE)/ease of use	• EE showed the second highest association with the actual use of CPOE (Table 4.9). • EE had the strongest correlation with order entry tasks ($r = 0.233$, $p = 0.002$) and the fifth strongest correlation with CDS tasks ($r = 0.226$, $p = 0.002$) (Table 4.10). Both correlations were significant at a p level of 0.01.	• All nine interviewees reported about the effect of ease of use or complexity on their use of the system via 10 different statements (see Table 5.2/SN9–10 and Table 653). Ease of use was the most cited among all the factors (Table 5.2).	Support

Information quality (IQ)	• IQ showed the third highest association with the actual use of CPOE (Table 4.9). • No significant correlation was found with order entry tasks. • IQ showed the second strongest correlation with the actual use of CDS tasks ($r = 0.359$, $p = 0.001$) (Table 4.10). The correlation was significant at a p level of 0.01.	• Five out of the nine physicians reported IQ as an important factor associated with the use of CPOE. This was expressed in eight statements (See Table 5.2/SN17–19 and Table 5.3).	Support
Facilitating conditions (FC)	• FC showed the fourth highest association with the actual use of CPOE (Table 4.9). • FC had the third strongest correlation with order entry tasks ($r = 0.160$, $p = 0.030$; significance level, < 0.05), and also had the third strongest correlation with CDS tasks ($r = 0.350$, $p = 0.001$; significance level, <0.01) (Table 4.10).	• All nine interviewees reported FC as a factor associated with CPOE use via 24 different statements (see Table 5.2/SN19–28 and Table 5.3), with an emphasis on access to IT staff and continuous training.	Support
System quality (SQ)	• SQ showed the fifth highest association with the actual use of CPOE (Table 4.9). • No significant correlation found with order entry tasks. • SQ showed the strongest correlation with the actual use of CDS tasks ($r = 0.386$, $p = 0.001$; significance level, <0.01) (Table 4.10).	• All nine interviewees reported SQ as a factor associated with CPOE use via 13 different statements (see Table 5.2/SN11–16 and Table 5.3).	Support
Social influence (SI)	• SI showed the lowest level of association with the actual use of CPOE (Table 5.9). • SI had no significant relationship with the actual use of order entry tasks or CDS tasks, as indicated by the weakest correlation coefficient (r) values (Table 4.10).	• SI was not reported. None of the interviewees mentioned or reported that SI was important or that it was related to the use of CPOE.	Support

6.2 Level of Physicians' Actual Usage of CPOE

The level of actual usage of CPOE refers to the self-reported frequency of use of each of the CPOE tasks. In this research, actual use was determined based on the use of 11 tasks. Two of the tasks are mainly order entry tasks: order medications and order lab requests. The other nine are related to the use of three CDS drug safety alerts: drug interaction alerts, drug allergy alerts, and dose range alerts. Each of these alerts cover three usage tasks (Table 4.4). The results indicated that CDS tasks had a lower usage pattern than order entry tasks (Table 4.4). The low usage of the CDS tasks is consistent with the review of van der Sijs (46). Their review examined physicians' use of the CDS drug safety alerts by assessing how physicians respond to all types of drug safety alerts (46). Among 17 studies, 8 studies reported 49% to 96% alert overrides, except for high-level overdose alerts, of which 27% were overridden. This percentage might be considered high according to the argument of Bates et al. (249) that the maximum override rate should not exceed 40%. Similar findings were reported by Qattan et al. (250) in their study that investigated physicians' adherence to drug safety alerts in the ICU, where 80% of the generated alerts were clinically significant and 50% were overridden by physicians (250). These results could be explained by the fact that order entry tasks are the only way to prescribe a medication and, hence, their use is mandatory for prescription by physicians. Thus, all the physicians were likely to order medications and lab requests using CPOE only, as the research setting of the current study is organizations that use an electronic system. This variation in the frequency of usage between the order entry tasks and CDS alerts tasks is probably related to the difference in the nature of each of these tasks. In order entry tasks, physicians choose the required medication or lab test from a list and click on the order. In CDS tasks, physicians

first read carefully what the alert is saying and then evaluate and assess the appropriateness of this alert. Sometimes, they might refer to a colleague for a second opinion. If the physician decides to override the alert, they must provide a justification. Because of the sensitive nature of the CDS alerts, as they are related to the safety of the patient, the usage of these tasks is dependent on the medical knowledge and training of the physician evaluating the alert (251). Therefore, physicians might not read the alert carefully, or just override or ignore them based on those aspects (251). This result may be explained by alert fatigue caused by the exceedingly high number of alerts generated (251). As stated by physicians during interviews, 'too many alerts' was the most cited factor that led them to ignore alerts sometimes (Table 5.3).

With respect to the usage of the three different types of CDS safety alerts, the results show that the level of usage of the CDS alerts was considered moderate. Yet, it varies according to the type of alert. Drug allergy alert tasks had the highest level of usage; that is, its usage was higher than that of drug interaction and dose range alert tasks (Table 4.4). This result is consistent with the results of Santucci et al. (159), who also noted that allergy alerts were more significant than the other two types of alerts and were described by physicians as 'the most useful' alerts. Similar findings were also reported by Bryant et al. (252), who indicated that the override rate for the latter was 95.1%, which was significantly higher than the rate for drug allergy alerts, which was 90.9% (p < 0.001). The high compliance and adherence to allergy alerts compared to the other two alerts may be explained by the fact that a drug allergy could have serious reactions and is more likely to harm the patient (252). As drug interaction and dose range alerts might have less impact, they may be perceived by physicians as less crucial by physicians (252). This result is supported by

statements obtained from the interviews, as several physicians' statements emphasized the significance of the allergy alerts (Table 6.1).

Dose range alert tasks are the second most utilised tasks after drug allergy alerts. While there are limited studies that explore how physicians handle dose range alerts, the few available studies discussing dose range alerts mostly involve paediatric or ICU patients (253). The observed significance of dose range alerts in the current study is in line with the findings of Wong et al. (254), who assessed dose range alert override among ICU patients. Their study reported that among 1418 overridden alerts, 80% were considered as appropriate overrides, where appropriate override means that the override does not cause harm (254). This indicates that dose range alert is a significant alert that needs to be complied with. This result is probably related to sensitivity to the dosage of drugs. An improperly (overdose or underdose) prescribed dose can have a significant impact on patient safety (253, 254). Ghaleb et al. (255) indicated that dose range alerts are considered important for paediatricians as dose errors were the most frequent among paediatric patients. This was highlighted by physicians' statements obtained from interviews in the current study (Table 6.1).

Drug interaction alerts were perceived as the least used by physicians. This result reflects those of Omar et al. (157), as stated by one physician: 'sometimes he dismiss alerts of the system because the drug interaction is irrelevant to the paediatrics patient' (p. 257). It is also in accordance with the results of Wright et al. (256), who investigated the reasons for drug interaction overrides: 'not clinically significant' was one of the three main reasons physician override these alerts. This result suggests that physicians occasionally consider it appropriate to override these alerts. A possible explanation is that because this type of

alert is the most repetitive, it causes alert fatigue. This leads them to override these alerts more than the other two types of alerts. Another explanation for this result is that the alerts are often clinically irrelevant, or that harmful interactions rarely occur, as indicated by physicians (Table 6.1).

In summary, this section has discussed the level of actual use of each task of CPOE, and hence answered the second research question. The next section discusses whether the usage of CPOE is associated with the physicians' position, gender, age, or years of experience.

6.3 Physicians' Demographic Characteristics and Actual Use of Tasks

The results showed that there was an association between physicians' characteristics, namely, position, gender, age, and years of experience, and actual use of 4 of the 11 CPOE tasks. The following section describes the association of each of the characteristics with each of the four tasks.

6.3.1 Position

The physicians' position affected the level of use of CPOE. Consultants in this study were shown to be the most careful with regard to reading dose range alerts; that is, they were more careful than the residents and physician assistants (Table 4.6). While the literature on handling dose range alerts by physicians has not been widely discussed, similar findings have been reported for all types of alerts (allergy, interaction, and dose range alerts). For example, Yoo et al. (257) investigated physicians' response to alerts in relation with physician's characteristics: they found that resident physicians reported higher rates of alert overrides while senior physicians reported the lowest rates. This result is also consistent with the findings of Cho et al. (258), who assessed physicians' characteristics in relation to response to alerts in the outpatient setting. They found that house staff (residents) were

more likely to override alerts than physician staff (seniors). This result can probably be explained by the experience of consultants in terms of education and years of working (259). The practical experience of consultants made them highly aware of the importance of dose alerts and how an error in the prescribed dose could be harmful for the patient, while residents and physician assistants might not have the same amount of experience with patients.

Although consultants have emphasized on the importance and usefulness of dose range alerts during interviews, there was no clear indication in the findings of interviews that could inform why consultants were more likely to use this task (Table 6.1).

6.3.2 Gender

Physicians' gender showed an association with three of the usage of CPOE tasks. Female physicians were more likely than male physicians to use the order medication task, carefully read the drug interaction alerts that they receive, and provide reasons for drug interaction alerts that they decide to override (Table 4.7). These outcomes are contrary to those of previous studies. Schectman et al. (160) reported that physician's gender was not related to the utilisation of CDS features. Moreover, Sittig et al. (260) indicated that gender has no association with the decision to accept or ignore CDS features. A potential explanation for this relationship may be gender-specific differences in attention to detail, as reported in the review by Roter et al. (261) on the effect of physicians' gender on communication with patients during medical visits. It was observed that female physicians showed more patient-centred communication skills in terms of patient–physician satisfaction, high levels of compliance to therapeutic recommendations, and better indicators of disease control (261). Another possible explanation may be gender-based

differences in the adoption of IT, as different usage patterns have been reported by males and females with regard to different types of ITs, such as the usage of online shopping, e-learning, internet usage, etc. (262, 263).

Venkatesh et al. (131) argued that females are more anxious when it comes to technology use, while males are more motivated. Other researchers have mentioned that females are more determined to use IT effectively than males (262). While studies have indicated that gender plays a role in the use and adoption of ITs, the reported observations differ across studies and contexts (264-266). In the current study, the responses of the interviewees did not indicate any obvious reasons for the gender-based difference observed.

6.3.3 Age

The current study found that age has no significant impact on the actual use of CPOE tasks. This means that a similar level of usage of CPOE tasks was observed across physicians of all ages. This relationship is consistent with what Schectman et al. (160) and Sittig et al. (260) reported in their studies, where they found that age has no association with the use of CPOE tasks. The reason for this finding is that age might not necessarily be as much of an indicator of the degree of usage as practical experience, knowledge, awareness, and knowledge of how to use CPOE. This is in accordance with an earlier observation by Ash et al. (267): in their study, physicians reported that 'age doesn't matter' and that it was more about the physician's perception about knowing how to use CPOE.

6.3.4 Years of Experience

Years of experience in this study refers to the physician's years of practical experience as a healthcare provider. The results indicated that years of experience is associated with the actual use of CPOE. Physicians with the highest number of years of experience (10 years

and more) were more likely to order medications and carefully read the dose range alerts than less experienced physicians (Table 4.8). This finding is contrary to that of previous studies. For example, Laka et al. (268) detected lower usage of CDSS for prescription of antibiotics among physicians with 20 years of experience than among physicians with less clinical experience. This contradictory finding is probably the result of the physicians being assessed during the implementation phase (268). They perceived the system as a threat to their clinical experience and expressed more distrust towards it than the less experienced physicians (268). However, in the current study, the use of CPOE was evaluated during a later stage of use. Hence, the perceived threat to physicians' clinical experience might be reduced as they build more trust in the system and confidence in their knowledge. Presumably, those with the highest number of years of experience could be consultants, and this might also explain why consultants showed more usage of the order medication task. Similar to the findings for physicians' position, years of experience was also related to response to dose range alerts. This is probably because consistent exposure to knowledge and practice through clinical experience may help experienced physicians understand the significance of the impact of improper dosing. Consultants with 10 or more years of experience asserted that the dose range function was effective with regard to their performance, productivity, and patient safety (Table 5.3).

6.4 Factors Associated with the Actual Use of CPOE in Government Hospitals in Saudi Arabia

6.4.1 Performance Expectancy

Performance expectancy refers to the physician's belief that using CPOE enhances his/her job performance (131). In this study, performance expectancy was found to have the

highest association with physicians' usage of CPOE tasks (Table 4.9). This result is similar with the results of previous studies by Chang et al. (269), who found that performance expectancy had the strongest effect on physicians' intention to use pharmacokinetics-based CDS systems and, further, influenced their actual utilisation behaviour. Phichitchaisopa and Naenna (270) examined the factors influencing healthcare IT services in a hospital and found that performance expectancy had the strongest influence on acceptance of the use of the technologies. In this study, the degree of correlation of performance expectancy with actual use varied between order entry tasks and CDS tasks: It had higher correlations with order entry tasks than with CDS tasks (Table 6.1).

The high level of association between performance expectancy and the usage of CPOE may be attributed to the fact that any physician's main purpose is to achieve patient safety and provide the best quality of care. Knowing that the use of CPOE with CDS features has the potential for the best medical services will consequently enhance their job performance. Another explanation based on interview statements is knowledge of the relative advantages CPOE offers and its effects on productivity and quality of work, for example, time saving, safety measures, improved patient safety, and useful alerts and reminders (Table 5.3).

6.4.2 Effort Expectancy

Effort expectancy refers to a physician's beliefs that CPOE is easy to use and free of effort (131). The present analysis revealed that effort expectancy had the second highest association with physicians' actual use of CPOE (Table 4.9). This finding is in line with the results of Chang et al. (269) and Phichitchaisopa and Naenna (270), who examined factors related to physician's intention to use pharmacokinetics-based CDS systems and a health information system. They reported that after performance expectancy, effort

expectancy was the most significant factor affecting the use of CPOE (269, 270). In this study, the degree of correlation of effort expectancy with order entry tasks and CDS tasks was different. It showed the highest correlation with order entry tasks, and a low degree of correlation with CDS tasks (Table 6.1). This result can be explained by the ease of using functions, the organised layout, the search function, and output quality, which can reduce the mental energy required to search for important information and the time taken to do this (271). As order entry tasks involve several steps/clicks, such as searching for medications, writing the reason for choices made if required, requesting certain lab tests, and renewal, according to physicians' statements, a free-of-effort ordering process was considered important for physicians when using CPOE. In contrast, CDS tasks are basically in the form of pop-up alerts, and after reading them, the physician is required to comply and write a note, or override and write a justification. Hence, it was more important for physicians to have an effortless process when ordering. This is in alignment with physicians' statements during interviews, as ease of use was the most cited factor (Table 5.3).

