DISSERTATION

On

"PERCEPTION OF HEALTHCARE PROVIDERS TOWARDS CLINICAL DECISION SUPPORT SYSTEM IN INDIAN HEALTH CARE"

SUBMITTED BY

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PG/15/022

UNDER THE GUIDANCE OF

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INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT & RESEARCH

INTERNSHIP TRAINING

At

ELI RESEARCH INDIA PVT. LTD.

"**Importance of Clinical Decision Support System in Predicting Ocular Disease Diagnosis & their Management**"

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ABSTRACT

Work of healthcare professionals and physicians is largely a work of making decisions and solving problems. It is a work of choosing issues that require attention, setting goals, finding or designing suitable courses of action and evaluating and choosing among alternative actions. They must choose from and interpret a huge variety of clinical data, while facing pressure to decrease uncertainty, risks to patients and costs. The true essence of healthcare delivery is decision making - what information to gather, which tests to order, how to interpret and integrate this information into diagnostic hypotheses and what treatments to administer.

Clinical decision support system is a software that assists the health care providers in making the clinical decisions. This study will help in increasing the understanding about CDSS and its scope.

The field of ophthalmology has a number of unique features, compared to other medical and surgical specialties, with regard to clinical workflow and data management. This has important implications for the design of electronic health record (EHR) systems that can be used intuitively and efficiently by ophthalmologists, and which can promote improved quality of care.

The purpose of this paper is to summarize the special requirements of CDSS that are important for ophthalmology that will help ophthalmologists to identify important features when searching for CDSS integrated EHR systems, stimulate vendors to recognize and incorporate these functions into systems, and assist federal agencies to develop future guidelines regarding meaningful use of EHRs. More broadly, the American Academy of Ophthalmology (Academy) believes that these functions are elements of good system design that will improve access to relevant information at the point of care between the ophthalmologist and the patient, enhance timely communications between primary care providers and ophthalmologists, mitigate risk, and ultimately improve the ability of physicians to deliver the highest-quality medical care

The study also demonstrates the existing architecture of CDSS that is usually followed and the importance of an integrated CDSS, CPOE and EMR software for an effective approach to deliver quality eye care.

An exploratory study was conducted to understand the existing framework of CDSS for ocular diseases in US Healthcare system and the integrated approach of ophthalmologists and optometrists in the management of pre & post-operative cataract cases.

The study proposed a framework for clinical pathway followed for the treatment of Cataract cases and also a description of Alert Features of CDSS required for its management that integrated CDSS, CPOE and EMR software can be an effective approach to deliver quality eye care and efficient management of pre & post-operative cataract diseases. Study can be utilized to further develop an electronic platform for efficient management and errorless treatment of cases.

ACKNOWLEDGEMENT

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

I am thankful to **Ms. Ranjeeta Basra** (Senior Manager) for giving me the opportunity to carry out my dissertation and for her constant support and encouragement. I am thankful to her for the time and efforts she spent from his busy schedule. I wish to express my sincere gratitude to **Mr. Achal Gogia** for his supervision, advice and guidance. He was a continuous source of ideas which inspired and enriched my growth as a student, a researcher.

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I am thankful to all the members of MDOffice 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.

Thank you,

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LIST OF FIGURES

LIST OF ABBREVIATIONS

1. AMD- Age related macular degeneration
2. CDSS- Clinical Decision Support System
3. CPOE- Computerized Physician Order Entry System
4. CMS- Center for Medicare & Medicaid Services
5. CQM- Clinical quality measure
6. EHR- Electronic Health Record
7. ELI- Engage Learn Inspire
8. EPR: Electronic Patient Record
9. GBD- Global Burden of Diseases
10. GP- General Practitioner
11. Healthcare IT- Healthcare Information Technology
12. HES- Hospital Eye Services
13. HIPAA- Health Insurance Portability & Accountability Act
14. IOL- Intraocular Lens
15. MD- Doctor of Medicine
16. MIPS- Merit –based Incentive payment system
17. OD- Doctor of Optometry
18. PM- Practice Management
19. PQRS- Physician quality reporting system
20. RCM- Revenue Cycle Management
21. USA- United States of America
22. WHO- World Health Organization

INTERNSHIP REPORT

Eli India is part of ELI Global-a globally diversified information and financial services group founded in 1991.Today ELI have more than 40 business units in diverse verticals across three continents.

Eli started its India operations in 2007 as a Research and Publications organization and our current business spans across diverse verticals including Healthcare, Market Research Reports, Collections & Recovery, Certifications, Online Reputation Management, Collectibles, Insurance and Annuities, Media & Publications and more. It offers a much sought-after work environment for people at different stages in their careers. They are agile towards our targets and they attract employees who are similar to us. They offer an enviable workplace with not just the tangible measures of remuneration, flexibility with working arrangements; it is also the less tangible measures of maintaining a strong company culture, work environment and support which make the real difference.

ELI's one of the business unit is MDOffice and they have Electronic Health Record (EHR),Practice Management, Revenue Cycle Management and Patient Engagement product which empower and enables ophthalmologist practices to provide effective and integrated care delivery. MDOffice delivers the next generation of electronic medical records and practice management solutions built upon best-of-breed and best-in-class healthcare software. The MDOffice solution creates a foundation for heterogeneous communication amongst healthcare providers throughout the ophthalmology sector as well as all caregivers within the Hospital Network.

MDOffice has been offering Electronic Medical Records and Practice Management systems since 1984.Regardless of the specialty or the number of locations and size of your practice, MD office's unified EMR and PM software will manage the flow of your patients from check-in to check-out smoothly. MDOffice understand that speed and agility are keys to success in competitive times.

At MDOffice, products are designed to help medical practices increase productivity, reduce account receivables, and increase cash flow. Healthcare providers know the powerful benefits of MDOffice unified solution: improved efficiency, increased revenue, fewer medical errors, and more personal freedom for you. MDOffice lets you tailor your own easy-to-use charts, whether you work in one office or are a physician linked to a clinic. MDOffice flexible and customizable medical records, you can write your own problem-specific forms and use personal phrases to detail encounters. You can quickly and easily organize notes and records of lab findings, prescribed medication, allergies, vitals, and images; you can also draw and annotate directly on stock drawings, or insert drawings and images into your notes and patient charts; you can make graphs to chart the trends of vitals, test and lab results; and you also get access to medical databases MDOffice takes the hassle out of managing medical records.

MDOffice list of products:

MDOffice desktop version (EMR+PRACTICE MANAGEMENT)

CLOUD (EMR+PRACTICE MANAGEMENT)

MOBILE (EMR+PRACTICE MANAGEMENT)

PATIENT PORTAL.

E-PRESCRIPTION.

AMBULATORY SURGICAL CARE.

REVENUE CYCLE MANAGEMENT.

In the MDOffice Cloud application, all the data is maintained in multiple tabs called modules:

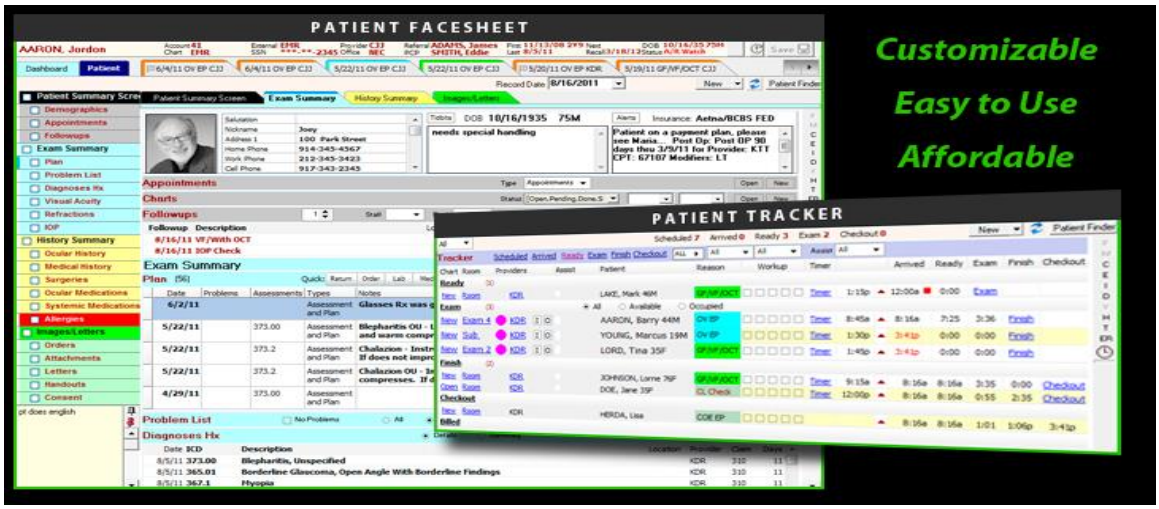
Ticklers

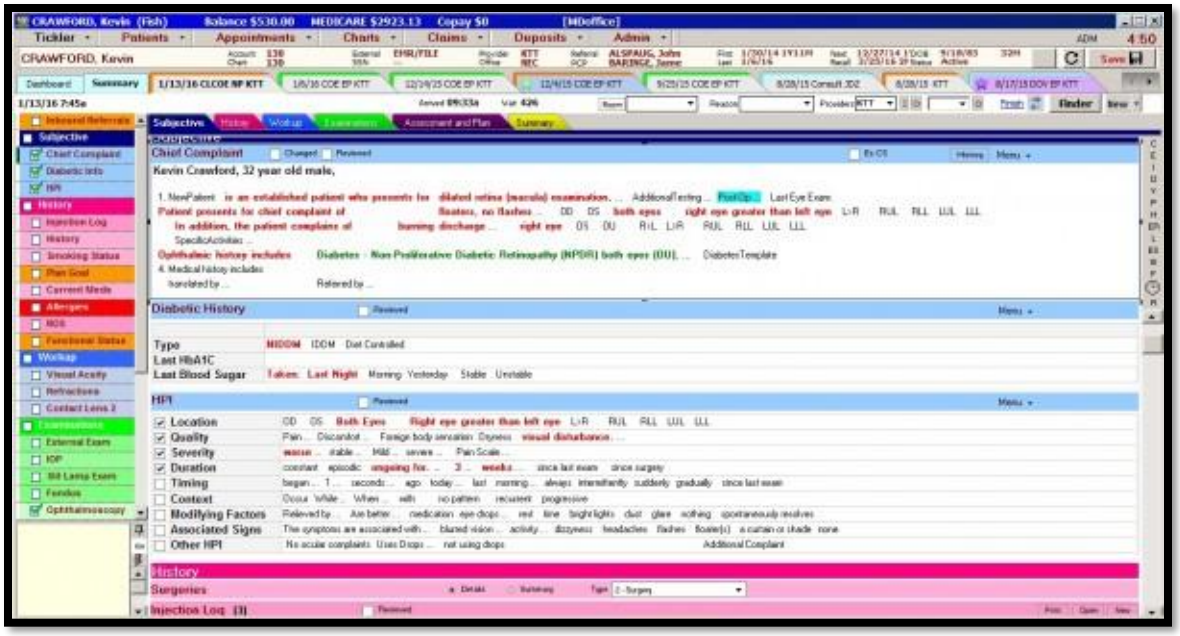
Patients

Schedules

Billing

Deposits





Ticklers:

Ticklers act as an in-house communication tool for a practice with single or multiple locations. The tickler messages can be patient messages or general messages for staff. You can also set event reminders for yourself or any other staff member using ticklers

Patients:

You have to access the Registration module either to register a new patient or access an existing patient's details like patient demographics, contacts, insurance coverage and claims. You can also store medical and accounting alerts to warn your staff about special patient conditions, needs, drug allergies, payment schedules, and overdue balances. You can create custom fields to print on letters, statements, and insurance forms.

Schedules:

You can check the encounters and appointment details of a patient from the Schedules accordion without going through the Schedule module. In this Schedules page of a patient, you will see the list of all appointments (encounters/old and future appointments) and recalls for that patient.

Billing:

The Billing module covers the complete cycle of validating claims, billing, and entering payments, posting collections and payments, and tracking receivables. It allows you to save time, monitor accounts more accurately, and improve collections.

Deposits:

All money coming in from any source must be entered in the Deposit module as New Deposit and then applied (posted) to open (unpaid) claims. Amounts when posting payments:

Allowed: The maximum amount an insurance company will pay for a particular service or procedure.

Payment: The actual amount paid by the source.

Adjustment: The amount adjusted as per your practice/provider's discretion.

Write-off: The difference between your charged amount and the amount covered or allowed by an insurance company.

During my internship I was involved in getting training with respect to EMR Software & studying and discussing the various modules of the software. I did market research on various organizations as a part of Mergers & Acquisitions activity of the organization. I underwent assessment of my learnings based on EMR Software. I was involved in getting training in relation to several tools of MS Excel. I underwent training about HIPAA Basics, Information Security Certificate and Preventing discrimination & Harassment at Workplace. I also did research on other ophthalmology software involved in providing co-management support to the health care providers.

LEARNING FROM INTERNSHIP PERIOD

The major learning gathered from this period are as follows-

1. Hands-on experience on EMR Software working.
2. Insight over the different queries raised by the clients over the EMR Software.
3. Overview of EMR softwares in field of Ophthalmology in US market
4. Overview of Glossary of Ophthalmic terminologies and insights of common eye diseases like AMD ,Cataract, Glaucoma
5. Market Research for Mergers & Acquisitions Activity using several market research tools like Zoho, Bloomberg, Owler etc.
6. Received several trainings like- HIPPA compliance, IT security, MS excel

DISSERTATION REPORT

"Importance of Clinical Decision Support System in Predicting Ocular Disease Diagnosis & Management

CHAPTER-1

1.1 INTRODUCTION

As the work of healthcare professionals and physicians is largely a work of making decisions and solving problems. It is a work of choosing issues that require attention, setting goals, finding or designing suitable courses of action and evaluating and choosing among alternative actions. They must choose from and interpret a huge variety of clinical data, while facing pressure to decrease uncertainty, risks to patients and costs. The true essence of healthcare delivery is decision making - what information to gather, which tests to order, how to interpret and integrate this information into diagnostic hypotheses and what treatments to administer.

Health care in general, is experiencing an information boom. The rapid expansion of scientific knowledge and pace of technologic development (e.g., pharmaceuticals, genomics, imaging modalities, procedures, diagnostics, and devices) have resulted in an overwhelming sea of data that is difficult to decipher and apply [1-4]. This expansion has translated into an ever-increasing set of variables that must be managed as part of clinical care. Just as technologic advancement has driven this information boom, technologic advancement, in the form of clinical informatics and electronic health data management, can be part of the solution for the challenges posed by this growth in information.

Rapidly accumulating clinical information can support quality care and discovery. Future success depends on information management, access, use, and reuse. Electronic health records (EHRs) are highlighted as a critical component of evidence development and implementation, but to fully harness the potential of EHRs, they need to be more than electronic renderings of the traditional paper medical chart.

Most hospitals collect huge amounts of electronic administrative and clinical data. Without returning these data to clinicians, collected e-information about healthcare services fails to inform clinicians [5]. Administrative and demographic information, diagnoses, treatments, prescription drugs, laboratory tests, hospitalizations, and patient insurances, are cumulated. Doctors are primarily involved in the collection of clinical data. Despite doctors invest energies and time collecting patient information during visits, this information, at best, comes back after some times (e.g., at the end of the year), in a report aggregating data from different patients and doctors. So, the feedback is not pertinent to a specific patient (i.e., non-selective) but applies to an average patient visited in the past (i.e. asynchronous) being not that helpful [6]. Computer applications that regularly and effortlessly track key clinical and administrative data and select the information that applies to a single patient may support real-time clinical decision-making conveying on time messages.

One of the major innovations in this field is computerized decision support systems (CDSSs) that are fully integrated with electronic health records (EHRs) and evidence-based knowledge [7]. CDSSs are information technology-based software that provides clinicians, staff, patients, or other individuals with person-specific, actionable recommendations, or management options that are intelligently filtered or presented at appropriate times to enhance health and health care [8,9]

Recent researches investigates the potential to assist with problems raised in clinical practice, decrease the rate of medication errors, increase the adherence of the clinicians to guideline-or- protocol based care, and, ultimately, to improve the overall efficiency and quality of healthcare delivery systems [10-23]

Large amount of Protected Health Information and health data is stored in the EMR & EHR software which could add to a great value in clinical research, errorless diagnosis, better treatment planning and efficient patient care.

1.1.1. US Healthcare

Health care in the United States is provided by many distinct organizations. [24]. Health care facilities are largely owned and operated by private sector businesses. 58% of US community hospitals are non-profit, 21% are government owned, and 21% are for-profit [25]. According to the World Health Organization (WHO), the United States spent more on health care per capita ($8,608), and more on health care as percentage of its GDP (17%), than any other nation in 2011.

64% of health spending was paid for by the government in 2013, [26,27] funded via programs such as Medicare, Medicaid, the Children's Health Insurance Program, and the Veterans Health Administration. People aged under 67 acquire insurance via their or a family member's employer, by purchasing health insurance on their own, or are uninsured. Health insurance for public sector employees is primarily provided by the government.

Meaningful use is using certified electronic health record (EHR) technology to:

- Improve quality, safety, efficiency, and reduce health disparities
- Engage patients and family
- Improve care coordination, and population and public health
- Maintain privacy and security of patient health information

Meaningful use sets specific objectives that eligible professionals (EPs) and hospitals must achieve to qualify for Centers for Medicare & Medicaid Services (CMS) Incentive Programs

CMS grants an incentive payment to Eligible Professionals (EPs) or Eligible Hospitals (EHs), who can demonstrate that they have engaged in efforts to adopt, implement or upgrade certified EHR technology. In order to encourage widespread EHR adoption, promote innovation and to avoid imposing excessive burden on healthcare providers, meaningful use was showcased as a phased approach, which is divided into three stages which span 2011 (data capture and sharing), 2013 (advanced clinical processes) and 2015 (improved outcomes). The incentive payments range from $44,000 over 5 years for the Medicare

providers and $63,750 over 6 years for Medicaid providers (starting in 2011). Participation in the CMS EHR incentive program is totally voluntary, however if EPs or EHs fail to join in by 2015, there will be negative adjustments to their Medicare/Medicaid fees starting at 1% reduction and escalating to 3% reduction by 2017 and beyond.

Meaningful Use Stage 2, Stage 3, and Clinical Decision Support requirements

The CMS EHR Incentive Program (Meaningful Use) Stage 3 final rule requires that eligible professionals and eligible hospitals should implement clinical decision support interventions. The CDS measures and objectives change from 2015-2017 and 2018.

- **2015-2017 Clinical Decision Support Objective**
  Use clinical decision support to improve performance on high-priority health conditions.

- **2015-2017 CDS Measure 1**
  Implement five clinical decision support interventions related to four or more clinical quality measures at a relevant point in patient care for the entire EHR reporting period. Absent four clinical quality measures related to an EP, eligible hospital, or
  CAH's scope of practice or patient population, the clinical decision support interventions must be related to high-priority health conditions**.**

- **2015 Alternative Measure 1**
  For an EHR reporting period in 2015 only, an EP, EH, or CAH who is scheduled to participate in Stage 1 in 2015 may satisfy the following in place of Measure 1:
  - Implement one clinical decision support rule relevant to specialty or high clinical priority, or high priority hospital condition, along with the ability to track compliance with that rule.
  - Measure: Implement one clinical decision support rule

- **2015-2017 CDS Measure 2**

  The EP, EHs or CAH has enabled and implemented the functionality for drug-drug and drug allergy interaction checks for the entire EHR reporting period.

    - Exclusion: For the second measure, any EP who writes fewer than 100 medication orders during the EHR reporting period.

- **2018 and Beyond Clinical Decision Support Objective**
  Implement clinical decision support (CDS) interventions focused on improving performance on high-priority health conditions.

CDS is not simply an alert, notification, or explicit care suggestion. CDS encompasses a variety of tools including, but not limited to:

- Computerized alerts and reminders for providers and patients
- Clinical guidelines

- Condition-specific order sets
- Focused patient data reports and summaries
- Documentation templates; diagnostic support
- Contextually relevant reference information.

These functionalities may be deployed on a variety of platforms (e.g. mobile, cloud-based, installed).CDS is not intended to replace clinician judgment, but rather is a tool to assist care team members in making timely, informed, higher quality decisions. The "Five Rights" concept provides a best practice framework that providers may consider in considering CDS options appropriate for their practice. The Five Rights concept states that in order to provide these benefits, CDS interventions must provide:

- The right information (evidence-based guidance, response to clinical need),
- To the right people (entire care team – including the patient),
- Through the right channels (e.g., EHR, mobile device, patient portal),
- In the right intervention formats (e.g., order sets, flow-sheets, dashboards, patient lists)
- At the right points in workflow (for decision making or action).

Ophthalmology is the branch of medicine that deals with the anatomy, physiology and diseases of the eyeball.

