Cloud Based Intelligent Decision Support Knowledge Based System for Kidney Transplant Patients (CBIDKBS): COVID-19 Response

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Abstract: *Covid-19 pandemic brought extraordinary disruption to the health care landscape. India has a vast majority of the population which are dependent on government hospitals for their health problems. India has approximately 10-11 lacks registered doctors to serve approx. 1.3 billion citizens. Now, when the private hospitals and Nursing Homes have been on a different track for health check-ups and treatment patterns, one cannot attend the OPDs physically and cannot discuss their problems with the doctors face-to-face. With our solution, they can take advice from the Artificially Intelligent Specialist which is a computer. With these AI-based systems in several cases, there is no need for doctor's intervention. In India's government hospitals, getting an appointment of a concerned doctor is a big challenge because the number of patients is enormous (e.g., AIIMS, PGI, ESIC, etc.). Vast variety of survey was conducted to check the utility and applicability for the same.*

In this paper, our primary focus is on Kidney transplant patients facing the problem after surgery for medical supervision because of the COVID-19 and impact of lockdown situation. We propose a Cloud Based Intelligent Decision Support Knowledge Based System (CBIDKBS) and a web-based intelligent application to aid risk analysis module.

Keywords: Artificial Intelligence (AI), Cloud Based Intelligent, Decision Support Knowledge Based System (DSKBS), COVID-19.

1. Introduction

Digital tools and health solutions have provided critical support to India's COVID-19 response; provide access to essential information and health services. The main objective of healthcare applications is to provide constant supervision on a patient's health with tele-monitoring. Tele-monitoring is a well-known term in information technology (IT), which is generally employed to monitor patient's health located in heterogeneous places remotely. With the inclusion of cloud computing technology and artificial intelligence, medical systems are now more capable, efficient, and scalable in processing, such as storage and access, with minimal development costs. Since IoT healthcare devices are strictly associated with patient's health and life, smooth communication is indispensable to guarantee safety in emergencies, especially for the far flung areas [1]. Nowadays, remote medical advice and keep track of kidney transplant patients are essential for possible infections and lack of treatment for existing conditions. Health care systems must design with AI Techniques such as Machine Learning.

In this paper, we propose a Cloud Based Intelligent Decision Support Knowledge Based System (CBIDKBS). It also suggests a web-based intelligent app. that helps patients with proper medication and required tests for that particular problem without visiting the hospital physically for fast and effective recovery.

2. Problems Faced by Patients

The Covid-19 pandemic brought exceptional disruption in the health check-ups to patients suffering from a severe problem like Kidney Transplant. Patients cannot attend OPD and discuss their medical issues with their doctors because of the COVID-19 situation, especially those who live far from the Hospitals. Some of the cases which are facing problem during lockdown are discussed below:

2.1 Case I: Exceeding of Haemoglobin (Hb) : After Kidney Transplant

As an example, a kidney transplant patient is having a problem with high hemoglobin (Hb). The normal range is 10-14, but after his Kidney function test, he found his Hb as 17.2, but average Hb is usually 12. So he wants to consult with the doctor of AIIMS, but he resides in J & K, and because of lockdown, he could not come to Delhi. If he can consult the doctor, he can suggest medicine that can dilating and relaxing the airway muscles like Etofylline and Theophylline and suggest Phlebotomy. Our solution will provide this medical advice without the geographical boundaries and availability of the doctors.

2.2 CASE II: Increased Creatinine: After kidney Transplantation

A Transplant patient's creatinine level increased, and because of that, he was in a panic situation that his transplanted kidney is not working correctly. After some time, he found this happened because of a stomach infection. He wants to consult with the Doctor because kidney transplant patients cannot take antibiotics and painkillers without consultation. Still, because of lockdown, he is not able to attend OPD to consult the Doctor. In this case, if an Intelligent DS knowledge-based system can guide him to take preferred medicine like pre-biotic or light antibiotic to recover without physically reaching the OPD and that can be a great solution.

2.3 CASE III: High Potassium: After kidney Transplantation

A patient from Sufderjung hospital Delhi was suffering from high Potassium; in this case, also because of the COVID situation, he could not consult the Doctor in OPD. Our proposed system can guide him or her to take medicines like Nodosis (bicarbonate lowers plasma potassium) or Sodium polystyrene sulfonate (it works by helping your body get rid of extra Potassium). This advice can help him a lot without coming to the hospital physically. Like this, we approached 50 patients and discussed the issues related to this kind of situation.