6.4.3 Information Quality

Information quality refers to the quality of information CPOE provides in terms of relevance, accuracy, comprehensiveness, understandability, prevalence, and timeliness (132). Information quality had the third highest association with the actual use of CPOE (Table 4.9). While it was not significantly correlated with order entry tasks, it showed a strong correlation with CDS tasks (Table 6.1). In accordance with the present results, previous studies have demonstrated that information quality has a significant impact on the use of CDS tasks. For example, Kim et al. (272) indicted that information quality had a

highly significant association with the use of CDS functions. Elsdiag (273) and Ojo (167) also indicated that information quality had a highly significant association with the use of an HIS. The observed high correlation of information quality with the actual use of CDS could be attributed to the fact that a physician's main concern is the safety of the patient and the CDS features of CPOE contribute to achieving this goal. It seems essential for physicians that this system provide a reliable output. For example, as stated by the physicians (Table 5.3), having a standardized name for some medications is important so that they do not get confused and prescribe the wrong drug. Thus, the trustworthiness and accuracy of the provided information are highly related to physicians' use of CPOE alerts.

6.4.4 Facilitating Conditions

Facilitating conditions are the resources, facilities, and infrastructure available for the use of CPOE (131). In this study, facilitating conditions showed the fourth highest association with physicians' actual use of CPOE (Table 4.9). For both order entry tasks and CDS tasks, the degree of correlation was considered moderate. For both tasks, it ranked third with regard to the degree of correlation (Table 6.1). Facilitating conditions appears to show less impact than performance expectancy, effort expectancy, and information quality on physicians' usage of CPOE. This finding broadly supports the work of other studies in this area that link CPOE usage with these factors. For example, Chang et al. (269) found that facilitating conditions showed a slightly significant impact on usage behaviour for pharmacokinetics-based CDS systems. A similar observation was reported by Kavandi and Jaana (274) in their review that assessed factors related to the use of mobile health applications among seniors. While facilitating conditions showed a positive impact on

usage behaviour, its impact was less commonly reported in comparison to performance expectancy, effort expectancy, and social influence (274).

These results could be explained by the research settings of this study, which was conducted at established organizations with a fully implemented CPOE with CDS that has been in use for over 10 years. Both organizations are considered leading healthcare centres in Saudi Arabia. Physicians in this study had already been through training and were working with a highly mature electronic infrastructure. Hence, at the time of this study, the main elements of the facilitating conditions required to use an electronic system, namely, training, IT staff, and available devices, were already established. Hence, it was not perceived as highly correlated with the use of CPOE at the time of the study. Yet, physicians' statements regarding training and the availability of IT personnel were the most cited in relation to facilitating conditions. Some physicians considered the training provided during interviews as sufficient, while others reported that it was available but not effective. Similarly, the availability of on-spot IT support when needed was considered as sufficient by some and insufficient by others (Table 5.3).

6.4.5 System Quality

System quality refers to the quality of the system in terms of its reliability, availability, usability, functionality, flexibility, integration, and response time (132). The present results showed that system quality had the fifth highest association with the actual use of CPOE (Table 4.9). While it had no significant relationship with the use of order entry tasks, it showed the strongest correlation with the use of CDS tasks, among all the other factors (Table 6.1). This result is consistent with the previous work of Ojo (167) and Petter and Fruhling (275), as they reported that system quality was the strongest factor associated with

the success of HISs and an emergency response medical information system. This relationship may be explained by the fact that the prescribing process, along with all patient care tasks, are all reliant on CPOE. Therefore, if the system is not reliable, integrated, easy to navigate, and fast, it would affect physicians' performance and, hence, the delivery of care.

Another possible explanation is what physicians emphasized on during interviews as the excess number of alerts (Table 5.3). Physicians in this study reported that an excessive number of alerts caused alert fatigue, which was the most cited issue under system quality. These alerts, according to the physicians, might not be clinically relevant (Table 5.3). The physicians pointed out that this issue affects their time and productivity. Delone and Mclean (132) assert that 'higher system quality is expected to lead to higher user satisfaction and use, leading to positive impacts on individual productivity' (p. 11).

6.4.6 Social Influence

Social influence is the physician's belief that the opinions of important others (seniors, boss, colleagues, and patients) affect their usage of CPOE (131). In this study, social influence showed the lowest level of association with the actual use of all CPOE tasks, as it did not have a significant correlation with any of the CPOE tasks. This finding indicates that physicians in this study do not experience any social pressure from their peers to use CPOE. This result is in agreement with those of Phichitchaisopa and Naenna (270), as they reported that social influence had no significant impact on healthcare in terms of behavioural intention to use and the accept the healthcare technology. This also in accordance with the findings of Weeger and Gewald (276), who investigated the use of EMR with CDS features. They reported that physicians did not consider their supervisors'

and colleagues' views of their usage of EMR to be important.. In contrast, according to Venkatesh et al. (131), 'Prior research suggests that individuals are more likely to comply with others' expectations when those referent others have the ability to reward the desired behaviour or punish non-behaviour. This view of compliance is consistent with results in the technology acceptance literature indicating that reliance on others' opinions is significant only in mandatory settings (Hartwick and Barki 1994), particularly in the early stages of experience' (p. 452–453). In this study, however, this finding was not observed even though the use of CPOE was mandatory. A possible explanation of this finding is that, as mentioned earlier, the CPOE system in this study has been in practice for many years. It has not been newly introduced or just implemented. Hence, physicians have been using it for some time as part of their job, and they are committed to its use. Another possible explanation is that it is a physician's obligation to use this system in order to deliver healthcare services to patients. Therefore, the influence of peers or bosses is not related to the physicians' commitment to his/her job.

6.5 Research Limitations and Future Work

This study provides an understanding of the factors associated with physicians' self-reported actual use of CPOE in government hospitals in Saudi Arabia. However, there are several limitations that need to be acknowledged. The first limitation of this study is that the data collection process took place during the outbreak of the COVID-19 pandemic in 2020 (224). Therefore, it was not possible to visit the research sites. This made it difficult to oversee the progress of the online survey, conduct face-to-face interviews, and observe physicians. Hence, on-line interviews were conducted, instead, and the observation process

was cancelled. Additionally, the sample size of this research was also affected by the pandemic.

A second limitation of this study is that actual usage was assessed using self-reported data, and data on physicians' log history and alert utilisation were not obtained. In order to protect the confidentiality and privacy of the physician's identity, the research settings did not provide their usage reports. Yet, the evaluation of actual usage through self-reported surveys has been supported by previous studies (196, 277).

A third limitation of this study is that the scope of the study is limited to hospitals that use CPOE for medication prescription with CDS features. Therefore, the results may not be generalizable to other settings such as hospitals that do not have a CPOE system or have a CPOE system without CDS features. Nonetheless, since all government hospitals in Saudi Arabia have a CPOE system for ordering medication with CDS features, the results of this research can potentially be generalized to all government hospitals as well as hospitals that have CPOE for prescription with CDS features.

A fourth limitation in this study is the potential bias that could have resulted from the survey responses. The overall response rate was 40%. This is not uncommon, as surveys of physicians tend to have response rates of 10–13%, which is lower than that of the general population (278). Therefore, response rates below 40% are not considered unusual among physicians. Response bias may not be a big concern in surveys of physicians, as they are a fairly homogeneous population in terms of training, education, experience, and employment (278). In this study, there were few differences between physicians who responded to the survey and non-respondents in terms of key characteristics.

A fifth limitation of this study is the absence of the intended observational data due to the restricted access to healthcare facilities and physicians posed by the pandemic. Observational data would have provided this research with insights into physicians' use of CPOE as it occurs in its natural setting. This would have provided highly discreet data, as participants would have been in their normal environment and would have been more likely to react in a genuine way. In order to mitigate the limitation posed by the lack of an observation analysis, the researcher was careful to obtain as much descriptive information from physicians as possible during the interviews. This was reflected in the high reliability of the findings, as the physicians' reports during interviews were consistent with the survey data.

Further research should investigate the factors associated with physicians' use of CPOE in other types of hospitals in Saudi Arabia. This can be done through a large-scale survey and comparison of the results. Future research should also explore how physicians' characteristics, such as position, age, gender, and years of experience, may impact the overriding of alerts or the response to the CDS safety alerts. As it has been observed, there is a major lack of research on the relationship between health provider characteristics and utilisation of HISs. A greater focus on safety alert types could produce interesting findings that explain better physicians' attitude and the reasons underlying their behaviours toward different types of safety alerts.

6.7 Summary

This chapter discussed the findings of the current research. The results from the surveys and interviews were discussed in conjunction with each other, and the discussion covers the findings related to each of the four research questions separately. The survey results

revealed the statistical relationships between all study variables, while the interview findings helped explain and understand these relationships. Overall, the results show that the factors associated with physicians' actual use of CPOE for medication prescription in government hospitals in Saudi Arabia are performance expectancy, effort expectancy, social influence, facilitating conditions, system quality, and information quality. The significance of each of these factors differ and is dependent on the type of task the physician is performing. The findings from the interviews helped in explaining these relations and provided better insight into the numbers from the survey. The next chapter provides further details by describing the key research findings, their implications, and their contribution.

Chapter 7: Conclusion

7.1 Key Findings of the Research

The main findings of this research are as follows:

- The level of actual usage of CPOE in governmental hospitals in Saudi Arabia was high for order entry tasks and moderate for CDS tasks. This is probably because the use of CPOE for medication prescription is mandatory, while the integrated CDS alerts tasks are handled according to the physicians' personal evaluation and decision on how to respond to each type of safety alert.

- A relationship was observed between physicians' characteristics, namely, position, gender, and years of experience, and CPOE use in government hospitals in Saudi Arabia. Specifically, physicians' position, gender, and years of experience were related to the use of CPOE tasks, ordering of medication, drug interaction alerts, and dose range alerts.

- Consultants were more likely to use dose range alerts than residents and physician assistants.

- Female physicians showed greater usage of the order medication task and drug allergy alerts than male physicians.

- Physicians with more than 10 years of experience showed increased usage of dose range alerts.

- Physicians' age showed no relation to the usage of CPOE.

The gender-based variance in order medication tasks was unexpected, as the of the system is mandatory for all physicians. The only possible reason for this variance could be gender-dependent differences in IT adoption. The usage of CDS safety alerts

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suggests that physicians in this study are in agreement that allergy alerts are clinically significant and, therefore, they are handled more cautiously than interaction alerts and dose range alerts.

Survey analysis showed that the highest variance in usage pattern between all types of physicians was related to the usage of drug interaction alerts and dose range alerts; this indicates that not all physicians respond to and handle these alerts in the same way. That is, the way physicians respond to and handle alerts is different and is dependent on their experience, awareness, knowledge, and possibly, experience with using the CPOE system.

- The investigated factors were performance expectancy, effort expectancy, facilitating conditions, social influence, system quality, and information quality. Each of these factors was investigated in more detail through the interviews. All the factors were positively correlated with the actual use of CPOE tasks. However, the degree (strength) of correlation varied between the order entry tasks and the CDS safety alerts tasks, and not all of them were significantly correlated with the CPOE tasks. For order entry tasks, that is, order medication and order lab requests, the associated factors were as follows, in descending order of significance:

1. Effort expectancy (significant)
2. Performance expectancy (significant)
3. Facilitating conditions (significant)
4. Information quality (not significant)
5. System quality (not significant)
6. Social influence (not significant)

For CDS tasks, which include nine tasks for three different alerts (drug allergy, drug interaction, and dose range alerts), the associated factors were as follows, in descending order of significance:

1. System quality (significant)
2. Information quality (significant)
3. Facilitating conditions (significant)
4. Performance expectancy (significant)
5. Effort expectancy (significant)
6. Social influence (not significant)

The interviews indicated that patient safety, quality of care, usefulness of alerts and reminders, and time saving were related to physicians' performance expectancy. Further, ease of system use was related to effort expectancy. System capabilities in terms of providing fast responses, reliability, and excess alerts (alert fatigue) were related to system quality. The provision of accurate and updated information about medications was related to information quality. The accessibility to on-spot IT support staff, availability of a reliable network infrastructure, availability of adequate devices, and training were mainly related to the facilitating conditions. None of the interviewees made any indication about the social influence of others on their usage of CPOE tasks.

The significant effects of effort expectancy, performance expectancy, facilitating conditions, system quality, and information quality indicate that CPOE is viewed as substantially helpful in enhancing physicians' productivity and, therefore, quality of care. Specifically, the system is perceived as simple, stress-free, and easy to use, and locating and finding the required functions are considered to be easy. In addition, facilitating conditions such as on-spot IT personnel and effective approaches for training are necessary

at later stages of usage. The significance of system quality and information quality with regard to the use of CDS safety alert tasks suggests that CPOE with CDS features needs to reliable and have a fast response system with flexible alert features, especially for drug interaction alerts, in order to reduce alert fatigue. Further, an accurate output that is consistent across other departments involved with the prescription process (pharmacy and lab) is required.

7.2 Research Implications

The findings of this study have a number of important implications, and some recommendations are suggested for healthcare professionals and decision makers. These recommendations are drafted in a recommendation letter, presented below:

31st March, 2022

To: Hospital Director
Hospital X
Jeddah, Saudi Arabia

Sub: Letter to Management about Recommendations for Improvements

Respected sir,

I am writing to you today to propose some recommendations for improvements to your hospital's adoption and use of computerised physician order entry (CPOE) for the prescription of medications by physicians. These recommendations are based on a research study that aimed to investigate the factors associated with physicians' self-reported actual use of the CPOE system for prescribing medication in government hospitals in Saudi Arabia. First, allow me to introduce myself. My name is Asra Mogharbel, and I am an academic lecturer in the Health Administration Department of the University of Jeddah, Saudi Arabia. I have recently completed my PhD studies at the Faculty of Biology, Medicine and Health, at the University of Manchester, UK.