An ophthalmologist is an MD, trained to care, diagnose and treat all eye diseases and conditions, performs eye surgery, prescribes & fits eyeglasses and correct vision problems. She/he specializes in a specific area of medical or surgical eye care. An optometrist's role is confined to performing eye exams, vision tests, prescribing and dispensing corrective lenses, detecting certain eye abnormalities, and prescribing medications for certain eye diseases. Many optometrists perform pre- and post- operative care for eye surgeries including cataracts, retinal detachments, laser refractive surgeries and diabetic retinopathy

There are approximately 23,861 ophthalmologists and 45000 optometrists in the United States, according to the American Medical Association. There are seven recognized subspecialties within ophthalmology, according to the American Academy of Ophthalmology. They include: cornea and external disease, glaucoma, neuro-ophthalmology, ophthalmic pathology, ophthalmic plastic surgery, pediatric ophthalmology and vitreoretinal diseases.*[28]

US Eye Disease Statistics

Visual impairment is a national and global health concern that has a negative impact on physical and mental health. Visually impaired individuals are at particularly high risk for chronic health conditions, accidents, social withdrawal, depression, and mortality.

Visual impairment is defined as 20/40 vision, or worse, in the better eye even with eyeglasses. Whereas a person is legally blind if their visual acuity, with best correction in the better eye, is worse than or equal to 20/200, or their visual field is less than 20 degrees in diameter.

Economic Burden

$139 billion = estimated annual economic burden of vision loss and eye diseases and vision disorders in the U.S.

Burden of Blindness and Low Vision

1.3million Americans are blind (≤20/200); an estimated 2.2 million Americans will be blind by2030. 2.9 million Americans have low vision (<20/40); an estimated 5 million Americans will have low vision by 2030.

Major Eye Diseases

Age-related Macular Degeneration (AMD)

2.1 million Americans have advanced AMD; an estimated 3.7 million will have advanced AMD by 2030.

Glaucoma

2.7 million Americans have glaucoma; an estimated 4.3 million will have glaucoma by 2030.

Diabetic Retinopathy

7.7 million Americans have diabetic retinopathy; an estimated 11.3 million will have diabetic retinopathy by 2030.

Cataract

24 million Americans are affected by cataract; an estimated 38.7 million will be affected by cataract by 2030.

Refractive Error

34.1 million Americans are nearsighted; an estimated 39 million will be nearsighted by 2030.

14.1 million Americans are farsighted; an estimated 20 million will be farsighted by 2030.

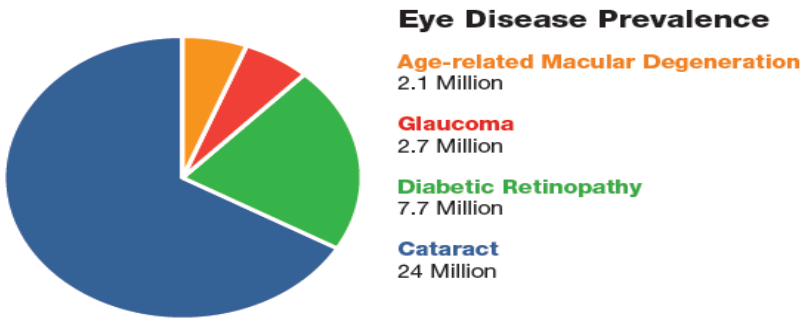


FIG-1 US EYE DISEASE STATISTICS

www.nei.nih.gov

Cataracts are the cause of half of blindness and 33% of visual impairment worldwide.

About 20 million people are blind due to cataracts. It is the cause of approximately 5% of blindness in the United States and nearly 60% of blindness in parts of Africa and South America. Blindness from cataracts occurs in about 10 to 40 per 100,000 children in the developing world, and 1 to 4 per 100,000 children in the developed world [9]. Cataracts become more common with age. More than half the people in the United States had cataracts by the age of 80.

Cataract surgery is one of the most common procedures in the United States, with more than 22 million Americans age 40 and older affected by cataracts. By age 80, more than half of all American will have cataracts and had cataract surgery, according to the National Eye Institute. The number of cataract cases is expected to increase in the next 10 years as a result of the aging baby boom generation

www.aao.org – PPP guidelines

1.2. EHR AND CDSS IN FIELD OF OPTHALMOLOGY

The field of ophthalmology has a number of unique features, compared to other medical and surgical specialties, with regard to clinical workflow and data management. This has important implications for the design of electronic health record (EHR) systems that can be used intuitively and efficiently by ophthalmologists, and which can promote improved quality of care.

The Institute of Medicine has described key capabilities of EHR systems related to health care delivery, and the Centers for Medicare and Medicaid Services (CMS) has defined specific "meaningful use" criteria for EHRs. These basic functions are required of all EHR systems, and include recording of problem lists and active diagnoses, electronic prescribing, computer-based provider order entry, and drug-drug interaction checks [5-7].

Beyond these general functions, EHRs must meet additional special requirements to be useful to address the unique needs of ophthalmologists. These stem from the field's constellation of medical and surgical care, heavy reliance on interpretation of diagnostic imaging, high-volume clinical practices with complex workflows, and documentation requirements involving a combination of numerical, text-based, and image-based data elements. By recognizing and accounting for these special requirements, EHR systems will be better able to help ophthalmologists provide higher-quality care, with improved safety and efficiency [8-10].

Virtually all EHR systems include traditional data fields for clinical documentation (e.g., history of present illness, family history). In addition to these traditional data fields, Ophthalmology EHRs should organize ophthalmology-specific data fields separately (e.g., past ocular history, ocular medications). EHRs should enable entry and storage of discrete clinical information specified in the Preferred Practice Patterns™ of the Academy that are relevant to patients. These Preferred Practice Patterns also provide a basis for developing computer-based clinical decision support tools. Systems should provide links to relevant Preferred Practice Patterns, other clinical decision support resources, and patient education materials.

Ophthalmology cases have the highest rate of incorrect procedures within the operating room, according to a study in the Nov. 2009 issue of the *Archives of Surgery*. The study found that 1.8 adverse events were reported per 10,000, more so than any other surgical specialty.

Ophthalmologists are continuing on the right path by embracing clinical and administrative data management technologies faster than many others, and for several reasons:

- A focus on treating medical problems beyond routine eye exams
- The requirement to capture and manage complex and interconnected data
- High patient volumes requiring practices to combine accuracy and efficiency

In addition, ophthalmology often combines medicine and surgery with a detailed clinical follow-up. Extensive data sets for each patient typically comprise numbers, text, and images.

So, at the point of care, ophthalmologists continue to evaluate and ask for electronic health record (EHR), practice management, and clinical decision support solutions developed explicitly for the clinical diagnoses, treatments, procedures, and administrative challenges inherent in ophthalmology.

CDS is maturing into a vital medical information, diagnosis, and procedural tool that may enhance both productivity and clinical accuracy across the spectrum of general and specialty medicine. At its core, computerized CDS is a knowledge-based computer program functionality that supports clinical diagnosis and treatment plan processes, promotes the use of best diagnostic and procedural practices, provides condition-specific guidelines, and may enhance population-based patient management

1.3. SCOPE STATEMENT

The study will be limited to defining the Importance of CDSS in diagnosis & Management of Ocular diseases with a specific focus on Cataract and its pre & post-operative co-management pertaining to United States Healthcare Scenario. The study will highlight the architectural framework of CDSS along with different types of CDSS and role of CDSS in improving the outcomes of Cataract treatment. Also the study proposes a CDSS alert system design with the help of a clinical pathway for management of cataract cases

1.4. PROBLEM STATEMENT

Aging baby boomers and their risk towards age related conditions add to the global burden of diseases. According to World Health Organization, approximately 285 million visually impaired people are reported; with cataract becoming the major cause of visual impairment. With a gro1.4.wing population of baby boomers and following the trends of growing eye diseases and eye conditions, there is a need of incorporation of the concept of CDSS in the field of optometry for precision decision making and errorless diagnosis.

Eye diseases and conditions require early diagnosis, prompt treatments, surgeries accompanied by follow up care as most of the eye diseases are associated with some or the other systemic, genetic & ocular comorbidities. The ocular comorbidities as well as the eye-related systemic disorders increasingly strain healthcare sectors and societies worldwide, especially within the aging population

Most patients are primarily managed by general physicians and advanced practice nurses. A precise early diagnosis is needed with appropriate protocols in order to avoid severe complications, visual impairment, and blindness. For successful global and eye/vision care, outstanding new strategies on the basis of an interdisciplinary team have to be established with the main goal of introducing a variety of quality improvement interventions that can achieve better results in the clinical practice and health systems [29-31].

Implementation of electronic medical records with integrated CDSS can reduce the US healthcare cost to great extent by reducing medical errors. This review study focuses on highlighting the existing framework of CDSS in the field of optometry in US healthcare system. It discusses the clinical pathways for cataract management and description of alert system required for its management

1.5. OBJECTIVE

To review the Importance of CDSS in predicting Ocular Disease Diagnosis and Their management.

SPECIFIC OBJECTIVES-

1. To review the existing framework of CDSS in US market
2. To review the importance of CDSS in field of Ophthalmology.
3. To propose a clinical protocol for the co-management of Cataract cases in US
4. To propose a model for description of type of alerts required for Cataract management as per CQM for meaningful use.

1.6. RESEARCH METHODOLOGY

- Research Design

The study is exploratory in nature. The data collection sources for this study are secondary data sources.

- Search Strategy

All major bibliographic databases and several specialist datasets were searched. The search strategies included terms such as CDSS, knowledge based care, and Evidence based care, Machine learning approach, decision support system in ophthalmologic-management of cataract cases, shared care, collaborative care in ophthalmic diseases, preferred provider practices, Quality of care in co-management of cataract cases. Citations of papers that used a reference standard for assessment of quality were searched. A literature search of three relevant databases ("Medscape", "BMJ" and "PubMed") and website search of AAO, CMS, HMISS, and meaningful use sites data was conducted. There was no limitation of publication date in the search.

- Selection Criteria

Selection criteria for the literature review:
1) Articles written in English
2) Articles focused on CDSS, Preferred practice guidelines, Clinical Practice Guidelines, knowledge based frameworks of CDSS, Medicare and co-management of cataract.
3) Articles related to quality of care and showing diagnosis and medication errors due to misdiagnosis
4) Based on empirical studies and published in scientific journals
5) Articles focused on importance of CDSS in ophthalmology. The articles first identified in the reference lists of the papers found through the database searches were also assessed.

Data Analysis

A sub-systematic method was followed, which was divided into three phases: literature collection, assessing, and selection. The literature search was conducted.40 articles were collected. After excluding the duplicated articles, some articles were excluded based on the following criteria:

1) Articles related to CDSS other than knowledge based or evidence based method.
2) Articles related to cataract co-management in geographical areas other than USA
3) Articles related to highlighting the role of CDSS in domains other than ocular diseases.

After filtering articles selected were investigated to explore the existing scenario of CDSS in ophthalmic disease management accompanied with focus on CDSS for high priority disease conditions as required for MIPS & PQRS requirement of meaningful use.

For each of the studies that had survived this filtering, the research approach was first assessed. If it was a qualitative study, the number of cases and the methods used in data collection were identified. If it had used a quantitative approach, information concerning the sample size was sought. Secondly, the results of the studies related to CDSS and its importance in co-management of cataract cases were summarized. In the analysis phase a comparative approach was used in which all the selected articles were investigated to review the existing scenario of CDSS as well as its Importance in ocular disease diagnosis and management.

LIMITATIONS

This review study experienced certain limitations, which are as follows-

1. Geographical Limitation- This review study was limited to United States Healthcare System. All the studies which were included in the review, were conducted in United States.
2. Specialty Limitation- The study was limited to review and explore importance of CDSS in ophthalmology. The search of articles & reports were restricted to ocular diseases only.
3. Disease Limitation- Among the Ocular diseases the requirement for CDSS for reporting high priority quality care as per CQM for Cataract management was considered
4. Source Limitation- The review study was limited by secondary data sources. Since there was no primary data source, the study included various reports, articles available on web portal, scholar articles & books etc.

1.7. REVIEW OF LITERATURE

Clinical Decision Support Systems are "active knowledge systems which use two or more items of patient data to generate case-specific advice" [Wyatt J, Spiegelhalter D, 1991].

Robert Hayward defines CDSS as, 'CDSS link health observations with health knowledge to influence health choices by clinicians for improved health care.' CDSS helps increasing the efficiency of health care, help reducing the human errors, and is a cost-effective and smart solution to healthcare industry.

CDSS is built upon the foundation of an electronic health record (EHR). CDSS includes functions like alerts, reminders, treatment focused order-sets, documentation templets, integration with clinical guidelines and protocols, patient reports and summaries, accurate and timely diagnosis, suggesting treatment available etc.

History of CDSS

- Many attempts have been made in past to make a software that can assist physicians in their decisions. History of CDSS dates back to 1972 when De Domble started early artificial intelligence and developed a system for acute abdominal pain at Leeds University. The method used by him was Bayesian method, describes the probability of occurrence of an event, based on prior knowledge of conditions that is related to the event.
- Another software called INTERNIST-1 was developed in 1974 at University of Pittsburg as an educational experiment, which was to capture the expertise of just one man, Jack D. Myers, MD [33]
- MYCIN, a software named after suffix 'mycin' was developed in 1976 at Stanford University. It was mostly used for detection of bacterial infections. It's knowledge-based and works on the principle of 'if, then' and the reasoning scheme to the uncertainty model. MLM or medical logic module is a knowledge based software which used logics feed into it to assist the physician, mostly alerts. ONCOCIN was the software developed to assist physicians treating oncology patients in 1979 [34, 35]. It consist of reasoner (knowledge base) and interviewer (interface between ONCOCIN and the user or physician). It worked on the principle of 'if-then'.
- DXplain was designed at Massachusetts General Hospital in1986, which was used for assisting diagnostic tasks like differential diagnosis based on the patient sign and symptoms and lab investigations conducted and its results. QMC or quick medical reference was another software developed by University of Pittsburgh in 1980. It was based on INTERNIST-1, and was specifically used for diagnostics purpose only, and consist of description of over 750 diseases. [35].

Importance of CDSS in Medical error reduction:

CDSS is a software that was designed to make the clinicians work easier and to assist him. Many studies have shown that CDSS have reduced the error rate of the hospital. Several studies were reviewed showing the reduction in rate of medical errors with the use of CDSS:

- In a study conducted by O'Connor et al in 2011 to know the impact of CDSS in patient care of those with diabetes 2 condition, there was a drastic improvement in in blood glucose level, and few aspects of blood pressure control. The study also showed that 94% of the physicians who were involved in the study were satisfied or very satisfied with CDSS [37].
- Press et al (sept 2015) conducted a study to know the usability level of CDSS and to improve the usability level of CDSS. The CDSS was installed in emergency room and testing methods used were "think aloud" and "near-live" method. This helped in assessing the CDSS and helped in refining the tool, which later helped in increasing the usability level [38].
- Chrimas et al conducted a study to analyses the usability of CDSS in the pre-diabetes counselling. They divided the usability testing into two phases, phase 1 consisting of "think aloud" protocols and phase 2 consisting of "near-live" stimulations. Maximum of the negative remark (approx. 80%) came in phase 1 and were associated with understanding the use of CDSS. Phase 2 associated with usability part was mostly had positive remark. This concluded that most of the problems came up with understanding part of CDSS [39].
- Goud et al (2009) conducted a study on multidisciplinary team for exercise and education therapy and found that CDSS guidelines was helping in improving team coordination [40].
- A study on prescription of pharmaceutical drugs integrated with CDSS done by Shemeikka et al (2015) concluded that CDSS increase the attention on patients with impaired renal function and helps to provide better medication dosing to patient [41].
- Bescos et al (2014) conducted a study on web-based CDSS on language disorder screening in nursery school and found that CDSS was able to detect more children with language disorder and helped monitoring neurodevelopment disorder [42]
- Fathauer and Meek (2012) conducted a comparison study to know the clinical outcomes on patients suffering from hepatitis c virus (HCV) in pre- CDSS and post-CDSS patients care. They found that there were higher frequency of reminders and better care provided to patients in post-CDSS implementation case [43]
- A recent report by Graber ML et.al on Diagnostic error in internal medicine**.** that 74 percent of misdiagnoses involved cognitive errors by the physician. The most common errors were associated with "premature closure", the tendency to stop considering other possibilities after reaching a diagnosis [44] Over a 25 year period, diagnostic errors accounted for 28.6% of US malpractice claims [45].

Limitations of CDSS:

Although many studies have shown that CDSS actually aids the physicians and increases the efficiency and effectiveness of the care being given to patient, but not necessary in all the cases it shows positive results.

- Gill et al in 2011 conducted a study on geriatric patients who were consuming NSAIDS and suffered from GI complications. CDSS guidelines were used to improve the condition, but the result showed only small impact on patient condition [46].
- Hagiwara et al (2014) conducted a study to assess the CDSS use in pre-hospital and hospital settings, it was found that CDSS increased the compliance of treatment in pre-hospital settings i.e. with medical emergency, but showed not significant effect in hospital settings [47].

- Dixon et al (2014) studied the comparison between a local and cloud-based CDSS and found that both showed similar results and were similarly effective [48].
- Kersting C (2016) studied the CDSS use for management of mutlimorbid conditions like hypertension, coronary heart disease, cardiac insufficiency, chronic stomach problems, and diabetes in senior citizens (above 64 years of age) in primary care. There was no significant improvement in the patients suffering from multimorbid condition [49].
- Sambasivan et al (2012) conducted a study to know the intention of the physicians towards CDS in developing countries in Kuala Lumpur, Malaysia. They found that physicians perceived a threat to professional autonomy from CDSS. But physicians' involvement I planning, designing and implementing of CDSS and making them aware of the benefits of CDSS can be helpful [50].

CHAPTER-2

2.1. GENERAL CDSS OF MODEL

CDSS model includes three basics:

1. Medical knowledge base: knowledge base is a computer program where all the reasoning process to make decision occur. All the logics and codes are applied here to solve complex problems.
2. EMR or electronic medical record: medical condition like signs and symptoms diagnostics and lab results and other information related to patient is here.
3. Interface engine: it's the connection between knowledge base and EMR. All the alerts, pop-ups and recommendations are given through interface engine.

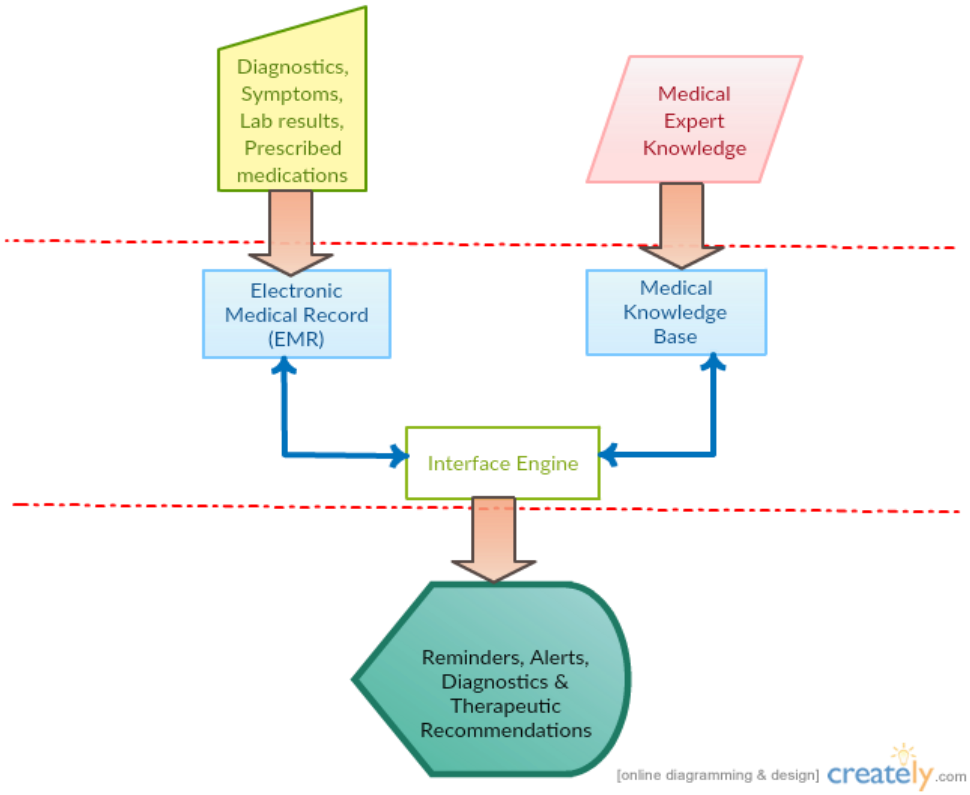


FIG2- Model of CDSS

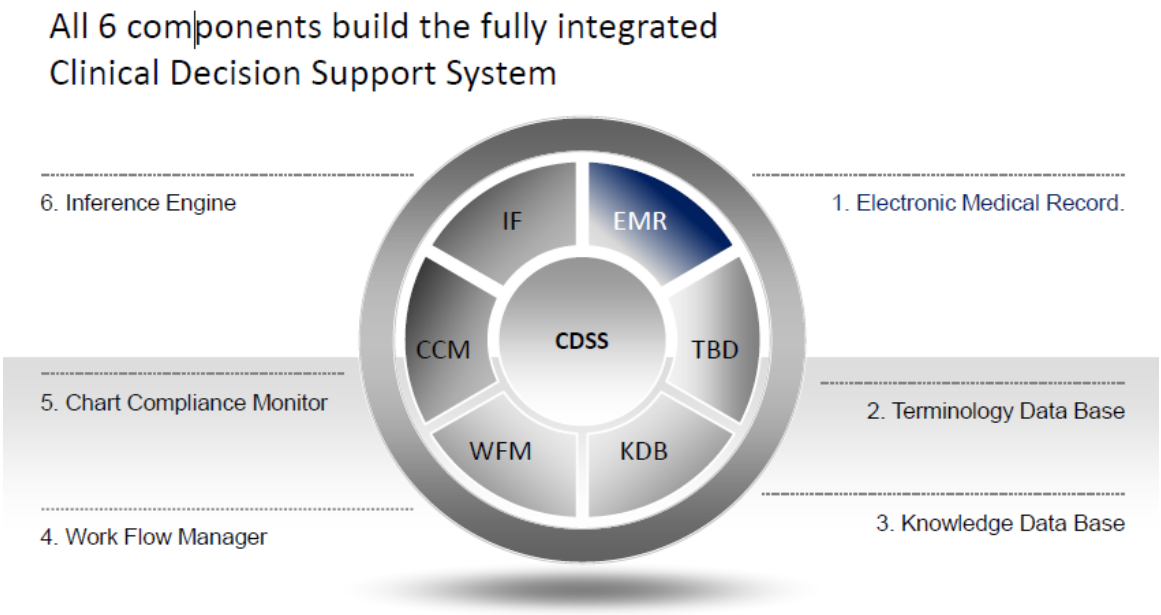


FIG-3 COMPONENTS OF CDSS (*Ref-CSC PAPERS)*

2.2. Types of CDSS

CDSS can be differentiated into many types based on its model, application, integration, mode of data extraction and storage etc. Following is the types of CDSS:

