Usability Evaluation of Computerized Provider Order Entry (CPOE) in Healthcare Delivery Systems in Bengaluru

By

Surabhi Priya

Dissertation submitted for the partial fulfillment of the

MBA Hospital and Health Management

Academic year, 2015-2017

The IIHMR University, Jaipur

1, Prabhu Dayal Marg, Sanganer, Airport
Jaipur 302029, Rajasthan
Ph: 0141 3924700, Fax: 3924738
Website: **www.iihmr.edu.in**

Usability Evaluation of Computerized Provider Order Entry (CPOE) in Healthcare Delivery Systems in Bengaluru

By

Surabhi Priya

Dissertation submitted for the partial fulfillment of the

MBA Hospital and Health Management

Academic year, 2015-2017

NTT Data Services, Bengaluru

The IIHMR University, Jaipur

1, Prabhu Dayal Marg, Sanganer, Airport
Jaipur 302029, Rajasthan
Ph: 0141 3924700, Fax: 3924738
Website: www.iihmr.edu.in

INSTITUTE OF HEALTH
MANAGEMENT RESEARCH
(WHO Collaborating Centre for District Health System Based on Primary Health Care)

IIHMR UNIVERSITY

TO WHOMSOEVER MAY CONCERN

This is to certify that Surabhi Priya student of MBA Hospital Management from The IIHMR University, Jaipur has undergone internship training at NTT Data Services, Bengaluru from February 6, 2017 to May 5, 2017.

The Candidate has successfully carried out the study designated to her during internship training and her approach to the study has been sincere, scientific and analytical.

The Internship is in fulfillment of the course requirements.

I wish her all success in all her future endeavors.

Col. Dr. Ashok Kaushik
Dean, Academics and Student Affairs
The IIHMR University, Jaipur

Dr. J.P.Singh
Associate Professor
The IIHMR University, Jaipur

1, Prabhu Dayal Marg, Near Sanganer Airport, Jaipur- 302029, Rajasthan, India.
Ph.: 0141- 3924700, 2791431- 32, Fax: 0141 3924738, E-mail: iihmr@iihmr.edu.in, Web.: www.iihmr.edu.in

NTT DATA Information Processing Services Private Limited
(Formerly known as Dell Business Process Solutions India Private Limited)
Plot 123, EPIP Phase II, Whitefield Industrial Area
Bengaluru, Karnataka 560 066, India

NTT DATA
Global IT Innovator

To whomsoever it may concern

This is to certify that **Surabhi Priya** of **The IIHMR University, Jaipur** has been working with NTT DATA Services for her summer project.

Project Details:

Project Name : Usability evaluation of Computerized Provider Order Entry (CPOE) in healthcare delivery systems in Bengaluru
Duration : 90 days
Location : Bangalore
Guide Name : Dr. Preetham H S & Rahul Chugh
Sponsor Name : Ajay Aiyar

She has successfully completed her project and her performance during the tenure of the internship has been found to be satisfactory.

Her findings in course of the project has been found to be practical and relevant and some of the recommendations will be incorporated on the floor on approval from the business.

Thanking You,

Regards,

Dilipkumar Santhanam
Business Partner Director, Services HRBP Team
NTT DATA Services

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled "**Usability evaluation of Computerized Provider Order entry (CPOE) in healthcare delivery systems in Bengaluru"** and submitted by **Surabhi Priya** Enrollment No. IIHMR-U/01/2015-17/0357 under the supervision of **Dr. J.P. Singh** for award of Postgraduate Diploma in Hospital and Health Management of the University carried out during the period from 6th February 2017to 5th May 2017 embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

Surabhi Priya

Signature

THE IIHMR UNIVERSITY, JAIPUR

CERTIFICATE BY SCHOLAR

This is to certify that all ethical issues have been considered while collecting data for my dissertation titled **Usability evaluation of Computerized Provider Order Entry (CPOE) in healthcare delivery systems in Bengaluru.** From February 06, 2017 to May 05, 2017.

Surabhi Ranjan

Signature of student

1. Abstract

Background: Computerized Provider Order Entry (CPOE) is an application which enables the end users mostly physicians to prescribe orders electronically.

Objectives: The purpose of this study was to assess the extent of adoption of CPOE in healthcare delivery setups specific to Bengaluru and assess the Usability, Knowledge, Attitude and Practice of the end users of CPOE. The study also aimed to identify the issues and challenges in using the CPOE.

Methodology: The study design was descriptive cross sectional. The tools which were used in data collection were a close ended checklist to assess the extent of CPOE adoption in the healthcare delivery setups and a close ended questionnaire to assess the Usability, Knowledge, Attitude and Practice of the end users of CPOE. The checklist consisted of four parameters namely, extent of adoption, education and training, support and maintenance, and leadership in the organization. These four parameters had five sub parameter each and based on the analysis, extent of CPOE adoption was measured. The questionnaire for the end user consisted of four parameters namely, Usability, Knowledge, Attitude and Practice out of which each were divided into sub parameters. The questionnaire was based on Likert scale.

Results: The maximum extent of CPOE adoption was in Hospital B and the minimum was found in Hospital E. Hospital B was a multi-specialty hospital with a bed strength between 21 to 100 and having two accreditations whereas Hospital E was a daycare center with less than 20 bed strength and no accreditation. For further analysis, Fisher Exact test was done and the study showed that the Usability, Knowledge, Attitude and Practice level was higher for users who placed more than twenty orders using computers in a day as compared to the users who placed less than twenty orders using computers in a day. The result also showed that respondents who were in physician role had higher Usability, Knowledge, Attitude and Practice level as compared to respondents who were in nursing staff and other allied health staff role.

Conclusions: The extent of CPOE adoption is dependent upon the kind of specialty services a healthcare delivery setup is providing. The usability, knowledge, attitude and practice level of end users depend upon the qualification and role of the end user in the organization**.** CPOE is a powerful tool which can be utilized to improve patient.

Acknowledgment

I started off my training with a vision in my mind so as to be able to learn about the practical aspects of Healthcare Information Systems in a detailed manner.

I am thankful to **Mr. Ajay Aiyar** (Senior Manager) for giving me the opportunity to carry out my dissertation and for his constant support and encouragement. I am thankful to him for the time and efforts he spent from his busy schedule. I wish to express my sincere gratitude to **Mr. Rituraj Choudhury (**IT Service Manager) for his supervision, advice and guidance. He was a continuous source of ideas which inspired and enriched my growth as a student, a researcher.

I am thankful to my team managers, **Mrs. Archika Roy** (IT Service Manager) and **Mr. Ramkishore M P (**IT Service Manager), who provided their support to me and helped me through my project from start.

My heartfelt thanks to my mentors **Dr. Preetham HS (**Business Systems Analyst) and **Mr. Rahul Chugh (**Business Systems Analyst) for their tremendous help as a mentor and providing the much needed support, meticulous work habits and for answering my endless questions when I started my work.

I am immensely grateful to my guide, **Dr. J.P.Singh** (Professor, IIHMR, Jaipur) for constantly counseling, motivating and guiding me. Her encouragement has enabled me to be a better person and a better worker.

I am thankful to all the members of NTT Data Service who helped me in one way or the other to carry out my work successfully and to learn about the Electronic Medical Records (EMR) systems and those who were a part of my project without whose unconditional cooperation my study would not have been completed successfully. My colleagues from different colleges also hold a special mention here for supporting me throughout the training and making it a great learning experience.

Surabhi Priya

2. Table of contents

3. List of figures

4. List of table

5. List of abbreviations

ACPOE	Ambulatory Computerized Physician Order Entry
ADE	Adverse Drug Events
CDSS	Clinical Decision Support System
CMS	Centers for Medicare and Medicaid Services
CPOE	Computerized Provider Order Entry
CSUQ	Computer System Usability Questionnaire
ED	Emergency Department
EMR	Electronic Medical Record
FDA	Food & Drug Administration
HIS	Hospital Information System
ICU	Intensive Care Unit
IPD	Inpatient Department
IT	Information Technology
KAP	Knowledge, Attitude and Practice
NRLS	National Reporting and Learning System
OPD	Outpatient Department
POESUS	Physician Order Entry User Satisfaction and Usage Survey
USAID	United States Agency for International Development
WHO	World Health Organization

7. Organization Overview

NTT DATA is a top 10 global business and IT services provider and global innovation partner with 100,000+ professionals in more than 50 countries now with $16B in revenue.

Headquartered in Tokyo, NTT DATA puts emphasis on long-term commitment and combine global reach and local intimacy to provide premier professional services from consulting, system development to business IT outsourcing. Since 1967, NTT DATA has played an instrumental role in establishing and advancing IT infrastructure. Originally part of Nippon Telegraph and Telephone Public Corporation, its heritage contributed to social benefits with a quality-first mindset. A public company since 1995, the company builds on this proven track record of innovation by providing novel IT solutions to bring results in greater quality of life for people, communities and societies around the world.

NTT Group consists of major companies like Nippon Telegraph and Telephone Corporation, NTT Communications Corporation, Dimension Data plc, NTT DOCOMO, INC. and many subsidiaries all over the world. Taking advantage of this opportunity of this scale, NTT DATA achieved a number of significant successes by collaborating with NTT Group and it provided enormous creative synergy.

The goal of NTT has been to create a foundation for future business by incorporating a number of overseas companies in order to establish a framework through which we can provide our diverse services, as typical Japanese courteous service, worldwide to support

our customers' needs. As one of the global innovators, NTT are always challenging more innovative business approach and enhancing our creativity by respecting diversity.

John W. McCain is the Chief Executive Officer of NTT DATA Services headquartered in Dallas, Texas, USA. He is a member of the NTT Holdings Global Strategy Committee and serves as senior vice president of NTT DATA Corporation.

Dan Allison is the President, Global Healthcare and Life Sciences. As head of the company's largest industry segment, Dan is responsible for leading the growth, profitability and transformation of the global healthcare business, which focuses on provider, physician, health plan and life sciences clients. Dan has more than 30 years of leadership experience in IT outsourcing and business process outsourcing services in various verticals, with a strong focus in healthcare.

Americas

North America

In North America, NTTDATA partnered with a range of businesses and government agencies providing a flexible array of engagement options, including consulting, managed services, outsourcing, and the cloud.

Leveraging strong technical know-how, practical industry insights, and global reach, it relentlessly drives improvement across systems and processes while increasing business flexibility. The company is focused on getting faster results with less risk, so its clients can flex their businesses to respond to changing market dynamics and capitalize on growth opportunities.

Latin America

NTT DATA entered the Latin American market through the acquisition of the Value Team Group, a specialist in IT consulting and services. Today, the company provides a wide offering of customized services and end-to-end solutions. The aim is to enable customers to grow and stand out from the competition by adopting innovative IT concepts and technologies.

Europe and Middle East

Over the past few years, we have expanded our IT service networks in Europe through the acquisition of a majority stake in intelligence, Cirquent, Value Team, Intelligroup and Keane.

NTT DATA Group offers best-in-class consulting services and enterprise solutions for industries in the manufacturing, banking, insurance, telecommunications, media, energy, retail, service and public sectors. Our consulting services range from business process consulting to conceptual design, implementation and integration, as well as the support, operation and maintenance of IT systems. Additional offerings include outsourcing, hosting and full-service solutions in the ERP environment.

APAC/ India

NTT DATA positions APAC and India region as both an emerging market and the delivery resource pool to provide cost competitive and high quality service in our global strategy. The company address both multinational corporations and local client in this region. With global capabilities, NTT DATA support multinational corporations, primarily in Healthcare, insurance, automotive and electronics industries in rapidly growing APAC market. In addition, NTT DATA offer the services to local clients in both financial and public sector by leveraging our accumulated experience across the world.

NTT DATA in Healthcare

Healthcare companies are balancing the quality and cost of care while serving a rapidly aging population and rising healthcare costs. At the same time, those firms are facing escalating competition, the feared patent cliff for many blockbuster drugs, and changing regulations and standards.

NTT DATA partners with some of the world's leading healthcare organizations to help them proactively manage their business through the use of information, data, and technology. In fact, its technology-enabled services support over thousands of organizations within the sector, enabling them to rapidly and cost-effectively adjust to dynamic market and regulatory demands.

Industry Recognition

- Positioned by Gartner in the "Leaders" quadrant of the Gartner Magic Quadrant for Data Center Outsourcing and Infrastructure Utility Services, North America for the fifth consecutive year.
- Ranked "#1 IT Services Provider to Healthcare Providers," by Gartner for the sixth straight year.

- Positioned as a leader in Everest Group's "IT Outsourcing in the Healthcare Provider Industry—Service Provider Landscape with PEAK Matrix Assessment" for a third consecutive year.

