Original Article:

Clinical Decision Support System for Oncologist: Perception, Expectations and Implementation

Rajesh Kumar Sinha, Associate Professor, Department of Health Information Management, Manipal College of Allied Health Sciences,
Manohara M Pai, Associate Director, Innovation Center, Professor, Information and Communication Technology, Manipal Institute of Technology,
MS Vidyasagar, Professor and Head, Department of Radiotherapy and Oncology, Sirdhi Saibaba Cancer Hospital and Research Center,
BM Vadhiraja, Associate Professor, Department of Radiotherapy and Oncology, Sirdhi Saibaba Cancer Hospital and Research Center,
Manipal University, Manipal - 576 104, Karnataka, India.

Address for Correspondence:
Dr. Manohara M Pai,
Associate Director, Innovation Center,
Professor, Information and Communication Technology,
Manipal Institute of Technology,
Manipal University, Manipal - 576 104,
Karnataka, India.
E-mail: mmm.pai@manipal.edu

Abstract: Background: Clinical Decision Support System is an integral application in modern healthcare practice to assist the clinicians with patient information and domain knowledge during patient care. **Purpose:** Assessment of perception and Identification of expectation are the prerequisite for the implementation of Clinical Decision Support System (CDSS). **Methodology:** A descriptive study was conducted among the 100 Oncologists of cancer hospitals and research centers of Southern India. A validated survey questionnaire related to the perception and expectation towards CDSS was provided to the participants and asked them to mark their response on a 5-Point Likert Scale i.e. from Strongly Agree to Strongly Disagree. The time motion study was also conducted to understand the issues related to the access of patient information and domain knowledge. **Result:** The Oncologist perception towards CDSS was found to be significant where the Oncologists felt that the implementation of CDSS will decrease the cost of healthcare and increase the productivity of the hospital. The Oncologists expected that the system should have the features to automatically capture the clinical knowledge, practice guidelines and updates related to cancer care. The time motion study revealed that the Oncologists spend their maximum time in documentation & retrieval of patient information during patient care and evaluation because they largely depend on printed text. A web enabled CDSS is developed, implemented, and tested against the requirement of the Oncologists where the system was found to be highly acceptable by the Oncologists. **Conclusion:** The expectations of the end users should be fulfilled to make the CDSS more acceptable and sustainable as the similar result had been observed and found in the present research.
Key Words: Perception; Expectation; Clinical Decision Support System; Oncology; Oncologist

Introduction:

Cancer control and prevention is considered to be an integral and challenging task for the healthcare professionals and hospital setup. The objective of cancer control and prevention is to reduce the incidence, mortality and morbidity of care and further improve the quality of life of the patient suffering from cancer.[1] To achieve this it is largely dependent on the clinician's ability to make quality decision in formulating the diagnosis based on information gathered from the patient and other sources.[2] Information and Communication Technology is always looked upon by healthcare as a tool for improving the accessibility of patient information and domain knowledge to improve the clinical outcome of the cancer patient.[3]

These technologies have the potential to facilitate or enhance communication and exchange of information between the cancer patients and the care providers with an ultimate aim to enhance the benefits to stakeholders, most importantly the patient. These technologies are acknowledged as a supportive tool to save time and money, increase convenience and choice, obtain timely information, and improve decision making during patient care.[4]

Clinical Decision support systems (CDSS) is an important application of Information and Communication Technology to assist the clinicians in gathering patient information and clinical knowledge related to the respective domain for making diagnostic and therapeutic decision. The system also supports in clinical coding and documentation, authorization of procedure, referral, clinical diagnosis, treatment plan process, condition-specific guidelines, and promoting the use of best practices.[5] It has the potential to minimize practice variation and improve patient care and create a marked surface throughout the healthcare industry.[6] It also assists in management of various other activities such as referral, diagnosis, classification and staging, treatment and follow-up of

the patient specific to neoplastic disease. The system also provides continuous monitoring of patient treatment.

The recent trends in healthcare showed the necessity for innovative and dependable clinical information systems with decision support capabilities for quality decision making in healthcare delivery system. But before the implementation of such system, it is required to understand the clinician's opinion as the acceptability of any such information system in the healthcare set-up largely depends on the positive attitude of the clinicians to use it for quality decision making in patient care.[7-11] To make the system more acceptable and sustainable in the healthcare delivery, clinician's needs and expectation towards the clinical decision support system must be assessed and considered. This helps in choosing the appropriate content and tool for the development of the system [12-14] and creates a feeling of ownership among the end users.