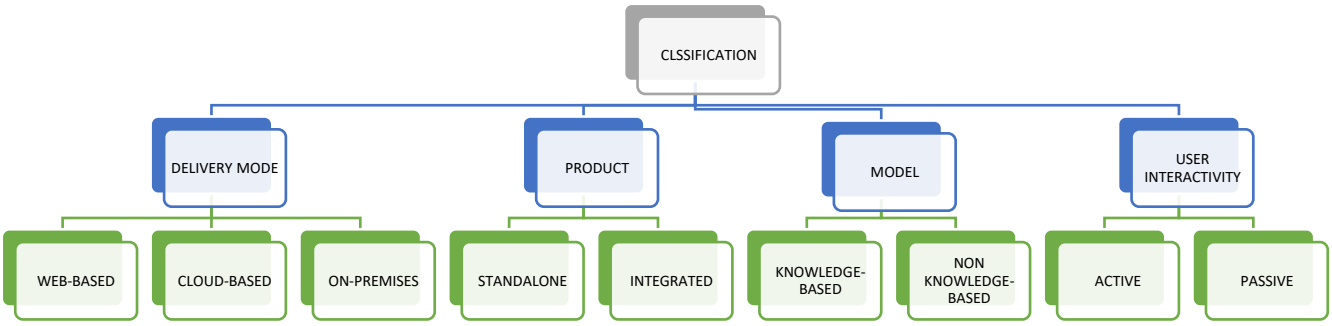


FIG-4 Classification of CDSS

Types of Clinical Decision Support System (CDSS) based on its model

- Knowledge based CDSS
- Non Knowledge based CDSS

Knowledge based CDSS extracts the knowledge form the existing database, applies some logic and gives an output based on it. It tries to replicate the logic and reasoning like a human decision making and gives results based on existing knowledge. The system theoretically mimics the thought processes of a real-life clinician and then give a finalized diagnosis based on the knowledge. CDSS provides variety of diagnostic as well treatment options to healthcare providers and allows them to analyses the decision options given by system based on the patient information. There are three main parts to a knowledge-based CDSS:

- Knowledge base
- Inference engine
- User communication method.

The knowledge base includes the information that is compiled in form of some logical rule so that the system understands the information and is able to make decision. User inputs patient information in the system and system searches through its knowledge base for matching the key words and then based on logical rule, like IF-THEN rule come to some decision with respect to the diseases or treatment possibilities.

Interface engine contains the necessary formulae that are required for combining the rules in the knowledge base in relation to available patient data, thus allowing the system to create patient-specific rules based on patient's data about past medical history and current condition.

User communication is the user interface where the healthcare provider inputs the patient's relevant data and then receives the corresponding results. The patient data may be provided by electronic records or may be manually entered.

The knowledge based CDSS process involves:

- Input: input is entering the clinical information into the system. As a symptom, disease or a condition may have synonyms and different vocabularies can be used, so there is always a set defined dictionary from which the key words can be selected. In most of the cases ICD coding can is used to define a disease.
- Inference Engine: Interface engine is the system that with the help of input and the knowledge base helps process the information to give a meaningful output. This process occurs in backend. Various techniques used in interface engine are IF-THEN rule, Mycin, Baye's rule etc.
- Knowledge Base: Knowledge base is the collection of all the medical information which is compiled in form of logical rule. This knowledge base is the storage house of all the medical or

clinical information and from here data is retrieved when required. The data is encoded in such manner that all the information can be computed by the processor to give desired result. There are four forms of knowledge representation:

- Logic: Some logic is applied to the knowledge based on which decisions are presented.
- Procedurals: Procedurals provides the knowledge and description of what actions and decisions are needed to be taken.
- Graph/network: It's the representation of knowledge in form of graphs and networks.
- Structured systems: It's the medical or clinical information stored in the knowledge base in a structured form. This structuring helps in easy computing of the knowledge in data base.

- Output: output is the result or the suggestion received from CDSS. The output in CDSS is represented in the form of a list of solutions raked in way of most probabilistic or suitable result at the top of the list, followed by other as per the rank. This list is generally in test form, but may also be in graphical or some other form.

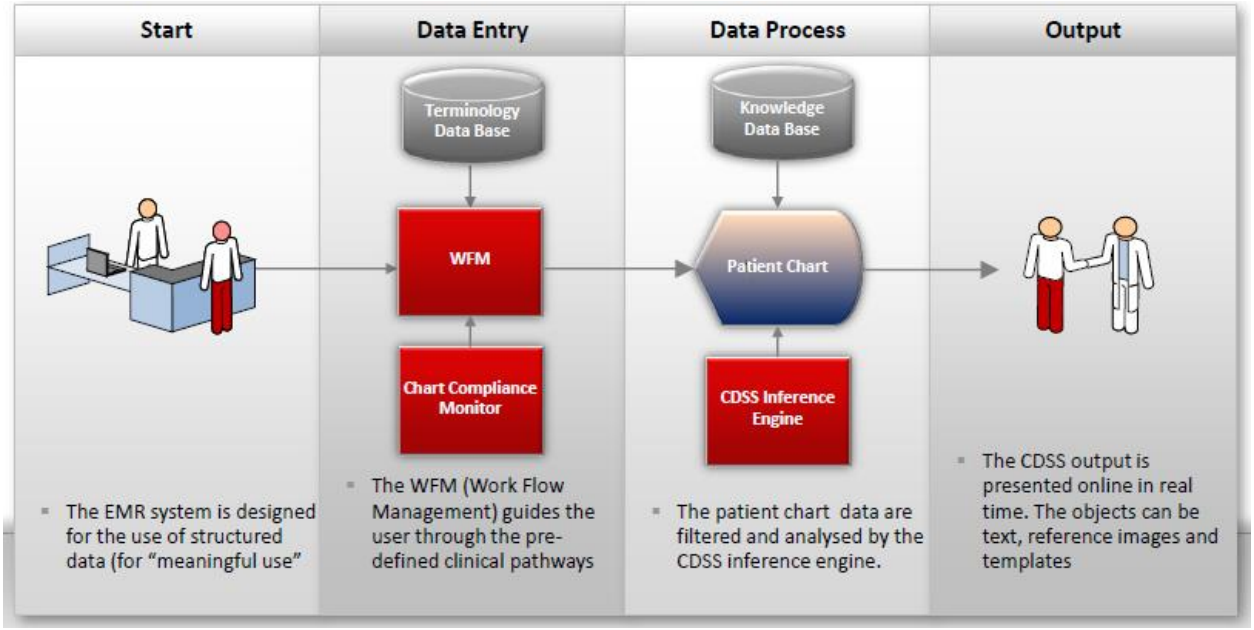


FIG- 5 Workflow of Knowledge Based CDSS *(www.engr.uconn.edu)*

Non-knowledge base CDSS

Non-knowledge base CDSS consist of artificial intelligence or 'machine learning'. It's a user-defined knowledge base in which the virtual knowledge is replicated form the real healthcare provider. The computer learns and gains its knowledge on the basis of past experience and replicate the clinical patterns into knowledge base. Non-knowledge based CDSS mostly focus on limited number of symptoms and diseases, whereas knowledge based CDSS cover a large number of diseases under it.

Types of Non-knowledge based CDSS are:

- Artificial Neural Networks (ANN)
- Genetic Algorithms

Artificial Neutral Networks (ANN)

Artificial Neural Networks (ANN) simulate human thinking by assessing and evaluating the occurrences and eventually learning from existing patterns. An ANN consists of:

- Neuro nodes: They are series of nodes, which may be related to neurons in human brain.
- Connections: These are weighted connections that perform the function of transmitting signals in unidirectional mode, and may be related to synapses in human brain.

An ANN contains three modules:

- Input: It receives the clinical data via user interface.
- Output: The results are the output and are displayed to user.
- Data processor: It processes the data to give significant result.

ANN does not consist of predefined knowledge base. It functions by studding the clinical patterns like signs, symptoms and conditions. ANN is initially trained by entering a large amount of data and clinical information into a neutral network. This results in giving outputs in form of educated guesses, and these guesses are adjusted according to its weights, with incorrect guesses being given more weight. This process is run until correct results are displayed. The training process may take a lot of time, thus is time consuming process. There are no logics and rules applied in it. ANN also has the ability of analyzing and processing incomplete data by guessing what the complete data could be. The system is unable to reason the logic behind the result it displays. ANN is mostly useful in case of chronic diseases like myocardial infarctions, cancers etc.

Genetic Algorithms

Genetic Algorithms are based on directed selection process which involves Charles Darwin's theories of natural selection and survival of the fittest. Genetic algorithms have the ability to regularly replicate themselves so as to give a better result. Genetic algorithms solve a problem via randomly generated solutions. These solutions undergo a fitness check through the use of a 'fitness function'. These solutions are ranked according to their fitness scores. The higher rank solutions have the ability to provide further better solution then lower ones. These higher ranked solutions are evaluated again in similar way to their parent solution to provide an upgraded result. This process is repeated until an appropriate solution is found. Genetic algorithms are not widely in use and mostly used in chronic diseases like chemotherapy administration and heart disease.

Other types of CDSS commercially available are discussed in the CDSS market section

2.3. The Five Rights of Clinical Decision Support

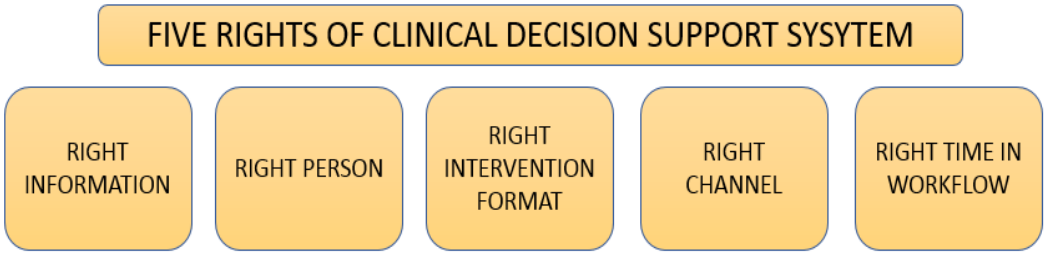


Fig-6 Five rights of CDSS (www.cms.gov)

Pillars of CDSS

To ensure optimal and effective use of CDSS and it's widely acceptance by providers, patients, and individuals, three pillars of CDSS were proposed by Osheroff are:

1. Pillar 1: Best Knowledge Available When Needed

Represent clinical knowledge and CDS interventions in standardized format and it should be both human and machine-interpretable. This is to aid variety of knowledge developers so that they can produce this information in a way that the users can understand, assess and apply it.

The users should be able to collect, organize, and distribute clinical knowledge and CDS interventions in standard format so that users can readily find the specific material they need and integrate that information into their own information systems and processes.

2. Pillar 2: High Adoption and Effective Use

To address policy, legal and financial barriers, and create additional support and aid for widespread CDSS adoption and deployment.

Improve clinical adoption and usage of CDS interventions by facilitating information system producers and implementers design CDSs with clinical knowledge, so that CDSS that are easy to deploy and use developed.

3. Pillar 3: Continuous Improvement of Knowledge and CDS Methods

CDSS data to be systematically captured, organized, and examined to prove access to data nationwide. Also sharing of the experience with CDSS and its usage to help in CDSS development.

Advancing the knowledge base by fully leveraging the data available in interoperable EHRs so as to enhance clinical knowledge and improve healthcare management

2.4. CDSS functional framework

CDSS framework consist of 3 phases [51]

Phase 1 (knowledge preparation): It is done via following:

- Data mining
- Data storage in knowledge base

Techniques such as classification, clustering and association are done here to enrich the knowledge base. Knowledge can be extracted from other sources, like domain expert experience and clinical practice guideline knowledge.

Phase 2 (knowledge interoperation): It takes the patient data that require decision making and translates it into standard XML (Extensible Markup Language) form and makes encoding of the knowledge from the knowledge base (KB) both patient data and knowledge base are converted to same format for easy functioning.

Phase 3(Knowledge interpretation): It extracts the previous standardized data and knowledge to makes decisions. This reasoning phase takes the patient current and historical data to search in the knowledge base for the most appropriate recommendations

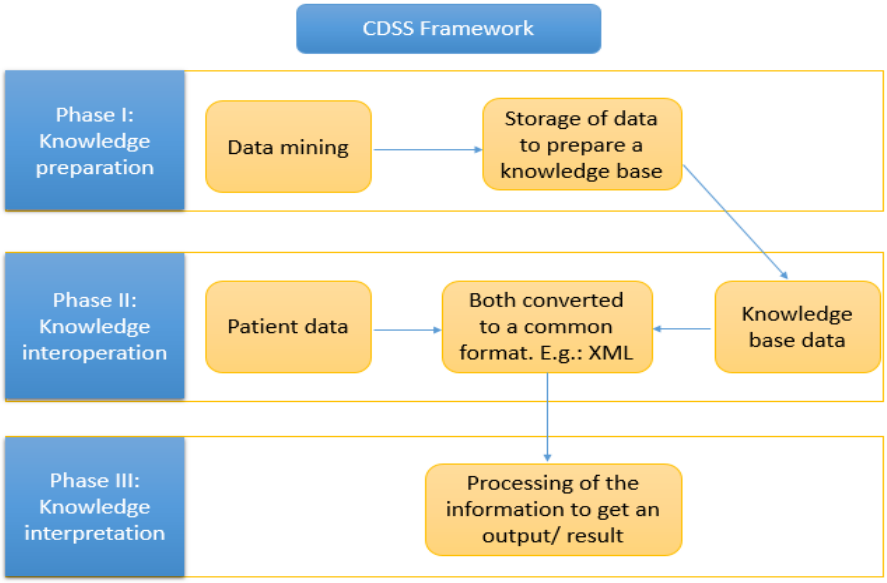


Fig-7 CDSS functional framework [51]

2.5. Logical Architecture of CDSS, applications of CDSS and implementation of CDSS

Architecture of CDSS consist of two parts that involve EHR architecture as well as CDSS architecture [52].

- Logical architecture of an EHR system
- Logical architecture of a CDSS system

Logical architecture of an EHR system

It is important to understand EHR architectural design to know CDSS architecture as CDSS is integrated with EHR. EHR consist of following components:

a) User Interface (UI)

User interface is the means by which the user and the computer system interacts and exchange information. User interface is a fundamental component of all clinical application, and is used to enter the records into the system (input), as well as to know the results generated by the system (output). Input involves recording a proposed medication or observed findings into the system. Output involves UI is to display alerts, messages and clinical guidelines to user.

b) Record Services

Record services are a set of services used for managing patient health record data. It helps to entry, search and retrieve health records, data extraction from health records and exchange of health records. Record services interact with other components such as the CDSS and the UI.

c) Terminology services

Terminology services are the standard medical terms that are given by the ARRA. They include SNOMED-CT, HL-7, etc. Terminology services are integrated with CDSS component

d) CDSS

CDSS helps to execute the decision support logic to assist the health care provider in decision making.

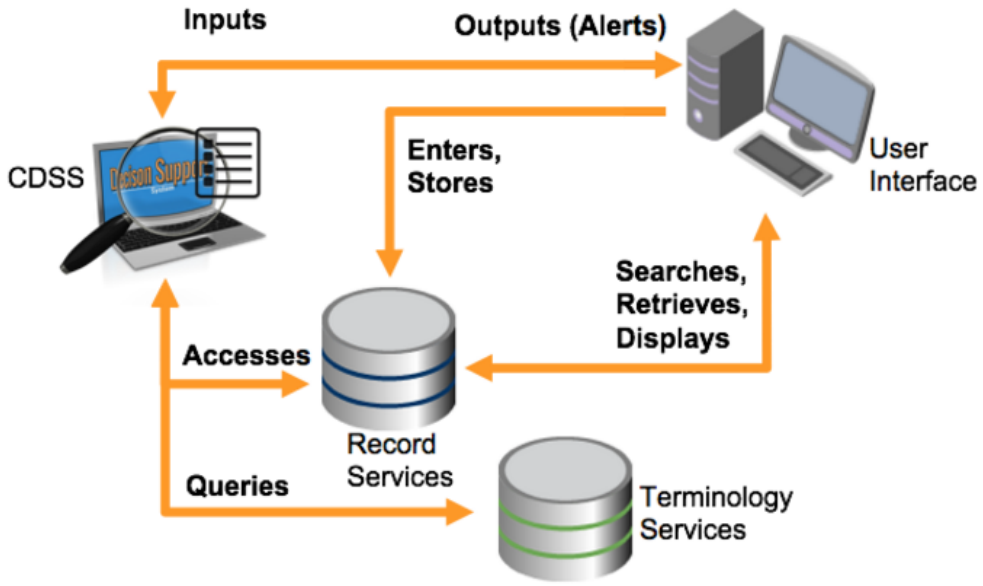


FIG-8 The logical architecture of an EMR system.[52]

Logical architecture of CDSS system

As CDSS has the ability of decision making, this process is done via logics to derive an appropriate result. This process involves many components, and they are as follow:

a) Knowledge Base (KB)

The knowledge base is the store house of clinical knowledge. It consists of rules and guidelines that are stored in a machine format and is made available to the user interface when required via data extraction. It contains the knowledge that is developed by clinical experts in their domain. This knowledge base is made available to the inference engine for data extraction to execute the decision support logic. Types of CDS knowledge artifacts include:

- Decision support rules
- Clinical guidelines and care pathways
- Documentation templates
- Order sets

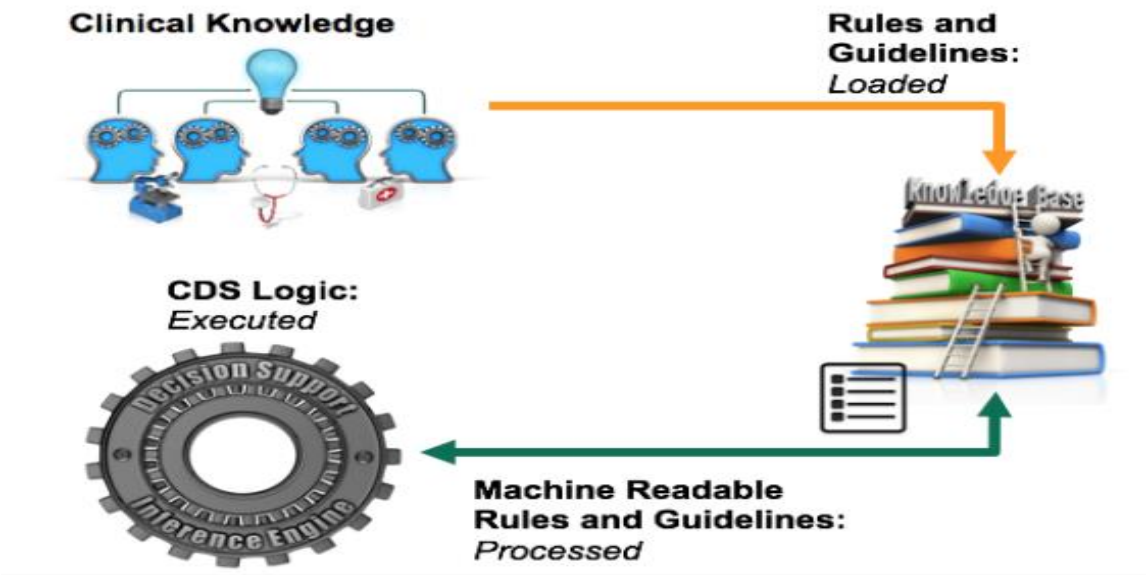


FIG-9 Logical Architecture of CDSS System [52]

Knowledge base consists of rules and guidelines.

Rules

It forms the logic patterns that are followed in CDSS and are modeled in several health standards. Rules are formed by following three components:

- Event: It is the clinical situation in which CDSS rule will apply. It is the event occurrence that triggers the CDSS to function and generate an output. Event is read as "ON".
- Condition: A condition defines the question set that must be answered to determine the outcome of the rule. It is used to answer various parameters in relation to the event. Condition is read as "IF".
- Action: It is the output. Action tells what should be done if an events occurs. Action is read as "THEN".