8. Introduction

A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health.[1] Healthcare organizations are composed of health care professionals from multiple disciplines forming several interconnected care teams that strive to provide safe and consistent care.[2] All the team member has to coordinate and work in a communicative and cohesive manner to execute this highly sensitive work and achieve the goal of patient care. Healthcare delivery organization have to maintain stability using institutional protocols but have to assess their performance and evaluate protocols to create and incorporate new knowledge.[3] New technological advancement is coming everyday along with new knowledge base, broader market coverage.

Hospital Information systems (HIS) are in high demand to handle increasing population needs and also aids the practicing doctors and hospital service and support staff with timely service and precision. Hospital information systems in most of the cases needs to be customized according to the hospital needs.[4] HIS has a varied aspect to it, which includes different applications which support and ease the functioning of the hospital.

One of the major concern while providing healthcare services is medication error. Medication errors occurred more frequently in adults compared with other age groups[5]. Approximately 1.25 million annual ADE's occur in the U.S.A.[6]

27000 unintentional drug overdose deaths occurred in United States in 2007.[7]The total number of adverse drug events (ADE) reported to Food and Drug Administration (FDA) summed up to 89,842 in 2005 which was more than the double amount in 1998.[8]

According to a report published by Food and Drug Administration (FDA) in 2016, at least one death is attributed to medication error every day and injure approximately 1.3 million people annually in United States. In the entire cycle of drug administration, medication error can occur at any stage:

- Prescribing
- Repackaging

- Dispensing
- Administering
- Monitoring

The reasons attributed to these errors are:

- Poor communication
- Ambiguities in drug name, directions of use/ administration, or writing.[8]

Out of the total 783,936 annual deaths from conventional medicine mistakes[9], approximately 106,000 were the result of prescription drug use.[10] Medication error is the third leading cause of death in USA.[11] Systems analysis of medication error and ADEs suggested that the changes in ordering and administration of drugs by providing the information as and when needed may reduce medication errors. System changes to display and disseminate drugs and patient data may reduce the chances of errors.[12]

Ordering is the first step in providing quality care to a patient. It is at this point where the clinical plans are finalized and delivered into practice. Therefore ordering is the first line of defense in ensuring quality of care and patient safety.

Almost one in five medication doses administered in hospitals is given in error. The two most common errors were dispensing medicine at the wrong time (43% of incidents) and omitting a dose (30%), the other was unauthorized drug (4%).[13]There were 525,186 medication error incidents reported to the NRLS over six years from 2005 to 2010. Of these, 86,821 (16%) of medication incidents reported actual patient harm, 822 (0.9%) resulted in death or severe harm.[14] Up to 77% of medication errors are preventable.[15]

In different countries, up to 12.9 per cent of hospitalized patients suffer at least one adverse event during their admission. Statistics reveal that out of these, 10.8 to 38.7 per cent were caused by medication errors.[16]

Computerized Provider Order Entry (CPOE) is an online computer application system which accepts physician’s orders electronically and replaces the traditional writing of prescription on pad.[17]

Computerize Provider Order Entry (CPOE) is an electronic system that allows a healthcare provide to order electronically and manage the results of the same.[18] CPOE systems allow healthcare providers to order medications and other tests through a centralized electronic system. Those orders were then conveyed to the respective departments.[19]

Adoption of CPOE has increased both quality of care and patient safety. CPOE is not just an information technology change, it involves a major role in healthcare delivery in clinical and ancillary services. It has redesigned the complex clinical processes by integrating technology at key points to enhance and optimize ordering. [18]

12.5% reduction in medication errors, or ~17.4 million medication errors averted in the USA in 2008 in 1 year.[20]

CPOE interfaced with the respective departments not only receives the confirmation of sending the order but also receives the test results which are generated from the department side.

The power of CPOE lies not only in automating the order-writing function of the physician but in incorporating clinical decision support system (CDSS) in the system. CDSS provides support from very basic edits for spelling checks, data types and required fields are filled are not to providing a comprehensive list of orders or order sets, to dosage selection support.[21] In addition to this CDSS provides alert about any existing allergies to the patient, alerts when an incorrect or duplicate medicine/test is ordered or check if there are any other contraindications.

Ambulatory computerized physician order entry (CPOE) systems that facilitate physician orders at the point-of-care for medications, laboratory and radiology tests provide significant opportunities for improving quality while reducing costs.[22]

It is estimated that using Advanced Ambulatory Computerized Provider Order Entry (ACPOE) would eliminate nine ADEs and six visits per year and four admissions and three life-threatening ADEs in five year of practice. Providers using intermediate systems would eliminate five ADEs per year and those using basic systems would avoid one ADE per year.[23]

CPOE helps ensure that the best practices and standards are followed. CPOE helps in increasing a physician's efficiency by modifying the orders for individual patient need. It allows the physicians to choose from a set of standard orders and customize it according to patients' unique needs.[24]

9. Literature review

WHO states that, Health-care facilities are hospitals, primary health care centers, isolation camps, burn patient units, feeding centers and others. In emergency situations, health-care facilities are often faced with an exceptionally high number of patients, some of whom may require specific medical care (e.g. treatment of chemical poisonings).[25]

Cohen et al., (1980) states the Operational definition of hospital as "A hospital can be described as a network of service units with finite capacity through which patients are flowing".[26]

A Case Study on Computerized Provider Order Entry, A Blueprint for a Beginning, December 2006, defines CPOE as, Computerized Provider Order Entry (CPOE) is a computer application that is used by physicians to enter diagnostic and therapeutic patient care orders. In most cases these orders are communicated electronically to the departments and personnel responsible for carrying them out, either by directly connecting to specific departmental computer systems that execute the order (such as laboratory or pharmacy systems), or by staff printing out the orders in the appropriate locations for execution. For CPOE applications electronically connected to departmental systems, confirmation of the order and the following result (in the case of tests) are transmitted back to the ordering physician.[27]

According to Eligible Professional Meaningful Use Core Measures Measure 1 of 13 Stage 1(2014 Definition), CMS, "CPOE entails 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."[28]

Usability Evaluation Basics, Usability.gov states that, "Usability refers to the quality of a user's experience when interacting with products or systems, including websites, software, devices, or applications. Usability is about effectiveness, efficiency and the overall satisfaction of the user.[29]

Dillon, A. (2001), The evaluation of software usability, states that, "Usability is the measure of interface with which a user can perform his tasks effectively, efficiently and satisfactorily. A variety of methods have been developed to evaluate the usability and it has become an essential part."[30]

The KAP Survey Model (Knowledge, Attitude and Practices), "A Knowledge, Attitude and Practices (KAP) survey is a quantitative method (predefined questions formatted in standardized questionnaires) that provides access to quantitative and qualitative information. KAP surveys reveal misconceptions or misunderstandings that may represent obstacles to the activities that we would like to implement and potential barriers to behavior change.[31]

Legislative Counsel Glossary from U.S. state- Oregon defines that, "Healthcare provider means a person licensed, certified or otherwise authorized or permitted by the law of this state to administer health care or dispense medication in the ordinary course of business or practice of a profession, and includes a healthcare facility."[32]

"Computer System Usability Questionnaire (CSUQ)", measures usability of a computer system upon various parameters. Few of them are ease of use, user friendliness, productivity of the user, time taken to do the task reduced and various other factors. [33]

"The Measurement of End-User Computing Satisfaction", have measured the end user satisfaction of computing. They have administered the questionnaire on the parameters, Content, Accuracy, Format, Ease of use and timeliness. The present study focuses on satisfaction with the information product provided by a specific application. The study also includes items to evaluate the ease of use of a specific application. [34]

"Physician Order Entry User Satisfaction and Usage Survey (POESUS)" assessed user satisfaction and usage using a questionnaire consisting of parameters such as consistency, reduction in patient error, ordering speed, ease to use, support received in solving issues, patient safety, education and training of users amongst other parameters. The study was aimed at increasing the understanding of CPOE and EHR systems in ICU setting. The study was aimed at identifying the medication inadequacies at ICU setting of the existing system and to facilitate end user knowledge and understanding of electronic order entry. The study measured the end user education and training required for efficient and effective use of Physician order Entry. [35]

"SUS - A quick and dirty usability scale" defined usability as being a general quality of the appropriateness to a purpose of any particular artefact. This paper assessed the usability of a system on different parameters such as consistency, frequency of using it, easy to learn and use, confidence while using it amongst others.[36]

The study, "Measuring Usability with the USE Questionnaire", aimed to come to a scale which would decide what is the acceptable level of errors or an acceptable speed of accomplishing a task and design the user interface in accordance with that. It developed the scale on the usability based on these factors: usefulness, ease of use, ease of learning, satisfaction.[37]

Computerized Provider Order Entry is used for entering, storing, exchanging and retrieving patient relevant data, still it is facing multiple issues and challenges in its implementation as well as usage by the end users. Despite the utility it provides, hospitals were slow to adopt it.[38]

Issues and challenges in adoption of CPOE, EMR and EHR[39, 40, 41, 42]

Organizational resistance: Organizations were concerned that the efficiency of the hospital would be compromised by 20% and in some cases 30% to 40%. Community hospitals who did not employ most of the physicians, were concerned that the physicians

might take and admit their patients in other local hospitals if pushed to use a system like this.[39]

High Cost: The cost included the existing IT infrastructure and the technological changes which would incur if they implement CPOE. The cost of CPOE depended upon the size of the facility and the existing IT infrastructure. These costs included the purchase price, coordination costs, monitoring costs, and negotiating costs, upgrade costs, and governance costs.[39]

Product immaturity: Product immaturity means that the product did not fit in the requirements of the organization. In order to make the product organization ready, multiple modifications and customizations needed to be done. The poor interfaces and the difficult processing speed also became a barrier in implementing and using CPOE.[39]

Time to search and implement the system: It takes time to search the system and implement it. Physicians do not preferably opt for taking part in selection as they think that they should focus on patient more.[40]

Data security and privacy concerns: Non users were more likely to believe that paper based health records are more secure and confidential.[41]

Lack of technical skills: good computer skills are and specifically typing skills are required to enter patient related details in EMR which becomes a challenge while the physicians.[42]

Low customization: Many physicians who did not use EMR of any other application were concerned that the system does not meet their requirements whereas many physicians also used lack of customization as a reason not to use the system.[40]

Difficult to enter data: A physician is required to have varied skills from treating vast age group of patients to diagnosing multiple conditions which make it difficult to enter data simultaneously.[41]

Physician resistance: Physicians often felt that the traditional paper based prescribing was much easier and faster and sometimes the physician resistance escalated to such extent that it led to physician rebellion too.[39]

Time to learn the system: In addition to the technical challenges physicians also needed time to learn the system along with the demands and pressures of the work they were doing. This sometimes led to the lack of time to learn the system.[42]

10. Contextual background

Available research papers aim to assess various aspects of CPOE from locations outside India and focus mainly on US healthcare delivery system in specific. The available research papers have specifically focused on the implementation of CPOE in a healthcare delivery organization, few of the studies also studied the organization before implementing the CPOE system and after implementing CPOE system. Few of the studies identified the issues, barriers and challenges in the usage of CPOE.

The present study aims to assess the status of CPOE in a healthcare delivery system in India specific to Bengaluru area. Current study aims to assess the Usability, Knowledge, Attitude and Practice level of end users of CPOE specific to Bengaluru area. Present study also aims at identifying the issues and challenges in use of CPOE.

Assessing the status of CPOE will provide insight about penetration of healthcare information technology specifically clinical information systems in the healthcare delivery system.

Assessing the Knowledge. Attitude and Practice of end users will provide deeper insight about the acceptance of CPOE amongst the end users. It will also assess the level of knowledge, attitude and practice and identify issues and challenges in using the same.

Evaluating usability of CPOE will provide a deeper understanding of the usage of application features and design consideration while development of a software.

11. Research question

- What is the status of CPOE in healthcare delivery system in Bengaluru?
- What is the Usability level of end users of CPOE in Bengaluru healthcare delivery system?
- What is the Knowledge, Attitude and Practice level of end users of CPOE in Bengaluru healthcare delivery system?
- What are the barriers and challenges the end users are facing which is effecting the usability of CPOE?

12. Objectives

- To assess the status of Computerized Provider Order Entry in healthcare delivery system.
- To assess the usability of Computerized Provider Order Entry from provider perspective.
- To identify issues and challenges in use of Computerized Provider Order Entry.
- To analyze Knowledge Attitude and Practice (KAP) of End users on Computerized Provider Order Entry.