3. S/W Tools and Techniques for Proposed System:

3.1 Decision Support System (DSS)

Nowadays, the remote medical advice and tracking of operated patients are even more relevant, considering epidemics that preclude physical presence in the hospitals. In India, the COVID-19 epidemic created fatalistic impacts on the health maintenance of low-income populations with severe diseases and increased death rates. The web-based DSS can solve this problem by improving remote accessibility, continuous health maintenance and quality of medical decisions.

3.2 Artificially Intelligent Machine Learning Model

In our proposed system, patient reports dataset will guide the evaluation of the patient's subsystem.
We will use the 10-fold cross-validation method. The 10-fold cross-validation will be executed several times to show stability.
Python sample code to implement K-fold:

```
from sklearn.datasets import make_classification

X, y = make_classification(n_samples=50, n_features=8, n_informative=4, n_redundant=5,
random_state=1)

from sklearn.datasets import make_classification
```

pr = KFold(n_splits=10, random_state=1, shuffle=True)

Our model will be powered by "self-learning" machine-learning techniques by which, it detects a best treatment plan with the minimum possible potential and repetition of doses that should still reduce the complications tolerated by the patients.

3.3 Knowledge-Based System (KBS)

A knowledge-based system will be developed that determines the right dosage of the immunosuppressive agent Tacrolimus and other medicines used for kidney transplant patients. A theoretical model to classify medication blood levels and medication adoptions will be created using gathering data from lots of patients and several examinations. This model will then translate into an Arden Syntax knowledge base (Arden syntax is a mark-up language used for representing and sharing medical knowledge) and then integrated directly into the hospitals' information system. In this paper, we give an overview of the construction and methodology of such a system. [2][3]

3.4 Cloud computing

The major consideration of this study consists of improvement in the health care system using the cloud. But currently, the cloud does not remain rigid to just simple applications and technological needs; the AI and Machine Learning techniques are proving to be the next technological inclination when combined with cloud computing. The health industry does not restrict fetching the previous patient's history from the physical reports. The assistance of the cloud computing in healthcare are: record-sharing is easier and safer, self-driven backend operations, and even expidite the creation and supporting of telehealth related apps. Fig.1 shows the use of cloud storage for e-health systems used by Hospitals.

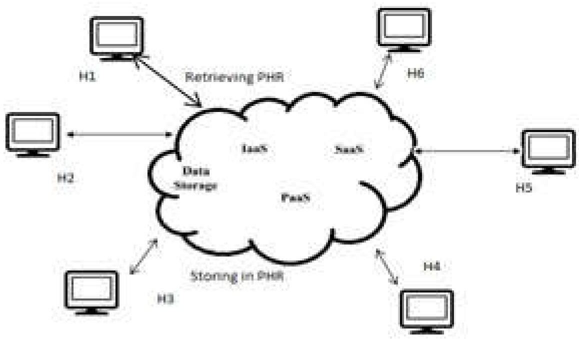


Fig.1. Hospitals connected with Cloud

4. Materials and Methods for Purposed System

We primarily collected the test reports of 50 patients and provided them a questionnaire to fill by which they can easily tell the current health problems they are facing. After compiling the report data, we consulted some senior nephrologists and created some high-risk and low-risk factors. This task will be guided by medical guidelines, specifically, the KDIGO guideline [4], the national institute for health and care excellence guideline [5], and the KDOQI guideline [6].

Based on the different patients' reports and problems, the risk analysis system categorizes the high-risk and low-risk patients.

The following Table.1 gives example results of Risk Analysis Module:

UHID	DM	U	Creat	Na	K	Hb	TLC	PLT Ct.	History	Risk
2675	True	23	1.7	149	6.3	14.7	4500	190	Low	High
2198	False	32	1.2	140	6.0	13.2	5300	245	Low	Low

1145	False	27	1.0	140	4.9	14.9	6000	195	Low	Low
1087	True	40	1.3	141	5.2	15.0	4700	150	Low	Low
2111	False	30	0.9	144	4.5	16.5	5300	230	Low	Low
1348	False	24	1.1	143	3.9	14.6	8700	175	Low	Low
1132	True	38	2.1	152	5.2	14.0	6200	210	High	High
2123	False	97	1.8	145	5.0	15.1	5100	240	Low	High
2000	False	34	0.8	141	4.6	13.5	9000	210	Low	Low

Table.1. Risk Analysis Module Results

Above Fields description:

UHID: - Patients ID in Hospital.