Methodology

Study Design: A descriptive method of research was used for the study. John W Creswell [15] describes the descriptive method of research where the researcher gathers information based on the present existing condition. The method is used to define the nature of the situation, as it exists at the time of study and to explore the causes of a particular phenomenon. In this study, the descriptive method was employed to identify the perception and expectation of Oncologists towards clinical decision support system using a tested tool by recruiting and selecting oncologists during the time of research. The aim of this research is to design and develop a customized decision support system for oncology where this method helped to obtain first hand data for deriving the rationale and sound conclusions and recommendations.

Study Setting: The participants were selected from 12 different Cancer Hospitals and Research Centers of Southern India.

Sample Size: In order to determine the level of awareness and utilization of cancer information system, perception and expectation from decision support system, 100 oncologists were asked to participate. A purposive sampling method was adopted where the three states i.e. Karnataka, Kerala and Tamil-Nadu were included in the study. In these three states, 12 hospitals were considered for selecting the Oncologists based on the availability and convenience and also as per the qualification of the Oncologist.

Inclusion Criteria: To obtain pertinent information, certain inclusion criteria were drawn. The participants with MD and 5 years of working experience in the oncology set-up qualified for the study. This qualification ensured that the participants understood the role of information support services in their practice and be able to give appropriate feedback in this regard. The participants who were not willing to participate in the study were excluded.

Data Collection Tool: In order to collect the data from the Oncologists, a validated and pre tested questionnaire was used. The questionnaire was prepared and validated by experts from the field of Oncology, and Health Information Management. The questionnaire consisted of three sections: *Demographic Details; Perception towards Clinical Decision Support System and Expectation from Clinical Decision Support System*. To understand the oncologists perception towards the clinical decision support system 8 parameters were included where the oncologists were asked to mark in a scale from 1 to 5 *(Strongly Agree to Strongly Disagree).* The oncologists were asked to rate their expectation from the proposed system in terms of quality decision making, coding, documentation and patient care. These expectations were captured using a checklist consisting of 14 components related to the above parameters. The oncologists were asked to respond by marking their response in a scale from 5 to 1 *(Strongly Agree to Strongly Disagree)*. The oncologists were first briefed

about the study and after obtaining an informed consent they were included in the study.

The existing workflow has also been observed to determine the total time for capturing and disseminating the patient information to the oncologists and also the issues related to the accessibility of clinical knowledge. The oncologists were also asked to list out the areas of improvement in terms of information support service in their practice.

Once developed and implemented, the CDSS is demonstrated among the Oncologist and their feedback was collected to understand their acceptance level.

Methods of Data Collection: The questionnaire was administered to the Oncologists after taking the consent from the concerned hospital authorities. The Oncologists were first briefed about the research and its objectives and the purpose of survey. An informed consent was obtained from the Oncologists for being the part of the study where the data was collected by distributing the questionnaire among those who responded. During the process of data collection, the workflow pattern and total time taken with respect to the documentation, retrieval and access of patient information and clinical knowledge were also noted down. The user acceptance test was also conducted to determine the acceptance of the CDSS.

Statistical Analysis: Statistical Package of Social Sciences (SPSS) 16.0 version was used to analyze the data. Chi square test was done and $P<0.05$ was considered significant. The average time for capturing and dissemination of patient information to the end users were also calculated to understand the issues related to the access and availability of information and clinical knowledge and to suggest the better CDSS for improving the information support service process.

Architecture to Develop Clinical Decision Support System: A CDSS was developed with 3-layer application with User Interface, Business Logic layer and Data layer. Data access layer is incorporated using ADO.NET to communicate with database. The software platform used to developed the CDSS was MS SQL 2005 and the Web Server i.e. IIS to serve the users request from their browsers like Mozilla Firefox, Internet Explorer etc. to access the system and its content. The end users operating system can be any version of Windows, Linux or any other which supports TCP/IP protocols. The communication interfaces is a local area network connected to local hosting server.

Results and Discussion:

Characteristics of the Oncologists: A total of 100 oncologists from 12 cancer hospitals and research centers of Southern India, participated in the study. The majority of the Oncologists (71%) were found to be male (Table 1).