13. Methodology

13.1 Scope of the Work

Available research papers aim to assess various aspects of CPOE from locations outside India and focus mainly on US healthcare delivery system in specific. Scope of the present study lies in- to assess the status of CPOE in a healthcare delivery system in India specific to Bengaluru area. Present study also conducts KAP study to analyze the Knowledge, Attitude and Practice of healthcare providers of Bengaluru.

Assessing the status of CPOE will provide insight about penetration of healthcare information technology specifically clinical information systems in the healthcare delivery system.

Assessing the Knowledge. Attitude and Practice of end users will provide deeper insight about the acceptance of CPOE amongst the end users and identify the issues and challenges in using the same.

Evaluating usability of CPOE will provide a deeper understanding of the usage of application features and design consideration while development of a software.

13.2 Approach

To accomplish study objectives following approach was adopted.

13.2.1 Study Design

Descriptive cross sectional study design was adopted.

13.2.2 Study Area

Healthcare delivery organizations of Bengaluru.

13.2.3 Study Duration

Three months (6^{th} February 2017 to 5^{th} May 2017)

13.2.4 Sampling method

Convenience sampling method.

13.2.5 Inclusion Criteria

- Healthcare delivery systems having specialty services namely: super specialty, multi-specialty, single-specialty and daycare center.
- Departments namely: OPD, IPD, ICU and ED.
- Healthcare delivery systems having more than 10 beds were included.
- Healthcare delivery systems having IT infrastructure which encompasses any form of Electronic Medical Record or Electronic Health Record or Health Information System.

13.2.6 Exclusion Criteria

- Healthcare delivery systems having standalone dialysis/ chemotherapy daycare center.
- Healthcare delivery systems having bed strength less than 10.
- Healthcare delivery systems which do not have IT infrastructure in form of Electronic Medical Record or Electronic Health Record or Health Information System.
- Healthcare delivery systems which used only paper based ordering systems.

13.2.7 Study Population

The respondents for the study were the Information Technology (IT) Department personal and end users of Computerized Provider Order Entry (CPOE).

13.2.8 Sample Size

A total of six healthcare delivery setups in Bengaluru were covered to assess the status of CPOE in their organization.

A total of 100 respondents were surveyed to assess the Usability, Knowledge, Attitude and Practice level.

13.2.9 Sources of data

13.2.9.1 Secondary data

Review of literature: Various studies and research papers related directly or indirectly to the aim and objective was reviewed.

The secondary data was collected from various journals, websites, and articles.

The secondary data was collected from research papers or journals which did any study related to Electronic Medical Record or Electronic Health

Record or Health Information System of the respective healthcare delivery systems.

13.2.9.2 Primary data

To assess the IT system and CPOE system of the healthcare delivery systems, a checklist was prepared consisting of various parameters and data was collected by self-administration of the checklist by the personnel of IT department.

To evaluate the usability of CPOE, eleven parameters were taken into account in a close ended questionnaire as well as a close ended KAP questionnaire was prepared and the entire process was self-administered by the providers/ end users.

13.2.10 Respondents

End users or providers:

- IT Department personnel.
- Physicians/consultants/Specialists
- Nurses
- Clinical nutritionist
- Physiotherapist.

13.2.11 Data collection Tool

A checklist was being used for IT Department personal. The checklist consisted of four parameters namely:

- Extent of adoption
- Education and training
- Support and maintenance
- Leadership

The parameters consisted of five sub-parameters each and measurement was done on Likert scale as well as basic yes and no based conditions.

To measure the Usability, eleven parameters were considered and each of them was measured on using Likert scale.

A close ended Knowledge, Attitude and Practice (KAP) questionnaire was prepared which used Likert scale to measure the agreement and satisfaction of the end users regarding those stated parameters.

13.2.12 Data Analysis and Presentation

Data collected was analyzed using Microsoft Excel. To analyze the checklist each parameter and sub-parameter was given equal weightage. After calculating the number of conditions and their equivalent scale, the output was presented in the form of column graph.

To analyze the questionnaire, data was converted into frequency format that is, for each sub-parameter out of five point scale of Likert scale, number of respondents were counted. For each sub-parameter, the percentage of user lying in each point scale was calculated and was projected in stacked bar graph.

A null hypothesis was created for two different parameters namely:

- End users who placed more than twenty order a day had better Usability, Knowledge, Attitude and Practice level than users who placed less than twenty orders a day.
- Respondents who were in physician role had better Usability, Knowledge, Attitude and Practice level than respondents who were in nursing and other allied healthcare role.
- The frequency of respondents was counted under these conditions and the data was subjected to Fisher Exact analysis.

14. Results

14.1 Extent of CPOE adoption

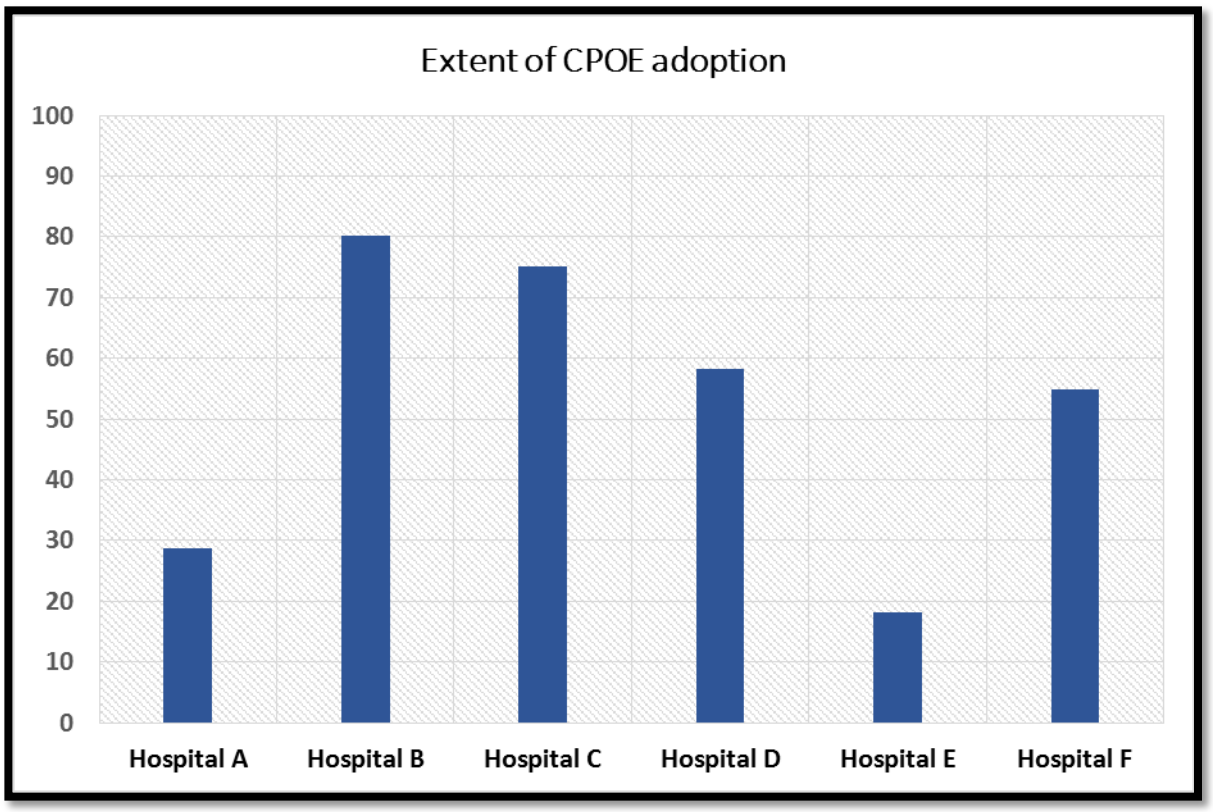

Figure 1 Extent of CPOE adoption

Hospital B had maximum extent of CPOE adoption whereas Hospital E had minimum extent of CPOE adoption. Hospital B was a multi-specialty hospital having 21 to 100 beds and it had two accreditations whereas Hospital E was a day care center with less than 20 beds and no accreditations.

14.2 Analysis for all the end users

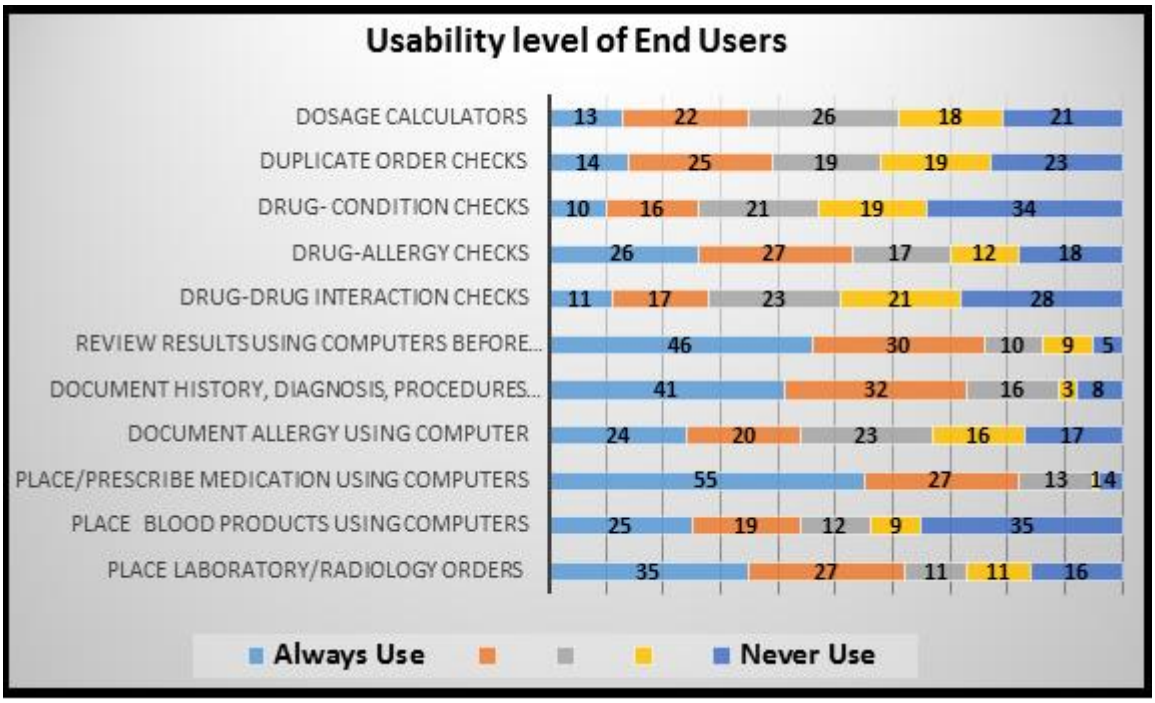

Figure 2 Usability level of all End Users

Usability level of end users was maximum for the feature of prescribing medications using computers and least used feature was drug condition check.

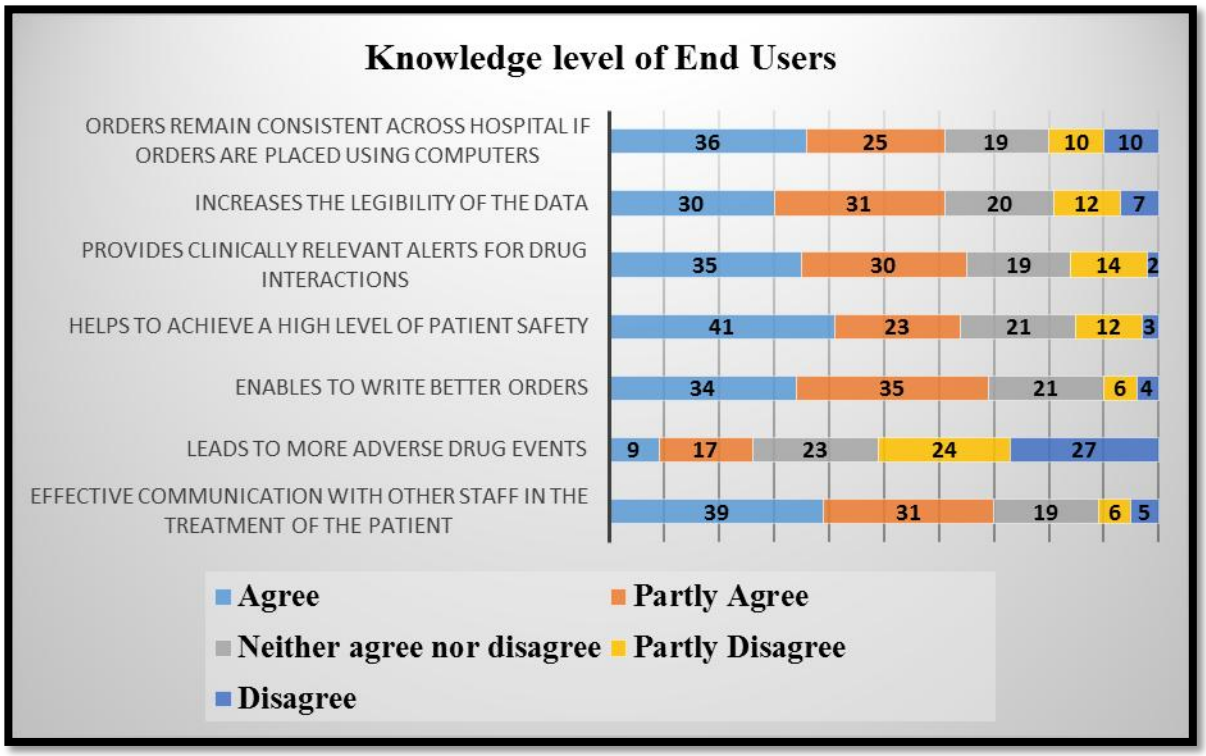

Figure 2.1 Knowledge level of all End Users

The knowledge level of end users was maximum for the statement that CPOE helps to achieve high level of patient safety and for the statement that it leads to more adverse drug effects minimum respondents agreed for the statement.

