



Impact of ‘Smart Applications of IoMT (Internet of Medical Things)’ on Health-Care Domain in India

Arunangshu Giri, Satakshi Chatterjee, Pradip Paul, Smita Chakraborty, Swatee Biswas

Abstract: *The conventional model of the healthcare system has become obsolete now. With the evolution of the digital era, new advanced technologies and service platforms are highly in demand now. One such technology is the Internet of Medical Things (IoMT) which is a sub division of Internet of Things. It allows rapid proliferation of the information from the various interconnected devices through the help of wifi or cloud. This technology is both patient centric and organisation driven. It has become a mandatory for the organisation to implement this technology as without this, the organisations would be facing great challenges to meet the demand of the industry. This technology allows optimal service production with minimal cost investment. In this paper we will try to find out the scope and opportunities of IoMT in Indian health care sector and the impact of IoMT on increasing efficiencies of healthcare management. As statistical tools, Multiple Regression and Exploratory Factor Analysis (EFA) have been used in this study.*

Keywords: *Internet of Medical Things, Technology, Healthcare, Internet of Medical Things.*

I. INTRODUCTION

The healthcare industry has undergone drastic changes in the recent times. One of the critical factors that is partly responsible for this change is that of the advanced information technology which is being implemented across the industry today. In order to address the growing demand of the services of the healthcare industry, the hospitals as well as the nursing homes require the aid of various IT service platforms and latest technologies. One of the most used technologies in the healthcare domain today is the Internet of Medical Things, otherwise known as, IoMT. Internet of Medical Things is a subsequent division of Internet of Things.

In a broader aspect, it is referred to as a collection of various devices which are interconnected through the help of various computer networks like wifi or near field communication technology. These devices provide medical care and are a crucial part of the information technology system of the healthcare industry. Thus, the basis of IoMT is the machine to machine communication maintained in the healthcare industry.

Statistics show that approximately 30 per cent of the devices used in Internet of things are utilised as a part of Internet of Medical Things today. The economic impact of the Internet of Medical Things is continuously increasing and it is expected to cross the \$6 trillion mark by 2025. Millions of people will be connected with each other through the help of these devices. In India, approximately 60 per cent of the hospitals have already implemented Internet of Medical Things in order to support the activities related to patient care. Patient files are maintained in cloud which is accessible from any device inside or outside the hospital, provided, the users have the access the details. IoMT has become one of the most sought after technologies in the world today. Healthcare industry requires prompt service delivery and IoMT helps the hospitals to achieve that. The productivity of the workforce has increased because of the implementation of IoMT. Also, a reduction in the medical care costs has also been seen. IoMT is also utilised for monitoring the patients on a daily level as per the requirement. This data is readily passed on to the relevant personnel so that the treatment regime of the patients could be designed accordingly. This data is also maintained by the hospitals for any future requirement of the same patient or any other similar cases. However, the data which is generated in the healthcare industry is very sensitive data. It just be protected at all costs by the industry as access to this data by irrelevant personnel is a breach of privacy. Unfortunately, IoMT does not do much in securing the data. As a result of that, data is leaked. That is why data security is a major concern for healthcare organisations using IoMT. There are seven categories in the healthcare industry where IoMT have given prompt solutions. These areas are increasing the clinical efficiency, increasing the consumer or home monitoring after discharge of the patient, fitness wearable's which would readily give certain numbers to the patients indicating their health level, increase in infant monitoring, increase in biometric sensors and wearable's, introduction of sleep monitors as well as introduction of brain sensors in the field of neuro-technology. IoMT has various advantages. Firstly, it allows the patients to be monitored round the clock.

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This can speed up the diagnosis of the patients, at the same time, increasing the efficiency level of the diagnosis. Remote monitoring of the patients is also made available. The costs related to medical care is reduced drastically as well. Disease management is facilitated. The treatment plan devised by the physicians is customised according to the needs of the patients. Drug management could also be improved.

The physicians can connect with each other in a common platform for discussing their various cases. Help could be sought out by doctors from other doctors who have dealt with similar cases. The only concern for IoMT is that the data security is very weak. Some of the well known healthcare systems which are pervasive in nature are HEARTFAID, ALARM-NET, CAALYX, TeleCARE, CHRONIC, MyHeart, OLDES, SAPHIRE, etc (Maksimovic, et al., 2016)³. This paper aims to study the impact of IoMT on the healthcare domain of India.