Table 1: Gender Wise distribution				
Male		**Female**		**Total**
Frequency	**%**	**Frequency**	**%**	
71	71%	29	29%	100

A mixed variation was observed in terms of the age of Oncologists where 41% of them were in the age interval of 36-40 followed by 20% under 41-45 age group, 18% under 31-35 group and 13% in 51-55 age group. Only 2 Oncologists were in the age group of 56-60 (Figure.1). Thus a relatively younger generation of oncologists, mostly below 40 (61%) were found in most of the hospitals.
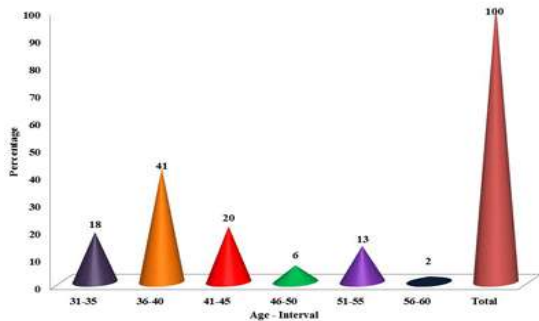
Figure 1: Age-wise Distribution of Oncologists

Table 2 represents the designation-wise distribution of the Oncologists. Of the total, 37 Oncologists were consultants followed by 27 Associate Professors and 15 Assistant Professors whereas Additional Professor and Professors constituted only of 11 and 10 respectively. This is attributed to the fact that the majority of the oncologists were below the age of 40 and the designations in most of the hospitals in India are based on the years of teaching and/or practice.

Table 2: Designation and Department Wise Distribution

Designation	Department				Total
	Gyn Oncology	Medical Oncology	Radiation Oncology	Surgical Oncology	
Professor	0	0	8	2	10
Additional Professor	0	2	8	1	11
Assistant Professor	2	1	11	1	15
Associate Professor	1	3	21	2	27
Consultant	1	7	22	7	37
Total	4	13	70	13	100

The majority of the Oncologists (41%) had 5 – 10 years of experience, 37% under 11 – 15 years, whereas, 22% of the Oncologists reported to have more than 16 year of experience in patient care and teaching (Figure 2).
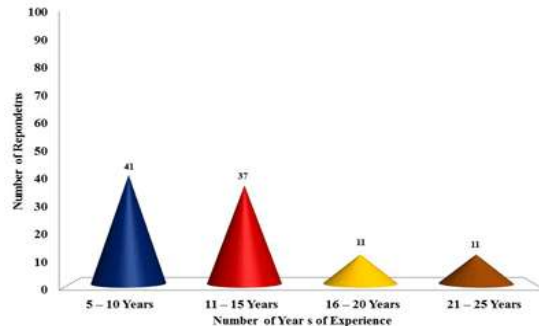

Figure 2: Distribution of Oncologists based on years of experience

Opinion of Oncologists on Clinical Decision Support System: The opinions of end users are required in easy and practical implementation of clinical decision support system in practice.

The oncologist who completed the survey offered diverse opinion about the clinical decision support system in healthcare practice. Table 3 summarizes the response of the oncologist towards clinical decision support system (CDSS). A total of 93% of the Oncologists were found to agree on the fact that the implementation of CDSS will increase the productivity of the hospital. This is attributed to the fact that most of the oncologists were found to be aware about the benefits of clinical decision support system. A systematic review conducted by Amit et al [16]; and Kensaku et al[17] also revealed that most of the CDSS improved the clinician performance and resulted in better patient outcome.

A mixed response had been observed when the oncologists were asked whether the implementation of CDSS will create hassles in their work, 42% of the Oncologists were found to disagree whereas 32% of them showed no opinion but only 26% of them agreed. When probed further, the clinicians felt that the CDSS may create hassles initially but at a later stage will definitely improve their workflow as well as their performance.

Out of total, 63% of the Oncologists believed and agreed that CDSS can do the job better whereas 25% did not have any opinion and 12% disagreed to it and expressed that the system cannot replace a human being.

