INTERNET OF MEDICAL THINGS(IOMT)- IMPLEMENTATION, APPLICATION, DATA MANAGEMENT & CHALLENGES

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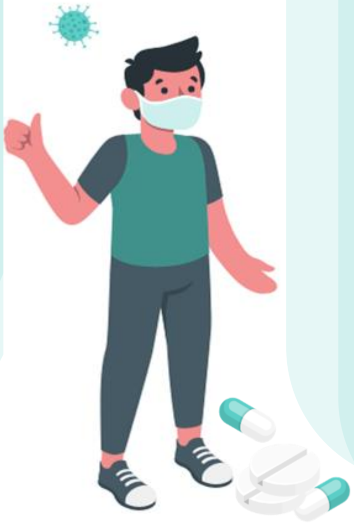
INTRODUCTION

The digitization of information including health information and its utilization in conveyance of medical services has been developing rapidly across the world. The COVID-19 pandemic has been a focus for outstanding development of Technology in medical services.

One such Technology is “**Internet of things (IOT)**”



What is IOT? What is IOMT?

IoT in healthcare refers to a network of connected medical devices that are able to not only generate, collect and store data but also connect with a network, analyse the data as well as are able to transmit data of various kinds such as medical images, physiological and vital body signatures and genomics data”

To describe all medical devices and medical applications, a newer term has been introduced called “**Internet of Medical Things (IoMT)**”

Research Motivation

- IOMT has proven to have a significant impact on the population's health and improve telemedicine tremendously.
- In a developing country like India, people are yet to fully understand the capabilities and positive outcomes of IoMT.
- A lack of scientific evidence involving the extensive use of IoMT, and proper utilization of real time health data in developing under-developed countries was the major motivation behind this research.
- A lack of understanding of how IoMT works, contemporary technologies, applications and data insights from the Patient related health Data collected from IoMT, led to an urge for developing this research.

RESEARCH QUESTIONS & OBJECTIVES

How can we integrate IoMT for chronic disease management to improve quality of care and overall population health?

How can we manage the big data that is collected from real-time monitoring using IoMT and gain data-driven insights using Machine Learning?

What are the challenges related to implementation of IoMT and how can we overcome them?

Study Objectives:

- To provide comprehensive literature review and scientific evidence for Implementation of IoMT and its technological architecture
- To discuss applications and uses cases of IoMT
- To use Predictive Analytics for IoMT Data Management and Analysis using Machine Learning
- To determine the challenges associated with IoMT and provide recommendations to overcome them.

METHODOLOGY

1. LITERATURE SEARCH

A search for relevant keywords was conducted on major scientific databases & additional sources

2. SELECTION OF LITERATURE

Literature was selected based on the inclusion criteria

3. SCREENING OF ARTICLES

Shortlisted Articles Were Screened Multiple Times Based On Title, Abstract, keywords And Full Text

4. ANALYSIS OF SELECTED LITERATURE-QUANTITATIVE & QUALITATIVE

The articles were studied thoroughly with suitable interpretations. meta-analysis was performed using google sheets

5. QUANTITATIVE DATA ANALYSIS AND INTERPRETATION

The quantitative data was analyzed using python programming language and prediction model was built on Google Colaboratory