Fig-10 Event-condition-action model

Guidelines

Guidelines are the set of recommendations or instructions that should be followed for a condition. Guidelines can be prepared in two formats:

- Simple guideline markup: It's the free texting clinical guideline.
- Standard guideline: it consist of Guideline Definition Language (GDL) and the Guideline Interchange Format (GLIF).

b) Interface engine

It is the connecting medium between various applications. Inference engine helps to establish a condition where CDSS can communicate with other applications coming into play when a function is performed.

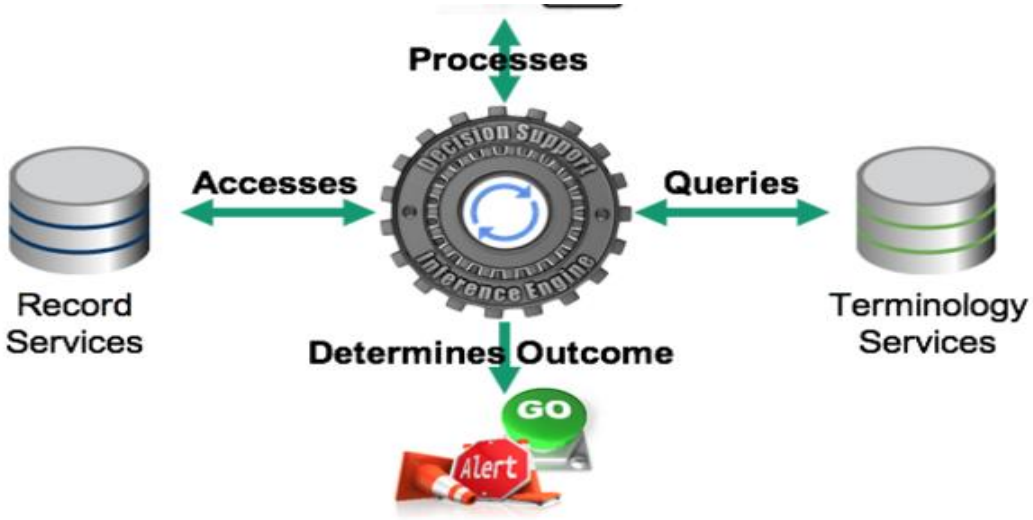


FIG-11 Interface Engine [52]

c) Communication

The communications mechanism is used to manage CDSS communications into and out of the system. Standards like HL-7 are used for medical data transfer and communication. Input data involves actions like entry of patient data, selection of order set, choosing medication or treatment regime. Output involves CDS interventions like alerts, suggestions, pop-ups, guidelines, diagnostic refinements, template/ forms, etc.

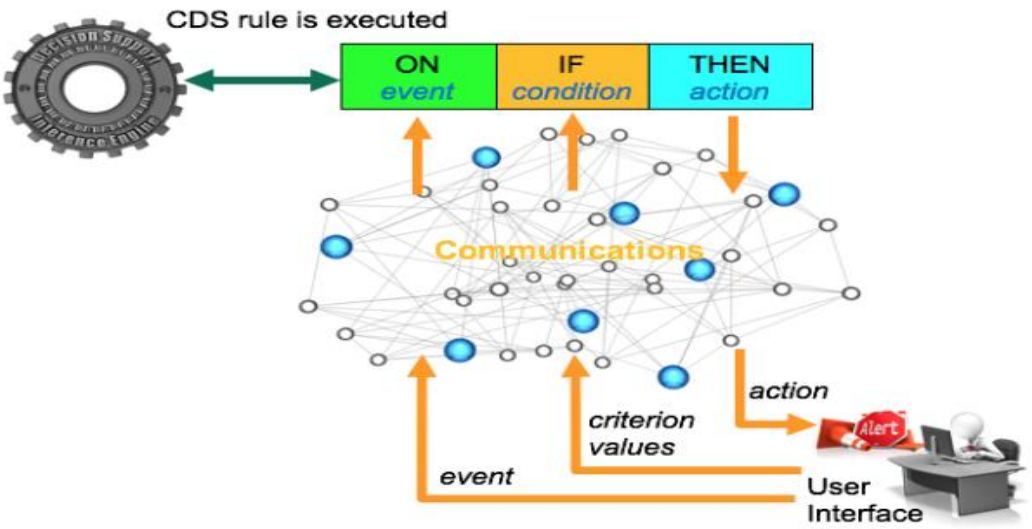


FIG-12 Communication process and CDSS rule execution [52]

2.6. Various tools being used for CDSS

Various ways by which CDSS provides information to the user.

- Alerts and reminders to care providers and patients: An alert is generated when the input data offers some potential risk to the patient.
- Clinical guidelines: Patient data is compared to system knowledge base (KB) when the healthcare provider is not very sure of the condition and not very familiar with it.
- Condition-specific order sets for diagnostic support: Once the condition is known, specific order-sets to diagnose the condition and treat it. It may consist of drop down menus.
- Focused patient data reports and summaries: Automated summary about the patient condition and treatment.
- Documentation templates: Templates that contain patient information about specific attributes.
- Contextually relevant reference information: Any information that's important and need attention with respect to particular patient or condition is displayed via pop-ups.

2.7. Application of CDSS

Preventive care:

- Immunization: CDSS generates timely reminders for various types of immunizations for specific patients.

- Early disease detection: CDSS analysis minor signs, symptoms and fluctuations in various lab results experienced by the patient and helps to take preventive measures beforehand.
- Drug allergy alerts: CDSS helps prevent the consumptions of the allergic drugs by providing alerts, thus preventing adverse drug reactions.
- Drug to drug interaction alerts: CDSS provides alters in case of contradictory drugs.

Diagnostic care:

- CDSS is used for suggesting diagnoses as per patient's signs and symptoms.
- CDSS have inbuilt order-sets with respect to given set of symptoms, which can be selected by the physician whenever required.
- CDSS also analysis the diagnostic results to recommend the possible condition or disease.
- Provide reminders for various **daily scheduled tests.**

Planning or implementing treatment:

- CDSS on the basis of signs and symptoms can recommend provisional diagnosis.
- CDSS provides treatment guidelines for specific diagnoses, especially for chronic diseases like cancer, heart diseases etc.
- CDSS recommends drug dosage, its route and frequency as per the condition.
- Follow-up management: CDSS provides reminders for follow-up dates for doctor visits, drug prescription and new drug orders, etc.

Hospital, provider efficiency:

- CDSS helps to form care plans and helps minimize the patient's hospital stay.
- CDSS increases efficiency of the physician by various pro-active approaches like order-sets, clinical reminder, etc.

Cost reductions and improved patient convenience:

- Duplicate drug alerts.
- Duplicate test alerts.
- Improve quality care given to patient
- Reduce hospital average length of stay of patients in hospital
- Standardize the care and treatment being provided to the patients.

Surveillance and research purpose: CDSS can be used for research purpose as it can help to convert all the patient electronic data or EMR of patients, which are in from of raw information into a useful data. All the variable or attributes required for study can be extracted from patient data and this can ease the gathering of data for a large sample size.

CHAPTER-3

3.1. Embedding CDSS implementation within CPOE and EMR

It is critical to design a useful CDSS so that it improves a clinician's workflow, it provides satisfactory system performance, and results in acceptable system reliability. Moreover, organizational factors, such as the leadership support, strong clinician champions and financial support, play a role in the success of CDSS implementation. A useable CDSS typically requires multifaceted domain knowledge that is expressed as inference rules in a computable, explicit and unambiguous form [53]

Three key elements for fully realizing the potential of a CDSS given by Osheroff are:

1. The best available clinical knowledge is well organized, accessible to clinicians, and encapsulated in a format that facilitates effective support for the decision making process

2. A useful CDSS is extensively adopted, and generates significant clinical value that contributes financial and operational benefits to its stakeholders.

3. Both clinical interventions and knowledge undergo constant improvement through user feedback, experience, and data analysis that are easy to aggregate, assess, and apply.

The integration of CDSS with EHR and CPOE helps in reduction the time consumed in providing the data about patient to computer to give some output, reduces the medical errors, increases efficiency of the healthcare providers and saves cost. This integration is done by standardizing both CDSS as well as EHR data into a single format that is read and understood by both. The standard used for exchange of medical messages is HL-7[56]. All the medical messages are HL-7 compatible, thus aids in exchange of medical records throughout the system. This exchange of messages takes place via an interface. Other standards used of medical information exchange are ICD (international classification of diseases), LOINC (Logical observation identifiers names and codes), SNOMED CT (Systematized Nomenclature of Medicine -- Clinical Terms), RXNORM, NDC (National Drug Code)

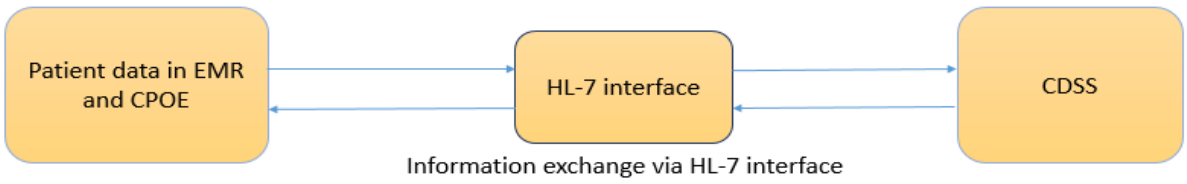


FIG-13 Information exchange via HL-7 Interface [53]

3.2. CDSS coding process

Every CDSS has at least two core components:

For accessing the health information manually the user need to access the MEDLINE databases. For this purpose different search engines have been developed, e.g. PubMed, HubMed, etc. These engines help to provide access to biomedical literature.

For accessing health information automatically in the clinical domain, 'Info-buttons' are used for data mining. Info-buttons are defined by Cimino as 'information retrieval tools that automatically generate queries to e-resources using contextual information and patient data from electronic medical records (EMR).' Info-buttons are based on topic-based linkages and it relates it to the data base with the help of query words. The query topics are pre-specified, and the user clicks on a specific Info-button next to query. The query is then generated from these topics and user receives potential external e-resources, e.g. Up-to-date, MedlinePlus, PubMed, etc.

The CDSS knowledge base imparts knowledge about the conditions via codes and logics in the form of rules including conditions (If part) and results (Then part). This creates knowledge-based query covering both patient context and user objectives. A standard language 'Arden Syntax language' is used for data transfer and use. Arden Syntax is a standard for representing clinical knowledge that is both understandable by humans as well interpretable by systems. CDSS has four key components, query management, communication management, evidence management, and rule management.

HL7 Arden Syntax and Medical Logic Module (MLM)

HL7 International Arden Syntax for Medical Logic Modules (MLMs) is used for encoding medical knowledge and also used for data sharing with other medical modalities and health information systems and institutions. It is approved by ANSI (American National Standard language). The Arden Syntax for Medical Logic Modules (MLMs) assists physicians in decision making via alerts, suggestions, guidelines etc. The logic encoded into MLM contains necessary knowledge to make a single decision.

An MLM is group of slots organized into three main categories and one optional category: maintenance, library, knowledge, and resources (optional).

3.3. Structure Parsing

- Simple If-Then statement
- If-Then-Else statement
- If-Then-Elseif statement
- NESTED IF: IF,IF,THEN
- Switch statement
- Call statemen

3.4. How to apply the logic?

Logic:

IF (treatment intent= 'the condition') THEN (treatment plan='the plan recommended') Output='this treatment plan is treatment recommended for this condition.' ELSEIF (treatment intend= 'condition') THENIF (treatment plan= 'the plan') Output='this treatment plan is treatment recommended for this condition.' ENDIF

3.5. User-CDSS interaction

CDSS, besides performing other functions need to be user friendly. Most of the clinicians are not very comfortable with technology, and thus may want some customization of the standard CDSS so as to operate it according to their will. The extent to which user can control CDSS may vary over largely. The CDSS may display suggestions on demand of user, i.e. whenever needed, or CDSS may be automated i.e. the circumstances under which users after viewing the CDSS information comes to a conclusion [22]. CDS may be designed to:

a) Reminder: Remind clinicians of things they should do but may not remember.
b) Provider: Provide information when physicians require.
c) Correct: Correct medical errors if any.
d) Recommend: Recommend treatment plans.

Most of the CDSS can be customized according to the requirements of the physicians, so that CDSS is able to provide the assistance to in most effective manner. But while preparing a CDSS, more focus is laid on its technical part than its user interface. CDSS may not be acceptable by many doctors because of many reasons like problems in its access during the point of patient care, complex and time consuming usage, etc. [2] Few issues may arise which physicians may face. They are:

a) Timing of the reminder: A message that should have been a reminder appears late and thus becomes recommendation.
b) Ease of access: Users may want the decision support but may be reluctant due to effortful access to information.
c) Information overload: Information may be overloaded by CDSS to user, thus interfering in efficient treatment process.
d) Click fatigue: Too many clicks may cause click fatigue, thus decreasing the efficiency of the user.

3.6. CDSS implementation process

CDSS has to undergo various technical as well no-technical processes to integrate it into hospital information system and gain acceptance by healthcare providers. This is done to achieve maximum usage of the CDSS and gain maximum benefits from it. According to Department of Health &Human Services [37] following is the brief of implementation steps that should be followed:

1. Involve Stakeholders and Communicate Goals: Effective communication and collaboration of all the stakeholders is required. The objectives of introducing CDSS in the organization should be clear and communicated in the organization. Mapping of clinical workflow should be done and all the stakeholders being effected by CDSS should be involved. Structure and size of the organization, culture and leadership factors should be considered.
2. Assess Readiness for Implementation: an assessment should be done to check the readiness of the organization towards CDSS adoption. Assessment helps in providing the understanding of the organization culture and view point of the end-users. It also helps to understand the weak points existing, which can be corrected.

Factors considered are:

- Medical staff's opinion about the existing HIS.
- Opinion regarding further advancement in the technology
- Know and understand the characteristics of the current workflow
- Barriers in current HIS

3. Assemble the CDS Implementation Team: A team is made to help proceed with the implementation of CDSS. The team member should involve clinicians, IT managers, administrative heads, department heads and evaluators. This team have following functions:

    - Understand the attitudes of the user-end towards CDSS adaption.
    - Rollout the whole implementation plan successfully.
    - Executing training programs for the end-users.
    - Getting the feedback about CDSS.

4. Select Effective Clinical Leaders and Champions: choosing the leaders from within the end-users and explaining them about the benefits about the CDSS. This is done so that they are able to communicate the benefits to all others and induce positive attitude towards the adaption of CDSS. They should be able to 'lead the change' and communicate well with the people.
5. Achieve Clinician Buy-In and Support: the clinicians should be motivated about the benefits of CDSS. However, the features of CDSS may demotivate the clinicians as it may be considered as a substitute for them. It must be made clear that CDSS is just to assist clinicians and not to replace them.
6. Integrate CDS into Workflow: as every organization may have their own workflow and CDSS may not be in sync with it, thus it may become an important barrier for its acceptance. So the

work flow of each department should be noted and CDSS must be brought in sync with it and a new improved workflow should be established.

7. Plan for Successful Rollout: Rollout process is very important as it involves the changes and stakeholders. The acceptance of the new model may take some time. An assessment should be done before rollout and readiness of the rollout should be considered.
8. Train and Support: Effective training and support should be given to all the end-users to bring the CDSS into effective usage.
9. Monitor and Evaluate CDS's Clinical Impact: assessment should be conducted to evaluate the improvement in the workflow and outcomes after CDSS implementation. Also, feedback from the end-users is important.
10. Knowledge Management: CDSS relies on knowledge base, and thus require continuous knowledge management. Continuous update of knowledge base is essential.

3.7. Barriers for implementation of CDSS

Common barriers and its potential threat to clinical practice are as following [23, 29]:

Evidence-Related:

- Lack of supportive research evidence: Decision and reasoning may not sync with patient condition and user may not be able to draw an acceptable conclusion or judgment.
- Incomplete or contradictory evidence: The decisions provided by CDSS may be contradictory in itself.
- Inaccessible evidence at the point of care: CDSS due to its complex use may not be always able to guide the user at point of care.
- CDSS use in limited domain of health: CDSS is mostly available for very limited diseases and conditions. Rather most of the CDSS are limited to a particular disease or a field of medicine only. Example: Cancer.
- Reasoning issues: Computers only provide bare facts and are unable to give detailed information of the condition. The information provided is limited to the extend computer has been programmed with.

Clinician-Related:

- Complexity in use of CDSS: Training to learn CDSS use is itself an issue for most of the physicians/ clinicians. It's complexity further creates more problems.
- Physician/ clinician autonomy: User autonomy might be challenged due to CDSS usage. The user may end up into an ambiguous situation.
- Limited access of patient information to CDSS: Patient data provided to CDSS may be limited as most physicians may prefer free texting about patient information to jot down patient details. This free text information cannot be provided to CDSS for making a decision.
- Ambiguousness: Use of CDSS may lead the heath care provider into an ambiguous state due to over loading of information via his/her own thinking as well as CDSS suggestions.

- Lack of in-depth knowledge of user in the specific evidence may hinder the use of CDSS in that domain. This can be due to reliability issues of user over CDS.
- Failure to use the CDSS: Many Physicians/ clinicians may not accept the CDSS and may not use it at all. Others might say yes to its use at first, but later mostly ignore its suggestions.
- Dependence on other diagnostic decision: Users may depend on various other diagnostic tools other than CDSS, and may not independently follow CDSS.
- Change in care providing pattern: Introduction to machines in healthcare industry have actually changed the basic pattern of providing healthcare to the patients. Healthcare providers mostly have to change their way of providing care in accordance to CDSS.

System-Related:

- Multiple requirements (e.g., billing and EMR) converge to stress clinicians for coding patient's disease with accurate diagnoses
- Throughput-oriented concerns may discourage the deliberate processes of analytic diagnostic thinking
- External incentives (e.g., reimbursement, patient satisfaction, quality demerits, malpractice) through the use of research evidence
- Desire for rewards or fear of punishments may influence diagnostic strategies more strongly than analytic thought using research evidence
- Poor usability or integration into practitioner's workflow
- Good system performance depends on the motivational effect of the developer's enthusiasm, creation of more usable and integrated software, better access to technical support and training, and improved on-site promotion and tailoring
- Reliability issues: computers may falter sometimes. Also treating a patient requires complex logical thinking, which done via computers may complicate the suggestion provided by CDSS.
- Lack of flexibility: computers are unable to solve problems that are even slightly out of their domain. They become incapable of solving any problem.
- Highly dynamic KB: the knowledge base is highly dynamic, and some of it might be computer infeasible.
- High cost: High cost for designing, implementing, testing, training, maintenance and support to CDSS.

Legal and ethical issues:

- Sensitivity of the healthcare being provided by CDSS: Health information being provided to CDSS has a limit. Various policies have been made to limit the use of CDSS in to a particular domain.
- Physician autonomy is a major ethical issue. Ethically, computers must not replace doctors.

- Liability issue in case of accident: the treatment being provided to patient is via doctor as well as CDSS decision power. But if some accident happens because of the treatment, who must be held responsible is another legal issue, the CDSS vendor or the doctor.
- CDSS may hinder human thinking: There is a concern over the CDSS that it amy hinder human thinking and create machine dependency.
- Limiting the human touch: computers and machines have limited the human touch in patient care process.

3.8. CDSS market

Recent years have seen a sudden increase in IT sector, including Health care IT. Health care IT is the use of information technology to transfer, analyses and store health information. Health care market have shown a sudden increase in recent years. It's due to its high value of perceived benefits that health IT got adopted and is being used at large scale. But the use of health IT is not same all over the world, also few applications of health IT are more in use then others.

Electronic health record (EHR) forms the major share of health IT and is used extensively in healthcare industry. Currently, health IT market comprises a large share in market. Market research have shown that in year 2016 the market for EHR was of USD 134.25 Billion, and expected to increase to USD 280.25 Billion by 2021 at a CAGR of 15.9% [26]. Health IT includes many users like hospitals, clinics, diagnostics centers, pharmaceutical industry etc. Major share of health IT users belongs to North America, followed by Europe.

CDSS market have grown in recent years and have shown rapid acceptance in Healthcare industry. CDSS market in years 2016 accounted for USD 856.3 million, which is forecasted to increase at a CAGR of 12.2% and reach to 1519.2 million by year 2021. CDSS market today include many software applications and are customizable as well.

Year	**Electronic Health Record (EHR)**	**Clinical Decision Support System (CDSS)**
2016	USD 134.25 billion	USD 856.3 million
2021 (future forecast)	USD 280.25 billion	USD 1519.2 million

Table1: Showing CDSS market in year 2016 and the future trends its likely to follow by year 2021, according to a report [57]

3.9. CDSS market analysis of year 2012-2018

The global knowledge-based CDSS market in year 2012 was valued at USD 245 million. This market expected to reach USD 418 million by 2018, at CAGR of 9.6% [54]The global non-knowledge based CDSS market in year 2012 was valued at USD 23.0 million, and it has the expected growth of CAGR of 1.6% and reach USD 26.0 million by year 2018 [55] Integrated CDSS accounts for about 70% of the total market. North America accounts for 70% of the global CDSS market, followed by Europe with a market share of 14% and Asia with 7%.