The following recommendations have been drawn based on the results of my PhD research, which used a survey and interviews to identify physicians' self-reported actual use of CPOE for prescribing medication. It is hoped that these recommendations can help future adopters and current adopters of CPOE for improving the overall quality of care in hospitals in Saudi Arabia.

- Based on the prevalence of CPOE and computerised decision support (CDS) systems in Saudi Arabian government hospitals, and the lack of evaluation studies on their usage, it is recommended that every healthcare facility in Saudi Arabia conduct studies on the use of healthcare information systems. Evaluation studies for any newly introduced or existing systems would help understand the main issues with usage and enable organisations to learn from past experiences. These studies should be published and be accessible to all stakeholders in healthcare systems in Saudi Arabia.

- Identify the appropriate CPOE systems to meet physicians' needs. The capabilities and functions of the selected CPOE products must be in alignment with physicians' job requirements. A major part of the physicians' job is providing quality care as a caregiver, ensuring the safety of the patients, and ensuring the quality of the service they provide. Having a COPE system that offers CDS features that provide safe delivery of care is important to the healthcare organization with regard to providing a culture of safety.

- Consider the functional and usability requirements of the CPOE system in terms of its reliability, integration, ease of use, and interoperability. A key part of this is to understand the fine details of how physicians see their own needs and problems. This could be achieved through performing usability testing for certain capabilities related to medication prescribing functions in CPOE. This could include case scenarios that measure competence, effectiveness, and physicians' satisfaction with functional elements of the system and its usability. This is important because of the impact it has on physicians' time and effort as the system end user.

- Encourage a culture of safety that prioritizes the usability of CDS medication alerts and works to optimise the significance of each type of CDS medication alert equally to mitigate risks. Medication alerts may need to be managed differently as, for example, allergy alerts are clinically significant and may need to have greater significance than drug interaction alerts and dose range alerts. The variance in usage in my study showed that there is variation in physicians' response to alerts according to their years of experience, awareness, knowledge, and potentially, experience with using the CPOE system.

- Customise the CDS features of CPOE through tailored coding and configuration of the product to meet the specific needs of each clinical specialty. For example, some medication related to certain conditions cannot be prescribed over a long time period; this means that irrelevant alerts may pop up in the system which physicians then have to override. Customisation and configuration decisions shape how information about medication is entered and displayed and affect the overall workflow. Such decisions will help in reducing alert fatigue and integrating layers of safety levels instead of having certain alerts being overridden.

- Prioritize training by tailoring it to the needs of physicians and making it readily accessible. This can be done through the use of simulations around workflows and provision of online training modules and continuous access to training materials. This will help physicians make sure that they are consistently updated regarding any new addition or rule within the system or if a new system is being introduced.

- Provide remote access to the CPOE system for physicians through an application on smartphones/tablets in order to facilitate the medication prescribing process, whilst ensuring that the application has appropriate privacy settings and can educate physicians about what information should be considered confidential and ways of protecting patient confidentiality when using the application for prescribing medication. Through this strategy, physicians might be enabled to perform their job

more effectively and the delivery of care would not be affected by a lack of devices or remote access.

- Engage physicians in regular meetings and encourage them to share their experiences and identify the gaps in using CPOE. At these meetings, physicians will have the chance to highlight the challenges they face when using the CPOE system. For example, they would be able to discuss why certain alerts are being overridden more than others. Through these meetings, any issues with the usage of CPOE could be identified, prioritized, and fixed in a timely manner. Listening to physicians will create incentives for them and enhance their proficiency in using CPOE for prescription functionalities.

Sincerely,

Dr. Asra Mogharbel

7.3 Research Contributions and Strengths

This section outlines the significance and main contributions of this research.

- Contribution to Literature:

  This research contributes to the existing literature that explores physicians' experiences with using CPOE. The initial literature review suggested that there is limited research on the factors associated with physicians' actual use of CPOE for medication prescription, and in particular, none of the research has been conducted in the context of Saudi Arabia. There are about 47 hospitals under government agencies in Saudi Arabia, and almost all of them have CPOE systems in place. These represent about 20% of the healthcare system and serve a large segment of society. Therefore, this study advances the knowledge on this topic by providing a robust reference for decision makers in healthcare systems and, also, by providing

insights into physicians' self-reported actual usage in the later stages of deployment. Understanding what factors are associated with Saudi physicians' self-reported actual use of CPOE will inform current CPOE adopters to improve, and also inform future adopters to choose the right vendor, customise their needs, and prevent issues and challenges that previous users faced. Since the use of a CPOE system involves individuals and is dependent on the organizational context, any organizational plan to implement such a system could be expected to have procedures for collecting and responding to users' opinions. Collection of such information will help to identify the best time to conduct interventions such as extra training, promoting or upgrading the system, integrating additional systems, enhancing awareness and embracement, and hence, better quality of care.

The study has extended previous knowledge by investigating the association of performance expectancy, effort expectancy, facilitating conditions, social influence, system quality, and information quality with the three different types of CDS tasks related to medication safety. It explores how each of the factors varies with regard to their degree (strength) of correlation with a mature CPOE system that has been in use for many years. None of the previous literature concerning the use of CPOE for prescribing medication with CDS alerts indicates the extent of the correlation between usability factors, information system quality, and the use of drug safety alerts. This specification of the relationship provides evidence about which of these factors should be emphasized in a mature environment that uses CPOE for medication prescription.

- This is one of the few studies that discusses physicians' self-reported actual use of drug safety-related CDS alerts. A significant contribution of this study is that it investigated the association between physicians' personal characteristics, namely, position, gender, and years of experience, and the three types of CDS alerts related to medication, namely, drug–drug interaction alerts, allergy alerts, and dose range alerts, individually. It was previously shown that personal characteristics (age, gender, etc.) were associated with the number of prescriptions written (Schectman et al. 2005); however, the role of physicians' personal characteristics has not been investigated for each type of CDS alert separately. Additionally, Morris et al. (257) and Yoo et al. (279) asserted that there is lack of evidence regarding the impact of personal characteristics on technology acceptance and use. Therefore, this study fills the gap in the literature concerning physicians' personal characteristics and how this impacts the usage of CDS alerts such as drug–drug interaction alerts, allergy alerts, and dose range alerts.
- Contribution to Theory:
- This study presents a theory-based model that has been validated. The model (Figure 2.1) has extended the existing literature by providing an empirical evaluation of all aspects of CPOE usage for prescribing medication. Among previous work identified through the systematic literature review, none of the studies considered a theoretical model for assessing CPOE usage for prescribing medication in later stages of implementation. Two studies did use theories in their investigation: Rahimi at al. (158) used the Diffusion of Innovation Theory questionnaire, but this has not been validated, and no model was examined. In the

other study, Omar et al. (157) used TAM2 questions for conducting interviews and identified a need to investigate human factors through a future evaluation which is not covered by TAM. Holden et al. (155) called for further research on the development of valid and practical theories for IT use in the health sector that are mindful of the unique healthcare context. What distinguishes the model used in the current study is that it has been validated and used to assess a CPOE system for medication prescription that has been in use for over a number of years.

- The literature on the use of HISs has been criticised for the lack of a theoretical framework to guide research on the adoption and use of these technologies (280-282). This research emerges as a response to the call for more empirical evidence about theory-based frameworks that can be used in healthcare practices. The UTAUT model and the D&M IS success model were used as frameworks to classify the evidence on the actual use of CPOE by physicians for prescribing medication (Table 3.4). Most of the published research on the integration between the UTAUT and D&M IS success models is in the form of studies on internet banking, software technologies, e-governments, and online shopping, and there are very few studies that focus on the healthcare context (168). Yet, the results of this study showed that there was a significant association between the constructs of the D&M IS success model and the use of CPOE.

- Contribution to Methodology:

- A substantial methodological contribution of this thesis is the development of a novel survey instrument that can act as an assessment instrument for stakeholders in healthcare organizations (e.g. managers, decision-makers, clinicians, and

investors) to evaluate and understand various factors associated with the use of CPOE for medication prescription by physicians. This research adapted survey items from various theories and the existing literature and modified them to fit the context of usage of CPOE with CDS features among physicians. The instrumentation of the survey went through several validation phases and demonstrated an acceptable level of reliability and validity. Moreover, the developed instrument was translated into the language of the target population (Arabic). Hence, two versions, Arabic and English, of this instrument are available for used by other studies (see Appendices C and D). Therefore, the developed survey can be replicated by future studies and validated for different technologies, users, and cultural contexts.

- A significant contribution of this research is the mixed-methods integration design presented in Section 3.4. From the previous literature, only one mixed-methods study that used both quantitative and qualitative approaches has been identified (156). Methodologists argue that there is a major lack of literature detailing specific analytic frameworks for merging mixed-methods data (283). Therefore, the presented mixed-methods approach has made a theoretical and empirical contribution to the area of integration in mixed-methods studies through merging quantitative and qualitative data. The detailed description of the converging of different results from the quantitative approach (survey) and the qualitative approach (interviews) and the two data sets can guide researchers on the application of mixed methods in this context in the future.

- Contribution to Practice:

As the selected settings are affiliated with different organisations in Saudi Arabia, this study provides insight into how the use of CPOE for prescribing medications can be more effectively implemented. This will enhance physicians' adoption of the systems in practice and, consequently, will lead to improved quality of care. The outcomes of this study provide a source of knowledge for healthcare decision makers, managers, and staff, and a clear understanding of the factors associated with the usage of CPOE by physicians for medication prescription; the findings can inform upgrading of the current systems as well as the designing and implementation of future systems.

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Appendix A: Systematic Review (Published)

Physicians' Use of the Computerized Physician Order Entry System for Medication Prescribing: Systematic Review

Asra Mogharbel 1   Dawn Dowding 2   John Ainsworth 1

Abstract

Background: Computerized physician order entry (CPOE) systems in health care settings have many benefits for prescribing medication, such as improved quality of patient care and patient safety. However, to achieve their full potential, the factors influencing the usage of CPOE systems by physicians must be identified and understood.

Objective: The aim of this study is to identify the factors influencing the usage of CPOE systems by physicians for medication prescribing in their clinical practice.

Methods: We conducted a systematic search of the literature on this topic using four databases: PubMed, CINAHL, Ovid MEDLINE, and Embase. Searches were performed from September 2019 to December 2019. The retrieved papers were screened by examining the titles and abstracts of relevant studies; two reviewers screened the full text of potentially relevant papers for inclusion in the review. Qualitative, quantitative, and mixed methods studies with the aim of conducting assessments or investigations of factors influencing the use of CPOE for medication prescribing among physicians were included. The identified factors were grouped based on constructs from two models: the unified theory of acceptance and use of technology model and the Delone and McLean Information System Success Model. We used the Mixed Method Appraisal Tool to assess the quality of the included studies and narrative synthesis to report the results.

Results: A total of 11 articles were included in the review, and 37 factors related to the usage of CPOE systems were identified as the factors influencing how physicians used CPOE for medication prescribing. These factors represented three main themes: individual, technological, and organizational.

Conclusions: This study identified the common factors that influenced the usage of CPOE systems by physicians for medication prescribing regardless of the type of setting or the duration of the use of a system by participants. Our findings can be used to inform implementation and support the usage of the CPOE system by physicians.

Introduction

Background

Computerized physician order entry (CPOE) systems for medication prescribing allow health care professionals to enter accurate and complete medication orders electronically [1]. The CPOE system has clinical decision support (CDS) features that help reduce medication errors and increase safety, such as an alert system, to warn a physician of drug allergies and drug-drug interactions and a feature offering advice regarding medication dosages and frequencies [1]. CPOE for prescribing medication has been reported to

be helpful to clinicians by providing them with easy access to patient data, a faster prescribing process [2], and guidelines to enhance compliance with best practices; it also reduces medical costs and improves organizational efficiency [3].

In addition to being beneficial for clinicians, CPOE for medication prescribing also has drawbacks that affect its usage by clinicians. Issues such as excessive alerting can lead physicians to ignore these safety warnings, which might be harmful for patients [4]. In addition, owing to the expense associated with continuous training required for such a system, physicians may lack adequate skills to use CPOE, which leads to underutilization [5].

The adoption and use of CPOE usually starts at the organizational level, where health organizations decide to implement such a system. Studies have shown that the adoption of CPOE for medication prescribing by health care organizations is associated with the high cost of installing a CPOE system. This may hinder many health care organizations from having a system within their practice. However, the benefits offered by the system in the long run can compensate for these costs [6].

For example, in 2013, a CPOE was implemented in 2 groups of 4 community hospitals in the United States at a cost of US $7,130,894 and US $19,293,379, respectively. After adopting the CPOE, the avoided financial cost of adverse drug events alone saves the hospital about US $7,937,651 and US $16,557,056 [7]. The organization makes the decision to implement the CPOE system; however, to achieve benefits and reach its full potential, CPOE depends on effective use by individual clinicians. There is a need to understand the factors influencing the usage of this system by physicians after it has been implemented. The aim of this review is to identify the factors that influence actual use of CPOE by physicians for medication prescribing.

The rationale for this systematic review was based on the results of previous studies, which suggested that the use of CPOE at the international level appears to be low [8-10]. The adoption of CPOE as a computerized ordering system for all types of medical orders (not only medication prescriptions) has international relevance [8,9]; however, evidence from studies conducted in several countries has shown a low rate of acceptance and adoption of these systems by health care providers [8,9]. For example, in some developing countries, despite the availability of several types of computerized health systems, such as electronic medical records, CDS systems, CPOE, and telemedicine, these systems are not properly used [9]. Although little has been reported in recent years about the proportion of CPOE users, in 2009 [8], the proportion of hospitals that implemented and adopted CPOE as an ordering system, including medication prescribing, in 7 western countries was reported. The study indicated that 15% of the hospitals in the United States, 2% in the United Kingdom, and 20% in the Netherlands had CPOE, with very few in Germany, France, and Australia. This shows a significantly low adoption rate [8], which was related to financial, organizational, and technological factors and attitudes of users [8].