Table 3: Opinion on Clinical Decision Support System

Implementation of Decision Support System will:	n=100				
	SA	A	N	D	SD
Increase the productivity of hospitals	29%	64%	7%	00	00
Create hassles for clinical staff	2%	24%	32%	26%	16%
Do a job better than the people	13%	50%	25%	8%	4%
Decrease hospital costs in the long run	24%	50%	14%	10%	2%
Mean less work for people	13%	53%	16%	18%	00
Upgrade job functions of non-medical personnel	8%	52%	29%	8%	3%
Reduce the doctors control over medical practice	00	11%	10%	49%	30%
Is unavoidable in healthcare practice	25%	46%	18%	9%	2%
SA= Strongly Agree, A= Agree, N= No Opinion, SD = Strongly Disagree, D=Disagree					

When asked whether they feel that the decision Support System will reduce the cost in the long run, 74% of the Oncologists agreed, 12% disagreed and 14% of them did not opine. When the Oncologists were asked whether the clinical decision support system will help in reducing the workload, 66% had positive opinion, whereas 18% disagreed, and 16% were found to have no opinion in this regard. It was evident from the study by Troy et al felt that the clinical decision support system had significantly decreased the clinicians prescription cost and improved their prescription efficiency.[18]

A good percentage of the Oncologists i.e. 29% were found to have no opinion on how the clinical decision support system will upgrade the job function of non-medical personnel where as 60% of them showed their agreement with this fact. When the Oncologists were asked whether the implementation of clinical decision support system will reduce their control over medical practice, 79% of the total Oncologists showed their disagreement and commented that the machine cannot replace the humans where the life of the patient is at risk whereas 10% did not have any opinion but 11% of them agreed with the same.

In response to the query whether CDSS will help in making quality decision during patient care, 81% of them agreed whereas 11% disagreed and 8% did not have any opinion (Table 3).

The study conducted by S. Trent Rosenbloom et al. was evident that the clinicians were satisfied with the computer provided order entry and reported that their efficiency in terms of quality patient care, order entry has been improved. They also commented that the decision support system is also assisting them in medical training.[19]

The results show that the Oncologists with clinical experience of 5-15 years were more interested in implementing CDSS in their day to day practice whereas the Oncologists with 16-25 years of clinical experience were not very much sure and confident on how CDSS will support them in their oncology practice. This can be attributed to the fact that the younger oncologists are more technology savvy and understand the

benefits from it fully, whereas the older generations still have certain trepidations. This behavior can also be seen in the study conducted by Helena Veronen where the younger physicians looked more enthusiastic towards the implementation of the use of the system in their practice where criticism was mostly presented by the older clinicians.[20]

Expectation from Clinical Decision Support System: Expectations of the end users and their needs have to be identified before designing and developing any information technology (IT) applications.[21,22] The same was conducted among the oncologists to understand their expectation from the CDSS.

Expectation with regard to Clinical Decision Making: Clinical decision making during the patient encounter always depends on the availability of complete and accurate patient information and domain knowledge to the healthcare professionals. The information also contributed in updating knowledge as well as planning for the therapy and care.

All the oncologists were found to agree with the fact that clinical decision support system should have the provision to provide various clinical knowledge and treatment guidelines to the end user in quality decision making. About 74% of the Oncologists showed their agreement but 22% were not sure about the role of clinical decision support system with respect to the etiological diagnosis and therapy. Out of total, 92% of the Oncologists wanted features where the proposed system will support them in updating the clinical knowledge for planning the treatment and care (Table 4).

Table 4: Expectations with regard to Clinical Decision Making

CDSS should help in quality decision making by:	n=100				
	SA	A	N	D	SD
Providing various clinical knowledge and guidelines	25%	75%	00	00	00
Answering questions concerning medical knowledge	18%	62%	7%	12%	1%
Correlating patient condition with clinical knowledge	10%	77%	12%	00	1%
Finding etiological diagnosis and therapy goal easier	9%	65%	22%	3%	1%
Updating the knowledge of healthcare team by providing reviews of scientific literature and current updates	27%	65%	8%	00	00

SA= Strongly Agree, A= Agree, N= No Opinion, SD = Strongly Disagree, D=Disagree

Expectation with regard to Documentation and Statistics of Patient Information: The healthcare professionals always expect that the information system if implemented in their practice should reduce their time in medical documentation and clinical coding and increase their time for patient care and evaluation.

In this study, the Oncologists were asked about their expectation from the proposed system in terms of medical documentation, clinical coding, statistic and recording of investigation results. The responses were as follows:

The International Classification of Disease-10th Version (ICD-10) and International Classification of Disease in Oncology (ICD-O) helps the healthcare professionals as well as the hospital to standardize the recording and reporting requirement and helping them in making quality decision. In view to this, 95% of the Oncologists expected to have an automated clinical coding and documentation features in the proposed system.