In North America, knowledge-based CDSS market was valued at USD 176.8 million in 2012. It is forecasted to expand to USD 283.2 million by year 2018, at CAGR of 8.1%. Non-knowledge based CDSS market was valued at USD 17.0 million in 2012, and is forecasted to expand to USD 20.0 million by year 2018, at a CAGR of 2.1%. North America accounts for 70% of the global CDSS market, with U.S.A accounted for 90% of the total North American CDSS market. North America is the global leader in the CDSS market. This is due to the policies and rules that have been implemented by American government, like Meaningful use, Medicare, Medicaid, etc.

In Europe, knowledge-based CDSS market was valued at USD 36 million in 2012, and is estimated to expand to USD 56 million by year 2018, at CAGR of 7.3%. Non-knowledge based CDSS market had values of USD 3 million in year 2012, and is estimated to expand up to USD 3.4 million by year 2018, at CAGR of 2.2. The European CDSS market accounts for almost 14% of the global market. Germany takes up the maximum share of CDSS market in Europe, accounting for almost 25% of total, followed by France at 20%.

In Asia, knowledge-based CDSS market was valued at USD 19.9 million in year 2012, and is estimated to reach USD 31.6 million by year 2018, at CAGR of 8.5%. Non-knowledge based CDSS market accounted for USD 3 million in years 2012, and is expected to expand to USD 3.4 million by year 2018, at CAGR of 2.4%. Japan accounts for maximum Asian market share, holding 35% of the total Asian CDSS market, followed by China at 30%.

Geography	Knowledge based CDSS		Non-knowledge based CDSS	
	2012	2018 (future trends)	2012	2018 (future trends)
Global	245	418	23	26
North America	176.8	283.2	17	20
Europe	36	56	3	3.4
Asia	19.9	31.6	3	3.4

Table2: Shows the markets share of CDSS globally and in various parts of the world, as well as their future trends, as per a report [54,55]

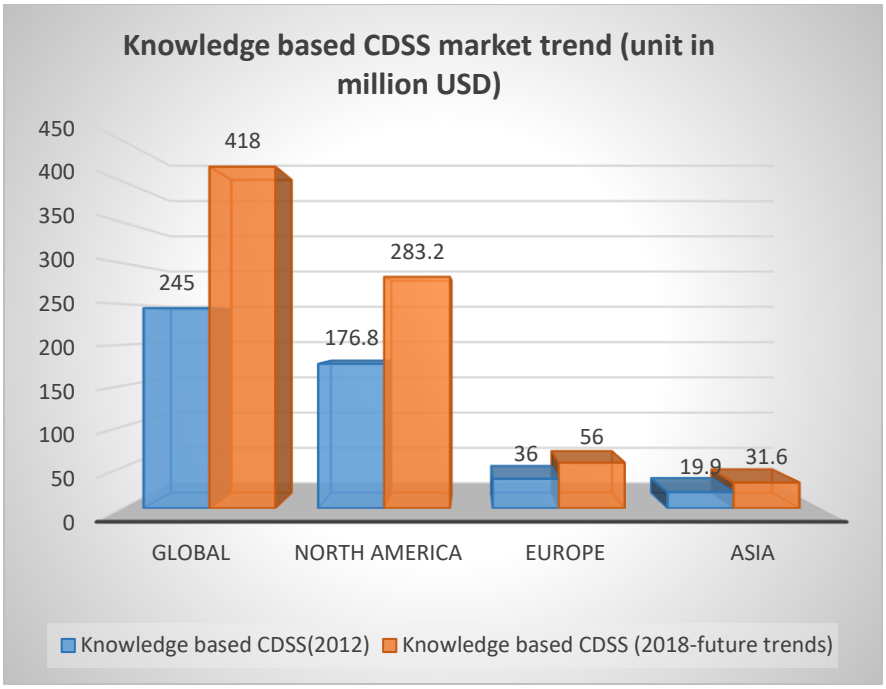


FIG-14. : Shows the Global, North American, European and Asian market share of knowledge-based CDSS.

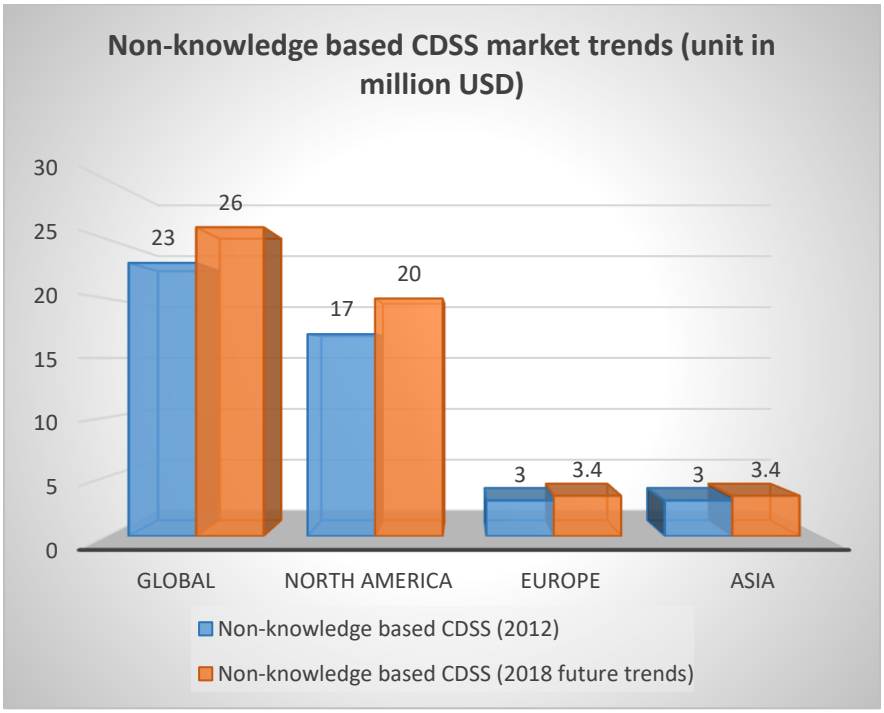


FIG-15. : Shows the Global, North American, European and Asian market share of non-knowledge based CDSS.

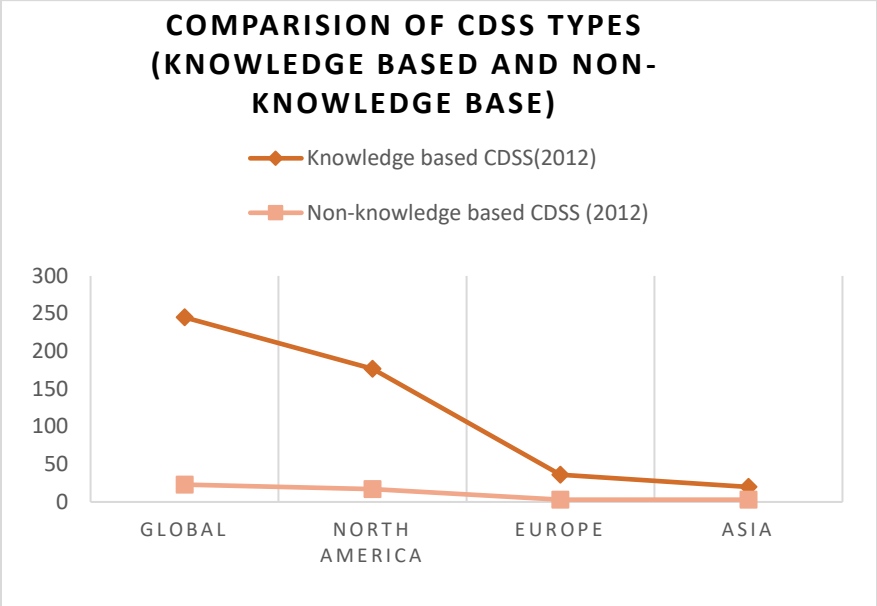


Fig.16: Compares the knowledge based and non-knowledge based market share at global level and in North America, Europe and Asia.[54,55]

EHR integrated CDSS market

CDSS interacts with EHR (Electronic Health Record) and is integrated with it to help data transfer, processing and storage. It aids in easy gathering, managing, retrieving, and updating patient records. North America had the largest share of the CDSS-EHR market globally in year 2012 and accounted for USD 51 million. Europe CDSS market accounted for USD 9 million in year 2012and Asia accounted for USD 5 million for the same. Integrated CDSS due to its benefits has been forecasted to grow at a faster rate than standalone CDSS.

Key vendors of CDSS in market

- Cerner Corporation (U.S.)
- FDB(first data bank)
- CIMS(clinical information management system)
- McKesson Corporation (U.S.)
- Epic Systems Corporation Inc. (U.S.)
- Medical Information Technology, Inc. (U.S.)
- Philips Healthcare (Netherlands)

- Allscripts Healthcare Solutions, Inc. (U.S.)
- Wolters Kluwer Health (U.S.)
- Zynx Health (U.S.)
- Elsevier B.V. (Netherlands)
- International Business Machines (IBM) Corporation (U.S.)

3.10. SWOT analysis of CDSS

Strengths	Weakness
• Improved health care outcomes • Improved quality care • Reduces cost to hospital due to reduced waste • Growing need to integrate healthcare system with IT • Growing incident of medical errors and its consequences faced by healthcare provider • Shift of disease pattern from communicable to non-communicable diseases, thus introduction to more sophisticated treatment procedures, that can be integrated with IT and improve the results. • Government support in many countries towards adaption of HIT • Coming up of corporate hospitals that are open to adoption of new technology that can improve the quality of the patient. • Recovering insurance reimbursement easier by hospitals.	• High cost for designing, implementing, testing, training, maintenance and support to CDSS. • Market of CDSS still in initiation stage and not very much explored. • Shortage of skilled IT professionals to maintain such sophisticated software. • Healthcare providers reluctant to adapt to new technology. • CDSS available is the market are mostly specific to particular health segment. • Legal issues: In case of any accident to patient, the accountable person to be held for the incident is a question.
Opportunities	**Threats**
• Increased focus on integration with IT sector in all markets. • Rules and policies favoring the adoption of health IT like EHR, cope, CDSS. • Growing need for integration of healthcare with IT. • Competition among various healthcare facilities to provide the best healthcare to the patients.	• Market of CDSS still in initiation stage and not very much explored. • Physician autonomy loss may leads to rejection of the technology by the healthcare providers • Ethical issues. • Other health information technologies like various diagnostic techniques, HIS, CPOE and other technologies already improved the quality of healthcare being provided to a very large extent, thus reducing the recognition for need of CDSS. • Reliability and security issues about CDSS.

CHAPTER-4

4.1. Requirements of CDSS in Ophthalmology

Preferred Practice Pattern® (PPP) guidelines—offered by the American Academy of Ophthalmology (AAO) (The Academy)—is the primary source for CDS parameters developed for the practice of ophthalmology. The AAO continuously develops and issues the most clinically relevant, specialty-focused procedural and practice data sets for ophthalmology. The Academy designs its PPP guidelines to identify characteristics and components of quality eye care. "Based on the best available scientific data, PPPs provide guidance for the pattern of practice, not for the care of a particular individual."

Integrated EHR and Practice Management systems for ophthalmology—flourish with CDS tools:

To evaluate and potentially engage CDS tools without first adopting a robust, integrated EHR and practice management system could be like putting the cart before the horse. For example, you may not be fully realizing the productivity and accuracy benefits gained by leveraging CDS without capturing the data in an EHR. The data becomes secure and the accuracy of the CDS-influenced data is maintained. Other approved professionals, departments, or institutions can access the data in the EHR. Best practice use of EHR and practice management systems provides several levels of value and impact across medicine, including ophthalmology.

Every ophthalmology practice should evaluate EHR and practice management solutions based on the specific needs and objectives of a practice. However, there remain core collections of shared factors that you should always consider when evaluating the systems for purchase and use that include: [58]

- Ease of use
- Practice subspecialty mix
- Patient volume
- Workflow and workflow cycles
- Clinical needs
- Number of office locations
- Data security and backup features
- Data exchange requirements (other healthcare orgs and clinicians)
- Image management needs
- Integration with image management systems Systems
- Integration with practice management software

Beyond the common factors of logical EHR and practice management systems evaluation, the AAO and NextGen Healthcare — a longtime AAO partner — recommend six additional criteria. These suggestions may help ensure that your practice selects an EHR and practice management system that provides both

technical excellence and specialty practice knowledge of clinical and administrative data management. The following six criteria include:

1. **A single system.** The AAO has commented at length about the difference between a single, integrated solution and an interfaced solution comprising several vendors' products. In the complex world of managing ophthalmic data and high patient volumes, the simplicity offered by a single, integrated system provides the best possible user experience and results. The additional complexity of multiple, interfaced databases may reduce functionality and specialty options compared to a robust, integrated, single system. Interfaced solutions that link separate databases, and often-separate servers, can open the practice to myriad data compatibility issues and the potential of multiple upgrading over time.

2. Select a Specialty Market Leader. If you have a mid-to long-term vision for your ophthalmology practice, you should select an EHR and practice management vendor with an equally long-term vision—and with an industry record of accomplishment to continually carry out that vision. The advantages of collaborating with a strong vendor include being able to confirm the vendor's financial stability; asking for and receiving their ongoing plans and progress for ophthalmology-specific enhancements to their offering; and knowing the company has the resources to quickly gain new industry certifications as they arise.

3. **Select an Ophthalmology Specialist**. Patients select ophthalmology specialists for good reason. Ophthalmic medicine providers should select an EHR and practice management provider for the same good reason. A health information data vendor with a record of accomplishment of providing ophthalmology EHR and practice management solutions can provide unique value, such as:

- Rich ophthalmic templates and workflow
- Clinical decision support and alerts
- Flexible and comprehensive reporting
- 5-Star usability within the specialty
- Image management integration
- MU certification under CMS
- Depth and functionality to achieve future stages of MU attestation

4. **Select a Meaningful Use (MU) Specialist**. Because the government is driving so much of our emerging digital healthcare trends, an EHR and practice management provider should have deep resources to track, understand, and educate clients on regulatory requirements and incentive opportunities. Gathering this intelligence, communicating its impact on clients, and providing solutions that will leverage these requirements do demand an integrated effort that requires a dedicated team of professionals.

5. **Select One Partner that Possesses Both Industry Knowledge and Good Products**. No one would argue that the overall health of "the practice" should be the number one priority of the ophthalmologist. However, over the long-term, sustaining a viable and profitable practice will require an increase in functional data management. While superior EHR and practice management "product" is important, so is collaborating with a vendor that stays on the leading edge of mega trends in

emerging healthcare delivery models, reimbursement protocols, regulatory requirements, and information interoperability standards.

6. **Select a Partner with a Track Record**. Research the reputational footprint of prospective EHR and practice management providers. How much testimonial communication do they use to gain market visibility? Have industry research firms, publications, and associations ranked them? Are they involved in the ongoing dialog of industry standards around interoperability and Health Information Exchange capabilities? Visit a regional or national healthcare information management tradeshow and get a feel for the company's presence at the show. Also, reach out and talk to your peers about their personal experiences with the system and company they chose as their EHR and practice management vendor.

The path forward for EHR, Practice Management and CDS systems in ophthalmology. The AAO provides very specific recommendations to guide the future development of these related technologies. Unique workflows in ophthalmology will continue to influence requirements. For example because the specialty integrates medicine and surgery so frequently, ophthalmological EHR applications should support documentation and data management in, and transitions between, the office and the operating room. Furthermore, non-ophthalmologists often perform medical clearance duties that may require data from other healthcare providers who are not part of the ophthalmology practice.[56] The AAO cites additional unique characteristics of ophthalmology that should influence future designs of EHR and practice management systems:

- Should incorporate into the EHR system useful mechanisms for drawing–including digital pen technologies. Ophthalmic medicine is visually intensive, comprising physician sketches, formal imaging studies, and other related imaging (as well as traditional, clinical quantitative and qualitative assessment) to evaluate a patient's condition.

- Incorporate features to capture, track, and display ophthalmic vital signs, such as visual acuity and intraocular pressure (IOP). Later stages of MU within the ophthalmology specialty may require capture of specialty-specific practice patterns and data.

- Multi-functionality of ophthalmology EHRs is important. Systems should support general testing; generate orders for and collect data from laboratory systems, Picture Archiving, and Communication Systems (PACS); and meet specific ophthalmology evaluation and testing needs. Conclusion Ophthalmology is a demanding medical specialty practice for EHR, practice management, and CDS systems. The layering and overlap of data types is significant. For example, patient evaluation and diagnostic workflows may simultaneously include multiple outputs from different tests including:

- Graphical displays of measurement (visual field testing, electroretinography)

- Numerical data (auto refraction, keratometry, biometry)

- Ophthalmic image data (fundus photography, optical coherence tomography)

4.2. Importance of CDSS for Cataract management

A cataract is a degradation of the optical quality of the crystalline lens that affects vision. Most cataracts are related to aging. They can occur in one or both eyes.

The risk of cataracts increases with each decade of life starting around age 40.4 Cataracts are the leading cause of visual impairment among Americans of African, Hispanic/Latino, and European descent and are the leading cause of treatable blindness among Americans of African descent age 40 and older.5,6 In the United States, cataracts account for approximately 50% of visual impairment in adults over the age of 40,5 affecting 24.4 million Americans,4 or about 1 in every 6 people in this age range. In 2010, half of white Americans had cataracts by 75 years of age, and 70% of white Americans, 61% of Hispanic Americans, and 53% of black Americans had cataracts by 80 years of age.4 In the United States, the number of people with cataracts is forecasted to double from 24.4 million to about 50 million by the year 2050.4 Cataracts are the leading cause of blindness worldwide.

There are several different types of cataracts (e.g., nuclear, cortical, subcapsular [anterior and posterior], and mixed). Each type has its own anatomical location, pathology, and risk factors for development. Several systems are available to classify and grade lens opacities,8-12 but variations in grading systems make comparing prevalence rates between studies difficult.

US cataract statistics

Cataract is a clouding of the eye's naturally clear lens. Most cataracts appear with advancing age. The exact cause of cataract is unclear, but it may be the result of a lifetime of exposure to ultraviolet radiation contained in sunlight, or may be related to other lifestyle factors such as cigarette smoking, diet and alcohol consumption.

Cataract can also occur at any age as a result of other causes such as eye injury, exposure to toxic substances or radiation, or as a result of other diseases such as diabetes.

Congenital cataracts may even be present at birth due to genetic defects or developmental problems. Cataracts in infants may also result from exposure to diseases such as rubella during pregnancy.

According to the World Health Organization, cataract is the leading cause of blindness in the world. In the United States, cataract is sometimes considered a conquered disease because treatment is widely available that can eliminate vision loss due to the disease. However, cataract still accounts for a significant amount of vision impairment in the U.S., particularly in older people who may have difficulty accessing appropriate eye care due to cost, availability or other barriers.

Treatment of cataract involves removal of the clouded natural lens. The lens is usually replaced with an artificial intraocular lens (IOL) implant. Cataract removal is now one of the most commonly performed surgical procedures with more than a million such surgeries performed each year.

Surgery is not truly a cure for cataract, however, and its success in controlling vision loss comes with a price. It is estimated that the direct annual medical costs for outpatient, inpatient and prescription drug services related to the treatment of cataract total $6.8 billion.

Ongoing research into the normal healthy functioning of the eye's lens may help us better understand the causes of cataract and how they might be prevented. Even partial achievement of this goal might save hundreds of millions of dollars in the annual costs of treating cataract. Because of the variety of opacifications possible, cases of cataract can be defined by a number of classification schemes. The cases included in the Vision Problems in the U.S. prevalence statistics include cortical cataract affecting 25% or more of the lens, posterior sub-capsular cataract 1mm or larger, and nuclear cataract greater than or equal to the next-to-the-highest grade in the grading system used (generally NII or NIII in the LOCS II grading system).

Cataract affects over 24.4 million Americans age 40 and older, or about one in every six people in this age range. By age 80, more than half of all Americans have cataract. Cataract is slightly more common in women than in men.