II. LITERATURE REVIEW

Healthcare Management is a holistic approach which deals with multiple areas right from diagnosis of the disease to the designing of a right treatment plan. Internet of Medical Things is a technology which simplifies the healthcare management system, thus, making it quite effective and efficient (Islam, et al., 2015)². The outcome of a case related to patient improves drastically. Diagnosis is also made faster, thus, making the life of the patients much easier. The quality of the life of the patient is improved (Yu, et al., 2012)¹. The use experience results in a satisfactory one which ensures that the patient will come back to the same hospital again. Diseases can be managed better with this technology and prevention of certain diseases could also be done by taking appropriate precautionary measures. Thus, the healthcare management system could be planned properly which would help the individual, family and on a broader aspect, the society as a whole. Health services could mean life or death for a patient. It is a race against time for the doctors to diagnose the ailment of the patients. As a result, as soon as the diagnosis is done, the treatment regime should immediately start without any delay. This is facilitated by that of Internet of Medical Things (Huang & Cheng, 2014)⁴. Also, the patient must be daily monitored after the treatment has been started. This reveals that whether the patient is positively responding to the medications or not. If there is no change, the doctor might consider changing the medication of the patients. Along with the patient treatment, this data is very important to the family of the patients as well. This data assures them that the patient is being given the treatment which will cure the ailment from which the patient is suffering from. Every small detail will be recorded related to the treatment of the patient and this data will be shared with the patient's family. A definite diagnosis would lead to planning of a correct treatment regime. This would cut down the costs significantly (Puri, et al., 2016)⁵. The treatment regime will be very simple to follow, thus, ensuring that no mistakes are made. If there is a definite and singular treatment plan, it will be beneficial for the patients as the treatment plan will be much more focused from the very beginning. Also,

majority of the healthcare investments happen out of pocket as the concept of health insurance is yet to become a household phenomenon. As a result, a prolonged treatment plan is not affordable by many households. Through the use of Internet of Medical things, the exact cause of the disease could be diagnosed early, thus resulting in a timely and focused treatment plan. This will ensure that the patient could go through with the treatment plan without any type of hitches. A lot of medical data is generated daily and is subsequently stored. The history of the patients is recorded in the medical files for future reference as well. Internet of Medical Things allows the healthcare organisations to carry out this humongous feat relatively easily. The doctors can get access to these files quite readily without any problem (Kumar & Venkateswarlu, 2016)⁶. If any remission of the diseases occurs, it will not be a problem to the doctor as they would not be wasting crucial time by looking for the previous records. They will be readily available to them. Also, during the transfer of a patient from one hospital to the other, the transferring of information is also facilitated by the use of Internet of Medical Things (Joyia, et al., 2017)⁷. However, the security of this data is not guaranteed by the usage of Internet of Medical Things (Manogaran, et al., 2018)¹¹. The health of the patients is regularly monitored and the data which is obtained are recorded. This is done with the smart application of Internet of Medical Things. The doctors can also go through these reports in their off time, thus resulting in maximum productivity and saving crucial time (Singh, 2016)⁸. Some of the applications of Internet of Medical Things allow the patients to monitor their vitals and record them throughout the day. They can do these things by themselves and do not need outside help for these activities.

Some of these applications are remote monitoring, using biometric sensors or wearable's to monitor one's own vitals, fitness wearable's to maintain optimal fitness conditions, etc. Some applications of Internet of Medical Things are also customised such as improved drug management, neuro technology, infant monitoring and sleep monitoring (Senthilkumar, et al., 2018)¹⁰. The use of such applications ensures a strong and sound monitoring system. Internet of Things is not just a patient centric system. It can be useful for the doctors and other allied staff of the hospitals as well. The data generated could be gone through as references for the other cases with similar symptoms. The management could also be aided through the use of this technology as it will give the user an understanding about the human resources that the hospital requires. A strategy could be drawn based on the gap analysis which can be made using this data. It will be helpful in forecasting the number of doctors which must be available at the organisation at a given point of time. These applications can also be helpful in maintaining a balance between that of the permanent doctors as well as the visiting doctors. The ultimate goal for the usage of this technology in this aspect is that the patients receive their treatment at the right time and at the right cost (Fischer & Lam, 2016)⁹.

III. HYPOTHESES AND RESEARCH MODEL

- H1: 'Effective Service Delivery' through IoMT positively influences 'Efficient Healthcare Management'.
- H2: 'Easier Management of Medical Records' through IoMT positively influences 'Efficient Healthcare Management'.
- H3: 'Timely Medication' through IoMT positively influences 'Efficient Healthcare Management'.
- H4: 'Effective Healthcare Monitoring System' through IoMT positively influences 'Efficient Healthcare Management'.
- H5: 'Affordable Treatment Regime' through IoMT positively influences 'Efficient Healthcare Management'.