The majority of the Oncologists i.e. 99% felt that the system should have the features in generating variety of statistical result for reporting and research. All the Oncologists agreed to have certain features where they can easily interact with each other using the same system and receive the investigation as well as therapy result without any delay (Table 5).

Table 5: Expectation with regard in Documentation Patient Information & Statistics

Clinical Decision Support System should:	n=100				
	SA	A	N	D	SD
Support in clinical coding and documentation	29	69	02	00	00
Generate a variety of statistical analysis and presentation	48	51	01	00	00
Improve communication and collaboration	15	85	00	00	00
Make following results of a test or investigation easier	25	75	00	00	00

SA= Strongly Agree, A= Agree, N= No Opinion, SD = Strongly Disagree, D=Disagree

Expectation with regard to Patient Care: Clinical Decision Support System assists the healthcare professionals in achieving the best patient outcome and maximum patient satisfaction by reducing the cost of healthcare, improving the clinical outcome, instant information retrieval and reducing the waiting time of the patient. The healthcare professionals also get benefited with this in promoting evidence based medicine.

In view to this, 91% of the Oncologists agreed that the system should have an automated feature to instantly access the patient's identification, clinical and investigation details. They also commented that the automation of this process will secure the patient data from misplacing, missing or any incident of loss and will directly contribute in reducing the cost of healthcare.

About 93% of the Oncologists felt that the system should have certain features to assist them in retrieving complete, accurate and adequate patient information and domain knowledge related to cancer for improving the clinical outcome of the patient.

All the Oncologists wish to have selective retrieval of patient information and domain knowledge. They also felt that the system should satisfy their day to day reporting activities such as administrative, clinical and reporting to National Cancer Registry Office. They felt the need of such system in getting access to all the patient information and the status of the patient during follow-up.

Evidence base medicine is the use of current medical knowledge and patient's clinical evidence to make quality decision during patient's treatment. In this view, 90% of the respondents expected to have this feature into the system but 10% of them were not sure whether the system will really assist them in improving the evidence based medicine. (Table 6)

Table 6: Expectation with regards to Patient Care

Clinical Decision Support System should:	n=100				
	SA	A	N	D	SD
Reduce the cost of healthcare	19%	72%	9%	00	00
Help in improving the clinical outcome of patients	24%	69%	17%	00	01
Make seeking specific information from patient records	31%	69%	00	00	00
Help in better reporting and follow-up of adverse events	19%	81%	00	00	00
Promote evidence based healthcare practice	27%	63%	10%	00	00

Strongly Agree, A= Agree, N= No Opinion, SD = Strongly Disagree, D=Disagree

All the respondents agreed to the fact that this kind of system should be implemented in all the hospitals and should have the provision where the decision taken by the clinician based on the knowledge provided by the system should automatically get saved into the system for future reference. (Table 7)

Table 7: Overall opinion on Clinical Decision Support System

Parameter	n=100	
	Yes	No
Do you think that the CDSS should be implemented and practiced in all healthcare facilities for quality decision making and quality healthcare?	100%	0
Do you think the CDSS should have the provision to automatically store the decisions made as a case base, which can be referred to later during a similar case?	100%	0