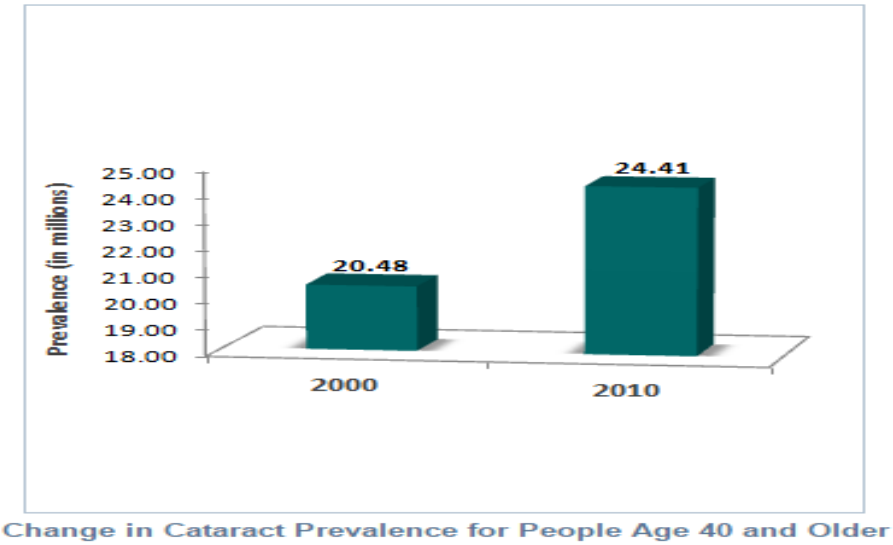
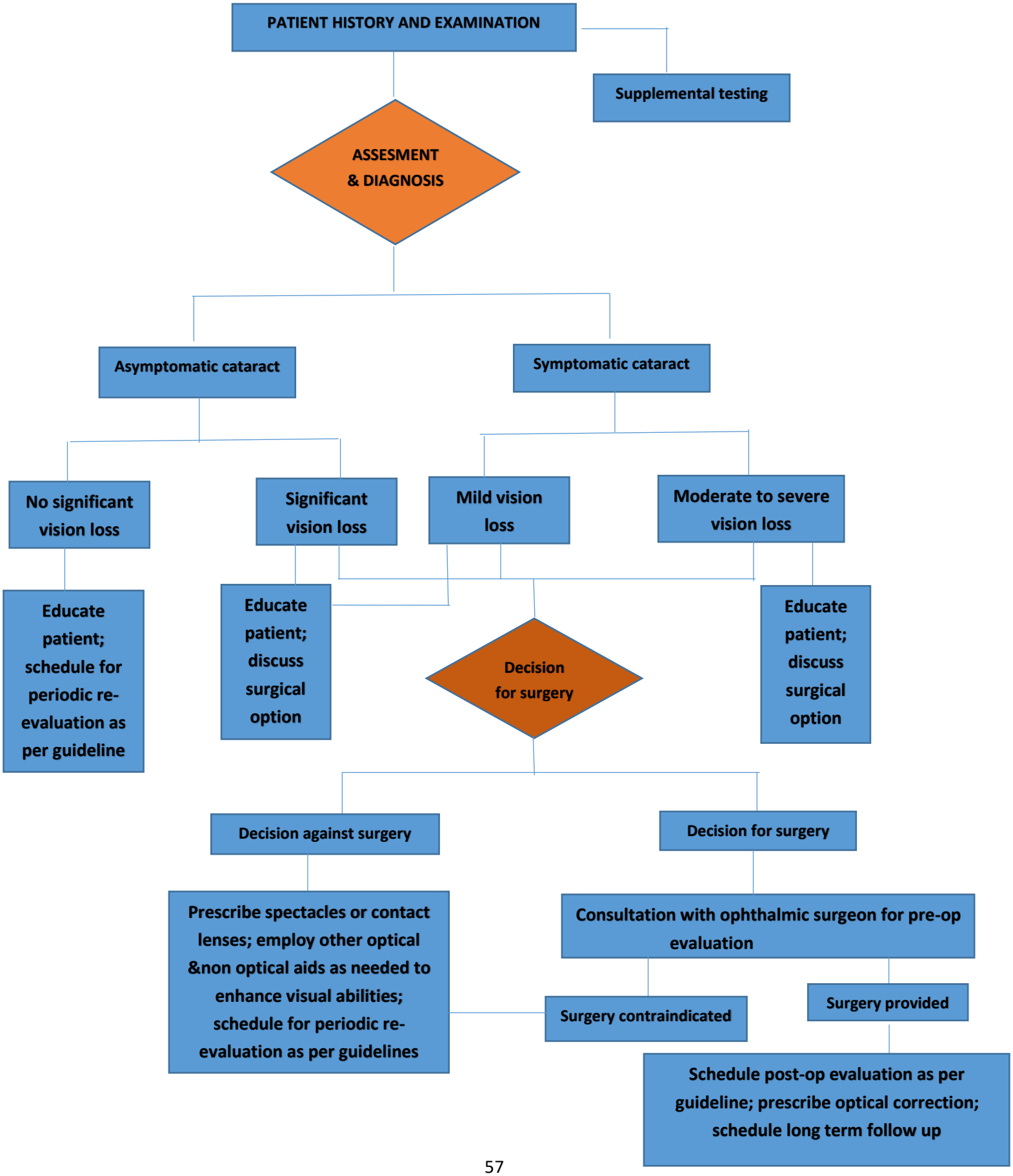


FIG-17 US Cataract Prevalence Statistics (www.aao.com)

Cataract surgery is one of the most common procedures in the United States, with more than 22 million Americans age 40 and older affected by cataracts. By age 80, more than half of all American will have cataracts and had cataract surgery, according to the National Eye Institute. The number of cataract cases is expected to increase in the next 10 years as a result of the aging baby boom generation, according to David Kwiat, MD, an ophthalmologist and part-owner of Fulton County Ambulatory Surgery Center in Johnstown,

4.3. Clinical pathway for cataract management


PATIENT HISTORY AND EXAMINATION
Supplemental testing
ASSESMENT & DIAGNOSIS
Asymptomatic cataract
Symptomatic cataract
No significant vision loss
Significant vision loss
Mild vision loss
Moderate to severe vision loss
Educate patient; schedule for periodic re-evaluation as per guideline
Educate patient; discuss surgical option
Decision for surgery
Educate patient; discuss surgical option
Decision against surgery
Decision for surgery
Prescribe spectacles or contact lenses; employ other optical &non optical aids as needed to enhance visual abilities; schedule for periodic re-evaluation as per guidelines
Consultation with ophthalmic surgeon for pre-op evaluation
Surgery contraindicated
Surgery provided
Schedule post-op evaluation as per guideline; prescribe optical correction; schedule long term follow up

4.4. Catract Co-management Use case

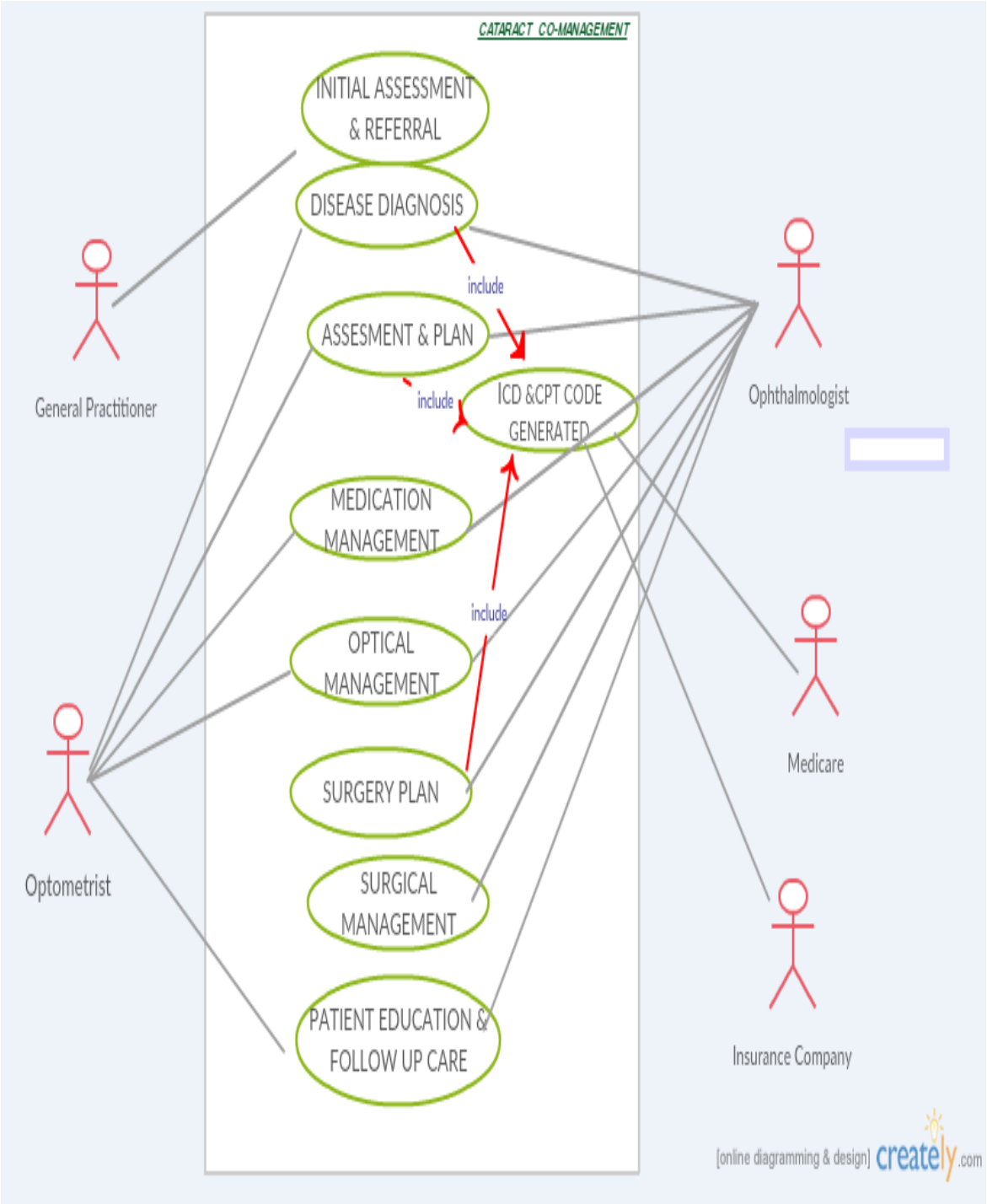


FIG 18- USE Case for Cataract Co-Management

4.5. Description of Alert Features of CDSS required For Cataract management

Some of the common alerts designed for Cataract management are as follows:

Category	Feature	Example
General system features	Integration with charting or order entry system to support workflow integration	Preventive care reminders attached to patient charts; clinician warned of raised creatinine concentration when using computerized physician order entry system to prescribe aminoglycoside for a hospitalized patient
	Use of a computer to generate the decision support	Patients overdue for Complicated cataract surgery done screening identified by querying a clinical database rather than by manual chart audits
Clinician-system interaction features	Automatic provision of decision support as part of clinician workflow	Diabetes care recommendations printed on paper forms and attached to relevant patient charts by clinic support staff, so that clinicians do not need to seek out the advice of the CDSS
	No need for additional clinician data entry	Electronic chart audits are conducted to obtain all information necessary for determining whether a child needs immunizations
	Request documentation of the reason for not following CDSS recommendations	If a clinician does not provide influenza vaccine recommended by the CDSS, the clinician is asked to justify the decision with a reason such as “The patient refused” or “I disagree with the recommendation”
	Provision of decision support at time and location of decision making	Preventive care recommendations provided as chart reminders during an encounter, rather as monthly reports listing all the patients in need of services

	Recommendations executed by noting agreement	Computerized physician order entry system recommends peak and trough drug concentrations in response to an order for aminoglycoside, and the clinician simply clicks "Okay" to order the recommended tests
Communication content features	Provision of a recommendation, not just an assessment	System recommends that the clinician prescribes antidepressants for a patient rather than simply identifying patient as being depressed
	Promotion of action rather than inaction	System recommends an alternate view for an abdominal radiograph that is unlikely to be of diagnostic value, rather than recommending that the order for the radiograph be cancelled
	Justification of decision support via provision of reasoning	Recommendation for diabetic foot exam justified by noting date of last exam and recommended frequency of testing
	Justification of decision support via provision of research evidence	Recommendation for diabetic foot exam justified by providing data from randomized controlled trials that show benefits of conducting the exam
Auxiliary features	Local user involvement in development process	System design finalized after testing prototypes with representatives from targeted clinician user group
	Provision of decision support results to patients as well as providers	As well as providing chart reminders for clinicians, CDSS generates postcards that are sent to patients to inform them of overdue preventive care services
	CDSS accompanied by periodic performance Feedback	Clinicians are sent emails every 2 weeks that summarize their compliance with CDSS

		recommendations for the care of patients with diabetes
	CDSS accompanied by conventional education	Deployment of a CDSS aimed at reducing unnecessary ordering of abdominal radiographs is accompanied by a “grand rounds” presentation on appropriate indications for ordering such radiographs

Ref**: Kensaku Kawamoto, Caitlin A Houlihan, E Andrew Balas, David F Lobach **Improving clinical practice using clinical decision support systems: a Systematic review of trials to identify features critical to success

TABLE-3: Alerts required for MIPS (Merit-Based Incentive Payment System) for Cataract Specialist's

S no	Measure	Measure Type	Description	Alert Type
1.	238: Use of High-Risk Medications in the Elderly	Process-High Priority	Percentage of patients aged 66 years and older who were ordered high-risk medications. Two rates are reported: 1. Percentage of patients who were ordered at least one high-risk medication. 2. Percentage of patients who were ordered at least two different high-risk medications.	If Pt. Age => 66 Red info button blinks ON CLICK asks if the patient is on any High Risk medication if yes asks whether you want to add it to MIPS list or not On click adds the patient to MIPS Report list & Red for not.
2.	130: Documentation of Current Medications in the Medical Record	Process-High Priority	Percentage of patients aged 18 years and older with a list of all current medications (includes prescription, over-the-counter, herbals, vitamin/mineral/dietary nutritional supplements) documented by the provider, including drug name, dosage, frequency and route.	Pop-up if Doctor/nurse tries to close the chart without entering current medication record or clicking on no current medication if not
3.	14: Age-Related Macular Degeneration (AMD): Dilated Macular Examination	Process	This measure is to be reported a minimum of once per reporting period for patients, aged 50 years and older, with a diagnosis of age-related macular degeneration (AMD) who had a dilated macular examination performed which included documentation of the presence or absence of macular thickening or hemorrhage AND the level of macular degeneration severity during one or more office visits. It's anticipated that clinicians who provide the primary management of patients with age-related macular degeneration (in either one or both eyes) will submit this measure.	By default the chart template for management of AMD opens on subsequent visit of such patient

4.	140: Age-Related Macular Degeneration (AMD): Counseling on Antioxidant Supplement	Process	Percentage of patients aged 50 years and older with a diagnosis of AMD and/or their caregiver(s) who were counseled within 12 months on the benefits and/or risks of the Age-Related Eye Disease Study (AREDS) formulation for preventing progression of AMD.	Pop-up for counselling on opening and if done also on marking the chart done
5.	374: Closing the Referral Loop: Receipt of Specialist Report	High Priority	Percentage of patients with referrals, regardless of age, for which the referring provider receives a report from the provider to whom the patient was referred.	Reminder for report
6.	402: Tobacco Use and Help with Quitting Among Adolescents	Process	The percentage of adolescents 12 to 20 years of age with a primary care visit during the measurement year for whom tobacco use status was documented and received help with quitting if identified as a tobacco user.	Pop-up for counselling on opening and if done also on marking the chart done
7.	117: Diabetes: Eye Exam	Process	Percentage of patients 18 - 75 years of age with diabetes who had a retinal or dilated eye exam by an eye care professional during the measurement period or a negative retinal or dilated eye exam (no evidence of retinopathy) in the 12 months prior to the measurement period.	Alert generated in form of beep and flashes on the screen for 30sec and subsides
8.	389-Cataract Surgery: Difference Between Planned and Final Refraction	Outcome	Percentage of patients, aged 18 years and older, who had cataract surgery performed and who achieved a final refraction within +/- 1.0 diopters of their planned (target) refraction	Incorporated in EMR chart, options of planned & final refraction
9.	192: Cataracts: Complications within 30 Days Following Cataract Surgery Requiring Additional Surgical Procedures	Outcome	Percentage of patients aged 18 years and older with a diagnosis of uncomplicated cataract who had cataract surgery and had any of a specified list of surgical procedures in the 30 days following cataract surgery which would indicate the occurrence of any of the following major complications; retained nuclear	Alert generated in form of beep and flashes on the screen for 30sec and subsides

			fragments, Endophthalmitis, dislocated or wrong power IOL, retinal detachment, or wound dehiscence.	
10.	191: Cataracts 20/40 or Better Visual Acuity within 90 Days Following Cataract Surgery	Outcome	Percentage of patients aged 18 years and older with a diagnosis of uncomplicated cataract who had cataract surgery and no significant ocular conditions impacting the visual outcome of surgery and had best-corrected visual acuity of 20/40 or better (distance or near) achieved within 90 days following the cataract surgery.	Reminder for report
11.	388: Cataract Surgery with Intra-Operative Complications (Unplanned Rupture of Posterior Capsule requiring unplanned vitrectomy)	Outcome	Percentage of patients aged 18 years and older who had cataract surgery performed and had an unplanned rupture of the posterior capsule during anterior segment surgery requiring vitrectomy	Alert generated in form of beep and flashes on the screen for 30sec and subsides

Ref: www.aao.org

4.6. Conclusion

Health IT is becoming a chief component of the health system. IT application have vast scope in streamlining the healthcare that is being provided to the patients. Health IT have improved the quality of care that is being provided to the patients. CDSS is one of the main module among health IT that is used to improve the healthcare quality being imparted to patients. CDSS have helped to standardize the quality healthcare. It has helped to reduce many errors that were common in health system and have proven to be highly useful to mankind. CDSS is still at its initiation stage and should be explored further to gain maximum output from it.

Providers are treating more patients and have less time with each patient; new research frequently changes standard protocols, and financial incentives have historically supported more testing. Providers are increasingly practicing defensive medicine. As a result, upwards of 30% of orders placed for patients are not necessary. These unnecessary tests lead to delays in care, potential harm to patients, and, in increasingly value-based reimbursement models, unnecessary spending.

CDSS can prove to be a solution to overcome above mentioned issues. CDSS is being able to successfully assist the healthcare providers to deliver quality healthcare to the patients. But there have been few ethical and legal issues regarding its use. These issues will not be a problem if one always remember that CDSS is to assist doctors' decisions, and doctors' autonomy should be prime focus

Ophthalmology is a demanding medical specialty practice for EHR, practice management, and CDS systems. The layering and overlap of data types is significant. For example, patient evaluation and diagnostic workflows may simultaneously include multiple outputs from different tests including:

- Graphical displays of measurement (visual field testing, electroretinography)
- Numerical data (auto refraction, keratometry, biometry)
- Ophthalmic image data (fundus photography, optical coherence tomography.

Ophthalmologists are combining state-of-the art EHR and practice management systems with an understanding of different types of CDS options available, to create a high performance ophthalmic medicine practice, which is sustainable, accurate, safe, productive, and accountable. Future EHR and practice management systems for ophthalmology should handle evolving AAO PPP guidelines and incorporate various levels of CDS solutions and tools offered directly by vendors or created by astute ophthalmologists and ophthalmic practice managers with various levels of healthcare IT skills

Cataract being one of the most complex co-managed treatment will have a positive turn over with CDSS being associated with the treatment plan. Current study shows way forward for development of CDSS for Cataract.

CHAPTER-5

PERCEPTION OF HEALTHCARE PROVIDERS TOWARDS CLINICAL DECISION SUPPORT SYSTEM IN INDIAN HEALTH CARE

5.1. Study Rationale

An exploratory study was conducted to see the relevance of CDSS in US market and also the existing frameworks of CDSS & their benefits. Most of the researches have shown that health care delivered in industrialized nations like US often falls short of optimal, evidence based care. A nationwide audit in US assessing 439 quality indicators found that the adults receive only about half of recommended care, [30] and the US Institute of Medicine has estimated that up to 98 000 US residents die each year as the result of preventable medical errors.[31] Similarly a retrospective analysis at two London hospitals found that 11% of admitted patients experienced adverse events, of which 48% were judged to be preventable and of which 8% led to death.[32]

To address these deficiencies in care, healthcare organizations are increasingly turning to clinical decision support systems, which provide clinicians with patient-specific assessments or recommendations to aid clinical decision making.[33] Examples include manual or computer based systems that attach care reminders to the charts of patients needing specific preventive care services and computerized physician order entry systems that provide patient-specific recommendations as part of the order entry process. Such systems have been shown to improve prescribing practices,[34-35] reduce serious medication errors, [36,37] enhance the delivery of preventive care services, [38,39] and improve adherence to recommended care standards.[36] Compared with other approaches to improve practice, these systems have also generally been shown to be more effective and more likely to result in lasting improvements in clinical practice.[38-48]

The quality of the health care in developing countries varies in several aspects from developed countries. There is an immense shortage of educated health professionals, hospital facilities, and higher amount of out of pocket expenditures, higher rates of mortality. Indian healthcare sector have to cover a large gap to be able to utilize the advance technologies in health sector and provide the best health care possible to the patients. Implementation of electronic medical records with integrated CDSS can prove to be turning point in the development of Indian Healthcare sector.

CDSS business have a great potential of growth in American market. Report from marketsandmarkets.com shows that North America had the largest share of the CDSS-EHR market globally in year 2012 and accounted for USD 51 million. Europe CDSS market accounted for USD 9 million in year 2012and Asia accounted for USD 5 million for the same. In Asia, knowledge-based CDSS market was valued at USD 19.9 million in year 2012, and is estimated to reach USD 31.6 million by year 2018, at CAGR of 8.5%. Non-knowledge based CDSS market accounted for USD 3 million in years 2012, and is expected to expand to USD 3.4 million by year 2018, at CAGR of 2.4%. Japan accounts for maximum Asian market share, holding 35% of the total Asian CDSS market, followed by China at 30%.