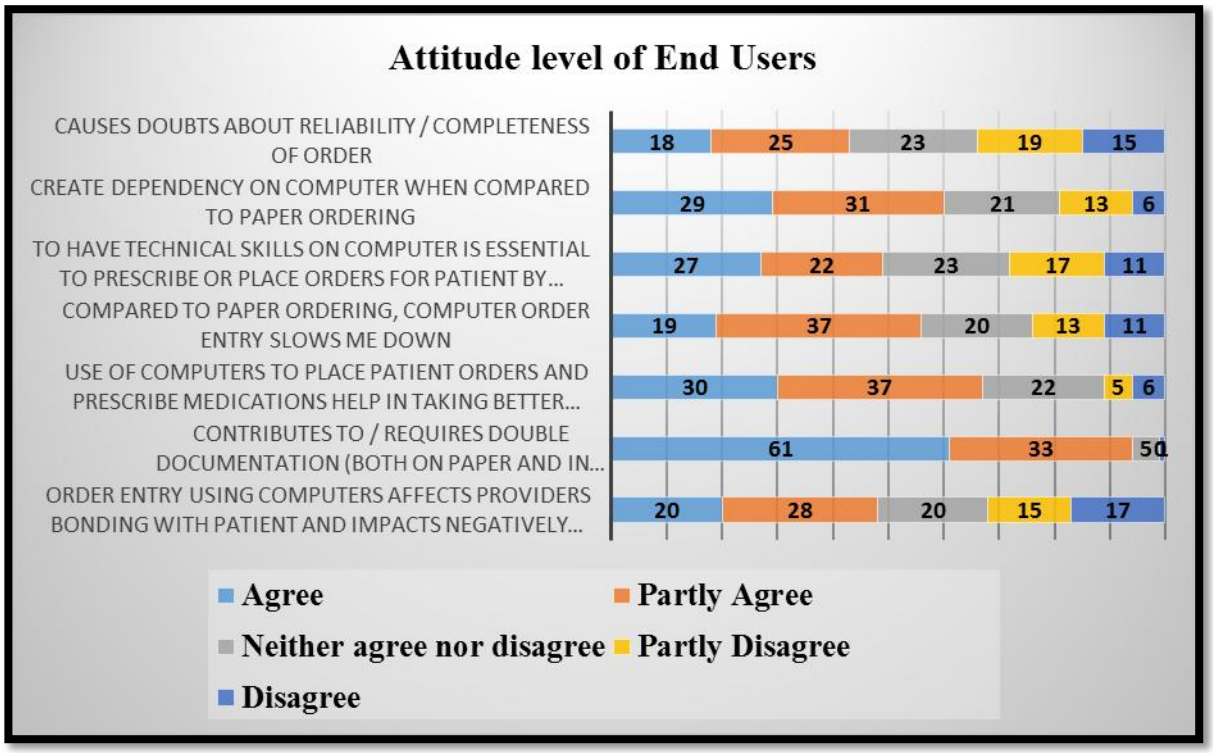

Figure 2.2 Attitude level of all End Users

The attitude level of end users of CPOE was that the CPOE system required double documentation and it was least for the statement that it causes doubts about reliability of data or completeness of data.

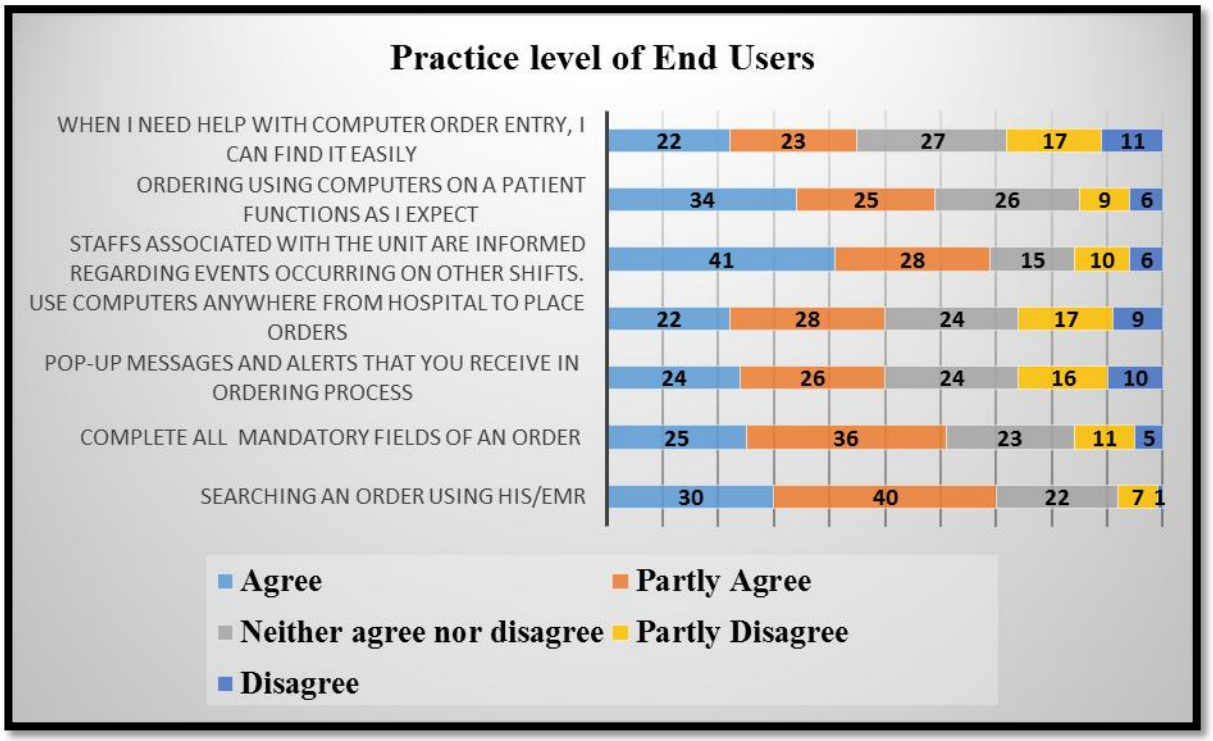

Figure 2.3 Practice level of all End Users

The practice level was agreed upon by the majority of the end users of CPOE was for the statement that the staff associated with the unit are well informed about the events occurring in other shifts and minimum number of respondents agreed upon the statement that they could find help with computers when needed and they could place orders from anywhere in the hospital.

14.3 Analysis for nursing staff & allied staff

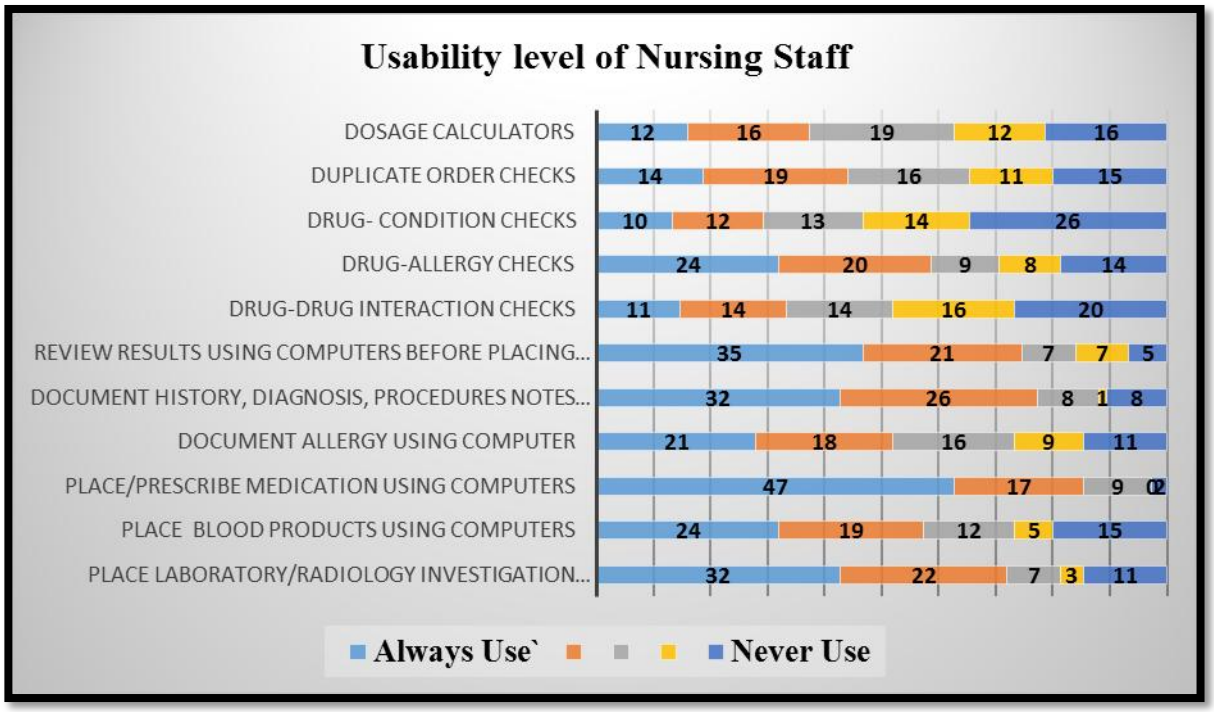

Figure 3 Usability level of Nursing Staff

Usability level of nursing and other allied healthcare staff was maximum for the feature of reviewing results using computers before placing orders whereas it was minimum for the feature drug-condition check.

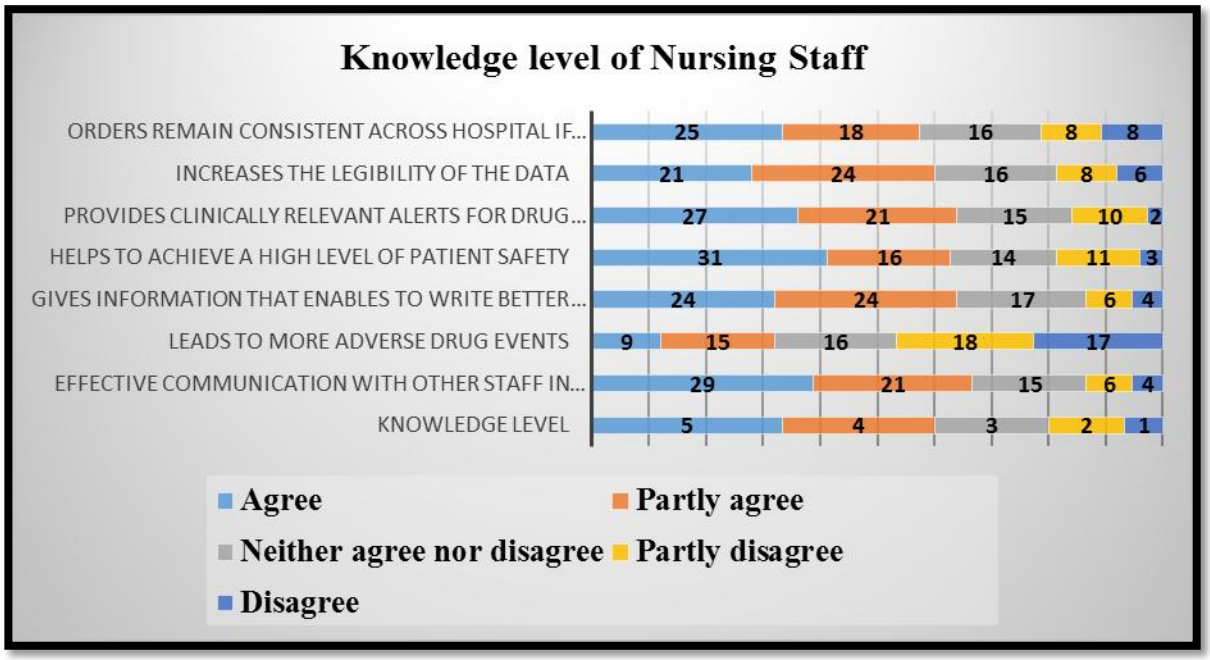

Figure 4 Knowledge level of Nursing Staff

The knowledge level of nursing and other allied healthcare staff was maximum for the statement that it helps to achieve high level of patient safety and for the statement that it leads to more adverse drug effects minimum respondents agreed for the statement.