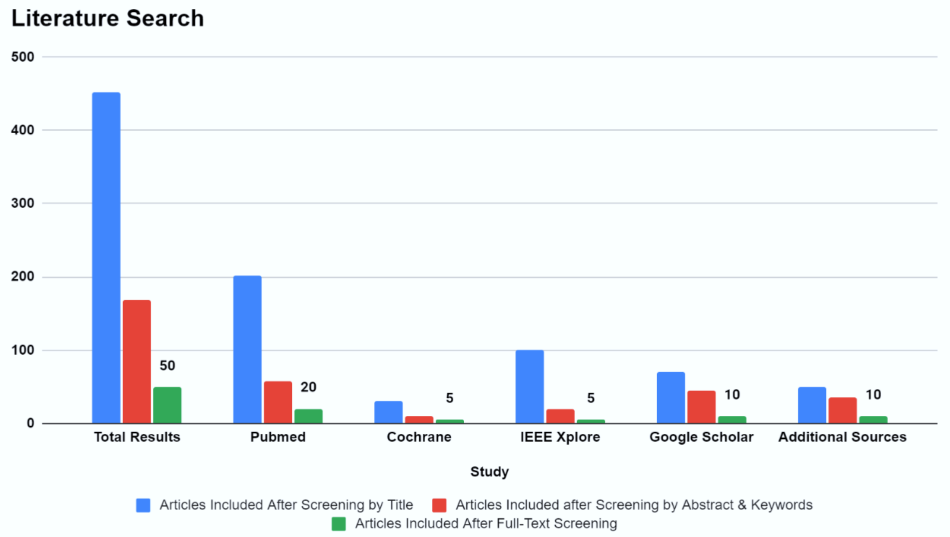
RESULTS & DISCUSSION

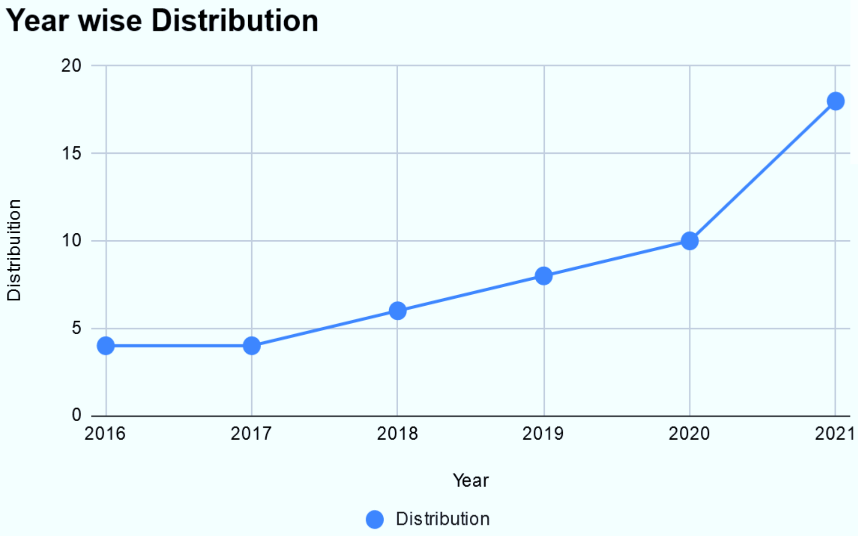
META-DATA ANALYSIS

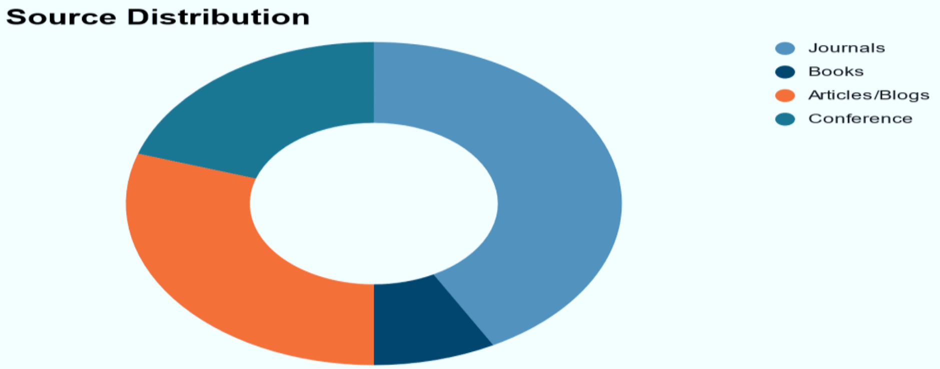
Quantitative Metadata Analysis of the literature collected from various sources, the details of results included from each database have been depicted.

This is a quantitative meta-analysis of the literature selected based on inclusion and exclusion criteria.

The data was stored and extracted from **Zotero Software**.







TECHNOLOGIES ENABLING IOMT

SENSORS

IoMT relies on sensors for its functionality. Both clinical and non-clinical scenarios can benefit from IoMT. IoMT is used to monitor patient vitals in a clinical setting, including temperature, ECG, blood pressure, and blood oxygen saturation using sensors.

CLOUD COMPUTING

IoT is enabled by cloud computing. The IoMT generates a huge amount of data, which can be stored and analyzed with the help of cloud infrastructure. Cloud computing provides an almost infinite number of resources at data centers, which enables healthcare stakeholders to gain helpful insights from data which is analyzed and then stored for later use.

FOG COMPUTING

With fog computing, data processing can be moved from the cloud to sensors. Physicians and clinicians will be able to provide emergency health care due to the reduction of latency. Fog nodes provide monitoring, preprocessing, storage, and security features. The monitoring facility allows the node to monitor the resources and services it provides.

Wireless Body Area Networks-WBANS

WBAN is the technology responsible for communication at the transport layer. It offers speed, accuracy, energy conservation, and reliable communication between sensors and actuators within, on, or close to the human body. By using different sensors to monitor a patient's vital signs, WBANs can help to reduce healthcare costs and improve quality.