Major players like Cerner, McKesson Corporation (U.S.), Epic Systems Corporation Inc. (U.S.), Zynx Health (U.S.) etc. systems are as per the requirement of US market

As Indian market holds a large potential for CDSS growth, this study was conducted to understand the knowledge, perception, awareness and acceptability regarding CDSS amongst Indian healthcare providers. Primary research was conducted to know the awareness level and perception about CDSS in Indian healthcare industry specifically urban facilities

5.2. Problem statement

The work of healthcare professionals and physicians is largely a work of making decisions and solving problems. It is a work of choosing issues that require attention, setting goals, finding or designing suitable courses of action and evaluating and choosing among alternative actions. They must choose from and interpret a huge variety of clinical data, while facing pressure to decrease uncertainty, risks to patients and costs. The true essence of healthcare delivery is decision making - what information to gather, which tests to order, how to interpret and integrate this information into diagnostic hypotheses and what treatments to administer.

Developing countries like India have a serious resource crunch in the healthcare sector having a dismal doctor to population ratio. This is also true for no of hospital beds per 1, 00,000 of Indian population. Any government or teaching hospital will have hordes of patients flocking for medical management. When a doctor is faced with 300 to 500 patients every day, the time available for each patient is limited. This highlights the problem with the system. Under such circumstances, it is impossible to prevent medical errors.

Moxey and colleagues [51] suggested that the variability in CDSS uptake may be attributable to the technical aspects of the technology itself. Second, most studies evaluated the perceptions of frontline clinicians, but did not address the perceptions of different organizational roles (*e.g*., hospital administrators, chiefs, or non-physician staff) that are key to establishing the overall mission and vision of the healthcare institution in addition to shaping the expected behavior and standards of its personnel. Organizational leadership that is supportive of technological innovation, for example, may encourage and reward the use of CDSSs to improve patient care. Third, the studies often addressed contexts in which CDSSs had already been introduced; these studies did not account for the perceived facilitators and barriers existing prior to CDSS introduction, or for the evolution of perceptions throughout the technology's various stages of uptake. These limitations are especially relevant in countries such as India where the majority of healthcare contexts have not yet adopted CDSSs.

The study addresses the limitations of previous studies by considering: a) multiple health professionals, including physicians, nurses, and hospital managers, and b) hospitals with different levels of Health IT infrastructure implementation.

5.3. Research Methodology

Research question

The following research questions will be covered within the scope of this study:

- What is the current level of knowledge and usability of computers among Indian healthcare providers?
- What is their awareness level about HIS & CDSS (Clinical Decision Support System)?
- What is the perception of healthcare providers about CDSS with respect to various attributes like its use, reliability etc.?

Objective

To know the perception about CDSS (Clinical Decision Support System) among healthcare providers

Limitations of study

The total subjects of this study are being selected through convenient sampling, thus the result outcome of the study cannot be generalized to the entire population. However the study is expected to throw light on the perceptions of the healthcare providers in general that may me further utilized in planning for CDSS implementation and research in this area.

Study design: Descriptive, cross-sectional study.

Sample population: Physicians, Ophthalmologists, Health IT, administrative staff, staff, nurse, medical students.

Sampling method: Convenient sampling technique.

Study Duration: 3 months

Data source: Primary and secondary data.

Sample size: 97

	Male	Female	
Medical Staff	26	32	58
Non-Medical Staff	18	21	39
Total	44	53	

Place of study: Several hospitals in Delhi and NCR region were visited to collect the primary data. Also few more respondents from other organizations were involved.

Tools to be used for data collection: Questionnaire will be filled in by the respondents.

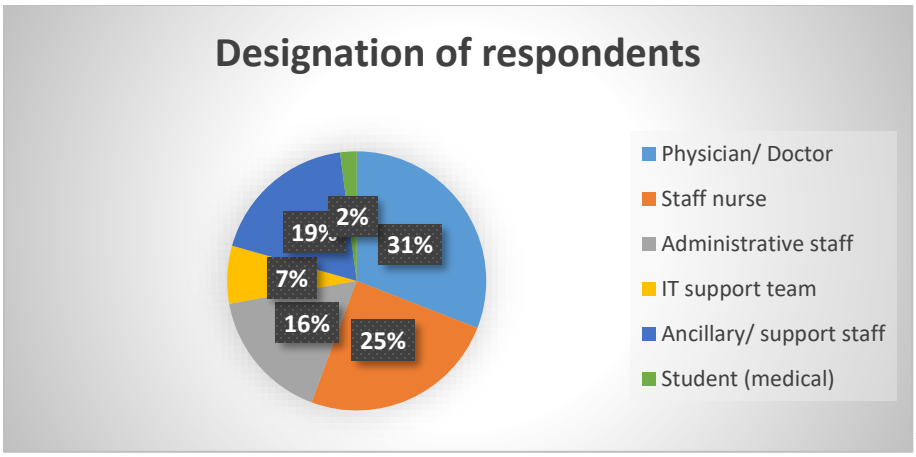
Ethical considerations: Before proceeding with the questionnaire consent of the respondent was taken. Confidentiality of the respondents will be maintained.

Data analysis: Data analysis was done using Microsoft Excel 2010.

1. Designation of the respondents:

Designation of respondents	**Number**
Physician/ Doctor	30
Staff nurse	24
Administrative staff	16
IT support team	7
Ancillary/ support staff	18
Student (medical)	4

Table showing the respondents with their designation.



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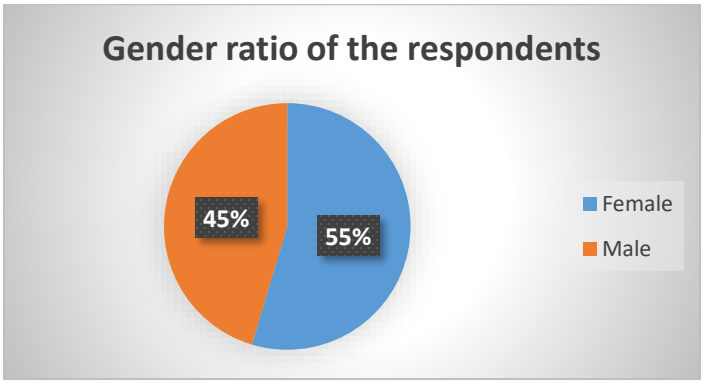
Graph showing respondents with their designation.

The respondents included all the end users of HIS in the hospital as well as the administration and IT team. These all respondents were included as they found to be a major stakeholder in usage or acceptance of any IT in the hospital.

2. Gender of the respondents

Gender of the respondents	**Number**
Female	53
Male	44

Table showing respondents gender ratio.



Graph showing respondents gender ratio.

Respondents included 55% of females and 45% males.

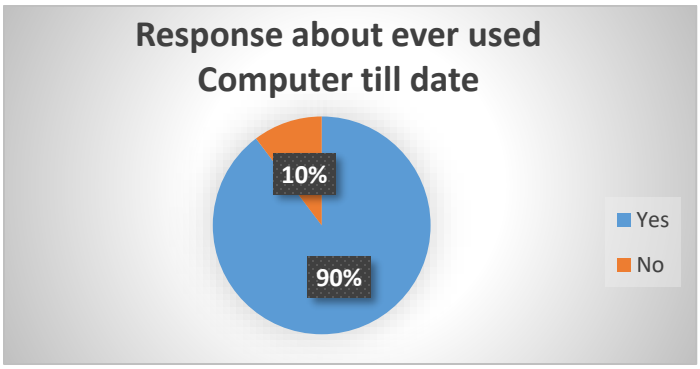
3. Computer literacy

Use of computer	**Number**	**Scoring**
Yes	87	1
No	10	0

Table showing respondents computer usability level

Analysis was done by giving each response for Yes as score “1” and for No score “0”.

Maximum score was 97 out of which 87 was for yes therefore showing higher level of usage of computers among the healthcare professionals.



Graph showing respondent’s computer usability level.

Respondents included 90% of people showed usability of computers and only 10% did not use computer.

4. Mode of computer Access

ACESS TO COMPUTER	Number	Scoring	Total Weightage
Home	14	1	14
Workplace	34	2	68
Home & Workplace	29	3	87
None	20	0	0

Table showing respondents modes of computer access

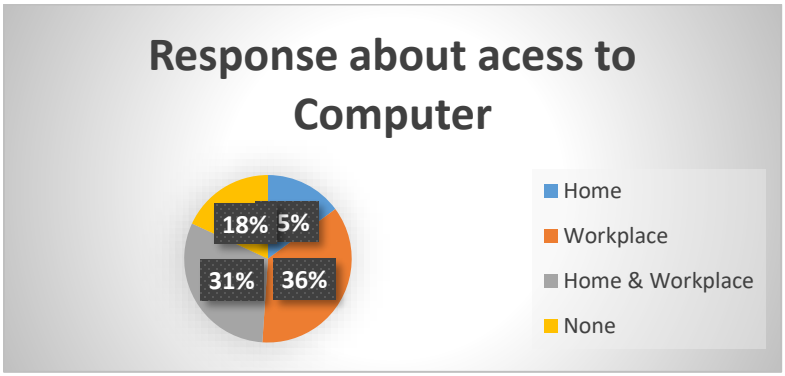
Analysis was done by giving each response for use at HOME as score "1", for WORKPLACE as "2", for HOME & WORKPLACE as "3" and for NONE score "0".

Maximum score was 291 out of which 87 was for both Home & Workplace therefore showing higher level of usage of computers from home and workplace both among the healthcare professionals.

Among the 29 responses given score 3 , there were 19 responses from medical staff and 10 were non-medical staff showing higher access to computers at both the place by medical staff.

Score	Med	Non Med
1	10	4
2	15	19
3	19	10
0	13	7

Most non-medical staff (19 responses) showed access to computers at workplace



Graph showing respondent's modes of computer access

Respondents included 36% of people showed workplace computer as mode to access computers and only 15% used it at home

5. Users Ability to Use Different Softwares

USERS ABILITY TO USE DIFFERENT SOFTWARES	Scoring
Word	1
Access	1
Excel	1
Email	1
PowerPoint	1
Internet	1
none	0

Each software use was assign a score of "1", maximum score any respondent could get was 6.

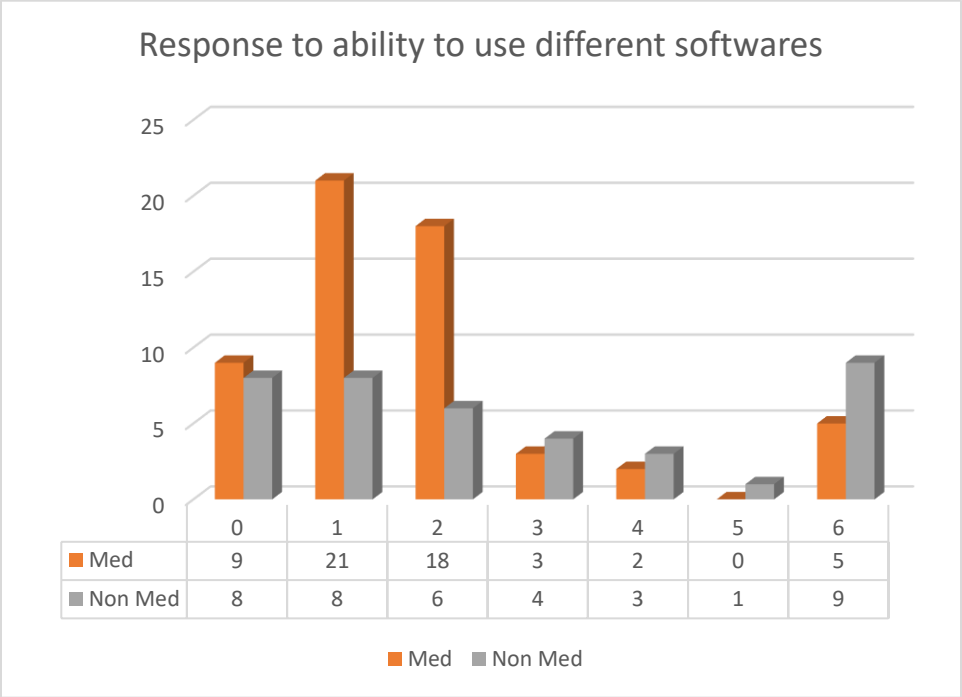
Out of 97 responses, 17 scored "0" as they responded to the none option.

Only 14 responses got score of "6" out of which 5 were medical staff and 9 were non-medical staff, thereby showing more usability of all the softwares by non-medical staff.

24 responses were for use of two softwares out of which 18 responses were by medical staff that too for use of internet and email. 29 responses were for use of only one software that too was either internet or emails mainly (21 responses) medical staff. Therefore showing maximum use of internet or emails among medical staff.

Scoring	Med	Non Med	Total
0	9	8	17
1	21	8	29
2	18	6	24
3	3	4	7
4	2	3	5
5	0	1	1
6	5	9	14
Grand Total	**58**	**39**	**97**

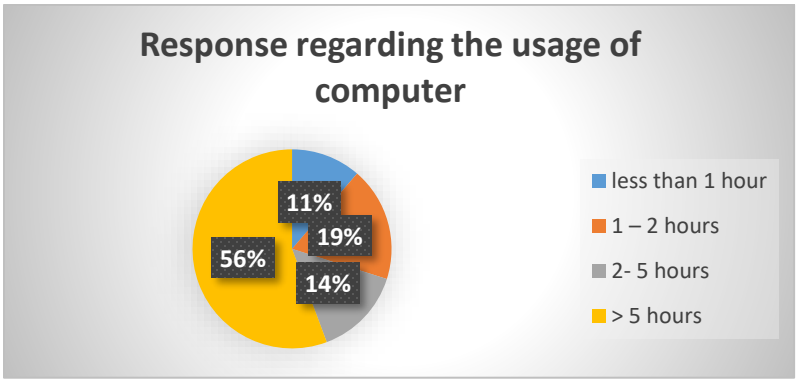
Table showing respondents Ability to use different software



6. Duration of use of computers

DURATION OF USE OF COMPUTERS	NUMBER
less than 1 hour	11
1 – 2 hours	18
2- 5 hours	14
> 5 hours	54

Table showing respondent's duration of use of computers daily



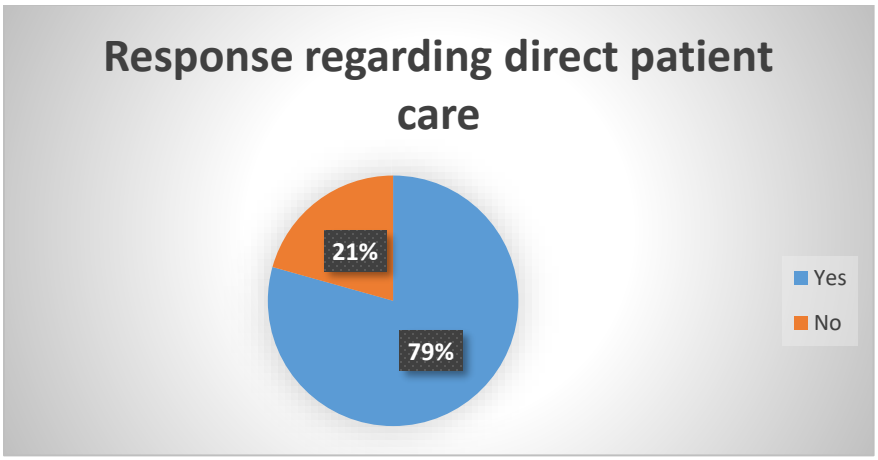
Graph showing respondent's duration of use of computers daily

Respondents included 56% of people who used computer for more than 5 hoursand11% for less than one hour.

7. Current direct patient care

Current direct patient care	Number
Yes	73
No	19

Table showing respondent's current status of direct patient care



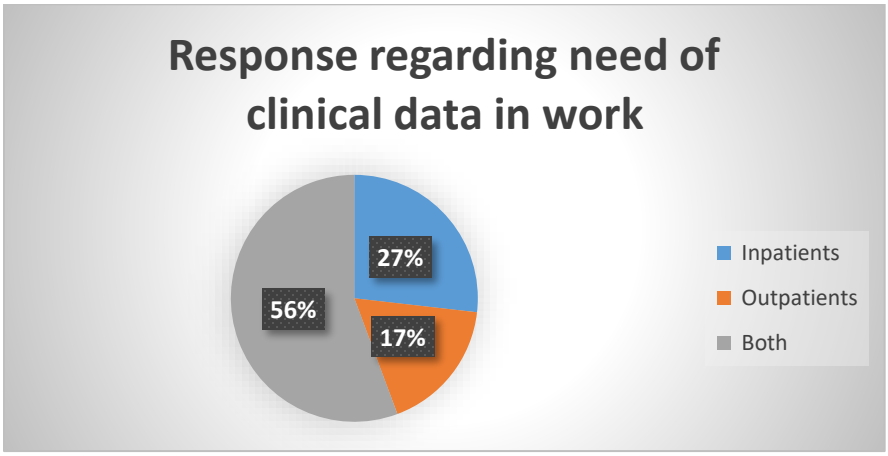
Graph showing respondent's current status of direct patient care

Respondents included 79% of respondents who are providing direct patient care

8. Need to access clinical data at work

Need to access clinical data at work	**Number**
Inpatients	26
Outpatients	17
Both	54

Table showing respondent's need to access clinical data at work



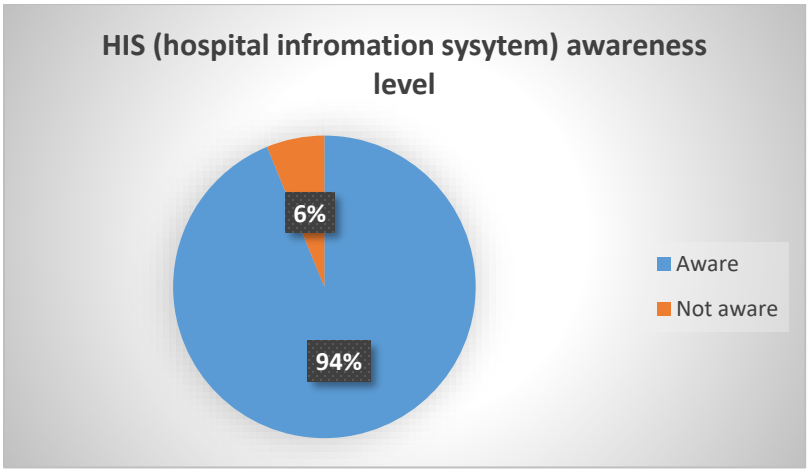
Graph showing the percentage of respondents who need to access clinical data at work

About 56% of the respondents need access to both inpatient and outpatient data in work.

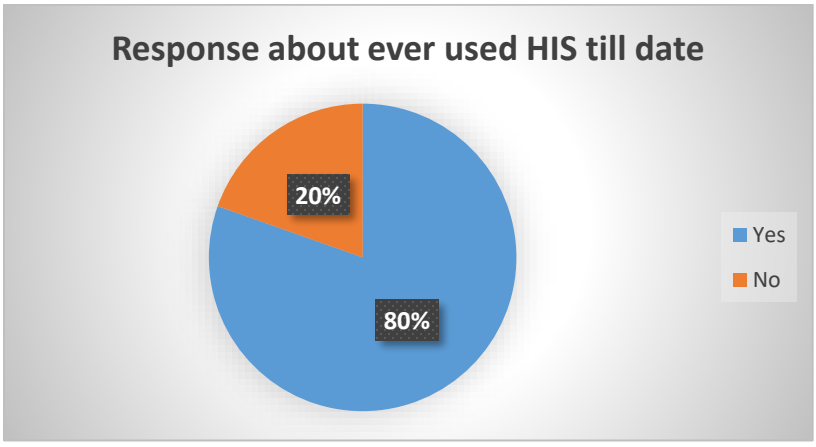
9. Awareness about HIS

Awareness about HIS	Number	Medical	Non-medical
Aware	91	54	37
Not aware	6	4	2

Table showing respondent's awareness about HIS



Graph showing awareness of respondents about HIS



Graph showing the percentage of respondents who have ever used HIS till date.

About 94% of the respondents are aware about HIS, and 6% were not aware. And about 80%of the respondents had used HIS till date.

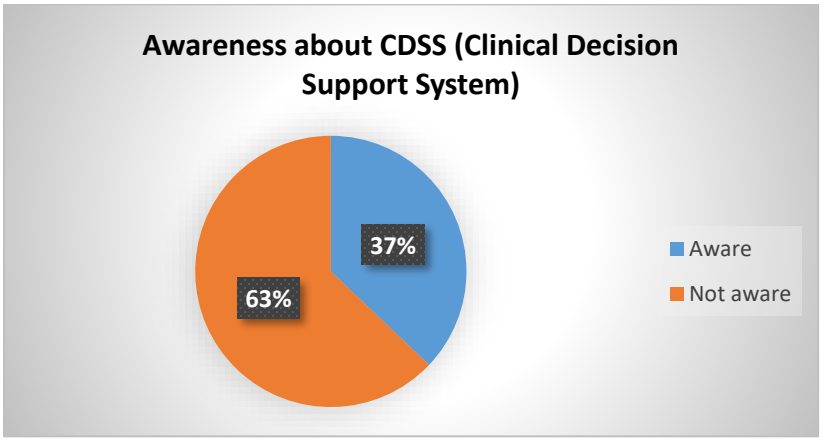
10. Awareness about CDSS

Response	Total	Medical	Non-Medical
Aware	36	22(61%)	14(39%)
Not aware	61	36(51%)	25(41%)
Total	97	58(38%)	39(36%)

Table showing awareness of respondents towards CDSS.