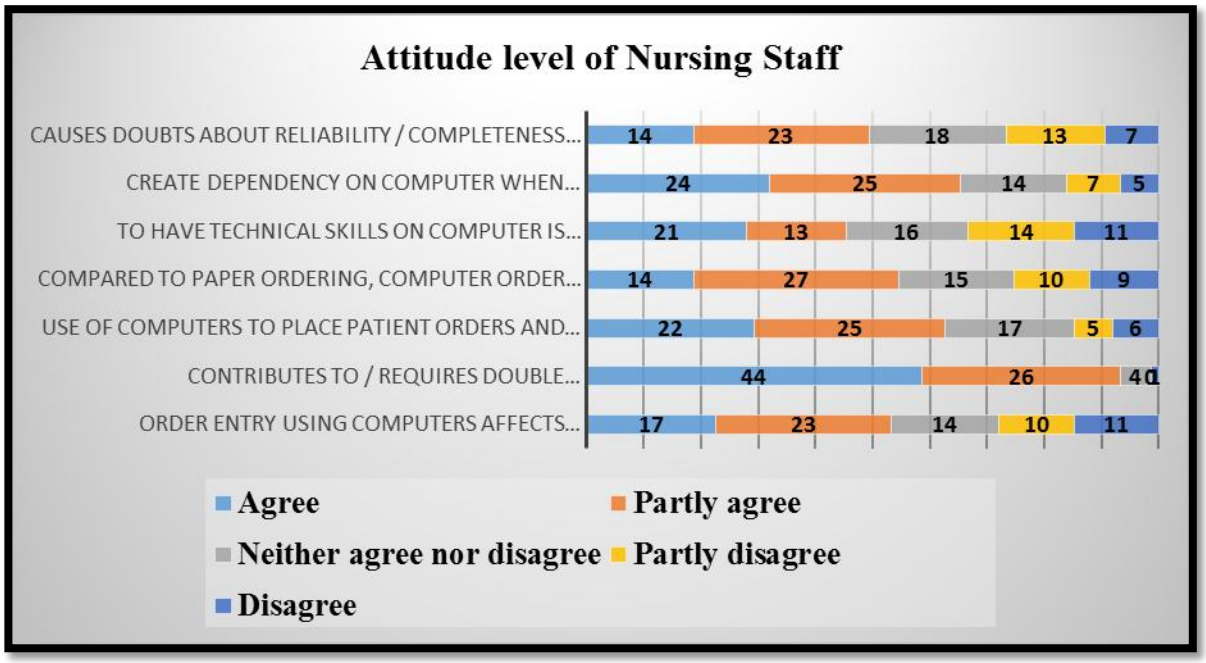

Figure 5 Attitude level of Nursing Staff

The attitude level of nursing and other allied healthcare staff was most agreed upon for the statement that it created dependency on computers and it was least agreed upon for the statement that it caused doubts about reliability of data and the statement that compared to paper ordering, computer ordering slowed them down.

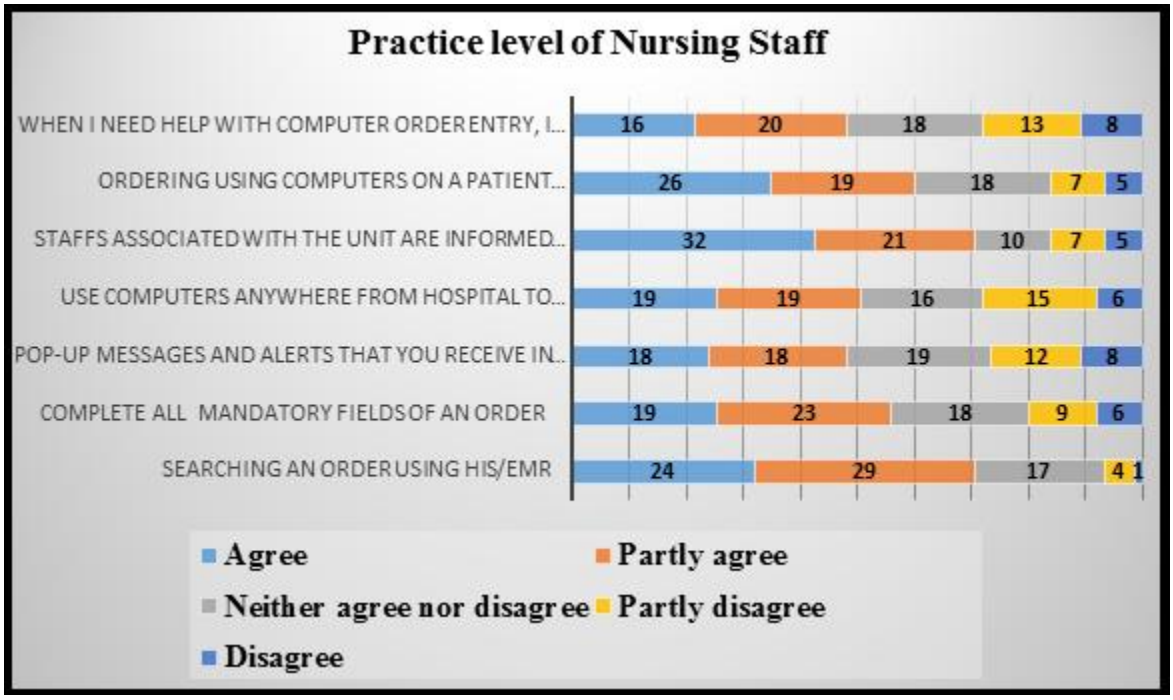

Figure 6 Practice level of Nursing Staff

The practice level of nursing and other allied healthcare staff was maximum for the statement that staff associated with the unit are well informed about the events occurring in other shifts and minimum for the statement that they could find help with computers when needed.

14.4 Analysis for Physicians

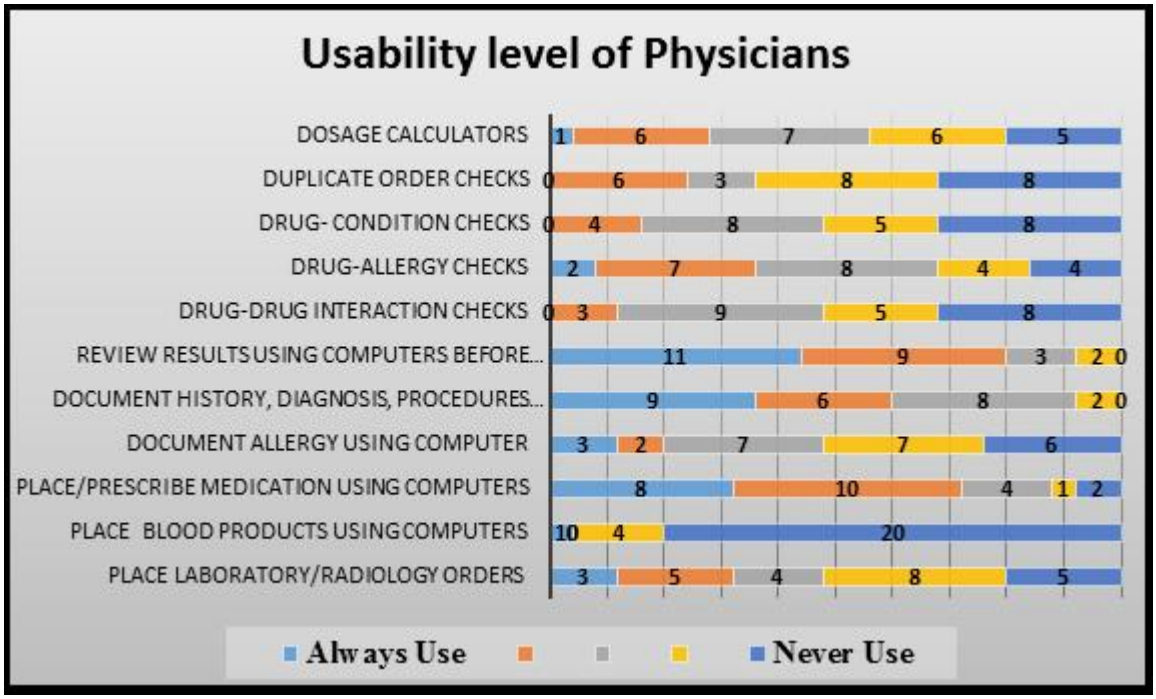

Figure 7 Usability level of Physicians

Usability level of respondents in physician role was maximum for the feature of reviewing results using computers before placing orders and it was minimum for the feature of duplicate order checks, drug-condition checks, drug-drug interaction checks.

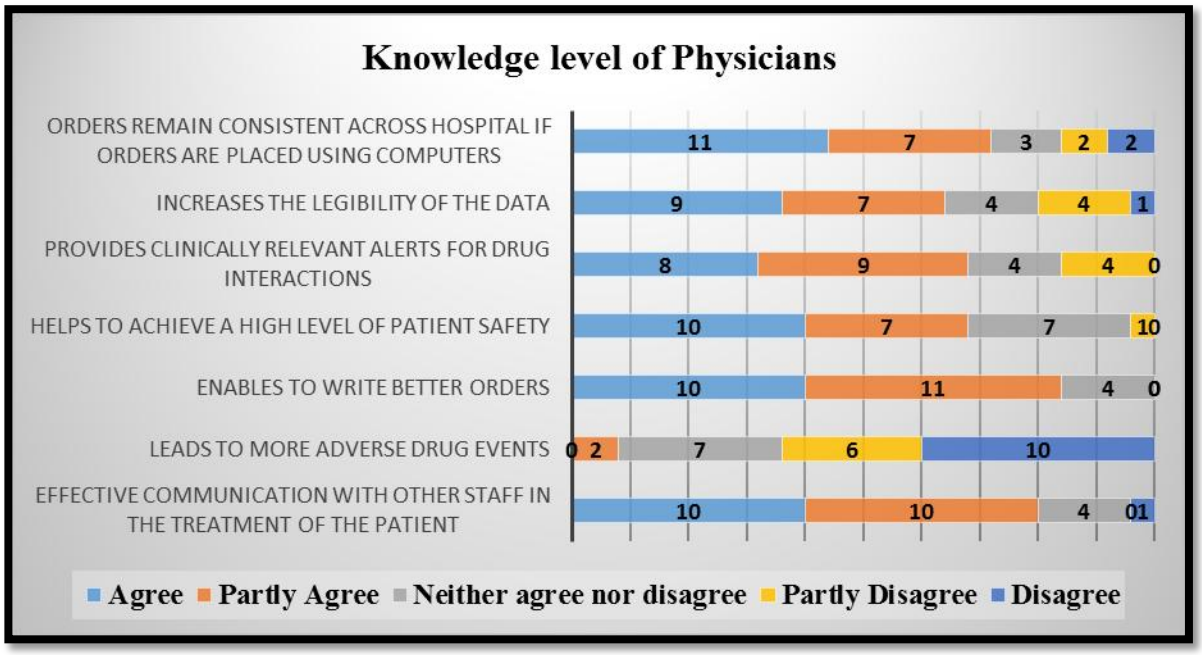

Figure 8 Knowledge level of Physicians

Knowledge level of respondents in physician role was maximum for the statement that orders remain consistent if placed using computers and minimum for the statement that it leads to more adverse drug effects.