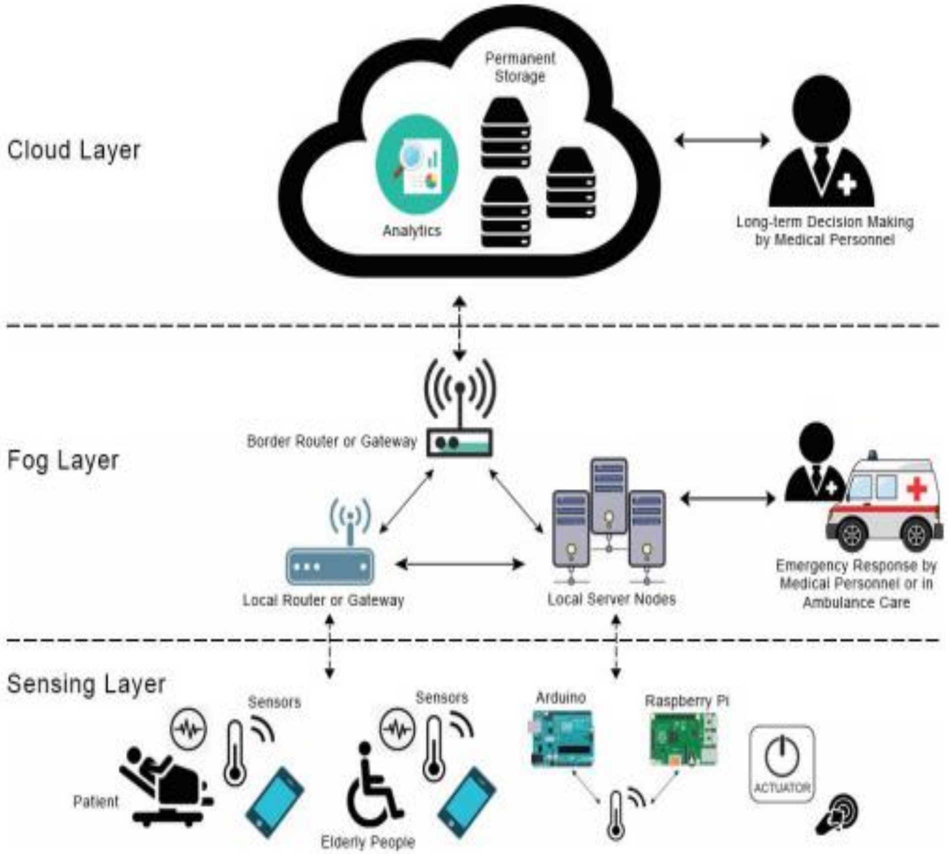
COMPARISON OF IOMT ARCHITECTURE

REFERENCE	NO. OF LAYERS	COMPLEXITY	RELIABILITY	REAL-TIME APPLICATION SUPPORT	SECURITY
Cerina et al.	4	Moderate	Low	Moderate	High
Nandyala et al	4	Moderate	Low	Moderate	High
Verma et al	5	High	Low	Moderate	Moderate
Villaba et al	2	Less	Low	Low	Moderate
V.S. Naresh et al	3	Less	High	High	High

- After the comparative analysis of the existing architecture, it has been found that the **Fog-Based architecture proposed by V.S. Naresh et al** is most suitable for IoMT.

- Having a low level of complexity, this architecture is designed to be flexible in how certain functions and modules are implemented at different layers.

- A real-time application needs to support the fog layer since it exists and a lot of work is being done at this layer. “The value of security is also high based on the number of layers.



APPLICATIONS OF IOMT

REAL-TIME PATIENT MONITORING

TELEHEALTH

CHRONIC DISEASE MANAGEMENT

HOME HEALTHCARE

GERIATRIC HEALTHCARE

DATA INSIGHTS-PREDICTIVE MODELLING

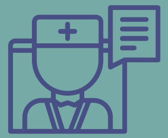
IOMT-DATA MANAGEMENT & INSIGHTS

Global connectivity

With an IoT platform, we can easily connect our devices, apply cloud-based analytics to gain insights, and apply device management functions.

Technology Integration

Data is able to be easily pulled in the cloud with the use of APIs, which bridge the data-cloud divide.



Simple Device Management

Management of a device in an efficient and effective way can improve availability, increase throughput, minimize unplanned outages, and reduce maintenance costs.

PREDICTIVE ANALYTICS

Machine learning algorithms are currently used for Predictive Analysis in Healthcare.
An application of IoMT Data for Predicting Diabetes Mellitus using Machine Learning is demonstrated in this study .

PREDICTIVE ANALYTICS

01 Importing Python Libraries

02 Data Loading

03 Data Analysis

04 Data Standardization

05 Classification of Data

06 Apply SVM Classifier

07 Model Accuracy

08 Predictive System

Findings

About the Dataset

Pima Indians Diabetes Database (PIDD)” which is sourced from “UCI machine learning repository on Kaggle. pertains to Pima Indian medical records regarding diabetes onset among the population. Multiple independent variables are included along with one dependent variable, i.e. the class value of diabetes as a 0 or 1.