In the United Kingdom, for example, vendors of CPOE systems for electronic prescribing have challenges related to implementation because of the factors related to policies [10]. In other countries with different health care systems and policies, the factors affecting the adoption and use of CPOE might vary.

Objectives

The first rationale for conducting this study was to identify the factors influencing the underutilization of CPOE by physicians for medication prescribing and understand their reasons.

Second, we identified only 4 reviews with a main focus on CPOE as a medication-prescribing system [11-14]. The evidence from these reviews focused on the factors affecting health care providers during the implementation and adoption phases, rather than their actual use of CPOE postimplementation. The implementation phase refers to the time between deciding to introduce a new system and the activities involved in this decision by the hospital, up to the point the system is ready to be used [11]. In this study, we aim to identify the factors affecting the actual use of CPOE.

The actual usage of a system follows the implementation process [15]: actual usage is defined as a behavior that can be measured through indicators, such as an individual's frequency or duration of usage [16]. The term system usage consists of 3 fundamental components: the subject using the system (user), the system itself, and the task to be accomplished through the system [17]. Although one of the reviews [14] focused on medication-related CDS after it was fully implemented, it included evidence only from qualitative studies, and there was no indication that the actual usage, as defined here, was the main focus of that review.

Two of the reviews [11,12] identified factors influencing different types of health care providers as users (eg, physicians, nurses, pharmacists), whereas the other 2 reviews [13,14] identified their targeted users. This study focused entirely on physicians as users and the factors that were likely to affect their usage, as professionals from different disciplines might be influenced by different factors in their decisions to use CPOE for prescribing medication. Hence, the second rationale for conducting this study was to fill the gap in the evidence found in prior reviews.

Third, most of the studies included in these reviews were conducted in industrialized western countries (the United States, the United Kingdom, Sweden, the Netherlands, Australia, and Canada); only 1 study was conducted in a developing country. There is a huge gap in the literature on the factors affecting the usage of CPOE for prescribing medication among developing countries [9]. This study was part of a research project conducted in Saudi Arabia (a developing country) to investigate the factors that influence the actual usage of CPOE by physicians for medication prescribing.

In summary, the aforementioned gap in the literature regarding the factors influencing the actual use of CPOE for medication prescribing by physicians is the reason for carrying out this systematic review. In this study, we used the unified theory of acceptance and use of technology (UTAUT) model [18] and the Delone and McLean Information System Success Model [19] as frameworks to classify the evidence on the actual use of CPOE by physicians for medication prescribing. To the best of our knowledge, there is no published analysis of the factors affecting the actual use of CPOE in particular by physicians for medication prescribing using this theoretical approach.

Methods

Search Strategy

This study was based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines [20]. The following databases were searched from September 2019 to December 2019: PubMed, Embase, Ovid MEDLINE, and CINAHL. The search was performed without any restrictions on dates; however, it was limited to English language papers. Reference lists in the identified reviews and included studies were checked to retrieve relevant papers. We combined medical subject headings (MeSH terms) related to CPOE retrieved from PubMed and keywords from the relevant research literature (Textbox 1).

Medical subject headings (MeSH) terms and keywords used in the searches of PubMed, Embase, Ovid MEDLINE, and CINAHL. The final search strategy (A10, B8, and C3) was applied to all 4 databases.

Group A: type of system

1. Medication alert systems
2. Computerized provider order entry
3. Computerized physician order entry
4. CPOE
5. Electronic prescription
6. Prescription decision support system
7. Computerized prescriber order entry
8. Pharmaceutical decision-support systems
9. Pharmacy information system
10. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9

Group B: usage

1. Use
2. Actual usage
3. System use
4. Utilization
5. Acceptance
6. Adoption
7. Usage
8. 1 or 2 or 3 or 4 or 5 or 6 or 7

Group C: factors

1. Factors
2. Determinants
3. 1 or 2

Textbox 1. Medical subject headings (MeSH) terms and keywords used in the searches of PubMed, Embase, Ovid MEDLINE, and CINAHL. The final search strategy (A10, B8, and C3) was applied to all 4 databases.

A draft of the search strategies used in three of the databases is presented in Multimedia Appendix 1.

Eligibility Criteria

The included studies were peer-reviewed research reports written in English, with the stated aim of exploring, investigating, or assessing factors that influence the use of medication-related CPOE systems as our target intervention. The population of interest was physicians, with the included studies reporting the results of physicians only or papers in which physicians' responses were reported separately. The included studies also had to be conducted in clinical settings, that is, inpatient and outpatient departments of hospitals, health care centers, primary care centers, and polyclinics. Quantitative, qualitative, and mixed methods designs were considered eligible for inclusion. Studies were excluded if the CPOE system had not been implemented at the time of this study or if the study assessed the influence of factors on intentions to use the CPOE system rather than on its actual use. Papers with a population of nurses, pharmacists, information technology (IT) personnel, managers, or patients and those with interventions that were not strictly CPOE, as defined earlier, were excluded from the review. Studies that were conducted in

nonclinical settings (eg, retail pharmacies, community pharmacies, nursing homes) were excluded from this review.

Selection Process

The primary researcher (AM) independently screened the titles and abstracts of all papers retrieved from the search using the inclusion criteria. The full-text articles of all potentially relevant studies were assessed independently by all 3 authors for eligibility. A calibration exercise was conducted to cross-check the results obtained by the authors. All disagreements were resolved through discussion. The details of the exclusion criteria are shown in Figure 1.
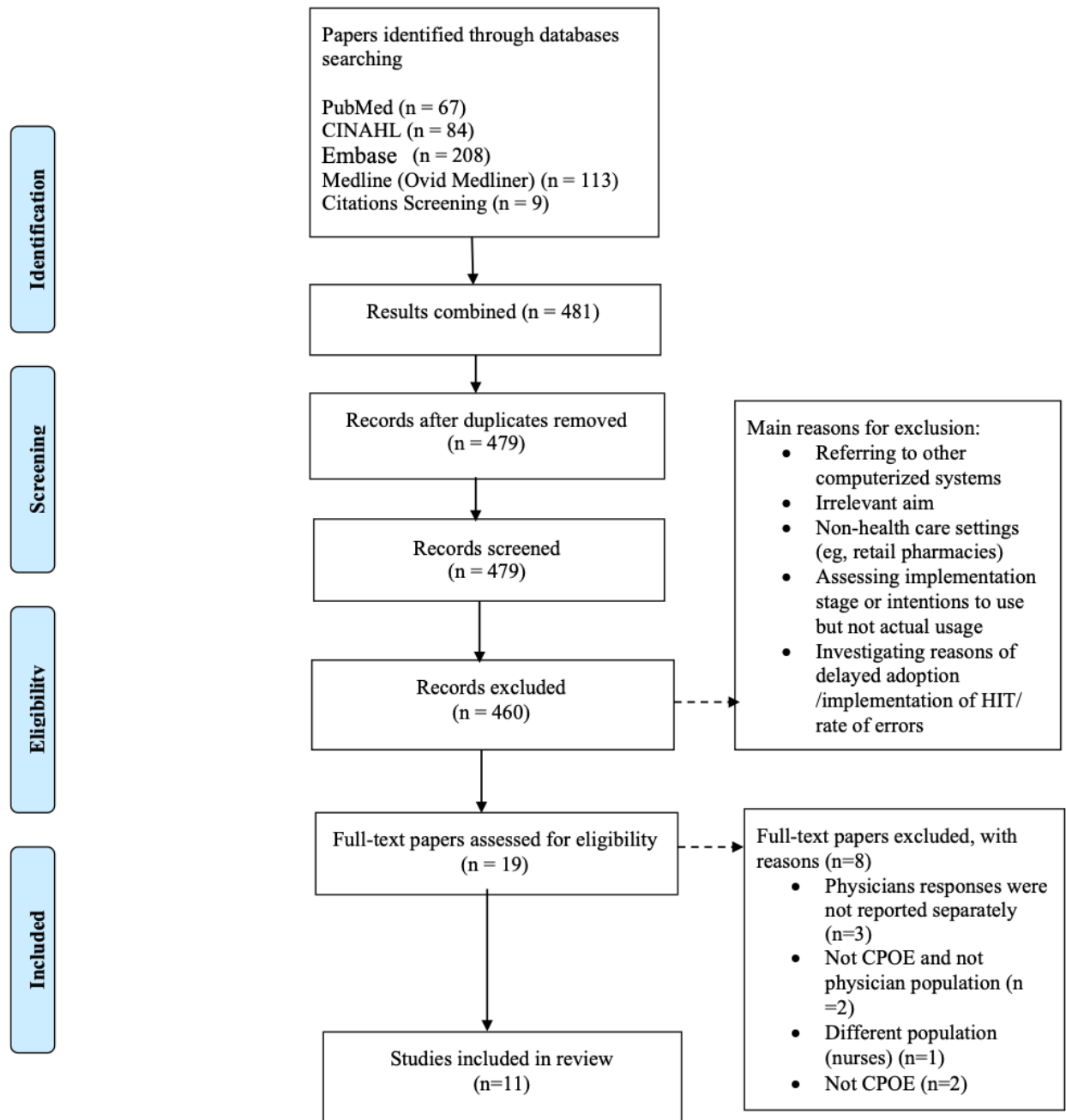
Figure 1. Flow diagram of the selection process for the included papers. CPOE: computerized physician order entry; HIT: health information technology. View this figure

Data Collection Process and Data Items

The primary researcher performed the data extraction. The data included names of the authors, publication year, country, objective, study design, data collection method, type of intervention, setting, population and sample, factors associated with CPOE use, how actual use was assessed, and the duration of the system's use before the data were collected.

Risk of Bias of the Included Studies (Quality Assessment)

The Mixed Methods Appraisal Tool (MMAT) was used to assess the quality of the included studies [21]. The MMAT is a comprehensive tool designed to evaluate reviews, including quantitative, qualitative, and mixed methods studies [21]. All the 3 authors independently appraised the included studies. The primary researcher (AM) reviewed all of the studies, and each of the other 2 researchers (JA and DD) reviewed half of the studies. Any disagreements were resolved through discussion. MMAT does not recommend assigning a single score based on the assessment [21]. However, in this review, we used a specific metric derived from a previous study [22]. To rate the quality of each of the studies to justify the reasons for the final inclusions and exclusions. Studies were classified as high, medium, or low quality, depending on the number of criteria that were met. A study was considered high quality if all 5 MMAT criteria were met, medium if 3 or 4 criteria were met, and low when a study met 1 or 2 criteria [22].

Data Synthesis

Narrative synthesis was used to summarize the evidence from the included studies. Narrative synthesis is appropriate when a review includes both qualitative and quantitative findings [23].

Results

Study Selection

The electronic database search retrieved 67 records from PubMed, 84 from CINAHL, 208 from Embase, 113 from Ovid MEDLINE, and 9 from the reference lists of the included studies. After duplicates were removed, the titles and abstracts of the remaining 479 studies were assessed for eligibility. Of these, 460 studies were excluded because they were ineligible and 19 articles were selected for in-depth analyses. A total of 11 studies were included in the final review. The study selection process and reasons for exclusion are shown in Figure 1.

Characteristics of the Included Studies

Multimedia Appendix 2 [24-34] summarizes the characteristics of the included studies. The 11 studies included in the review were from different regions of the world: 4 are from the United States [24-27], 3 are from Sweden [28-30], 1 is from the Netherlands [31], 1 from Saudi Arabia [32], 1 from Australia [33], and 1 from Singapore [34]. Of the total number of studies, 4 used qualitative methods (interviews) [24,25,29,33], 6 used quantitative methods (surveys or questionnaires) [26-28,30,32,34], and 1 used a mixed methods approach [31]. Among the 11 included studies, the factors associated with the use of CPOE for medication prescribing were mainly related to technical, organizational, or individual characteristics. All the included studies were conducted in either a hospital or a primary care center. Of the total number of studies, 7 were conducted in a hospital setting [24-27,29,32,33], 2 in a hospital and a primary care center [28,30], 1 in a primary care center [31], and another in a group of polyclinics [34].

Quality of the Included Studies

Multimedia Appendix 3 [24-34] summarizes the results of the quality assessment of the included studies. Of the total number of studies, 3 (all qualitative) were rated as *high* quality because they met all 5 MMAT criteria [24,25,29]. Of the total number of studies, 5 (all quantitative) were rated as *medium* quality, as they met 3 or 4 of the MMAT criteria [26,28,30,32,34] and 3 studies were evaluated as having low quality because they met either 1 or none of the MMAT criteria. Of these, 1 was a quantitative study [27], 1 study used a mixed methods design [31], and 1 was a qualitative study [33]. We chose not to exclude these studies from the final synthesis based on their quality because of the exploratory nature of the review.

Synthesis of the Results

The factors that influenced physicians' usage of CPOE for medication prescribing are presented in Table 1. On the basis of the perceived commonality among the reported factors, we organized them according to the definitions of the constructs from the UTAUT [18] and the Delone and McLean Information System Success Model [19]

UTAUT is a theoretical model that can explain about 70% of the variance in a user's behavior in relation to technology acceptance and use [18]. It consists of 4 main constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions [18]. Performance expectancy refers to physicians' perceptions that using CPOE will improve their job performance [18]. Effort expectancy refers to physicians' beliefs that using CPOE is effortless and easy [18]. Social influence pertains to physicians' perceptions of the importance of others' (eg, leaders' and colleagues') opinions about whether physicians should or should not use the system [18]. Facilitating conditions refers to the existence of resources, facilities, and infrastructure that are helpful to physicians when using CPOE [18].

The Delone and McLean Information System Success Model is used to assess and understand the success of any information system and its impact on the individual and the organization [19]. It consists of 6 components: system quality, information quality, use, user satisfaction, individual impact, and organizational impact [19]. However, we assessed only system quality and information quality. Information quality refers to the system's outputs or content in terms of relevance, accuracy, comprehensiveness, understandability, prevalence, timeliness, and usability [19]. System quality refers to the quality of the system, in particular, the system's reliability, functionality, flexibility, ease of use, integration, and response time [19]. We assessed these 2 constructs because the identified factors that are mainly related to the technological aspects of the CPOE system are also related to the quality of the information and the system. The other 4 constructs were addressed in the UTAUT model.