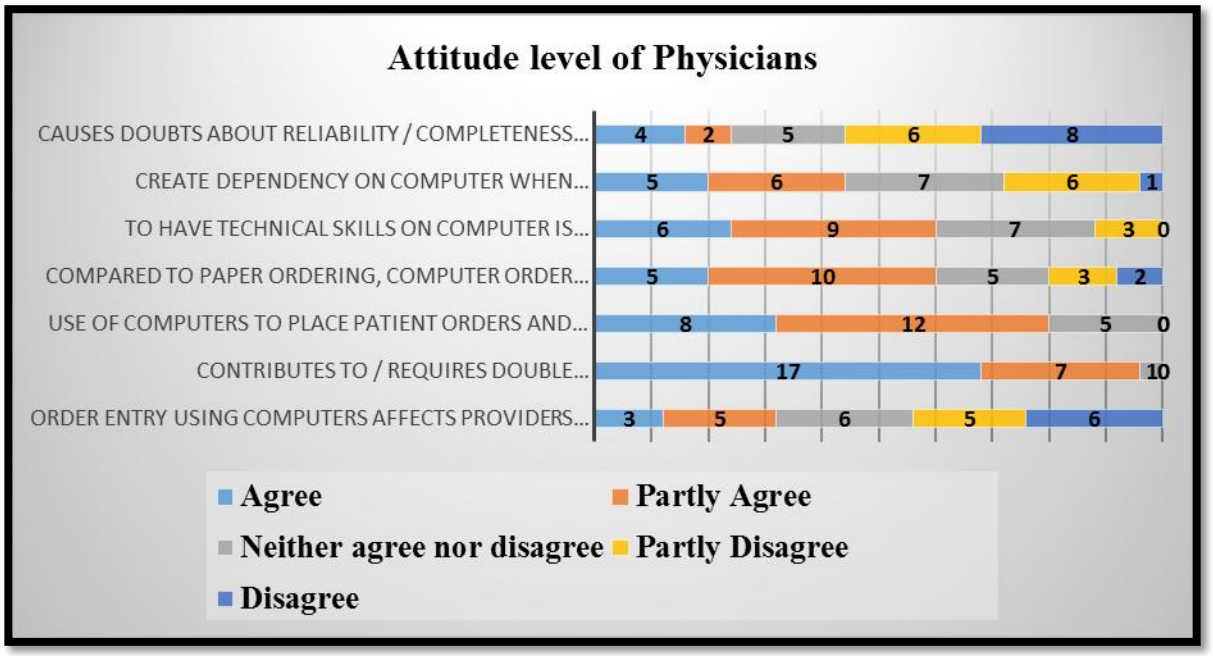

Figure 9 Attitude level of Physicians

Attitude level of respondents in physician role was maximum for the statement, use of computers to place patient orders and prescribe medications help in taking better decisions and it was minimum for the statement order entry using computers affects provider relationship with patient and impacts it negatively.

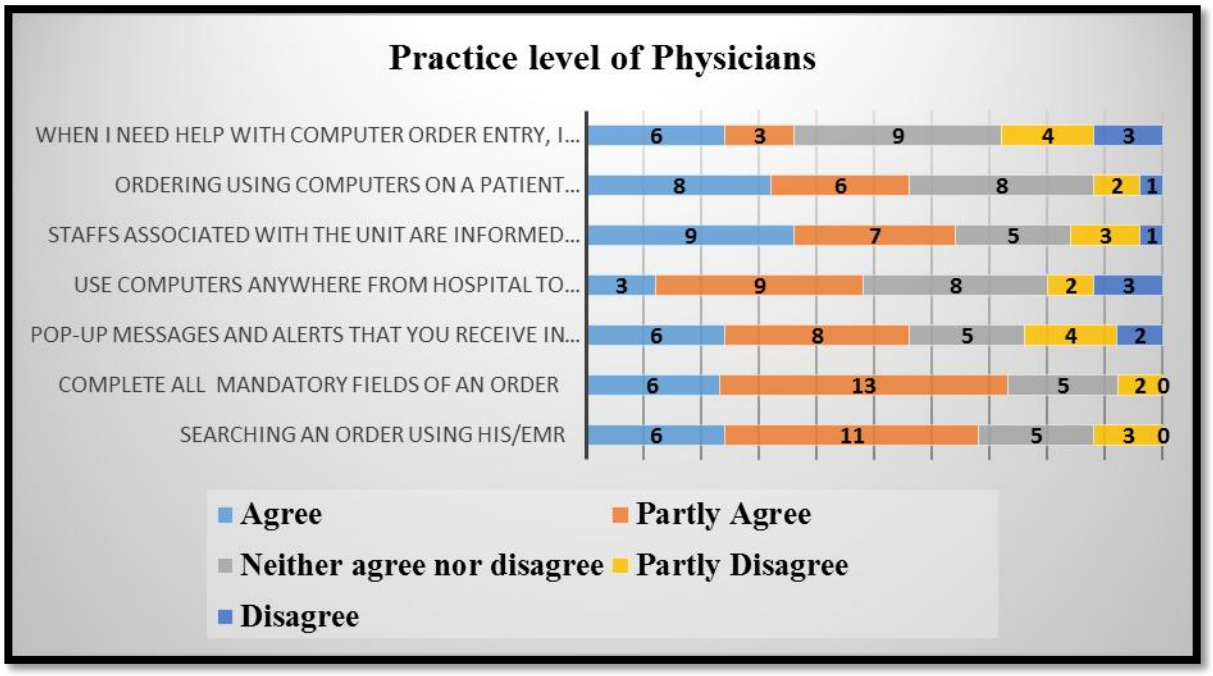

Figure 10 Practice level of Physicians

Practice level of respondents in physician role was maximum for the statement that the staff associated with the unit are well informed about the events occurring in other shifts and minimum for the statement that they could place orders from anywhere in the hospital.

15. Issues and challenges

Stage	**Issues/ Challenges**
Implementation	**Organizational resistance**
	High cost
	Product/ vendor immaturity
	Time to search and implement the system
Usage	**Physician resistance**
	Time to learn the system
	Lack of technical skills
	Low customization
	Difficult to enter data
	Insecure about the data
	Uncertainty about the reliability of the system
	Doctor patient relationship affected
	Privacy concerns

Table 1 Issues and Challenges in CPOE

16. Discussion

16.1 CPOE Workflow

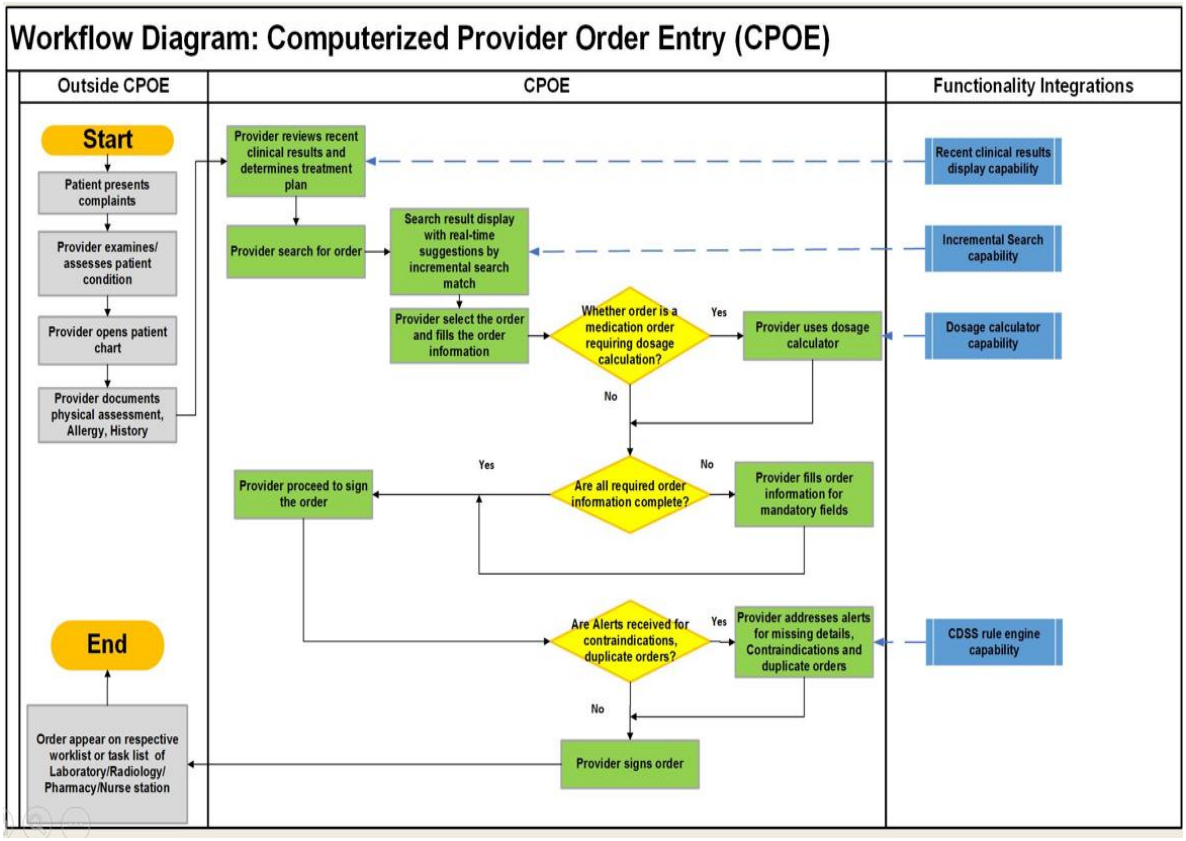

Figure 11 Workflow of CPOE

- The workflow of CPOE starts from the point when a patient comes to a physician with any complaint. The provider examines the patient checks his/her past medical history or any other kind of documentation.
- Then the provider proceeds to access the recent clinical data of the patient if the CPOE is enabled with such a feature. Then the provider searches for the order and finds the order through incremental search method.
- If the order is a medication order and it requires any dosage calculation then dosage calculator feature is used and.
- If all the mandatory fields are filled then provider proceeds to sign to the order and if there is any pop messages received regarding any allergy or contraindications then the provider addresses those issues and signs the order.

- Order then gets transmitted to the respective department and appears in the worklist or task list of the respective department.

Findings and analysis showed that the Hospital B had maximum extent of CPOE adoption whereas Hospital E had minimum extent of CPOE adoption. Hospital B was a multi-specialty hospital having 21 to 100 beds and it had two accreditations whereas Hospital E was a day care center with less than 20 beds and no accreditations.

Usability level of end users was maximum for the feature of prescribing medications using computers and least used feature was drug condition check. For a CPOE, dosage calculator, drug condition check, duplicate order check, drug- drug interaction check feature are the most critical feature and they were the least used features in the respondents.

The knowledge level of end users was maximum for the statement that CPOE helps to achieve high level of patient safety and for the statement that it leads to more adverse drug effects minimum respondents agreed for the statement.

The attitude level of end users of CPOE was that the CPOE system required double documentation and it was least for the statement that it causes doubts about reliability of data or completeness of data.

The practice level was agreed upon by the majority of the end users of CPOE was for the statement that the staff associated with the unit are well informed about the events occurring in other shifts and minimum number of respondents agreed upon the statement that they could find help with computers when needed and they could place orders from anywhere in the hospital.

It was found in the study that the respondents who placed more than twenty order a day using computers had better Usability, Knowledge, Attitude and Practice level than users who placed less than twenty order a day except for drug- drug interaction check. For drug-drug interaction check it was found to be better for users who placed less than twenty order a day.

The study also showed that respondents who were physicians had better usability except for respondents who were physician had better knowledge and practice than respondents who were nursing staff and other allied staff. Usability level was better for physicians except for placing lab/radiology order using computers, place blood products using computers, prescribe medication using computer and document allergy. Attitude level was better for physicians except for the fact that it causes doubts about reliability or completeness of data.

17. Limitations

- Efforts were made to capture maximum healthcare delivery setups and all the respondents present there, due to time constraint the present study was limited to smaller number of healthcare delivery setups and smaller sample size especially with respect to the healthcare delivery setups.

- Possibility of bias from the respondents are likely to occur because of the Hawthorne effect and the factor might also have contributed to the deviation of the analysis.

- Chances of error are likely to occur while capturing the data by the due to consciousness of the respondents, efforts have been made to minimize the error by assuring them that the data would not be shared with anyone and would not be used for anything except for the study purpose.

- There could be other departments which were indirectly related with the usage and workflow of CPOE but are not included in the present study.

18. Conclusion

Computerized Physician Order Entry (CPOE) is a powerful tool which can be utilized to increase the efficiency of care provided to the patients. CPOE supports in order management, reducing prescription error, reducing the blocks in workflow of the patient care by streamlining the process. CPOE will not only improve the efficiency but also the effectiveness of the quality patient care given.

It is rightly quoted by Mr. Inderjith Davalur, CEO, Aosta Software Technologies, that, "a large portion of the responsibility in advancing this electronic revolution in India rests upon the software community".[43]

Allocating adequate funds, identifying the needs and meeting the requirements of medical community is the need of the hour. Vendors are designing better and user friendly products and applications for physicians in particular in addition to the existing Electronic Medical Record (EMR).