S. No.	Attributes	Values
1	No. of time pregnant (NTP)	Numerical Value
2	Plasma Glucose Concentration (PGC)	Numerical Value
3	Diastolic Blood Pressure	Numerical Value(mm Hg)
4	Triceps Skin Fold Thickness (TSFT)	Numerical Value
5	Serum Insulin (SI)	Numerical Value (mu U/ml)
6	Body Mass Index (BMI)	Numerical Value (weight in kg/(height in m)^2
7	Diabetes Pedigree Function (DPF)	Numerical Value
8	Age	Numerical Value
9	Diagnosis of type 2 diabetes disease	Boolean Value Yes=1 No= 0

S. No	Feature	Mean	Standard Deviation
1	No. of time pregnant (NTP)	3.8	3.4
2	Plasma Glucose Concentration (PGC)	120.9	32
3	Diastolic Blood Pressure	69.1	19.4
4	Triceps Skin Fold Thickness (TSFT)	20.5	16
5	Serum Insulin (SI)	79.8	115.2
6	Body Mass Index (BMI)	32	7.9
7	Diabetes Pedigree Function (DPF)	0.5	0.3
8	Age	33.2	11.8

Accuracy Score

Accuracy Score

```
[ ] # accuracy score on the training data
    X_train_prediction = classifier.predict(X_train)
    training_data_accuracy = accuracy_score(X_train_prediction, Y_train)

[ ] print('Accuracy score of the training data : ', training_data_accuracy)

    Accuracy score of the training data :  0.7866449511400652

[ ] # accuracy score on the test data
    X_test_prediction = classifier.predict(X_test)
    test_data_accuracy = accuracy_score(X_test_prediction, Y_test)

[ ] print('Accuracy score of the test data : ', test_data_accuracy)

    Accuracy score of the test data :  0.7727272727272727
```

77%

The Accuracy of the model was found to be 77% which is considered to be a good accuracy score. A score more than 70% is optimal for building a predictive model.

Predictive System

Making a Predictive System

```
input_data = (5,166,72,19,175,25.8,0.587,51)

# changing the input_data to numpy array
input_data_as_numpy_array = np.asarray(input_data)

# reshape the array as we are predicting for one instance
input_data_reshaped = input_data_as_numpy_array.reshape(1,-1)

# standardize the input data
std_data = scaler.transform(input_data_reshaped)
print(std_data)

prediction = classifier.predict(std_data)
print(prediction)

if (prediction[0] == 0):
  print('The person is not diabetic')
else:
  print('The person is diabetic')
```

```
[[ 0.3429808   1.41167241  0.14964075 -0.09637905  0.82661621 -0.78595734
   0.34768723  1.51108316]]
[1]
The person is diabetic
```

To test the predictive system data points for two people were taken. The predictive model correctly predicted the outcome when the data points were entered. If the outcome of the predictive model is 0 then the person is not diabetic and if the outcome of the predictive model is 1 then the person is diabetic.

Challenges of IoMT

Interoperability

The lack of interoperability means that data can't be effectively exchanged and sometimes overlap. These closed ecosystems/silos pose multiple problems.

Security

The IoMT concerns a wide range of modules like the data acquisition, communication, sensors etc. They have an inherent technical debt which results in compromised medical devices with unpredictable behavior.

Latency

Network latency at the transport layer and the communication layer are crucial for the efficiency of healthcare applications. In addition, the impact of latency depends on the type of healthcare application

Fault tolerance

Sensors and communication nodes that transfer data to the cloud or a processing layer determine the reliability of an IoT healthcare system.

CONCLUSION

- IoMT can play a huge role in preventing and predicting diseases, which is perhaps its most profound impact. It serves to reduce the number of hospitalizations while improving the quality of care and allocating resources to the most critical areas.

- Healthcare is rapidly undergoing a digital transformation thanks to the IoMT. In addition, it is redefining people's interactions with devices and delivering healthcare services. The adoption of IoMT in healthcare benefits patients, families, doctors, hospitals, and insurance companies.

- IoMT could be of use to Indian healthcare, but there are a few bottlenecks to its adoption. Health care is forecast to generate more data than any other industry by 2025. It is possible that healthcare organizations may experience unexpected issues as a result of the flood of data created by IoMT devices and equipment. Healthcare systems must be scaleable and robust in order to handle the voluminous data they generate.

- Indian healthcare will need to reanalyze the future with evolving technologies, while striking a delicate balance between:

1. Increasing expectations of care for patients in a connected ecology and the facelessness of technology-driven healthcare
2. Increasing costs and limited budgets in healthcare
3. Integrating New technologies are complex and difficult to deploy, integrate, and secure

Healthcare organizations will need to take the necessary precautions and put proper security measures in place in order to find endless opportunities for innovations for IoMT

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THANK YOU