The results of the included studies were synthesized under 3 themes: individual, organizational, and technological factors. Individual factors are related to the constructs of performance expectancy, effort expectancy, and social influence. Organizational factors are related to the construct of facilitating conditions, and technological factors are related to the constructs of information quality and system quality (Table 1).

Individual Factors

Individual factors refer to issues related to physicians' perceptions of the possible effects of using CPOE for medication prescribing [35]. A total of 11 factors related to physicians' perceptions were identified. The most cited factors were the effect on the quality of patient care [25,26,32] and ease of use [28,29,32]. Physicians perceived that using CPOE enhanced patient care. In one study [26], the features of the CPOE system were associated with better quality of patient care by providing easy and direct access to patient records and reminders and alerts for physicians, which led to a reduction in duplicate tests and expediting the ordering process. Ease of use refers to physicians' belief that using the system is easy and effortless [18,28,29]. In another study [32], physicians agreed that their satisfaction with the system was greater because it was easy to use, which led to their usage of the system. Three studies reported limited use of CPOE by physicians because they found it difficult to use and complex in terms of navigating, accessing, and finding information [24,29,30].

Organizational Factors

Organizational factors include resources (eg, materials, humans, circumstances) provided by the organization that facilitate usage of the CPOE system by physicians [12]. In total, 8 studies identified 9 organizational factors that affected the use of CPOE. Training [24,25,33,34], availability of technical support (such as a help desk) [25,27,31,32], and time constraints [24,25,27] were the most cited factors. Training issues reported by physicians included either the need for retraining because of new features [24] or lack of training [33]. The availability of technical support means the physicians need to have IT staff

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accessible to help them in case of any technical issues while using the CPOE system [25,27,32] or the extent of the physician's awareness that there is a designated help desk to assist them [31].

The timing of the reporting of these factors in the included studies suggests that the factors related to the organization were critical for the usage of the CPOE system by physicians, regardless of whether the physicians recently began using the system or have been using it for a longer time. For example, studies that reported training [24,25,33,34] were conducted at different time points after the implementation of CPOE. One study conducted its assessment after 2 years of CPOE usage [24], while 3 other studies investigated the factors affecting usage after only months of use [25,33,34]. Technical support availability was reported in studies after weeks [25,31,32] and after 1 year of usage [27].

Time constraints were the second most cited factor influencing physicians' CPOE usage [24,25,27]. The complexity of CPOE [24], its slowness [25], and physicians' unfamiliarity with its features [27] were reasons why it was so time-consuming for physicians to use it.

Technological Factors

Technological factors included the technical and design aspects of CPOE in terms of the system's quality; information quality; and its reliability, functionality, flexibility, ease of use, integration, and response time [19]. Evidence from 8 of the included studies [24-26,28,31-34] indicated that the factors related to CPOE were the most relevant for affecting its use by physicians. A total of 17 factors were reported (Table 1). The system's efficiency was the most cited factor [31,32,34], specifically the quick prescribing process [31], fast data retrieval, response time [32], and the system's speed, in terms of entering patient data [34]. Furthermore, studies that reported the system's speed as an influential factor in its use by physicians were conducted shortly after the implementation phase, that is, halfway through the intervention year (about 6 months later), shortly after implementation (not clear), and 3 months after implementation. This finding suggests that because the system was newly implemented, the processing speed was significant for physicians' performance of tasks.

The findings indicate that ease of use, the effect of using CPOE on quality of care, training, availability of technical support, time, and the system's speed were the factors with the strongest influence on the use of CPOE for medication prescribing among all the studies.

Discussion

Principal Findings and Comparisons With Other Works

CPOE for medication prescribing can serve physicians as a tool to enhance patient quality of care. However, this has not led to a rapid uptake of the system by health organizations and clinicians to use it [6,14]. A key factor in the slow adoption of CPOE by health care organizations is attributed to the costs associated with installing the system and the costs of sustaining it [6]. The first CPOE was installed in the United States in 1971 [36]. Although that was long ago, the adoption rate in health organizations is still rare to moderate, with a percentage of 15.7% [13]. This low adoption rate has been reported in other countries [8,9].

Despite many years of implementation of CPOE for medication prescription, development, and research, the issue of low adoption postimplementation remains. This study focuses on the usage of the user—the physician—after the system has been implemented. We identified factors that were related to the users (physicians), organization, and technological aspects of CPOE that influence the actual use of CPOE by physicians for medication prescribing, rather than intention to use a CPOE system.

The findings of this study are consistent with those of Van Dort et al [14] and Gagnon et al [12]. Nevertheless, these reviews identified other factors that were not found in this study. Resistance to use was reported in both reviews [12,14], as a factor that negatively affected the usage of the system by physicians

for medication prescribing. CDS systems embedded in the CPOE system for medication prescribing were examined in Van Dort et al [14]. As CDS systems are known to offer suggestions and recommendations, user resistance was present as the physicians reported concerns that the information presented might not be reliable [14].

In addition to resistance to using CPOE, Gagnon et al [12] described how the system could negatively affect the patient-clinician relationship and identified financial issues as another influential factor, neither of which was detected in this study. This inconsistency might be because of the focus of this study on the actual use of CPOE after the system had been installed and used and resistance is no longer an issue.

This study showed that technological factors related to the system were the most frequently reported factors that influenced how a physician used the CPOE system for medication prescribing. This finding is consistent with the results reported by Gagnon et al [12]. As their findings suggest, technical and design concerns were the most frequently identified factors limiting the system's use [12].

One of the principal findings of this study is that among the 3 main themes, 5 factors were cited most frequently (any factor cited 3 or more times was considered frequently cited), indicating that it was significant in the physicians' decisions about using the CPOE system. Quality of care, ease of use, training, availability of technical support, time constraints, and system speed were key factors in the use of CPOE by physicians. A similar pattern of results has been reported in an extensive body of literature [12,14,37,38]. One unexpected finding was that the effect of alert fatigue, as a factor in the use of CPOE, was identified in only 2 studies [24,33]. Alert fatigue is the receipt of a massive amount of reminders or warnings that cost time and effort and is eventually ignored [39].

This finding contradicts the observation that alert fatigue has previously been found to be associated with the usage of CPOE for medication prescribing. In their review, Gagnon et al [12] showed that alert fatigue was associated with the use of an electronic prescription system in 5 studies. In addition, Van Dort et al [14] showed that too many irrelevant alerts were related to the uptake of medication-related CDS systems in 10 studies.

In these 2 studies [24,33], alert fatigue affected physicians' use. In the first study [24], physicians' perception of the alerts was that after transitioning to a more advanced new system, the alerts were more sensitive than those of the older system. In the second study [33], the ratings of the alerts were higher when the study's setting was an intensive care unit (ICU), compared with their ratings by other departments in the hospital.

All factors identified in this study are similar to those of other reviews related to the implementation [12], adoption [37], or acceptance [38] of CPOE.

However, a factor not discussed in previous CPOE for e-prescription studies and detected in this study was customization of the CPOE system's features for medication prescribing to each department. Customize refers to tailoring the features of a CPOE system to the preferences and needs of a specific department. For example, ICU physicians reported that some alerts were irrelevant to ICU patients and more suitable for other departments in the hospital [33]. This finding is in line with that reported in the review by Li et al [40], who suggested the importance of customization of the system's features according to different specialties and emphasized its significance for the provider's workflow.

We have used constructs from the UTAUT [18] and Delone and McLean Information System Success Models [19] to organize the identified factors to provide a better understanding of what each factor means to the user and how it may influence physicians' attitudes toward the actual use of the CPOE for medication prescribing. The UTAUT model is a combination of 8 technology acceptance models, which covers almost all the factors identified in the literature [18]. All the factors reported in the included literature in this study were aligned with the constructs of the UTAUT and Delone and McLean

Information System Success Models. The examination of factors using these 2 models provides a useful framework for this systematic review.

Two of the constructs (system quality and information quality) from the Delone and McLean Information System Success Model were found to be highly relevant, as the most frequently reported factors were the technological ones [19]. These factors were mainly related to the quality of the system or information. Both models have been extensively used in research related to health care technology assessment [41,42].

Limitations and Strengths

The limitations of this study should be acknowledged. First, we searched only 4 databases. Although these databases are the most relevant for health care publications, there is a possibility that relevant studies could have been missed. Second, the first step of the database search—checking every single title and abstract—was performed by a single author. However, we believe that this does not affect the quality of this paper as the results of the selection and screening were revised in regular meetings with the other reviewers who are experts in the field and no issues were raised by them during the review process. In addition, all the assessment steps for article eligibility were conducted by all 3 authors in parallel. We systematically discussed any disputes between all the reviewers to ensure consistency.

Third, we acknowledge the fact that our search resulted in only 11 articles that could be viewed as a small sample for a system that has been in use for a number of years. However, this study focused on the medication ordering aspect of the CPOE and did not evaluate the CPOE as a whole system. In addition, we also focused on physicians as our target population and studies that indicated that the system is being actually used and not the intention to use (installation phase or implementation phase). The strength of this study lies in the presentation of 4 elements that are absent from previous attempts to synthesize primary research on this topic: (1) it evaluated research that used major study designs (quantitative, qualitative, and mixed methods); (2) it drew on the perspectives of physicians only; and (3) it included research on the period of actual usage of CPOE for e-prescribing in particular (while the physicians were using the system) and not the intention to use. (4) Factors that are unique to the physician's actual usage were explained using a framework that consists of a combination of 2 theoretical approaches. To the best of our knowledge, no previous systematic reviews have explored specific factors influencing physicians' actual usage of CPOE or e-prescriptions according to the presented framework.

Conclusions

This study suggests that an individual's perceptions, technical factors, and organizational factors are all significant influences on the usage of CPOE by physicians for medication prescribing. Although most of the identified factors are similar to those reported in previous reviews related to CPOE, the results of our work have allowed us to identify an additional factor that was not discussed in earlier reviews, namely, the preference of physicians to customize the CPOE system to the needs of the medical department. Finally, as much as there are issues at the organizational level during the implementation process, it is important to focus on the individual physicians after the implementation is completed. The outcomes of this study provide a source of knowledge for health care decision makers, managers, and staff and a clear understanding of the factors influencing the usage of CPOE by physicians for medication prescribing, which can inform future system designs and implementation.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Results of the search strategies used in the PubMed, EMBASE, and CINAHL databases.

DOCX File , 16 KB

Multimedia Appendix 2

Characteristics of the included studies.

DOCX File , 24 KB

Multimedia Appendix 3

Quality assessment of the included studies using the Mixed Methods Appraisal Tool (2018).

DOCX File , 17 KB

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Abbreviations

CDS: clinical decision support

CPOE: computerized physician order entry

ICU: intensive care unit

IT: information technology

MMAT: Mixed Methods Appraisal Tool

UTAUT: unified theory of acceptance and use of technology

Copyright

Appendix B: Results of the Search Strategies used in PubMed, EMBASE, and CINAHL.

PubMed

Search	Results
1. (Medication Alert Systems[Title/Abstract] OR Computerized Provider Order Entry[Title/Abstract] OR Computerized Physician Order Entry[Title/Abstract] OR CPOE[Title/Abstract] OR Electronic Prescription[Title/Abstract] OR Prescription decision support system[Title/Abstract] OR computerized prescriber order entry[Title/Abstract] OR pharmaceutical decision support systems [Title/Abstract] OR Pharmacy information system[Title/Abstract]) Sort by: Best Match	2443
2. (actual use[Title/Abstract] OR Use[Title/Abstract] OR System use[Title/Abstract] OR utilization[Title/Abstract] OR Acceptance[Title/Abstract] OR Adoption[Title/Abstract]) Sort by: Best Match	283962
3. (Factors[Title/Abstract] OR determinants[Title/Abstract]) Sort by: Best Match	2054241
4. (((((Medication Alert Systems[Title/Abstract] OR Computerized Provider Order Entry[Title/Abstract] OR Computerized Physician Order Entry[Title/Abstract] OR CPOE[Title/Abstract] OR Electronic Prescription[Title/Abstract] OR Prescription decision support system[Title/Abstract] OR computerized prescriber order entry[Title/Abstract] OR pharmaceutical decision support systems [Title/Abstract] OR Pharmacy information system[Title/Abstract]))) AND ((actual use[Title/Abstract] OR Use[Title/Abstract] OR System use[Title/Abstract] OR utilization[Title/Abstract] OR Acceptance[Title/Abstract] OR Adoption[Title/Abstract]))) AND ((Factors[Title/Abstract] OR determinants[Title/Abstract])) Sort by: Best Match	67

EMBASE

Search	Results
1. (actual usage or Use[a] or System use[b] or utilization or Acceptance or Adoption).ab.	8554140
2. (factors or determinants).ab.	2547366

	Search	Results
3.	**(Medication Alert Systems or Computerized Provider Order Entry or Computerized Physician Order Entry or CPOE or Electronic Prescription or Prescription decision support system or computerized prescriber order entry or pharmaceutical decision support systems or Pharmacy information system).ab.**	2648
4.	**1 and 2 and 3**	217
5.	**limit 4 to English language**	208

CINAHL

	Search	Results
1.	**AB Medication Alert Systems OR Computerized Provider Order Entry OR Computerized Physician Order Entry OR CPOE OR Electronic Prescription OR Prescription decision support system OR computerized prescriber order entry OR pharmaceutical decision support systems OR Pharmacy information system**	1137
2.	**AB actual usage OR Use OR System use OR utilization OR Acceptance OR Adoption**	601932
3.	**AB factors OR determinants**	515609
4.	**S1 AND S2 AND S3**	84

[a]actual usage or Use: The CPOE system in the study is already installed and physicians are practically using it . Not intended to be used or still not installed.
[b]System use: the utilization of the CPOE system

Appendix C: The Survey (English)

Dear Participant

You are invited to participate in a research study titled "Factors Associates with Physicians Actual Use of Computerized Physician Order Entry System (CPOE) for Medication Prescribing in Government Hospitals in Saudi Arabia".

The aim of this study is to investigate factors that associates with physician's utilization of CPOE for medication prescribing in government hospitals in Saudi Arabia.

CPOE refers to a computerized system that allows the physicians to enter medication orders electronically in a way that ensures a clear, accurate, and complete ordering process. CPOE has Clinical Decision Support (CDS) features that helps reduce medication errors and increase safety (e.g. alerting system in case of drug-drug allergy, drug-drug interaction, medications dosages recommendations, or frequencies).