The thing that is required by the vendors is the need to take into consideration a holistic view of healthcare delivery while designing the product in order to bridge the large gap between the providers and beneficiary. The gap can be reduced by educating the providers and creating awareness amongst the people regarding the tangible advantages of the system.

19. References

1. World Health Organization (WHO); Everybody's Business. Strengthening Health Systems to Improve Health Outcomes: WHO's Framework for Action, http://www.who.int/ health systems/strategy/everybodys_business.pdf
2. Peirce, J.C.; The paradox of physicians and administrators in health care organizations. Health Care Manag. Rev. 2000, https://tinyurl.com/mazsuhz
3. Savithiri Ratnapalan and Elizabeth Uleryk, Organizational Learning in Health Care Organizations, 2014, www.mdpi.com/2079-8954/2/1/24/pdf
4. Premkumar Balaraman, Kalpana Kosalram; E –Hospital Management & Hospital Information Systems – Changing Trends, 2013, http://www.mecs-press.org/ijieeb/ijieeb-v5-n1/IJIEEB-V5-N1-6.pdf
5. Kaushal R, Bates DW, Landrigan C, McKenna J, Clapp MD, Federico F, et al; Medication Errors and Adverse Drug Events in Pediatric Inpatients, 2001; http://www.pharmainfo.net/files/groupsimages/medication_errors_jama.pdf
6. U.S. Food and Drug Administration Bar Code Label Requirements for Human Drug Products and Biological Products; Final Rule, 2004, https://www.datarayusa.com/resources/stats/
7. CDC; Morbidity and Mortality Weekly Report (MMWR) https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6101a3.htm
8. U.S. Food & Drug Administration; U.S. Department of Health and Human Services, https://www.fda.gov/Drugs/DrugSafety/MedicationErrors/ucm080629.htm
9. Null, G; Death by Medicine. Mount Jackson, 2011, http://www.webdc.com/pdfs/deathbymedicine.pdf
10. Jason Lazarou, Bruce H. Pomeranz, Paul N. Corey; Incidence of Adverse Drug Reactions in Hospitalized PatientsA Meta-analysis of Prospective Studies, 1998, http://jamanetwork.com/journals/jama/article-abstract/187436
11. Martin A Makary and Michael; Medical error-the third leading cause of death in the US., 2016, http://www.bmj.com/content/353/bmj.i2139

12. Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gallivan T, et al; Systems analysis of adverse drug events. ADE Prevention Study Group, 1995, http://som202d.ucsd.edu/HCS%20Course%20PDFs/Weinger_Leape.pdf
13. Kenneth N. Barker, Elizabeth A. Flynn, Ginette A. Pepper, David W. Bates, MD, Robert L. Mikeal; Medication Errors Observed in 36 Healthcare Facilities, Archives of Internal Medicine, 2002, http://drbobseiler.com/wp-content/uploads/2010/09/article_02-26_barker.pdf
14. David H Cousins, David Gerrett, and Bruce Warner; A review of medication incidents reported to the National Reporting and Learning System in England and Wales over 6 years (2005-2010), 2012, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3477327/
15. Institute of Medicine; To Error is Human: Building a Safer Health System, 1999, IOM ../../Documents/to%20err%20is%20human.pdf
16. Safe medication, safe healthcare, http://www.qcin.org/nbqp/qualityindia/Vol-3-No1/medical.htm
17. A Primer on Physician Order Entry. California HealthCare Foundation and First Consulting Group, 2000 http://www.chcf.org/~/media/MEDIA%20LIBRARY%20Files/PDF/PDF%20C/PDF%20CPOEreport.pdf
18. Andrew M. Steele, Mical DeBrow; Efficiency Gains with Computerized Provider Order Entry, 2008, https://www.ncbi.nlm.nih.gov/books/NBK43766/
19. Jos Aarts and Ross Koppel; Implementation Of Computerized Physician Order Entry In Seven Countries, 2009, http://content.healthaffairs.org/content/28/2/404.full.pdf
20. David C Radley, Melanie R Wasserman, Lauren EW Olsho, Sarah J Shoemaker, Mark D Spranca, and Bethany Bradshaw; Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems, 2013, https://www.ncbi.nlm.nih.gov/pubmed/23425440
21. Advanced Technologies to Lower Health Care Costs and Improve Quality, First Consulting Group for MTC and NEHI, 2003,

http://www.nehi.net/writable/publication_files/file/advanced_technologies_to_lower_health_care_costs_and_improve_quality.pdf

22. Douglas Johnston, Eric Pan, John J., Blackford Middleton, Janice Walker, David W. Bates; The Value of Computerized Physician Order Entry in Ambulatory Settings, Executive Preview, Center for Information Technology Leadership, 2003, https://healthit.ahrq.gov/sites/default/files/docs/page/CITL%20ACPOE%20Executive%20Preview_0.pdf

23. Douglas Johnston, Eric Pan, John J., Blackford Middleton, Janice Walker, David W. Bates; The Value of Computerized Physician Order Entry in Ambulatory Settings, 2003, https://rdcms-himss.s3.amazonaws.com/files/production/public/HIMSSorg/Content/files/jhim/18-1/clinical.pdf

24. Erica Drazen, Bethany Gilboard, Jane Metzger, Emily Welebob; Saving Lives, Saving Money In Practice: Strategies for Computerized Physician Order Entry in Massachusetts Hospitals, 2009, http://mehi.masstech.org/sites/mehi/files/documents/cpoe2009.pdf

25. World Health Organization, http://www.who.int/environmental_health_emergencies/services/en/

26. Cohen, M.A., Hershey, J.C. and Weiss, E.N.; Analysis of capacity decisions for progressive patient care hospital facilities, 1980, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1072154/

27. A Case Study on Computerized Physician Order Entry, A Blueprint for a Beginning, 2006, http://mehi.masstech.org/sites/mehi/files/documents/cpoeDecember2006.pdf

28. Eligible Professional Meaningful Use Core Measures Measure 1 of 13 Stage 1(2014 Definition), CMS, 2014, https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/downloads/1_CPOE_for_Medication_Orders.pdf

29. Usability Evaluation Basics, Usability.gov, https://www.usability.gov/what-and-why/usability-evaluation.html

30. Dillon, A.; Usability evaluation, 2001, https://www.ischool.utexas.edu/~adillon/BookChapters/Dillon-evaluation%20of%20software%20usab.htm
31. The KAP Survey Model (Knowledge, Attitude and Practices), US AID, from the American People; 2011, https://www.spring-nutrition.org/publications/tool-summaries/kap-survey-model-knowledge-attitudes-and-practices
32. Oregonlaws, https://www.oregonlaws.org/glossary/definition/health_care_provider
33. Lewis JR; Computer System Usability Questionnaire (CSUQ): IBM Computer Usability Satisfaction Questionnaires: Psychometric evaluation and instructions for use. Int J Human-Comp Inter, 1995, http://garyperlman.com/quest/quest.cgi
34. William J. Doll , Gholamreza Torkzadeh; The Measurement of End-User Computing Satisfaction, MIS Quarterly Vol. 12, 1988, https://www.jstor.org/stable/248851?seq=1#page_scan_tab_contents
35. P.L.T. Hoonakker, P. Carayon, and J.M. Walker; Measurement of CPOE End-User Satisfaction Among ICU Physicians and Nurses, 2010, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3059318/
36. John Brooke; Redhatch Consulting Ltd., SUS - A quick and dirty usability scale, 1996, http://cui.unige.ch/isi/icle-wiki/_media/ipm:test-suschapt.pdf
37. Lund, A., Measuring Usability with the USE Questionnaire,2001, https://www.researchgate.net/publication/230786746_Measuring_usability_with_the_USE_questionnaire
38. Sharon Silow-Carrol; Using Electronic Health Records to Improve Quality and Efficiency: The Experiences of Leading Hospitals, 2012, https://pdfs.semanticscholar.org/0e75/8272eab4ba74933ed4fdf860362f2365f3d3.pdf
39. Eric G. Poon, David Blumenthal, Tonushree Jaggi, Melissa M. Honour,David W. Bates and Rainu Kaushal; Overcoming Barriers To Adopting And Implementing Computerized Physician Order Entry Systems In U.S. Hospitals, 2004, http://content.healthaffairs.org/content/23/4/184.long

40. Albert Boonstra and Manda Broekhuis; Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions, 2010, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2924334/
41. Loomis GA, Ries JS, Saywell RM Jr, Thakker NR; If electronic medical records are so great, why aren't family physicians using them?, 2002, https://www.ncbi.nlm.nih.gov/pubmed/12160503
42. Sima Ajami, Tayyebe Bagheri-Tadi; Barriers for Adopting Electronic Health Records (EHRs) by Physicians, 2013, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3766548/#ref13
43. Davalur I.; EHR and EMR in India fantasy or reality?, 2009, http://ehealth.eletsonline.com/2009/06/11287/

20. Appendix

20.1 Appendix A: Response of all the End Users

Usability features	**Always Use 5**	**4**	**3**	**2**	**Never Use 1**
Place Laboratory/Radiology orders	35	27	11	11	16
Place blood products using computers	25	19	12	9	35
Place/prescribe medication using computers	55	27	13	1	4
Document allergy using computer	24	20	23	16	17
Document history, diagnosis, procedures notes using computers	41	32	16	3	8
Review results using computers before placing orders	46	30	10	9	5
Drug-drug interaction checks	11	17	23	21	28
Drug-Allergy checks	26	27	17	12	18
Drug- condition checks	10	16	21	19	34
Duplicate order checks	14	25	19	19	23
Dosage calculators	13	22	26	18	21

Table 2 Usability response of all the End Users

Knowledge level	**Agree 5**	**Partly Agree 4**	**Neither agree nor disagree 3**	**Partly Disagree 2**	**Disagree 1**
Effective communication with other staff in the treatment of the patient	39	31	19	6	5
Leads to more adverse drug events	9	17	23	24	27
Enables to write better orders	34	35	21	6	4
Helps to achieve a high level of patient safety	41	23	21	12	3
Provides clinically relevant alerts for drug interactions	35	30	19	14	2

Increases the legibility of the data	30	31	20	12	7
Orders remain consistent across hospital if orders are placed using computers	36	25	19	10	10

Table 3 Knowledge response of all the End Users

Attitude Level	**Agree 5**	**Partly Agree 4**	**Neither agree nor disagree 3**	**Partly Disagree 2**	**Disagree 1**
Order entry using computers affects providers bonding with patient and impacts negatively on patientcare	20	28	20	15	17
contributes to / requires double documentation (both on paper and in Computer/HIS)	61	33	5	0	1
Use of computers to place patient orders and prescribe medications help in taking better decisions	30	37	22	5	6
Compared to paper ordering, computer order entry slows me down	19	37	20	13	11
To have technical skills on computer is essential to prescribe or place orders for patient by using computers	27	22	23	17	11
Create dependency on computer when compared to paper ordering	29	31	21	13	6
causes doubts about reliability / completeness of order	18	25	23	19	15

Table 4 Attitude response for all the End Users

Practice Level	Agree 5	Partly Agree 4	Neither agree nor disagree 3	Partly Disagree 2	Disagree 1
Searching an order using HIS/EMR	30	40	22	7	1
Complete all mandatory fields of an order	25	36	23	11	5
Pop-up messages and alerts that you receive in ordering process	24	26	24	16	10
Use computers anywhere from hospital to place orders	22	28	24	17	9
Staffs associated with the unit are informed regarding events occurring on other shifts.	41	28	15	10	6
Ordering using computers on a patient functions as I expect	34	25	26	9	6
When I need help with computer order entry, I can find it easily	22	23	27	17	11

Table 5 Practice response for all the End Users

20.2 Appendix B: Response of nursing & other allied staff:

Usability Level	Always Used 5	4	3	2	Never Used 1
Place Laboratory/Radiology investigation orders	32	22	7	3	11
Place blood products using computers	24	19	12	5	15
Place/prescribe medication using computers	47	17	9	0	2
Document allergy using computer	21	18	16	9	11
Document history, diagnosis,	32	26	8	1	8

procedures notes using computers					
Review results using computers before placing orders	35	21	7	7	5
Drug-drug interaction checks	11	14	14	16	20
Drug-Allergy checks	24	20	9	8	14
Drug- condition checks	10	12	13	14	26
Duplicate order checks	14	19	16	11	15
Dosage calculators	12	16	19	12	16