Assessment of Existing Workflow Pattern: Figure 3 represents the conventional workflow pattern in the hospital for patient care and evaluation where the easy and instant access of patient information and clinical knowledge play a vital role and also influence the process of care.
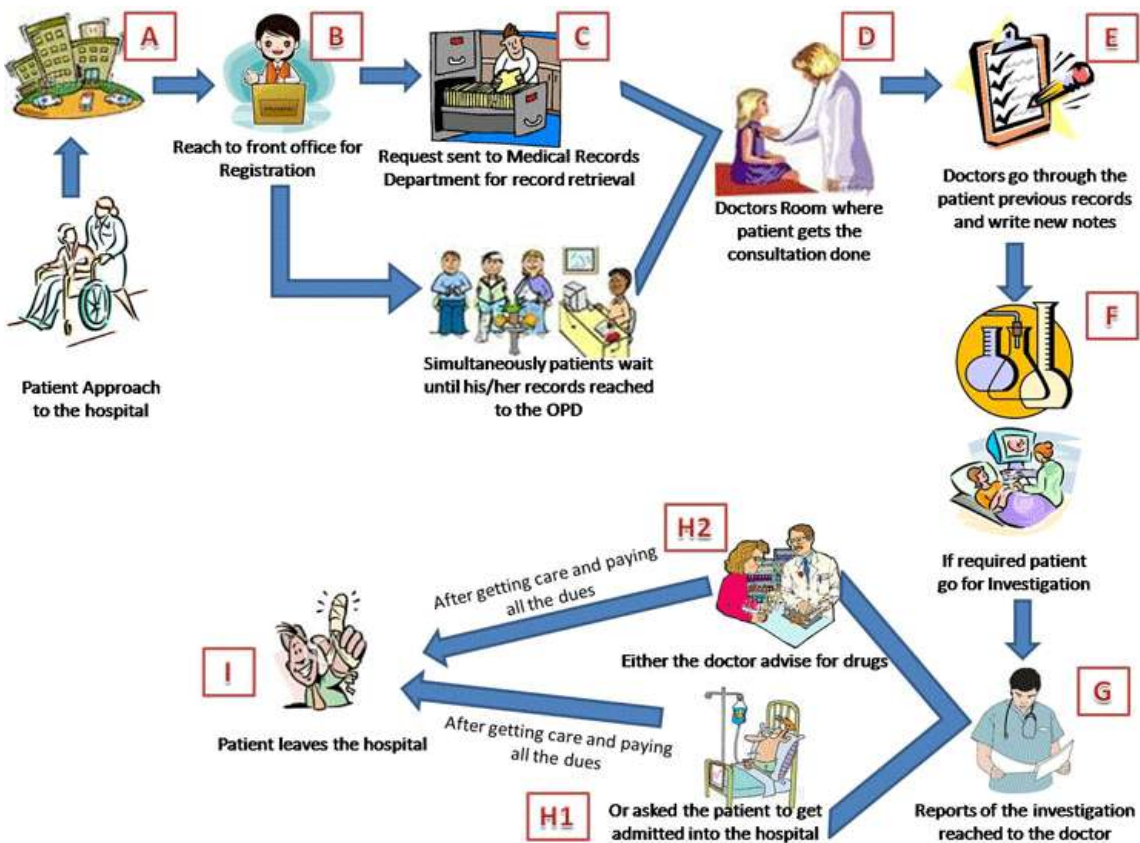
Figure 3: Conventional Flow of Information for Patient Care

| Table 8: Comparative list of conventional workflow pattern with CDSS		
Process	**Conventional (Manual)**	**Estimated With CDSS (Electronic)**
Registration of patient data – Request sent to MRD	**10 Min. (Avg.):** As the patient information record manually on paper.	Records are electronically documented into the system that is available instantly in any location.
Time to reach the medical records from MRD to OPD	**20 Min. (Avg.):** Records are sent through the messenger boy to the respective unit.	Instant access of patient information by the oncologist at their respective OPD.
Recording the patient information onto the medical records.	Manual entry of the patient data increases the clinician time for documentation.	Menu driven entry decreases the oncologist's time in documenting the patient information.
Reporting of patient investigation result	**20 Min. (Avg.):** Manual entry of patient investigation result and reporting on paper	Instant access of up-to-date investigation result at the oncologists desktop
Access of recent clinical knowledge	Through text book or internet **Issue:** Difficult to search the instant and accurate knowledge related to oncology.	Instant access of clinical knowledge as the rules or algorithm will automatically filter and rank the online and offline latest evidence related to the respective domain.
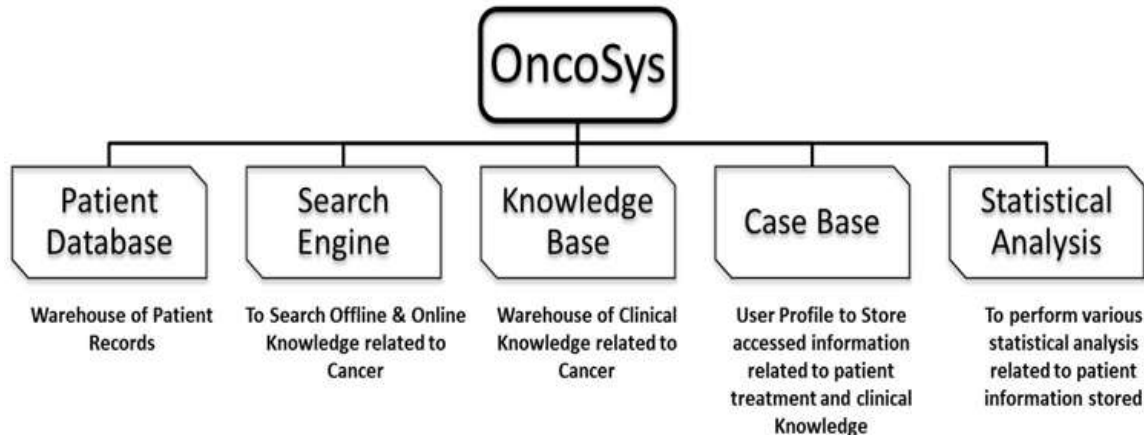
Figure 4: Module of Clinical Decision Support System