In this study, you will be asked to complete an electronic survey. Your participation in this study is voluntary and you are free to withdraw your participation from this study at any time. The survey should take about 7 minutes to complete. There are no risks with participating in this study. The survey collects no identifying information of any respondent. All the responses in the survey will be recorded anonymously.

By clicking the 'Next' button, you are indicating that you have read the consent form and agree to participate in this study. Your participation is appreciated. If you have any questions, please contact the researcher:

Ms. Asra Mogharbel – PhD Student in Health Informatics

Faculty of Biology, Medicine, and Health - The University of Manchester, U.K

Email: asra.mogharbel@postgrad.manchester.ac.uk

Thank you for your cooperation

Consent

Consent statement (before the online survey starts)

I confirm that I have read the previous information sheet for the above study and have had the opportunity to consider the information. I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason and without detriment to myself. I understand that it will not be possible to remove my data from the project once it has been anonymized and forms part of the data set. I agree to take part on this basis.

I agree that any data collected may be published in anonymous form in academic books, reports, or journals. I agree to take part in this study.

By clicking the "I agree" button, you are indicating that you have read the consent form and agree to participate in this study.

Part 1. User Characteristics

Position	Consultant
	Resident
	Assistant Physician
Gender	Male
	Female
Age	20 –29 years
	30 –39 years
	40-49 years
	50 and above years
Setting	A
	B
Years of experience	Less than 2 years
	Between 2 and 5 years
	Between 5 and 10 years
	More than 10 years
Generally, how do you rate yourself in using computer/ technology devices at work (computer skills)?	Poor
	Average
	Good
	Excellent
How many years have you been using the CPOE?	Less than 2 Years
	2 to 5 Years
	5 to 10 Years
	More than 10 Years
Medical Department	Internal Medicine
	Family Medicine
	General Surgery
	Emergency

	Obstetrics and Gynecology
	Pediatric
	Neurology
	Cardiology
	E.N.T (Ear, Nose, and Throat)
	Orthopedics
	Anesthesiology
	Cardiac Surgery
	Dentistry
	Urology
	Vascular
	Other (Specify)

Part 2. Actual Use of CPOE

Please report your use of CPOE for medication prescribing for the following tasks:

Question	Never	Rarely	Some of the time	Most of the time	Always
Actual Use Orders Entry Tasks					
1. Order medications.	1	2	3	4	5
2. Ordering laboratory requests.	1	2	3	4	5
Actual Use Clinical Decision Support Tasks					
1. Carefully read the drug drug interaction alerts that I receive.	1	2	3	4	5
2. Provide reasons for drug drug interaction alerts that I decide to override.	1	2	3	4	5
3. Drug drug interaction alerts presented to me during order entry change my prescribing decisions.	1	2	3	4	5
4. Carefully read the drug allergy alerts that I receive.	1	2	3	4	5
5. Provide reasons for drug allergy alerts that I decide to override.	1	2	3	4	5
6. Drug allergy alerts presented to me during order entry change my prescribing decisions.	1	2	3	4	5
7. Carefully read the dose range alerts that I receive.	1	2	3	4	5
8. Provide reasons for dose range that I decide to override.	1	2	3	4	5
9. Dose range alerts presented to me during order entry change my prescribing decisions.	1	2	3	4	5

Part 3: Please report your level of agreement with the following statements:

Performance Expectancy

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I find the CPOE for medication prescribing useful in my job.	1	2	3	4	5
2. Using the CPOE medication prescribing in my job enables me to accomplish tasks more quickly.	1	2	3	4	5
3. Using the CPOE medication prescribing improves the quality of output of job.	1	2	3	4	5

Effort Expectancy

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. My interaction with the CPOE for medication prescribing is clear.	1	2	3	4	5
2. It is easy to get the CPOE for medication prescribing to do what I want it to do.	1	2	3	4	5
3. I find the CPOE for medication prescribing easy to use.	1	2	3	4	5

Social Influence

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. My supervisors / leaders influence my use of the CPOE for medication prescribing.	1	2	3	4	5
2. My colleagues influence my use of the CPOE for medication prescribing.	1	2	3	4	5
3. Patients influence my use of the CPOE for medication prescribing.	1	2	3	4	5

Facilitating Conditions

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I have the technological resources necessary (PC /laptop/tablet) to use	1	2	3	4	5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
the CPOE for medication prescribing.					
2. The CPOE for medication prescribing I'm using is compatible with other systems (EHR, I can open other links, windows in the same time) that I'm using in the hospital.	1	2	3	4	5
3. A technical support form specific person or group (IT staff /help desk) is available for assistance when problems are encountered when using CPOE for medication prescribing.	1	2	3	4	5
4. There was enough time for me to familiarize with the CPOE for medication prescribing.	1	2	3	4	5
5. The training I received was relevant to how to use the CPOE for medication prescribing.	1	2	3	4	5
6. The management team provide me enough support and encouragement to use the CPOE for medication prescribing.	1	2	3	4	5

Information Quality

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. Information from the CPOE for medication prescribing is relevant to my work.	1	2	3	4	5
2. Information I get from the CPOE for medication prescribing is accurate.	1	2	3	4	5
3. The information from CPOE screen is easy to understand.	1	2	3	4	5

System Quality

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. The layout of CPOE for medication prescribing is well-organized.	1	2	3	4	5
2. Any error during prescribing/ordering is quickly corrected.	1	2	3	4	5
3. The CPOE for medication prescribing response time is acceptable (not slow).	1	2	3	4	5

4. The CPOE for medication prescribing can be accessed using different devices.	1	2	3	4	5
5. it's easy to find information (about the patient, medications) when using CPOE for medication prescribing.	1	2	3	4	5
6. The CPOE for medication prescribing features contains timely updates that meets my needs.	1	2	3	4	5
7. I can easily retrieve information from the CPOE for medication prescribing.	1	2	3	4	5

Appendix D: The Survey (Arabic)

نموذج موافقة على المشاركة في استبيان

عزيزي المشارك

ندعوكم للمشاركة في بحث بعنوان " العوامل المرتبطة باستخدام الأطباء الفعلي لنظام إدخال الأوامر الطبية CPOE المحوسب المختص بوصف الأدوية في مستشفيين حكوميين بالمملكة العربية السعودية".

تهدف هذه الدراسة إلى تحديد العوامل المرتبطة باستخدام الأطباء لنظام إدخال الأوامر الطبية المحوسب المختص بوصف الأدوية في مستشفيين حكوميين بالمملكة العربية السعودية.

نظام إدخال الأوامر الطبية المحوسب المختص بوصف الأدوية يقصد به برنامج يسمح للأطباء بإدخال وصفات الأدوية للمرضى إلكترونيا بشكل يجعل من هذه العملية عملية واضحة ودقيقة و كاملة، ويتميز هذا البرنامج بوجود خاصية دعم القرار العلاجي فيه مما يقلل من مخاطر وصف الأدوية الخاطئة ويؤدي إلى زيادة الأمان في تحديد الأدوية (مثل نظام التنبيه في حالة وجود الأدوية التي تسبب الحساسية عند تناولها مع بعضها أو التي تتفاعل مع بعضها و تحديد الجرعة العلاجية المناسبة أو عدد مرات تكرار الجرعة).

الاشتراك في هذه الدراسة سيكون من خلال ملأ الاستبيان الكترونيا، علما بأن مشاركتك في هذه الدراسة هي مشاركة اختيارية ولك الحق في الانسحاب منها في أي وقت، والاستبيان يتطلب ٧ دقائق للإجابة عليه، وليس هناك أي مخاطر مرتبطة بمشاركتك في هذه الدراسة، حيث أن الاستبيان لن يقوم بجمع أي معلومات شخصية عن المشاركين فيه، وكل إجاباتك في الاستبيان سيتم تسجيلها بدون ذكر أي معلومات عن المشارك.

الضغط على زر (التالي) يعني أنك قد قرأت نموذج الموافقة هذا وأنك توافق على المشاركة في هذه الدراسة، ونحن نقدر لكم هذه المشاركة.

إذا كان لديك أية أسئلة يرجى الاتصال على الباحثة:

إسراء مغربل ـ طالبة دكتوراه في تخصص المعلوماتية الصحية

كلية الأحياء والطب والصحة، جامعة مانشستر، المملكة المتحدة

البريد الالكتروني:Asra.mogharbel@postgrad.manchester.ac.uk

وشكرا لكم على تعاونكم معنا

□ إستشاري □ طبيب مقيم □ طبيب مساعد	الوظيفة
□ ذكر □ أنثى	الجنس
□ 20-29 سنة □ 30-39 سنة □ 40-49 سنة □ 50 سنة أو أكثر	العمر
□ أ □ ب	مكان العمل
□ أقل من سنتين □ من 2 إلى 5 سنوات □ من 5 إلى 10 سنوات □ أكثر من 10 سنوات	سنوات الخبرة كطبيب
□ ممتاز □ جيد □ متوسط □ مقبول □ ضعيف	بشكل عام كيف تقيم نفسك في استخدام الكمبيوتر/ والأجهزة التكنولوجية في العمل (مهارات الحاسوب)؟
□ أقل من سنتين □ من 2إلى 5 سنوات □ من5 إلى 10 سنوات □ أكثر من 10 سنوات	منذ كم سنة وأنت تستخدم نظام وصف الأدوية الكترونيا؟
□ الباطنة □ طب الأسرة □ الجراحة العامة □ الطوارئ □ النساء □ الأطفال □ الأعصاب □ القلب □ طب الشيخوخة □ أنف وأذن وحنجرة □ العظام □ جراحة التجميل □ الأورام □ غير ذلك (الرجاء التحديد)	القسم الطبي

1 . الاستخدام الفعلي:

كيف تستخدم نظام وصف الأدوية الكترونيا في الأمور التالية:

دائما	غالبا	أحيانا	نادرا	إطلاقا	السؤال

5	4	3	2	1	
					إدخال الأوامر:
					1. طلب الأدوية
					2. طلب الفحوصات المخبرية
					دعم اتخاذ القرارات:
					1. اقرأ بعناية التنبيهات المتعلقة بتفاعلات الأدوية مع بعضها البعض.
					2. أذكر أسبابا عند تجاوز تنبهات تفاعل الأدوية مع بعضها.
					3. تنبيهات التفاعل بين الأدوية المقدمة إلى أثناء إدخال الطلب تغير قراراتي في وصف الدواء.
					4. أقرأ بعناية تنبيهات حساسية الأدوية التي أتلقاها.
					5. أذكر أسبابا عند تجاوز تنبهات حساسية الأدوية
					6. تنبيهات حساسية الأدوية المقدمة إلي أثناء إدخال الطلب تغير قراراتي في وصف الدواء.
					7. أقرأ بعناية تنبيهات جرعات الأدوية التي أتلقاها.
					8. أذكر أسبابا عند تجاوز تنبهات جرعات الأدوية.
					9. تنبيهات جرعات الأدوية المقدمة إلي أثناء إدخال الطلب تغير قراراتي في وصف الدواء.

2 . حدد مدى موافقتك على العبارات التالية:

الآداء المتوقع

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١. أرى أن استخدام برنامج وصف الدواء إلكترونيا لوصف العلاج للمرضى مفيد في عملي.
					٢.استخدام برنامج وصف الدواء إلكترونيا لوصف العلاج للمرضى يساعدني على إتمام عملي بشكل أسرع.
					٣.استخدام برنامج وصف الدواء إلكترونيا يرفع من جودة العمل.

الجهد المتوقع

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١. طريقة استخدام برنامج وصف الدواء إلكتروني لوصف العلاج واضحة بالنسبة لي.
					٢. من السهل جعل برنامج وصف الدواء إلكترونيا أن يقوم بما أريده بالشكل الذي أريد.
					٣.أرى أن برنامج وصف الدواء إلكترونيا سهل الاستخدام.

التأثيرات الاجتماعية

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١. يؤثر المشرفون/المدراء على استخدامي لبرنامج وصف الدواء الكترونيا.
					٢. يؤثر زملائي على استخدامي لبرنامج وصف الدواء إلكترونيا.
					٣. يؤثر المرضى على استخدامي لبرنامج وصف الدواء إلكترونيا.

التسهيلات المتاحة

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١.لدي التكنولوجيا اللازمة (مثل الكمبيوتر أو اللاب توب أو الجهاز اللوحي) لاستخدام برنامج وصف الدواء إلكترونيا.
					٢. برنامج وصف الدواء إلكترونيا الذي أستخدمه في المستشفى متوافق الاستخدام مع البرامج الأخرى (مثل السجلات الطبية ، أستطيع فتح نوافذ / روابط أخرى) في نفس الوقت.
					٣. هناك شخص أو مجموعة اشخاص من الدعم الفني (فريق تكنولوجيا المعلومات) للمساعدة عند مواجهة مشاكل عند استخدام برنامج وصف الدواء الكترونيا.
					٤. كان لدي الوقت الكافي لأتعرف على طريقة استخدام برنامج وصف الدواء إلكترونيا.
					٥.التدريب الذي حصلت عليه ساعدني على معرفة كيفية استخدام برنامج وصف الدواء إلكترونيا.
					٦.الإدارة تقدم ما يكفي من الدعم والتشجيع لاستخدام . برنامج وصف الدواء إلكترونيا.

جودة المعلومات

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١.المعلومات التي أحصل عليها من برنامج وصف الدواء إلكترونيا ذات صلة بعملي.
					٢.المعلومات التي أحصل عليها من برنامج وصف الدواء إلكترونيا معلومات دقيقة.
					٣.أستطيع فهم المعلومات التي أحصل عليها من شاشة برنامج وصف الدواء إلكترونيا.