Analyzed in three ways:

a) Out of 97 only 36 respondents were aware of CDSS
b) Out of 36 respondents aware 22 i.e. 61% were medical staff and 14 i.e. 39% were non-medical staff
c) Out of total 58 medical staff if analyzed 22(38%) are aware of CDSS and out of total 39 non-medical staff analyzed 14 (36%) are aware of CDSS



Graph showing awareness of respondents about CDSS.

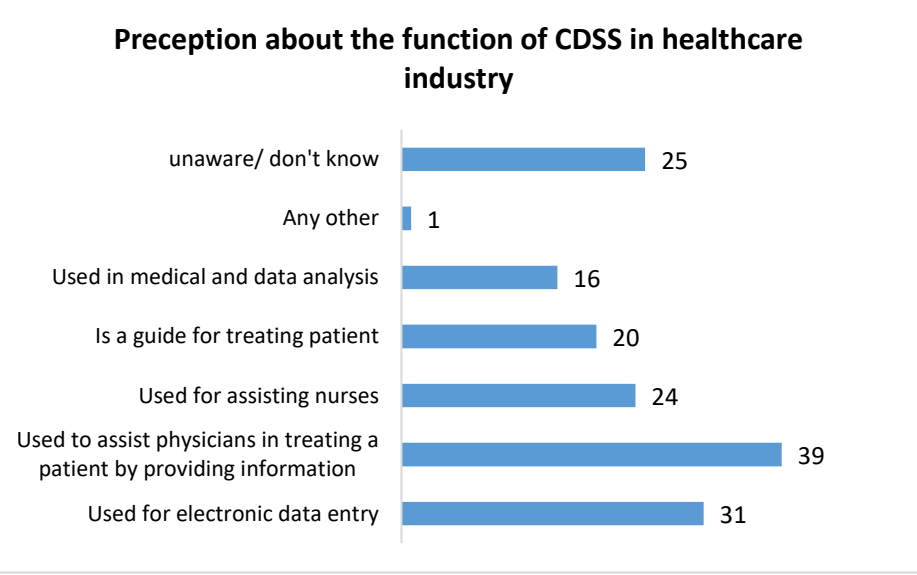
Response	Total	Medical	Non-medical
Yes	10	8	2
No	81	50	37

Out of all the 97 respondents only 36 were aware of CDSS And out of 36 only 10 respondents have used CDSS till date , out of which 8 were medical staff and 2 were non-medical staff

11. Perception about use of CDSS in healthcare

Respondents perception about use of CDSS in healthcare	**Number**	**Medical**	**Non-medical**
Used for electronic data entry	31	13	18
Used to assist physicians in treating a patient by providing information	39	25	14
Used for assisting nurses	24	13	8
Is a guide for treating patient	20	13	7
Used in medical and data analysis	16	7	9
Any other	1	0	1
unaware/ don't know	25	10	15

Table showing respondents' perception about use and function of CDSS in healthcare.



Graph showing respondents' perception about use and function of CDSS in healthcare.

Frequency about perception about the function of CDSS in healthcare among respondents was maximum for its use to assist physicians in treating patient, accounting for 39 responses among which 25 response were from medical staff showing more awareness regarding the actual use of CDSS among medical staff. This was followed by its use in electronic data entry accounting for 31 responses out of which 18 were non-medical staff responses thereby showing misconception of non-medical staff regarding use of CDSS

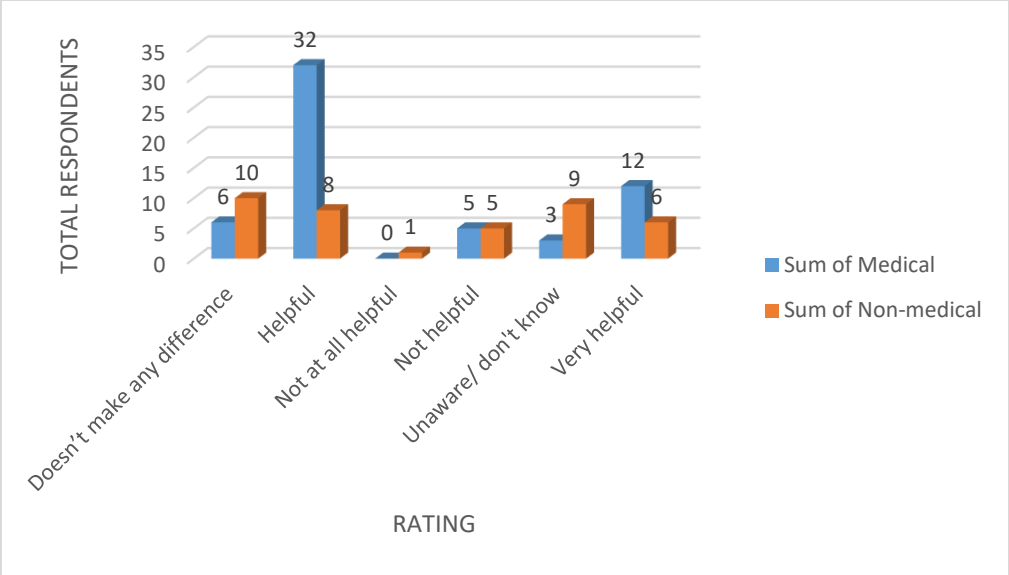
12. Perception about Helpfulness of CDSS in healthcare

Respondents rating on level of helpfulness of CDSS	**Rating**	**Total responses**	**Medical**	**Non-medical**
Very helpful	5	18	12	6
Helpful	4	40	32	8
Doesn't make any difference	3	16	6	10
Not helpful	2	10	5	5
Not at all helpful	1	1	0	1
Unaware/ don't know	0	12	3	9

Table shows rating given to CDSS in its level of helpfulness as perceived by the respondents.

Total response to helpfulness was (very helpful+ helpful) 58 responses out of which 44 were medical staff and only 14were non-medical staff thereby showing stronger positive perception of medical staff towards the helpfulness of the system.

Not aware and not helpful accounted for 39responses out of which 25 were non-medical staff and only 14 were medical staff.



Graph shows rating given to CDSS in its level of helpfulness as perceived by the respondents.

13. Perception about whether CDSS should be used by other healthcare Providers

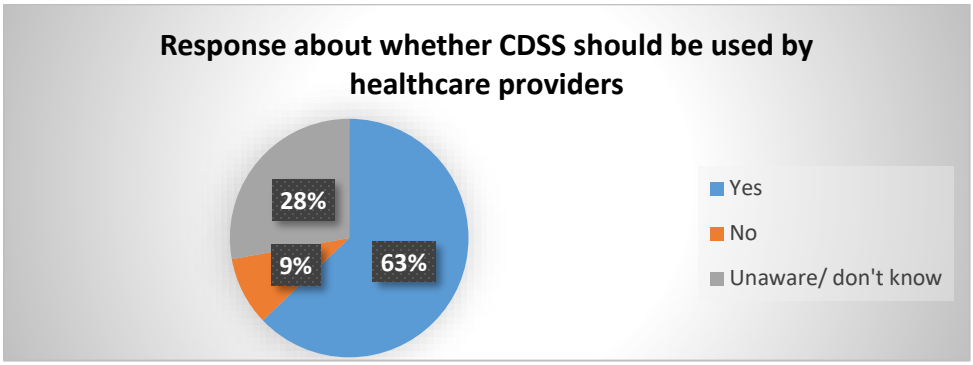


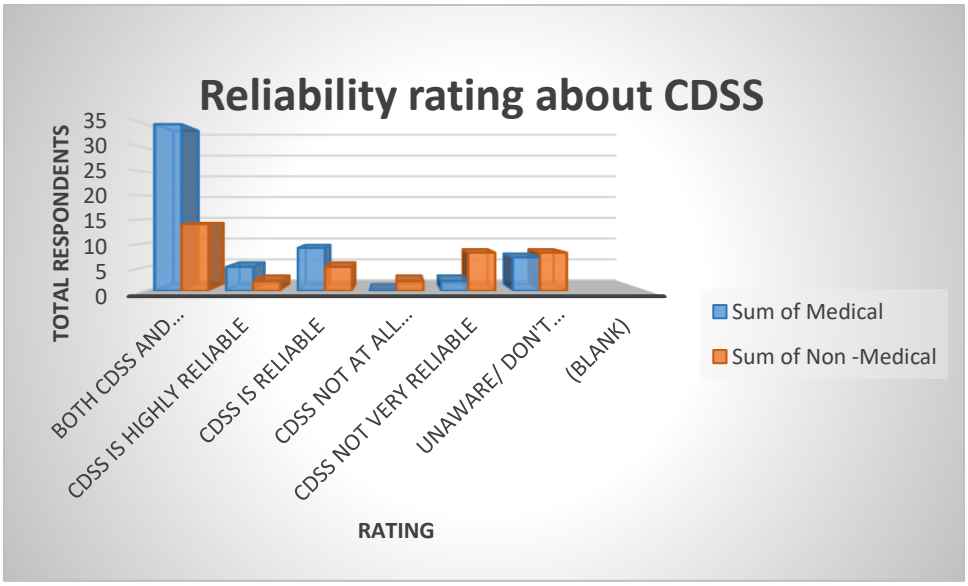
Table shows response on whether CDSS should be used by healthcare providers.

About 63% of the respondents agreed that CDSS should be used by healthcare providers, and only 9% thought that CDSS should not be used. And 28% respondents were didn't know about CDSS use in patient healthcare.

14. Perception about reliability of CDSS in healthcare

Reliability rating about CDSS	Rating	Total responses	Medical	Non - Medical
CDSS is highly Reliable	5	7	5	2
CDSS is reliable	4	14	9	5
Both CDSS and Doctors are together reliable	3	49	35	14
CDSS not very reliable	2	10	2	8
CDSS not at all reliable	1	2	0	2
Unaware/ don't know	0	15	6	9

Table shows reliability rating about CDSS by the respondents.



Graph shows reliability rating about CDSS by the respondents.

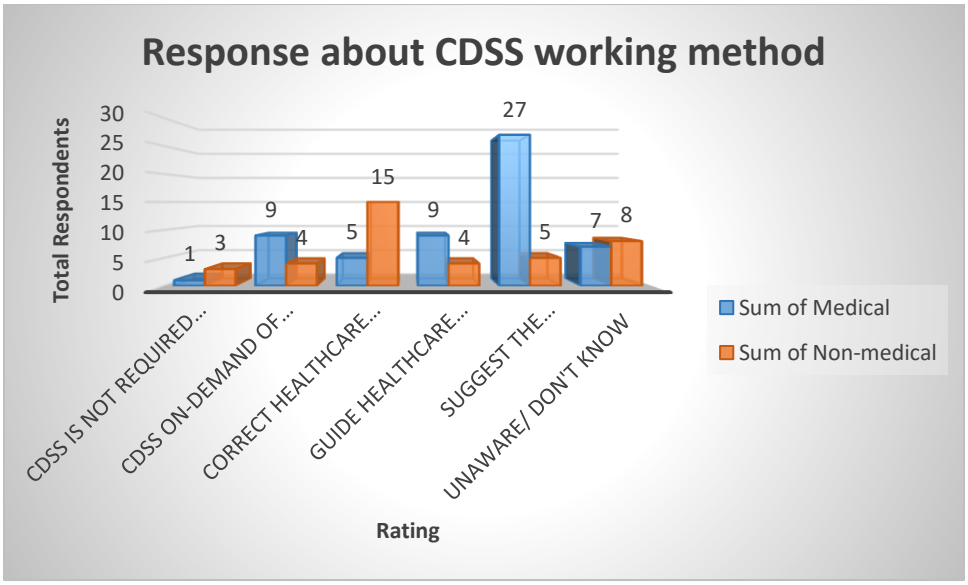
CDSS reliability rating score was maximum in the median position, i.e. 49 respondents think that both CDSS and doctors are together more reliable than CDSS alone being reliable or its not reliable. There

were 21 respondents who thought that CDSS is reliable, and in contradiction there were 12 respondents who doubt CDSS reliability.

15. Perception about Acceptability of CDSS in healthcare

Response about CDSS working method	Rating	Total responses	Medical	Non-medical
Guide healthcare providers	5	13	9	4
Correct Healthcare Providers when needed	4	20	5	15
Suggest the treatment plan	3	32	27	5
CDSS on-demand of caregiver	2	13	9	4
CDSS is not required at all	1	4	1	3
Unaware/ don't know	0	15	7	8

Table shows rating of respondents about CDSS working method and its acceptance level.



Graph shows rating of respondents about CDSS working method and its acceptance level.

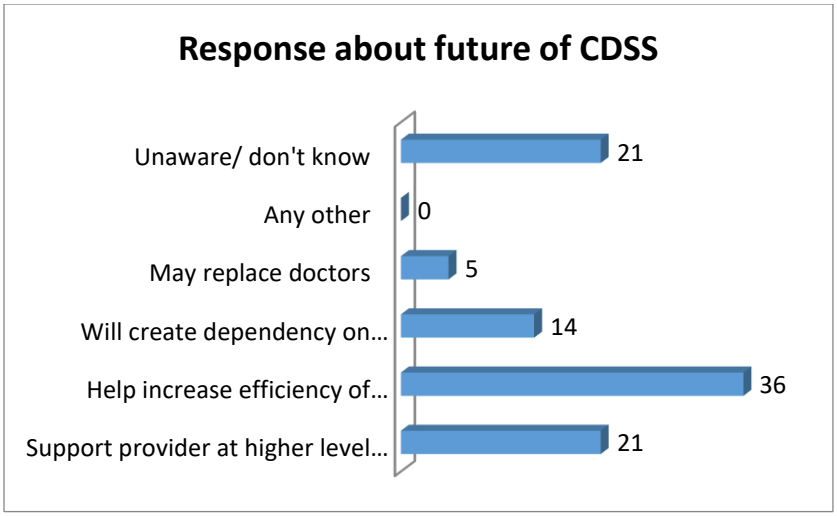
Among all the methods of CDSS assistance to healthcare providers, maximum score rating was given its assistance via suggestion method (32 responses), followed by correcting the healthcare provider (20 responses). Both guide the healthcare providers and CDSS on demand only on contrary got rating of 13 responses each. Four respondents thought that CDSS is not required at all.

Out of 32 responses for suggesting treatment plan 27 responses were from medical staff and 5responses were from non-medical staff

16. Perception about future use of CDSS in healthcare

Response about future use of CDSS	**Number**
Support provider at higher level of healthcare delivery	21
Help increase efficiency of healthcare system	36
Will create dependency on artificial intelligence	14
May replace doctors	5
Any other	0
Unaware/ don't know	21

Table shows the frequency of respondents' perception about future scope of CDSS.



Graph shows the frequency of respondents' perception about future scope of CDSS.

Respondents who thought that CDSS will be helpful in increasing healthcare system efficiency in future were maximum and accounted 36 in number. There were 21 respondents who thought CDSS will be useful in more sophisticated type of treatments and at higher level of healthcare delivery. Also 21 respondents were unaware about CDSS future scope.

Most of the respondents believed that CDSS in future will majorly help in increasing the efficiency of healthcare system.

5.4.Discussion

Present study was conducted with an aim to know the perception of healthcare providers regarding CDSS including both medical and non-medical staff. Medical staff accounted for 60% of the respondents and non-medical staff was 40%. Majority of the respondents were doctors accounting for 30% of the respondents, followed by nurses which formed 25% and ancillary and support staff forming 17% of the respondents. Respondents included 55% of females and 45% males.

Computer literacy

Before knowing the awareness level regarding CDSS, level of computer literacy among the respondents was assessed which is the prime requirement for success of any health IT project and as stated by Kaya N [48, 47] that requirements for the success of computer-based interventions in healthcare include the familiarity of the users with the technology and positive mental attitudes and motivation regarding the computer us· The present study shows that the literacy and awareness regarding computer usability is significantly good among the health workers in the urban facilities. 87 out of 97 respondents had used computers before and maximum respondents (34) were using computers from workplace which when analyzed further showed that amongst those who use computers at workplace were non-medical staff

(19 responses) and those who used computers from both home and workplace maximum respondents were medical staff (19 out of 34). Response to usability showed that most of the medical staff were using computers to access either emails or internet .Only 14 responses got score of "6" out of which 5 were medical staff and 9 were non-medical staff, thereby showing more usability of all the softwares by non-medical staff.24 responses were for use of two softwares out of which 18 responses were by medical staff that too for use of internet and email. 29 responses were for use of only one software that too was either internet or emails mainly (21 responses) medical staff. Therefore showing maximum use of internet or emails among medical staff.

Awareness regarding HIS

CDSS is more effective when integrated with EMR as it will allow a continuous and n time flow of information for decision making regarding a particular patient. Both being a part of HIS awareness regarding HIS was assessed.

The respondents' awareness about HIS was 94%, and all those who had ever used HIS were 80%, thus showing the respondents awareness towards healthcare IT and its acceptance. Awareness level about HIS is quiet favorable among healthcare providers of India, most of them have also used it till date.

Awareness regarding CDSS

Though awareness regarding HIS is good but CDSS is still a new concept for many healthcare providers and still to be recognized in India. Out of 97 respondents only 36 were aware of CDSS which when analyzed 22 were medical staff and 14 were non-medical staff. If analyzed out of total medical staff (58) respondents 38% were aware of CDSS and out of total non-medical (39) respondents 36% were aware i.e in both ways of analysis percentage of medical staff aware of CDSS was more than non-medical staff.

Perception about usability, helpfulness, reliability & acceptability of CDSS

Most frequent use about CDSS perceived by the respondents was that CDSS was used to assist physicians in treating patients by providing information (39 responses), which is true as also mentioned by Wyatt J, Spiegelhalter D, 1991, that Clinical Decision Support Systems are "active knowledge systems which use two or more items of patient data to generate case-specific advice" and Robert Hayward defines CDSS as, 'CDSS link health observations with health knowledge to influence health choices by clinicians for improved health care.' CDSS helps increasing the efficiency of health care, help reducing the human errors, and is a cost-effective and smart solution to healthcare industry.

But this response was followed by the perception that CDSS was used for electronic data entry (31 responses), which is rather not true. Thus the above two statements shows that most of the respondents may confuse CDSS with other health IT systems.

So this was further analyzed to see that which category were the respondents belong. It showed maximum respondents who considered CDSS to be used to assist physician (25 out of 39) were medical staff respondents and those who said it is used for electronic data entry were non-medical staff respondents (18 out of 31), also those who said it is used to guide in treatment were majorly medical staff (13 out of 24), which showed that there was much more clarity about the role of CDSS among medical staff than non-medical staff.

Most of the respondents (58 out of 97) considered CDSS to be helpful to healthcare providers .Total response to helpfulness was (very helpful+ helpful) 58 responses out of which 44 were medical staff and only 14were non-medical staff thereby showing positive perception of medical staff towards the helpfulness of the system. Not aware and not helpful accounted for 39responses out of which 25 were non-medical staff and only 14 were medical staff showing uncertainty towards the helpfulness of CDSS amongst non-medical staff.

49 respondents out of 97 believed that CDSS alone may not be as reliable and agreed on its reliable with doctors only out of which 35 were medial staff respondents. There were very few respondents who disagreed on CDSS reliability (2 out of 97). Majority of medical staff 49 out 58 considered CDSS to be reliable. Among all the methods of CDSS assistance to healthcare providers, maximum score 32 rating was given its assistance via suggestion method, thus suggestion being the most favorable to for most healthcare providers. When analyzed further it showed most of the medical staff 27 out of 32 considered it to assist via suggestions whereas most of non-medical staff considered it for correcting healthcare providers 15 out of 20.

Recommendations

- Differences in perception of medical and non-medical staff regarding usability of CDSS shows a need for creating more awareness regarding role of CDSS to healthcare providers.
- Need for training the hospital staff in basic computer softwares is required for success of health IT softwares
- To ensure the reliability of the CDSS software needs more of evidence based knowledge base of CDSS which should be updated on regular basis.

5.5. Conclusion

India Today needs a healthcare solution that is easily affordable and accessible by all. Such a system is only possible if it has the back bone of an advance IT technology that caters to the need at affordable price point.

Hospitals using a hospital information system (HIS) accumulate a huge amount of transactional data during their daily activities. Extraction of this data is an analyzable form to maximize the benefits of the HIS is given relatively low importance. Most hospitals rely on a set of standard reports made using fixed criteria.

Health IT is becoming a chief component of the health system. IT application have vast scope in streamlining the healthcare that is being provided to the patients. Health IT have improved the quality of care that is being provided to the patients. CDSS is one of the main module among health IT that is used to improve the healthcare quality being imparted to patients. CDSS have helped to standardize the quality healthcare. It has helped to reduce many errors that were common in health system and have proven to be highly useful to mankind. CDSS is still at its initiation stage and should be explored

further to gain maximum output from it. Future CDSS market shows a great potential of growth in both developed and developing countries like Asia (markets and markets.com) which will provide a strong base for quality healthcare solutions in countries like India.

CDSS is being able to successfully assist the healthcare providers to deliver quality healthcare to the patients. But there have been few ethical and legal issues regarding its use. These issues will not be a problem if one always remember that CDSS is to assist doctors' decisions, and doctors' autonomy should be prime focus. India has advanced a lot in IT sector but still lags behind in health IT when compared at global level. Indian healthcare system need to focus on development in health IT and make the best benefit out of it.

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