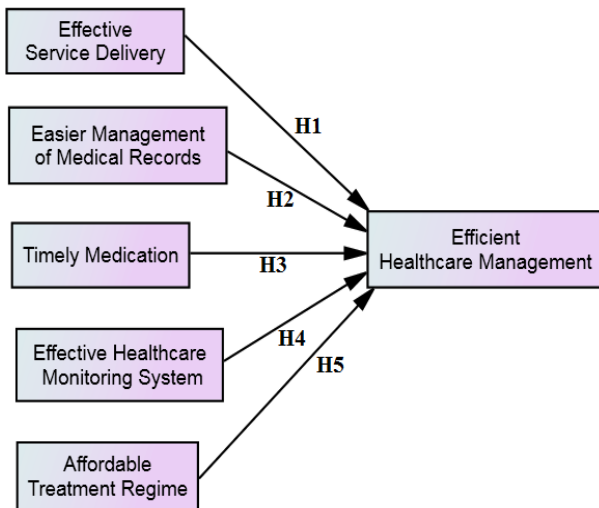


Figure 1: Hypothesized Research Model

IV. RESEARCH METHODOLOGY

Data Types	Secondary and Primary data
Survey Instrument	Structured questionnaire
Scaling Technique	Multiple Item 5 Point Likert Scale with Strongly Agree (5) to Strongly Disagree (1)
Sample Elements	Doctors & Users of IoMT
Industry	Health Care Sector
Sampling Technique	Convenience Sampling
Sample Size	145
Study Period	July 2019 – September 2019
Statistical Software	SPSS-21
Statistical Techniques	Multiple Regression & Exploratory Factor Analysis (EFA)

V. DATA ANALYSIS AND RESULTS

A. Reliability Testing & Validity Testing:

Cronbach's Alpha value (0.809) under acceptable range of below 0.70 indicates the optimum reliability (Table: 1) of collected primary data. Here acceptable range of KMO value (0.802) and significant (<0.001) Bartlett's Test of Sphericity (Table: 2) support the execution of Exploratory Factor Analysis (EFA). Also the output of EFA indicates the validity of primary data (Table: 3) by showing significant correlations among variables under each factor. By the help of Rotated Component Matrix (RCM), 6 different factors

with higher 'factor loadings' (>0.5) have been created for research model.

Table1: Reliability Statistics

Cronbach's Alpha	No. of Items / Variables
.809	12

Table 2: KMO Measure of Sampling Adequacy and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.755
Bartlett's Test of Sphericity	Significance Level <0.001

Table 3: Exploratory Factor Analysis by RCM

Factors	Questions/ Variables	Factor Loading (>0.50)	% of Variance Explained
Affordable Treatment Regime	q10	.935	14.774
	q9	.915	
Easier Management of Medical Records	q4	.924	14.362
	q3	.881	
Timely Medication	q6	.917	13.939
	q5	.879	
Effective Healthcare Monitoring System	q8	.904	13.521
	q7	.863	
Efficient Healthcare Management	q12	.847	12.340
	q11	.836	
Effective Service Delivery	q1	.860	11.941
	q2	.816	

Extraction Method: Principal Component Analysis (PCA), Rotation Method: Varimax & Rotation converged in 5 iterations.

Also, acceptable 'Variance Inflation Factor' (VIF) values (<3) indicate that all factors influencing dependent factors are free from Multi-co-linearity error (Table: 4).

Table 4: Co-linearity Statistics

'Efficient Healthcare Management' as dependent factor		
	Tolerance	VIF
Effective Service Delivery	.535	1.868
Easier Management of Medical Records	.595	1.680
Timely Medication	.734	1.362
Effective Healthcare Monitoring System	.556	1.797
Affordable Treatment Regime	.629	1.589

In this study multiple regression analysis was used to evaluate the relative impact of independent factors on the dependent factor. Following table (Table: 5) shows the strong R-Value (0.899) which implies overall correlation between collective-independent-variables and dependent variable is high. Also R² value (0.808) implies that 80.8% variance of the dependent variable 'Efficient Healthcare Management' can be explained by all independent variables, which is significantly high.

Table 5: Regression Analysis: Model Summary

Model-1	R	R-Square	Adjusted R Square	Std. Error of the Estimate	F-Value	Sig.
		.899	.808	.801	.401	121.137

Note: Dependent Variable: Efficient Healthcare Management
Predictors: (Constant), Affordable Treatment Regime, Timely Medication, Effective Healthcare Monitoring System, Easier Management of Medical Records, Efficient Service Delivery
 For testing hypothesis, Regression Coefficients along with significance level were judged in this study (Table: 6).