جودة النظام

أوافق تماما 5	أوافق 4	محايد 3	لا أوافق 2	لا أوافق أبدا 1	العبارة
					١.شكل / تصميم برنامج وصف الدواء إلكترونيا منظم بشكل جيد.
					٢.أي خطأ خلال عملية وصف الدواء أو طلبه يتم تصحيحه بسرعة.
					٣.سرعة الاستجابة لبرنامج وصف الدواء إلكترونيا سرعة مقبولة (سريع بما يكفي وليس بطيء).
					٤. يمكن الدخول على برنامج وصف الدواء إلكترونيا من خلال أجهزة مختلفة.
					٥.من السهل الوصول للمعلومات(عن المريض أو الأدوية)عند استخدام برنامج وصف الدواء إلكترونيا.
					٦.تتضمن خصائص برنامج وصف الدواء إلكترونيا تحديثات زمنية تحقق احتياجاتي من استخدام البرنامج.
					٧.من السهل استرجاع المعلومات من برنامج وصف الدواء إلكترونيا.

Appendix E: Interview Protocol

Study Title: Factors Associates with Physicians Actual Use of Computerized Physician Order Entry (CPOE) for Medication Prescribing in Government Hospitals in Saudi Arabia

Coded Name	Date	Time	Duration

Introduction:
- Introduce myself, my organization, and study.
- Thank the participant for agreeing to be a part of this study.
- Inform / remind interviewee of confidentiality and anonymity according to the UOM policy.
- Start collecting demographic information.

User's Characteristics:

Physician's Position	□ Consultant □ Resident □ Assistant Physician □ Other
Gender	□ Male □ Female
Age	□ 20 –29 yrs □ 30 –39 yrs □ 40-49 yrs □ 50 and above yrs
Years of experience as a physician	□Less than 2 years □Between 2 and 5 years □Between 5 and 10 years □ More than 10 years
Medical Department	□ Internal Medicine □ Family Medicine □ General Surgery □ Emergency □ Obstetrics and Gynecology □ Pediatric □ Neurology □ Cardiology □ Geriatric □ E.N.T (Ear, Nose, and Throat) □ Orthopedics □ Plastic Surgery □Other (please specify)
Generally, how do you rate yourself in using computer/ technology devices at work (computer skills)?	□ Poor □ Average □ Good □ Excellent
How many years have you been using the CPOE for medication prescribing	□ Less than 2 Years □ 2 to 5 Years □ 5 to 10 Years □ More than 10 Years

Interview Questions:

<u>General Open questions:</u>

- What are the advantages of using the CPOE for medication prescribing? how does it help you with your practice?

- What are the challenges of using the CPOE for medication prescribing?

<u>In-depth questions:</u>

Topic: Individual Factors

- Ordering medications through the CPOE system, how does it affect you as physician doing his job / performance? is it helpful is it not helpful?

Topic: Technological Factors

- What are the technical factors of the system that you believe affect your use of CPOE for medication ordering? Why?

Topic: Organizational Factors

- What are the organizational factors related to the hospitals management that you believe?

affect your use of CPOE for medication prescribing? Why?

Topic: Other Factors

- Are there any other type of factors you would like to discuss your believe that influence your use?

<u>Closing:</u>
- Concluding statement
- Thank the respondent
- Provide contact information if they need to contact the organization about the study

Appendix F: EMRAM Adoption Model Capabilities

Stage	Capabilities
Stage 0	The organization has not installed all of the three key ancillary department systems (laboratory, pharmacy, and radiology).
Stage 1	All three major ancillary clinical systems are installed (i.e. pharmacy, laboratory, and radiology).
Stage 2	Major ancillary clinical systems feed data to a clinical data repository (CDR) that provides physician access for reviewing all orders and results. The CDR contains a controlled medical vocabulary, and the clinical decision support/rules engine (CDS) for rudimentary conflict checking. Information from document imaging systems may be linked to the CDR at this stage. The hospital may be health information exchange (HIE) capable at this stage and can share whatever information it has in the CDR with other patient care stakeholders.
Stage 3	Nursing/clinical documentation (e.g. vital signs, flow sheets, nursing notes, eMAR) is required and is implemented and integrated with the CDR for at least one inpatient service in the hospital; care plan charting is scored with extra points. The Electronic Medication Administration Record application (eMAR) is implemented. Medical image access from picture archive and communication systems (PACS) is available for access by physicians outside the Radiology department via the organization's intranet.
Stage 4	Computerized Practitioner Order Entry (CPOE) for use by any clinician licensed to create orders is added to the nursing and CDR environment along with the second level of clinical decision support capabilities related to evidence based medicine protocols. If one inpatient service area has implemented CPOE with physicians entering orders and completed the previous stages, then this stage has been achieved.
Stage 5	A full complement of radiology PACS systems provides medical images to physicians via an intranet and displaces all film-based images. Cardiology PACS and document imaging are scored with extra points.
Stage 6	Full physician documentation with structured templates and discrete data is implemented for at least one inpatient care service area for progress notes, consult notes, discharge summaries or problem list & diagnosis list maintenance. Level three of clinical decision support provides guidance for all clinician activities related to protocols and outcomes in the form of variance and compliance alerts. The closed loop medication administration with bar coded unit dose medications environment is fully implemented. The eMAR and bar coding or other auto identification technology, such as radio frequency identification (RFID), are implemented and integrated with CPOE and pharmacy to maximize point of care patient safety processes for medication administration. The "five rights" of medication administration are verified at the bedside with scanning of the bar code on the unit does medication and the patient ID.
Stage 7	The hospital no longer uses paper charts to deliver and manage patient care and has a mixture of discrete data, document images, and medical images within its EMR environment. Data warehousing is being used to analyze patterns of clinical data to improve quality of care, patient safety, and care delivery efficiency. Clinical information can be readily shared via standardized electronic transactions (i.e. CCD) with all entities that are authorized to treat the patient, or a health information exchange (i.e. other non-associated hospitals, outpatient clinics, sub-acute environments, employers, payers and patients in a data sharing environment). The hospital demonstrates summary data continuity for all hospital services (e.g. inpatient, outpatient, ED, and with any owned or managed outpatient clinics). Blood products and human milk are included in the closed-loop medication administration process.

Appendix G: Interview Participant Information Sheet and Consent Form

You are being invited to take part in a research study through an interview. Please take time to read the following information carefully before deciding whether to take part.

Who will conduct the research?

Ms. Asra Mogharbel - PhD Student in Health Informatics

The University of Manchester, U.K

What is the purpose of the research?

The aim of this study to investigate factors that are associates with physician's actual use of CPOE for medication prescribing in government hospitals in Saudi Arabia.

Who is eligible to take part in this research?

In order to take part in this study you must be **a physician** .

What would I be asked to do if I took part?

In this study, you will be asked several questions through an interview about what factors affect your use of the CPOE for medication prescribing. The interview should take about 30 to 45 minutes to complete.

Will my participation in the study be kept confidential?

Yes. Your participation in the study will be kept confidential to the study team. All responses will be reported anonymously . No names or personal identifications will be used. A unique ID number will be given to each interviewee for anonymity purposes. Additionally, this anonymity will also be maintained during data analysis, thesis writing, and publication .

Will I be recorded, and how will the recorded media be used?

The interview will be audio recorded. The audio responses will be transcribed anonymously and then destroyed after the completion of this study. All data will be reported and analyzed anonymously .

If you agree to participate, <u>please sign</u> the below consent form and click on "agree to patriciate".

Consent Form

If you are happy to participate, please complete and sign the consent form below

	Statement	**Initials**
1	I confirm that I have read the attached information sheet for the above study and have had the opportunity to consider the information and ask questions and had these answered satisfactorily.	
2	I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving a reason. I understand that it will not be possible to remove my data from the project once it has been anonymised and forms part of the data set. I agree to take part on this basis.	
3	I agree to the interviews being audio recorded .	
4	I agree that any data collected may be published in anonymous form in academic books, reports or journals.	
5	I agree that any anonymised data collected may be shared with researchers/researchers at other institutions.	
6	I agree to take part in this study.	

Name of Participant: *Signature:*

Name of Researcher: *Signature:*

Appendix H: IRB Approval form Research Settings in Saudi Arabia

Type of project application: Non-Interventional studies
Study Number: IRB 2020-43
Expected start date: 01/08/2020
Expected end date: 30/06/2022

Abstract:

Computerized Physician Order Entry Systems (CPOE) for medication prescribing offer many benefits within the clinical setting. These include improved patient safety, workflow efficiency, and quality of services. Physicians utilization of these systems is crucial for their success. That is why there is a need to understand what factors influence them to use these systems in order to achieve their benefits. The objective of this study is to investigate factors that influence physicians actual use of Computerized Physician Order Entry System (CPOE) for medication prescribing in two government hospitals in Saudi Arabia.

A mixed methods approach will be used for this research. We will use a self-report questionnaire to collect the quantitative data, compare the a system's logs retrieved reports for physicians' actual utilization of the system with the self-reported utilization, and a semi-structured interview to collect qualitative data to explain and further understand the results of the quantitative responses. SPSS will be used to analyze the quantitative data, and a thematic framework approach will be used to analyze the qualitative data. Our population will be physicians who work in 2 government hospitals in Saudi Arabia.

The results of this study will provide a comprehensive understanding of the factors that influence physicians' actual utilization of CPOE systems for medication prescribing in Saudi Arabia. The findings of this study will help managers, policy makers, and investors in the healthcare system to understand the reasons why physicians tend to use the CPOE systems or not use them to support their decision making about medication prescribing. Hence, they can develop strategies to overcome such issues, and therefore, increase the adoption of such a system.

Detailed description:

Introduction:
CPOE for medication prescription is an essential part of the physician's work, however, literature showed that physicians are facing challenges upon utilizing these systems due to many factors. In order to achieve CPOE's full potential, there is a need to understand what factors influence physician's utilization of these systems. A comprehensive literature review has been conducted , to understand the current state of knowledge on the topic and to identify the knowledge gap regarding the factors influencing physicians to use the CPOE for medication prescribing. We conducted a systematic search using 4 databases. PubMed, CINAHL, Medline (Ovid), and EMBASE. Searches were performed from September 2019 to December 2019. Relevant articles were identified by examining the titles and abstracts, with the full text of potentially relevant articles screened by two reviewers. All types of study designs aimed to assess or investigate factors that influence the use of CPOE for prescribing among physicians were included.

The identified factors were grouped based on constructs from two models. The Unified Theory of Acceptance and Use of Technology Model (UTAUT) and the Delone and Mclean Information System Success Model (D&M IS Success Model). We used the Mixed Method Appraisal Tool (MMAT) for quality assessment, and narrative synthesis to report the evidence. Eleven articles are included in this review, with 37 factors identified as influencing how physicians use CPOE

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for mediation prescribing. These factors represented 3 main themes: individual factors, technological factors, and organizational factors.

The review suggests that features related to individual perceptions, technical factors, and organizational factors are significant for physicians as an end-user to utilize CPOE for prescribing. The outcomes of this review provide a source of knowledge for healthcare decision makers, managers, workers of a clear understanding of what influences physicians utilization of CPOE, which can help to inform future system design and implementation.

Our comprehensive literature search show that there is a huge lack in literature discussing the factors that affects physicians utilization of CPOE for medication prescription.Thus, the first contribution of this research will be to investigate factors that affect physicians actual use of CPOE for medication prescribing in government hospital Saudi healthcare . To the best of the researcher's knowledge, this research is going to be one of the few studies to address physicians experience with CPOE for medication prescribing in the Saudi healthcare context using both quantitative and qualitative methods; therefore, this research will fill a gap in the literature concerning Saudi Arabia.

Various researchers have acknowledged the necessity for an interdisciplinary framework when examining the use of healthcare information systems in healthcare organizations , , The developed integrated questionnaire presented in this research can act as an assessment instrument for stakeholders in healthcare organizations (e.g. managers, decision-makers, clinicians, and investors) to evaluate and understand various factors affecting the use of CPOE for medication prescribing by physicians. This will help healthcare managers to gain an insight into what factors influence physicians to use the system and to develop approaches to overcome those factors and enhance its utilization.

This research also will contribute by delivering a critical assessment of numerous studies that discussed the issue of CPOE for mediation prescribing actual use in several different settings and different cultures. This critical assessment can be a resource of knowledge for decision-makers in other contexts that involve humans interacting with systems to retain an updated knowledge about the issues related to adopting information systems. We anticipate that the findings of this study could be generalized, as the selected settings are affiliated with different organizations in Saudi Arabia. Implications of this study will provide and insight of how CPOE for medication prescribing interventions can be more effectively implemented. This will tend to enhance physicians' adoption of the systems in practice, and consequently, will lead to improved quality of care.

Methodology:

Participants :

Research participants are all physicians who are using the CPOE for medication prescribing at the time of the study . All physicians in both genders and all ages and all positions (consultant, resident) who use the CPOE for medication prescribing in the study site will be included. All healthcare professional other than physicians such as nurses, pharmacists, radiologist, etc, will be excluded.

Data Collection:

Collection of the Quantitative Data

Participants will be asked to complete an online self-report questionnaire (See Annex D). The web link questionnaire will be distributed through an online survey tool that is approved by the University of Manchester (Select Survey). Using an online questionnaire has several advantages. It will provide access to a wider population , will save time, as it will reach a large portion of the targeted population , and will allow other tasks to be performed while data are being collected . For the participants, it is convenient, and it will guarantee the respondents' anonymity .

The aim of the questionnaire is to know physicians' level of actual use of CPOE for medication prescribing features using a self-report scale, and to assess the influence of the factors that may affect the use of CPOE for medication prescribing. To ensure the content validity of the

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questionnaire , a careful selection of measurement items from a previously validated and reliable instruments was conducted. All items are adapted from studies that had validity and reliability tests performed to their instruments

In addition, validity of the questionnaire content has been assessed by 3 experts , 1 academic in the field of healthcare informatics and 2 physicians in terms of the format, clarity , relevancy, consistency and appropriateness . Based on the feedback from the experts' review , the questionnaire was modified.

It will then be piloted with a sample of 30 physicians to verify the feasibility , estimate response rates , and to assure the questionnaires' reliability, using Cronbach Alpha Coefficient .