DM: - Diabetes mellitus

U: - Urea level

Creat: - Creatinine

Na: - Sodium

K: - Potassium

Hb: - Haemoglobin

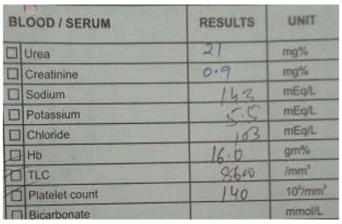
TLC: - Total leucocyte count

PLT Ct.:- platelet count

History: - Patients previous risk history

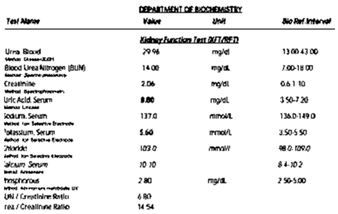
Risk:- Current Risk analysis

4.1 Below figures shows some patient reports for analysis and finding Risk Factor



BLOOD / SERUM	RESULTS	UNIT
Urea	21	mg%
Creatinine	0.9	mg%
Sodium	143	mEq/L
Potassium	5.5	mEq/L
Chloride	103	mEq/L
Hb	16.0	gm%
TLC	9600	/mm³
Platelet count	140	10³/mm³
Bicarbonate		mmol/L

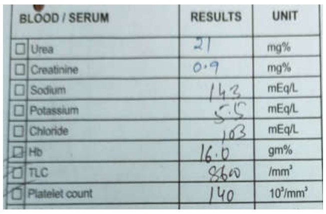
Fig 2:Sample Report of a patient for analysis



DEPARTMENT OF BIOCHEMISTRY

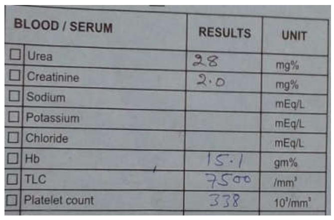
Test Name	Value	Unit	Bio Ref.Interval
Kidney Function Test (KFT/RFT)			
Urea, Blood	29.96	mg/dl	13.00-43.00
Blood Urea Nitrogen (BUN)	14.00	mg/dL	7.00-18.00
Creatinine	2.06	mg/dl	0.6-1.10
Uric Acid, Serum	[illegible]	mg/dL	3.50-7.20
Sodium, Serum	137.0	mmol/L	136.0-149.0
Potassium, Serum	5.60	mmol/L	3.50-5.50
Chloride	103.0	mmol/l	98.0-109.0
Calcium, Serum	10.10		8.4-10.2
Phosphorous	2.80	mg/dL	2.50-5.00
BUN / Creatinine Ratio	6.80		
Urea / Creatinine Ratio	14.54		

Fig 4: Sample Report of another patient for analysis



BLOOD / SERUM	RESULTS	UNIT
Urea	21	mg%
Creatinine	0.9	mg%
Sodium	143	mEq/L
Potassium	5.5	mEq/L
Chloride	103	mEq/L
Hb	16.0	gm%
TLC	9600	/mm³
Platelet count	140	10³/mm³

Fig 3:Sample Report of another patient for analysis



BLOOD / SERUM	RESULTS	UNIT
Urea	28	mg%
Creatinine	2.0	mg%
Sodium		mEq/L
Potassium		mEq/L
Chloride		mEq/L
Hb	15.1	gm%
TLC	7500	/mm³
Platelet count	338	10³/mm³

Fig 5: Sample Report of another patient for analysis

The data collected by these reports and the advice given by the nephrologists to these patients our knowledge base prototype is prepared and the Risk Analysis module calculates the risk factor with the help of that knowledge base.

5. Proposed System Methodology Schema

Fig. 6 shows the architecture for the proposed methodology to design CBIDKBS for identifying and monitoring CKD in Brazilian communities. Two entities interact with the proposed system: Patient, and Hospital. This type of architecture is advisable because countries such as India usually lacking of precarious health care in remote areas, e.g., hard-to-reach and rural settings. Below Fig.6 shows the architecture of the proposed system

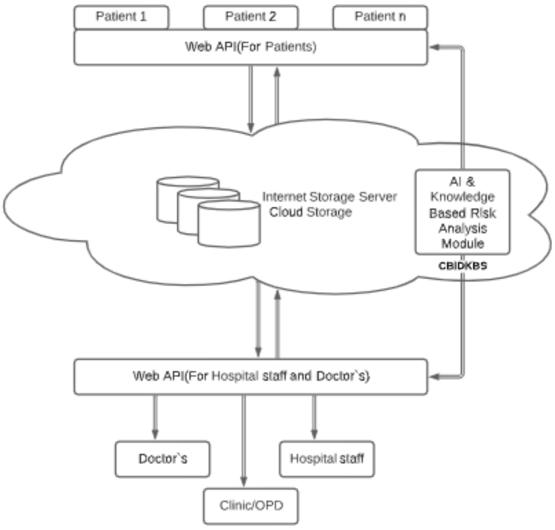


Fig.6. Architectural Schema for the proposed system

5.1 System for Patients

The system must contain previous health records data (PHR) and risk evaluation functionalities.