Table 6: Hypothesis Testing by Regression Coefficients

Model-1	Un-standardized Coefficients		t- Value	Sig.	Hypothesis
	B	Std. Error			
(Constant)	-1.546	.257	-6.023	<0.01 [#]	
Effective Service Delivery	.217	.055	3.949	<0.01 [#]	H1 (S)
Easier Management of Medical Records	.254	.049	5.225	<0.01 [#]	H2 (S)
Timely Medication	.358	.060	5.980	<0.01 [#]	H3 (S)
Effective Healthcare Monitoring System	.335	.058	5.737	<0.01 [#]	H4 (S)
Affordable Treatment Regime	.213	.040	5.334	<0.01 [#]	H5 (S)

Note: Dependent Variable: Efficient Healthcare Management
[#] indicates 1% level of significance
 (S)- indicates ‘Hypothesis is supported’

In this study following Regression equation has been established.

$$\text{‘Efficient Healthcare Management’} = (-1.546) + 0.217* (\text{Effective Service Delivery}) + 0.254* (\text{Easier Management of Medical Records}) + 0.358* (\text{Timely Medication}) + 0.335* (\text{Effective Healthcare Monitoring System}) + 0.213* (\text{Affordable Treatment Regime})$$

VI. HYPOTHESIS TESTING AND FINDINGS

H1: ‘Effective Service Delivery’ through IoMT positively influences ‘Efficient Healthcare Management’.

Positive (+.217) path co-efficient with significant P-value (<0.01) supported the hypothesis. IoMT technology facilitates doctors and other allied staff of the hospitals to deliver competent services to patients and healthcare organizations which maintain efficient healthcare management.

VII. CONCLUSION

Internet of Medical Things has a lot of smart applications that are currently being implemented across the healthcare industry. It makes the process increasingly easier as the

H2: ‘Easier Management of Medical Records’ through IoMT positively influences ‘Efficient Healthcare Management’.

Positive (+.254) path co-efficient with significant P-value (<0.01) supported the hypothesis. Therefore, managing, smooth accessing and transferring medical records of the patients as per the requirement through IoMT can effectively manage healthcare system.

H3: ‘Timely Medication’ through IoMT positively influences ‘Efficient Healthcare Management’.

Positive (+.358) path co-efficient with significant P-value (<0.01) supported the hypothesis. Diagnoses of the illness of the patients as well as quick medical treatment through IoMT facilitate to increase efficiency of healthcare management.

H4: ‘Effective Healthcare Monitoring System’ through IoMT positively influences ‘Efficient Healthcare Management’.

Positive (+.335) path co-efficient with significant P-value (<0.01) supported the hypothesis. Regular monitoring of patient’s health by doctors and self monitoring by patients through IoMT can significantly increase the efficiency of healthcare management.

H5: ‘Affordable Treatment Regime’ through IoMT positively influences ‘Efficient Healthcare Management’.

Positive (+.213) path co-efficient with significant P-value (<0.01) supported the hypothesis. Early detection of disease and rapid proper diagnosis through IoMT can reduce the cost of the treatment. It helps to provide efficient healthcare management.

IMPLICATION OF THE STUDY

Internet of Medical Things is a very useful tool which ensures that the services are provided at the right time and the right place. The organisations need a competitive edge and internet of medical things can help them achieve that. From the societal point of view, health of the people should be given primary importance. If the health index is optimally maintained, their individual productivity will increase as well.

patients could themselves do them. The data generated is stored and analysed for proper diagnosis and future use. This technology is highly in demand by the industry as it enables a lot of jobs and it is not expensive at all. The only problem of this technology is its issue with data security.

ANNEXURE: 1

Factors	Structure Questionnaire with Different Variables
Effective Service Delivery	q1: IoMT technology helps doctors to deliver competent services to patients.
	q2: IoMT technology helps other allied hospital staffs to deliver proficient services to healthcare organizations.
Easier Management of Medical Records	q3: Smooth accessing of medical records through IoMT facilitates to enhance the efficiency of healthcare management.
	q4: Easy transfer of patient’s medical records through IoMT facilitates to enhance the efficiency of healthcare management.
Timely Medication	q5: Quick diagnosis of illness through IoMT helps to increase the effectiveness of healthcare management.
	q6: Quick medical treatment through IoMT helps to increase the effectiveness of healthcare management.
Effective Healthcare Monitoring System	q7: Regular monitoring of patient’s health by through IoMT facilitates to increase the efficiency of healthcare management.



	q8: Self monitoring by patients through IoMT facilitates to increase the efficiency of healthcare management.
Affordable Treatment Regime	q9: Early detection of disease through IoMT reduces the cost of the treatment. q10: Rapid proper diagnosis through IoMT reduces the cost of the treatment.
Efficient Healthcare Management	q11: IoMT can manage Healthcare system cost effectively. q12: IoMT can monitor Healthcare system time efficiently.

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