The observation of workflow pattern and feedback received from the oncologists reveals that they spend maximum time in accessing patient information during the follow-up. It takes longer time in retrieving and sending from the medical records from medical records department to the OPD. This results in increased waiting time of the patient who requires immediate attention.

The following interpretations were drawn by assessing the existing workflow in the hospital with the estimated workflow using clinical decision support system.

Accessing the recent domain knowledge, practice guidelines and protocols were also found to be the major issues where maximum Oncologists use Google as a search engine but it provides the information without any ranking and filter. On comparison, it is felt that the implementation of CDSS will definitely improve the information support service in the hospital in this regard (Table 8).

Implementation Details: Based on the result receive from the survey, a web enabled clinical decision support system model is developed and implemented. The model consist of Patient Database to capture the demographic and clinical events occur in care of a cancer patient with automated ICD-Oncology-3rd Version and AJCC TNM-Staging ; Knowledge Base to create a warehouse of knowledge related to oncology domain; Search Engine to search domain knowledge based on two criteria such as the latest evidence and review article; Case base to create a user profile to store all the transaction details of the end user and Statistical Analysis to generate various statistics related to patient care. The ultimate aim of the system is to completely support the oncologist in accessing patient information and clinical knowledge for quality decision making in patient care and evaluation.

The suggestions given by the Oncologists were mainly related to the strengthening of the knowledge base where they suggested various text materials in terms of textbooks, journals, practice guidelines and websites related to oncology practice and the same were incorporated into the knowledge base of the CDSS.

The model is tested against the requirement and expectation of Oncologists identified during the survey. The CDSS is demonstrated to the Oncologists where the result revealed that the Oncologists were highly satisfied with the user interface and felt that the system is friendly, supportive, logical, consistent, helpful and easy to use. The Oncologists also felt that implementing OncoSys would be wise for them and hospital. The Oncologists intended to use the system in case of doubt during patient care and evaluation.

On comparison with the existing workflow pattern the Oncologists felt that the OncoSys can greatly reduce their time in access and management of patient information. They agreed on the fact that the statistical analysis module will contribute in generating variety of statistical data for health research, conducting various cancer control and prevention programs and also for National Cancer Registry reporting. The Oncologists felt the system will help in enhancing their productivity and also will contribute greatly to the evidence-based practice. All Oncologists felt that the system has all the features to support them in quality decision making and should be implemented in all the hospitals for quality decision making in patient care and evaluation.

Conclusion:
The study concludes that the oncologist had positive opinion in implementing the clinical decision support system in their practice. The majority of the Oncologists felt that the implementation of clinical decision support system will decrease the hospital cost in the long run, reduce the work load in terms of documentation and reporting, upgrade the job functions of non-medical personnel, do the job better than people and it is unavoidable in healthcare practice. The

clinicians only disagreed to the fact that implementation of clinical decision support system will reduce their control over medical practice. There was an awareness that CDSS will only assist in decision making and is not a replacement for the clinicians.

The Oncologists felt that the CDSS will support them in easy documentation, statistical analysis and also assist them in improving the clinical outcome of the patient. The oncologists' major concern was to reduce their time in accessing patient information and clinical knowledge and they felt that the developed CDSS will definitely support them in doing so. All the Oncologists felt that the implementation of the system will increase the productivity of the hospital and it should be implemented in all the hospitals.

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