Fig.7. Flow Chart Patient Module

Patients residing in distant and hard-to-reach areas can work on it using different gadgets, such as desktop PCs, smart-phones, and tablets.

Fig.8 shows the sample online input form to be filled by the patients.

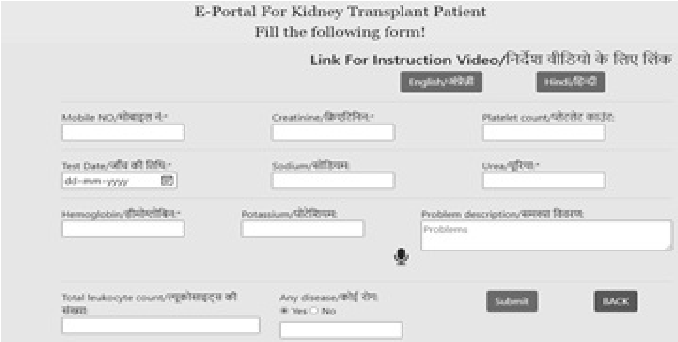


Fig.8. Patients Online Form

After submitting the input by the patient the intelligent system evaluates the patient's test results and problems he/she is facing. Then it sends clinical feedback or an appointment for the patient, and a message is forwarded to the patient's mobile number.

6. New system adoption survey and result

During the pandemic situation patients are not able to visit the hospitals physically. OPDs of the hospitals are not open for a long time because of that every patient specially suffering with chronic diseases are in great trouble. So we want to know our proposed system will help them in this scenario or not and will they actually use it or not. For this purpose we conducted a survey on the group of 137 patients (out of which only 100 responded) to find out, is the proposed web based system is worthy for them and will they actually use it as shown in Fig 9. For analysis we used chi-square test to understand impact of proposed system on the patients.

The questions in the survey are:

Q1. Is this intelligent system useful for patients?

Q2. Will they use it?

Below diagram show the actual questionnaires provided to the patients.

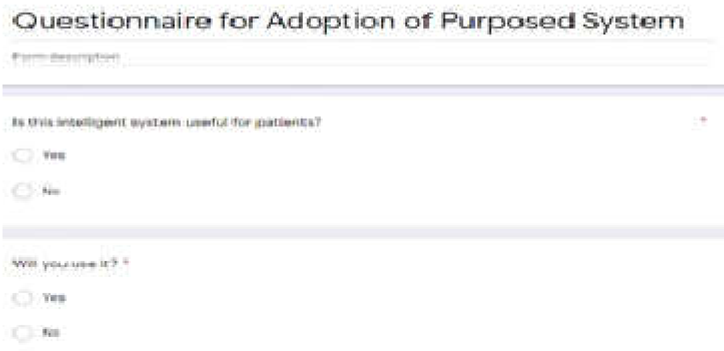


Fig: 9 Questionnaires for patients

Below table shows the results of above questionnaires.

		Question:2		
		Yes	No	
Question:1	Yes	51	19	70
	No	10	20	30
Total		61	39	100

Table 9 Result summary table of the survey:

6.2 Survey Evaluation Results:

To evaluate our proposed systems usability we conducted this survey. And for analysing the results we used chi-square test. Fig 10 Chi-square is a statistical hypothesis test also named x2. It is used to determine the difference between the observed and expected frequencies from a crosstab. Yates gives the correction for this test also known as Yates's chi-squared test. It focuses to correct the error caused by taking the discrete probabilities. Evaluation results are shown below:

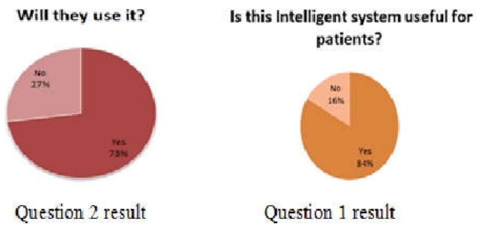


Fig 10. Result of Questionnaire for Adoption of Purposed System

Chi-square with Yates correction:
Chi squared equals 12.178 with 1 degrees of freedom.
The two-tailed P value equals 0.0005

The association between rows (Question 1) and columns (Question 2) is considered to be extremely statistically significant.

From the above we conclude that, our hypothesis is accepted and according to patients surveyed, the AI based Web portal is worthy and can be used.

7. Conclusion and Future Scope

The proposed model is an effort towards the integration of cloud and AI technique in the health delivery procedure. Furthermore, we can expand this system for other patients (AKD, CKD) and other departments (Cardio, Cancer, Neuro,) as well as we can include new services also. The proposed approach will surely help remote medical advice and tracking of patients having severe diseases. Considering epidemics that preclude physical presence in the hospitals, this concept is even more relevant.

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