Table 6 Usability response of Nursing Staff

Knowledge Level	**Agree 5**	**Partly agree 4**	**Neither agree nor disagree 3**	**Partly disagree 2**	**Disagree 1**
Effective communication with other staff in the treatment of the patient	29	21	15	6	4
Leads to more adverse drug events	9	15	16	18	17
Gives information that enables to write better orders	24	24	17	6	4
Helps to achieve a high level of patient safety	31	16	14	11	3
Provides clinically relevant alerts for drug interactions	27	21	15	10	2
Increases the legibility of the data	21	24	16	8	6
Orders remain consistent across hospital if orders are placed using computers	25	18	16	8	8

Table 7 Knowledge response of Nursing Staff

Attitude Level	**Agree 5**	**Partly agree**	**Neither agree**	**Partly disagree**	**Disagree 1**

		4	**nor disagree 3**	**2**	
Order entry using computers affects providers bonding with patient and impacts negatively on patientcare	17	23	14	10	11
contributes to / requires double documentation (both on paper and in Computer/HIS)	44	26	4	0	1
Use of computers to place patient orders and prescribe medications help in taking better decisions	22	25	17	5	6
Compared to paper ordering, computer order entry slows me down	14	27	15	10	9
To have technical skills on computer is essential to prescribe or place orders for patient by using computers	21	13	16	14	11
Create dependency on computer when compared to paper ordering	24	25	14	7	5
causes doubts about reliability / completeness of order	14	23	18	13	7

Table 8 Attitude response of Nursing Staff

Practice Level	**Agree 5**	**Partly agree 4**	**Neither agree nor disagree 3**	**Partly disagree 2**	**Disagree 1**
Searching an order using HIS/EMR	24	29	17	4	1
Complete all mandatory fields of an order	19	23	18	9	6
Pop-up messages and alerts that you receive in ordering process	18	18	19	12	8
Use computers anywhere from	19	19	16	15	6

hospital to place orders					
Staffs associated with the unit are informed regarding events occurring on other shifts.	32	21	10	7	5
Ordering using computers on a patient functions as I expect	26	19	18	7	5
When I need help with computer order entry, I can find it easily	16	20	18	13	8

Table 9 Practice response of Nursing Staff

20.3 Appendix C: Response of Physicians:

Usability Level	**Always Use 5**	**4**	**3**	**2**	**Never Use 1**
Place Laboratory/Radiology orders	3	5	4	8	5
Place blood products using computers	1	0	0	4	20
Place/prescribe medication using computers	8	10	4	1	2
Document allergy using computer	3	2	7	7	6
Document history, diagnosis, procedures notes using computers	9	6	8	2	0
Review results using computers before placing orders	11	9	3	2	0
Drug-drug interaction checks	0	3	9	5	8
Drug-Allergy checks	2	7	8	4	4
Drug- condition checks	0	4	8	5	8
Duplicate order checks	0	6	3	8	8
Dosage calculators	1	6	7	6	5

Table 10 Usability Response of Physicians

Knowledge Level	Agree 5	Partly Agree 4	Neither agree nor disagree 3	Partly Disagree 2	Disagree 1
Effective communication with other staff in the treatment of the patient	10	10	4	0	1
Leads to more adverse drug events	0	2	7	6	10
Enables to write better orders	10	11	4	0	0
Helps to achieve a high level of patient safety	10	7	7	1	0
Provides clinically relevant alerts for drug interactions	8	9	4	4	0
Increases the legibility of the data	9	7	4	4	1
Orders remain consistent across hospital if orders are placed using computers	11	7	3	2	2

Table 11 Knowledge response of Physicians

Attitude Level	Agree 5	Partly Agree 4	Neither agree nor disagree 3	Partly Disagree 2	Disagree 1
Order entry using computers affects providers bonding with patient and impacts negatively on patientcare	3	5	6	5	6
contributes to / requires double documentation (both on paper and in Computer/HIS)	17	7	1	0	0
Use of computers to place patient orders and prescribe medications help in taking better decisions	8	12	5	0	0
Compared to paper ordering,	5	10	5	3	2

computer order entry slows me down					
To have technical skills on computer is essential to prescribe or place orders for patient by using computers	6	9	7	3	0
Create dependency on computer when compared to paper ordering	5	6	7	6	1
causes doubts about reliability / completeness of order	4	2	5	6	8

Table 12 Attitude response of Physicians

Practice Level	**Agree 5**	**Partly Agree 4**	**Neither agree nor disagree 3**	**Partly Disagree 2**	**Disagree 1**
Searching an order using HIS/EMR	6	11	5	3	0
Complete all mandatory fields of an order	6	13	5	2	0
Pop-up messages and alerts that you receive in ordering process	6	8	5	4	2
Use computers anywhere from hospital to place orders	3	9	8	2	3
Staffs associated with the unit are informed regarding events occurring on other shifts.	9	7	5	3	1
Ordering using computers on a patient functions as I expect	8	6	8	2	1
When I need help with computer order entry, I can find it easily	6	3	9	4	3

Table 13 Practice response of Physicians

20.4 Appendix D: Checklist

Checklist for assessment of status of implementation and usage of computerized physician order entry (CPOE) in healthcare delivery setup

This checklist is given to you as your role of IT administrator. Your organization has been using Computerized Physician Order Entry (CPOE) at the workplace. This checklist is a part of a research study focussed on understanding the status of CPOE implementation and usage in your organization. A high response rate increases the validity of study. Answering the survey is estimated to take 15 to 20 minutes.

Confidentiality: The data collected will be confidential and will only be used for research purpose. Only the researcher will have access to the data. (Your employer won't have access to the data). It will not be possible to detect individuals when reading the report data.

Respondent Hospital Code	
Your role in the hospital	

Hospital type	Single specialty	Multi-specialty	Super specialty	Daycare center

Bed strength	0 to 20 beds	21 to 100 beds	101-300 beds	above 300 beds

Number of years of the hospital in operation	

Accreditations received	

A1. What all below options are used for placing clinical orders at your hospital? (Check all that apply)	
Verbal	
Hand written prescription	
Electronically (Using computer)	
Electronically (Using mobiles/ tablets)	
Others; Specify	

A2. What all below features are integrated with CPOE at you hospital? (Check all that apply)	
Drug to drug interaction checks	
Drug allergy interaction checks	
Drug Condition checks	
Duplicate order checks	
Incremental search for order search	
Drug Dosage Calculator	
Access to recent investigation results while placing orders	
Disease specific order sets	
Clinical guidelines accessed within EMR	
Rule based Alerts and reminders	

A3. What all below standards or similar standards adopted at your hospital? (Check all that apply)	
ICD-9/10 (International Classification of Diseases)	

SNOMED (Systematized Nomenclature of Medicine Clinical Terms) in Pharmacy)	
LOINC (Logical Observation Identifiers Names and Codes) in Laboratory	
UMLS (Unified Medical Language System)	
HL7 (Health Level 7 standard)	
Others; Specify	

A4. Which all end users of below departments/locations have access to clinical orders Placed through computers? (Check all that apply)

Laboratory	
Radiology	
Blood bank	
Dietary services	
Bedside procedures	
Operation Theatre	
Outpatient Department	
Inpatient department/ Nursing Unit	
Cathlab	
Dialysis	
Chemotherapy	
Intensive Care Unit	

B2. How frequently is training program for the end users of CPOE conducted at your hospital?

Monthly	
Quarterly	
Semi annually	
More than annually	

Never	

B3. Who are the participants of the training program? (Check all that apply)	
Physicians	
Nurses	
Lab/Radiology staff	
Blood bank/ Dietary staff	
OT/ICU staff	
Chemotherapy/ Cathlab/ Dialysis staff	

	Yes	No
A5. Is there a system to report back to CPOE whether all the order/ tests/ procedures have been performed or not?		
B1.Do you have training programs for the end users of CPOE?		
B4. Are the participants given any training material such as book or handout?		
B5. Are there any metrics/ dashboard report available and is being used to analyze training need for end users?		
C1. Is there any alternative (workaround process) available during the downtime of the system?		
C2. Is there a defined escalation matrix for the IT issues resolution?		

D1. Does your organization has a set policy for patient safety?		
D2. Is there a steering committee to keep the HIS/EMR system robust?		
D3. Is there any recognition received to end users based on CPOE usability?		
D4. Is there a representation of end users/ clinicians in organizational decision making related to CPOE?		

	Highest				Lowest
	5	4	3	2	1
D5. How would you rate the willingness of organization to adopt new technology for CPOE?					

C3. How frequently are systems audits and flashes conducted to keep orders in system updated?

Monthly	
Quarterly	
Semi annually	
More than annually	
Never	

C4. What all from below infrastructure requirements are in place at your hospital to support and maintain CPOE features? (Check all that apply)

Access to CPOE from remote location	
Tools in place to support backups and recovery for CPOE suite	

Tools in place to monitor system and network performance	
Appropriate business continuity/ disaster recovery plan appropriate CPOE application suite	
Wireless LAN is in place to support CPOE use from point of care devices (Mobiles, Tablets etc.)	

C5. What is the level of IT support available for technical and non-technical issues?

Only during working hours of organization in normal shift	
Outside working hours of organization in two shifts	
Round the clock support within the organization	
Support not available organization	
Support not available organization	

20.5 Appendix E: Questionnaire

Questionnaire for understanding the usability of computerized provider order entry (CPOE) from a provider perspective

This questionnaire is given to you as your role of healthcare provider. Your organization has been using Computerized Physician Order Entry (CPOE) at the workplace. This questionnaire is a part of a research study designed to capture data on Knowledge, Attitude and Practice of CPOE from healthcare provider perspective. It also aims to understand issues and challenges in using CPOE from the provider perspective. The survey consist of multiple choice questions consisting of single selection and multiple selection questions. Answering the survey is estimated to take 15 to 20 minutes.

Confidentiality: The data collected and the identity of the respondent will be kept confidential and will only be used for research purpose. Only the researcher will have access to the data

R1	Respondent number	

D1	Age of respondent	Years	Months

D2	Gender	M	F

D3	Educational qualification	

D4	What is your current position	

D5	Total number of experience (in years)	Years	Months

D6	Department	

R2	Since how long you are using HIS/EMR	Years	Months

R3	Approximate number of orders you place on patients in a day	Very many (>20)	Many (10-20)	Few (<10)	None

Are you aware of /have been using below functionalities using computers (HIS)

(Please rate your usage of features)

		Always use				Never used
		5	4	3	2	1
U1	Place Laboratory/Radiology investigation orders using computers					
U2	Place blood products using computers					
U3	Place/prescribe medication using computers					
U4	Document allergy using computer					
U5	Document history, diagnosis, procedures notes using computers					
U6	Review results using computers before placing orders					
U7	Drug-drug interaction checks					
U8	Drug-Allergy checks					
U9	Drug- condition checks					
U10	Duplicate order checks					
U11	Dosage calculators					

Please indicate to what extent you agree with the following statements:

Use of computers in placing/prescribing patient orders,

		Agree	Partly agree	Neither Agree nor Disagree	Party disagree	Disagree
K1	Provides an opportunity for effective communication with other staff in the treatment of the patient					
K2	Leads to more adverse drug events					
K3	Gives information that enables to write better orders					

K4	Helps to achieve a high level of patient safety					
K5	Provides clinically relevant alerts for drug interactions					
K6	Increases the legibility of the data					
K7	Orders remain consistent across hospital if orders are placed using computers					

Please indicate to what extent you agree with the following statements:

Use of computers in placing/prescribing patient orders,

		Agree	Partly agree	Neither Agree nor Disagree	Party disagree	Disagree
A1	Order entry using computers affects providers bonding with patient and impacts negatively on patientcare					
A2	contributes to / requires double documentation (both on paper and in Computer/HIS)					
A3	Use of computers to place patient orders and prescribe medications help in taking better decisions					
A4	Compared to paper ordering, computer order entry slows me down					
A5	To have technical skills on computer is essential to prescribe or place orders for patient by using computers					
A6	Create dependency on computer when compared to paper ordering					
A7	causes doubts about reliability / completeness of order					

Please indicate to what extent you agree with the following statements:

		Satisfying	Easy	Neither Easy nor Difficult	Difficult	Frustratin
P1	How would you find searching an order using HIS/EMR					

P2	While you place an order using computers, How would you find to complete all requirements including mandatory fields of an order						
P3	Your reactions on Pop-up messages and alerts that you receive at various steps of ordering process using computers						
P4	I use computers anywhere from hospital to place orders even if I am not on bedside or nearby patient						

Please indicate to what extent you agree with the following statements:

		Agree	Partly agree	Neither Agree nor Disagree	Party disagree	Disagre
P5	When you place orders using computers, Staffs associated with the unit remain well informed regarding events occurring on other shifts.					
P6	Within HIS/EMR, Ordering using computers on a patient functions as I expect					
P7	When I need help for a problem with computer order entry, I can find it easily					