Collection of Qualitative Data

Following on from completion of the questionnaire, we will conduct semi-structured interviews with a sample of the physicians. A semi-structured interview is a data collection technique where the researcher asks the participant several predetermined open-ended questions . The purpose of using the semi-structed interviews is to provide the researcher with comprehensive insights into the issues physicians encounter when using the CPOE for medication prescribing by having physicians explaining the reasons of the questionnaires results. At the beginning of each interview, the researcher will explain to participants the purpose of the study, the confidentiality terms, the structure of the interview, how much time it will take, and the researcher's contact information in case they need further information later. All this information will be presented in a consent form (Annex C). An audio-recording device will be used to record participants' responses . Interview questions will be developed based upon the data that will obtained through the questionnaires. A sample of the potential interview questions attached in Annex D . The interview questions will not include any material associated with either the interviewees or their organisations to ensure their anonymity. Furthermore, we will have experts assess the questions and use feedback from potential study participants to determine the questions' validity . Principal investigator will be present during the Interviews .

To maintain participants' confidentiality, 2 separate informed consents will be provided to the participants. One related to the questionnaire and the other one is related to the interview. Both consents will explain the objective of this study and all other information the participants might need to know (see Annex C). Participants personal information will be anonymous and confidential during this study.

Physicians Recruitment:

A weblink questionnaire will be sent over to all physicians via their email addresses list form the hospitals' system. Selection and sending the invitation will be conducted by the principal investigator. Reminders will be sent during the responses collection assigned time frame.

In regard to physicians recruitment for interviews, since our questionnaire is anonymous , we would not able to identify the participants. So, the recruitment of interviews shall be from all the physicians who works in both research settings and meet the inclusion criteria. The aim of integrating the interviews in this research is to explain the results of the questionnaire and since all the physicians are using the same CPOE and working under the same environment , they will be eligible for recruitment for interviews. The recruitment for interviews will be as follows; the principal investigator will send an invitation email to all physicians in the hospitals asking if they would like to patriciate in the study. The invitation email will include a consent form explaining everything about the study. If the physician agrees, they will send a reply to the principal -investigator. The principal investigator then will arrange for the interview and inform the primary researcher. The principal investigator will be present at the times of the interviews .

Outcome Measures :

The literature search showed that there are limited studies about the factors that influence physicians' actual usage of the CPOE for medication prescribing . Thus, the results of this study will help to understand what are the factors that affects the physicians who work in government hospital in Saudi Arabia when utilising CPOE systems to support their decision making around medication prescribing. To the best of the researcher's knowledge, this is a first attempt to investigate the factors influencing actual use of a CPOE system for medication prescribing using both quantitative and qualitative methods; therefore, this research will fill a gap in the literature in general and in particular in Saudi Arabia. We anticipate that
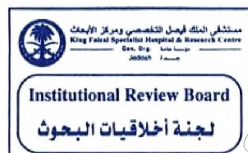
the findings of this study could be generalized, as the selected settings are affiliated with different organizations in Saudi Arabia. Implications of this study will provide and insight for managers, policy makers, and decision makers of how CPOE systems interventions can be more effectively utilized. That can apply in case of introducing new system, developing and existing system , or in case new features happen to be installed. That will guarantee that the physician will use and hence the benefit of the system will meet its full potentials and that will reflect on the quality of patient care.

Sample Size:

We will distribute the weblink questionnaire to all physicians who work in the hospital. Physicians are known with a low response rate comparing to other types of professionals in research studies . So, in order to get a sufficient number of responses we choose to include all physicians. Additionally, at the time of this stduy - March 2020 - , the Covid-19 outbreak has just happened all over the world. All healthcare providers and especially physicians are overwhelmed and in an unusual high demanding time. Numbers of infected cases in Saudi Arabia are continuing. We are uncertain about how busy the physicians would be at the time of the questionnaire distribution as they might not have time to answer the questionnaire. So again, we chose to include everyone to make sure we get a high response rate. The higher the response rate the higher the results can be generalised.

For interviews , the recruitment of physicians will be from those who agrees to be interviewed . If a number between 15 physicians and over agreed to be interviewed, then the selection of the interviewees will be purposeful. We will include a mix of male and female, seniors, juniors, and in order to obtain insights form different points of view of the phenomena under investigation . If the number is below 15, then we will be interviewing the total potential number with no purposeful selection.

Statistical Considerations:
Data will be summarized using descriptive statistics; frequency of occurrence, its central tendency, and its distribution. . Variation in user's characteristics and their level of agreement with of the questionnaire statements' will be tested using chi-square test . The Statistical Package for the Social Sciences (SPSS) will be used to analyze the quantitative data. SPSS known to be the most common statistical tools to analyze social sciences data . With regard to the qualitative data , we will use framework thematic analysis . In order to perform a thematic analysis, we will follow the step-by-step guide that was described by Braun and Clarke .

Ethical and Regulatory Considerations
Since this study's population are physicians (professionals) expressing perceptions, this study does not require an ethical approval from the University of Manchester's ethical committee. There will be no collection for any personal or identifiable information, nor any sensitive or confidential material. The population is not a vulnerable group. Hence, ethical approval is not a requirement according to the university's policies
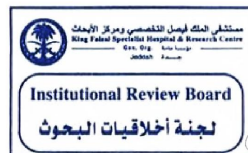
Official Documents

Interview Questions - June 2020.docx

IRB Application Form - June 2020.docx

Feedback on IRB committee comments.docx

IRB Application Form -July 2020.docx

Invitation Letters updated Aug 2020.docx

Principal Investigator

BENSLIMANE, NABILA, J61933

Co-Investigators

Sahar , Alsharif - J1502610 - INFORMATICS AND AUTOMATION (Sec) -J (Active)

Ethics Reviews

Ethics Review for: Factors that Influence Physicians' Use of a Computerized Physician Order Entry System (CPOE) for Medication Prescribing in Two Government Hospitals in Saudi Arabia – Jeddah, IRB 2020-43   Non-Interventional studies 17/08/2020
Ethics Review for: Factors that Influence Physicians' Use of a Computerized Physician Order Entry System (CPOE) for Medication Prescribing in Two Government Hospitals in Saudi Arabia – Jeddah, IRB 2020-43   Non-Interventional studies 20/07/2020
Ethics Review for: Factors that Influence Physicians' Use of a Computerized Physician Order Entry System (CPOE) for Medication Prescribing in Two Government Hospitals in Saudi Arabia – Jeddah, IRB 2020-43   Non-Interventional studies 17/08/2020
Ethics Review for: Factors that Influence Physicians' Use of a Computerized Physician Order Entry System (CPOE) for Medication Prescribing in Two Government Hospitals in Saudi Arabia – Jeddah, IRB 2020-43   Non-Interventional studies 20/07/2020

Keywords

Health informatics

REC / IRB Approval date

18/08/2020
18/08/2020

Ethics Review/IRB Memo to PI

Thank you for your resubmission of the above-mentioned research protocol to the Institutional
Review Board. The submitted documents were presented and discussed in the board's
meeting and was found satisfactory. All submitted documents will be included in our file for
this research project at the Research Centre.

On behalf of the Board, scientific and ethical approvals are extended for six (6) months
starting **18 August 2020**. You are requested to kindly submit the MRNs list for the enrolled
participants for the Compliance Assurance Office in the Research Center along with the next
progress report please by 17 January 2021 to ensure continuous approvals. The approvals shall
be automatically suspended on 17 February 2021 pending submission of the progress report.

Furthermore, kindly notify the Board if there were any change in the protocol, termination
or completion of the research project, adverse reactions or adverse events (unexpected,
suspected, or serious during the said six-month period.

Furthermore, kindly notify the Board if there were any change in the protocol, termination
or completion of the research project during the said six-month period. You and your team
are required to abide by the rules and regulation of the Kingdom in regard to the conduct
of research as well as the IRB and international policies on human subject protection and
confidentiality rights.

Please note the following guidance in the conduct of this research project:

1. You and your team are required to abide by the rules and regulation of the Kingdom in
regard to the conduct of research as well as the IRB and international policies on human
subject protection and confidentiality rights.
2. Kindly make sure that three (3) original Informed Consent Forms (ICFs) are signed
accordingly, i.e., one (1) for the study file, one (1) for the participant or legal guardian (in case
patient is a minor), and one for the Medical Record file of the participant Personally identifying
data should only be collected when necessary for research.
3. Data should be stored securely so that only a few authorized users are permitted to access
the database.
4. Secondary disclosures of personally identifiable data are not allowed.
5. Secondary use of the collected data requires IRB clearance/approvals.
6. The research project shall be timely monitored by the Assurance & Compliance Section of
the Research Centre in order to ensure that research is carried out according to the approved
protocol and in line with the applicable institutional policies and international guidelines.

We wish you every success in the conduct of this research project.

NCB/KACST Reg.# H-002-J-009

المملكة العربية السعودية

وزارة الحرس الوطني - الشؤون الصحية
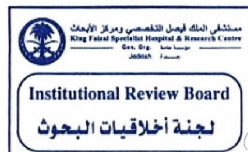
King Abdullah International Medical Research Center
(KAIMRC)

IRB Office

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IRB NCBE Registration No.:
H-01-R-005

Memo Ref.No. IRBC/1126/20   E-CTS Ref. No.   JED-20-427780-85380

Study Number: **SP20/242/J**
Study Title: **Factors that Influence Physicians' Use of a Computerized Physician Order Entry (CPOE) System for Medication Prescribing in a Government Hospital in Jeddah, Saudi Arabia**
Study Sponsor: **Non Grant**
IRB Approval Date: **15 July 2020**
IRB Review Type: ■ **Expedited Review** ☐ **Full Board**
Study site(s): **Western Region**

KAIMRC
APPROVED
IRB

Dear **Dr. Tahgreed Justinia**
Regional Director Information Technology Services & Health Informatics, KSAU-HS, Jeddah
Ministry of National Guard – Health Affairs

Sub-investigator: Ms. Asra Mogharbel

After reviewing your submitted research proposal/protocol and related documents, the **IRB has APPROVED** the submission. The approval includes the following related documents:

Document/Title	Version	Date
Research Proposal	01	15 July 2020
Informed Consent	01	15 July 2020
Data Collection/Questionnaire	01	15 July 2020

The approval of the research study is valid for **one year** from the above approval to expiration date.

Terms of Approval:

- **Annual Reports:** An Annual report must be submitted for approval to avoid termination/suspension of your research.

- **Financial report:** If your study is funded project, details financial report should be submitted with the scientific report.

- **Final Report:** After completion of the study, a final report must be forwarded to the IRB.

- **Retention of original data:** The PI is responsible for the storage and retention of original data pertaining to the project for a minimum of five years.

- **Reporting of adverse events or unanticipated problems:** The PI is responsible to report any serious or unexpected adverse events or unanticipated problems, which could involve any risk to participants or others, or any event on incidents that may have impact on the research or participants.

- **Biological samples:** No biological samples to be shipped out of the Kingdom of Saudi Arabia without prior IRB approval.

- **Participant incentives:** No financial compensation or gifts to be given to participants without prior IRB approval.

- **Storage of biological samples:** All biological samples collected for the purpose of this research must be stored in the KAIMRC related repository.

- You will need to resubmit the proposal to the IRB for review and re-approval before implementing any changes to the approved proposal.

- It is possible that the IRB may decide that the proposed new changes may exclude the proposal from being accepted for exempt review.

- It is your responsibility to safely store the data collected.
- Please note that phone based surveys are not permitted.

1 6 JUL 2020

Prof. Abdullah Al Sayyari
Chairman, Institutional Review Board (IRB)
Ministry of National Guard - Health Affairs

AS/HK/rla

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Appendix I: Example of the Coding Process for One Interview

Participant Code	Q1	Q2	Q3	Q4	Q5
B1	First of all, its more accurate and it is helping me in history of medication that the patient is use. When its paperwork a paper-based system ,these papers might get lost, so I wouldn't know whish medication the patient is using, but if its computerized bases , first of all its accurate, everything is there . the second thing if the patient was using any previous medication, I can search in the patient history.	sometime, that the same medication has many orders in different form. So sometimes I got confused whish one to give the patient. This is one of the challenges. especially if there are several forms of insulin or there are mixed types of insulin , when you click on you got 5 or 6 forms, by mistakes sometimes you click in one of them instead of the other, this is what sometimes happened.	Less mistakes in ordering medication, the probability that I might forget to order a certain medication is less with a CPOE. The second thing , sometimes I do not recognize the full spelling of the medication name , I just start writing the initials it appeared immediately which is make my life easier in searching for medications. Also, sometimes it gave contradiction alert when the patient is taking two medications, it gave me contradiction alert, this sometime is useful for me and sometimes I skip it depends on the patient's condition. The second thing this is the alert system for the allergies in the computerized system is very useful.	To be honest ,it is amazing , very easy, everything is clear, however sometime there is delay in response, when I click send, I have to wait if the order went through or not. But other than that, it's very clear and very nice to work with it. If the patient is in anticoagulants with antiplatelet (drugs to prevent clotting) the system gives me an alert that there would be a risk of bleeding , it's nice but always we skip, but the better than that one is the allergy alerts that is always useful for us. Sometime also for example , if I put the medication (iv flued for example) if I put high rate for 3 or 4 days , it gives me an alert that this is a high amount of fluid for a prolonged period , are you sure you want that. So it's really helpful to be honest.	The first time we work they gave us orientation about how to order medications. But there not much affect form the hospitals administration. We have IT staff and there are available. but Sometime things happen at night (system goes down) if it took too long, we do it paperwork. During my two years in the hospital, I've never go through such a thing.

Color Codes Indications

Yellow	Usefulness
Green	System quality/ information quality
Grey	Paint safety
Pink	Ease of use/ effortless
Blue	Organization's support

Appendix J: Thematic Map

Theme	Code
Individual	*Effects on Performance*
	• Enhances quality
	• Effect on Patient Safety
	• Alerts
	• Accessing to patient history
	• Dose functions
	• Renewal reminders
	• Relative advantages
	• Time Saving
	Effort Expectancy
	• Ease of use
	• Complexity
Technological	*System Quality*
	• Organized
	• Reliability
	• Response time
	• Too many alerts
	• Integration
	• Interoperability
	Information Quality
	• Information reliability
	• Standardisation
	• Updated status of medications availability

Organizational	*Facilitating Conditions*
	• Accessibility to on spot IT support staff
	• Reliable network infrastructure
	• Availability of adequate devices
	• Training
	• Time Constrains
	• Accessibility to remote ordering
	• The suitable work environment
	• Ownership of the CPOE system
	• Unified ordering system across the branches