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Internet of Medical Things (IoMT) Based Framework for Smart Healthcare Tourism Sector

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Abstract *Corona virus disease, COVID-19, has emerged as a pandemic covering the entire world, almost every country is effected by COVID-19. Numbers of infected people across the world are increasing at an exponential rate. Such large number of patients put extra ordinary demand of health care facilities. Although every country is putting tremendous efforts in frontline to fight with this pandemic but shortage of medical facilities, especially for densely populated countries like India, it becomes a serious challenge. The fear of pandemic has arrested everyone in homes due to which various sectors are affected badly. Pandemic situations are badly deteriorating the hospitality and tourism business. Smart healthcare tourism is the new prominence application of IoT based healthcare tourism. This paper presents an IoT based health monitoring framework, which may be helpful for medical tourists as well as the hotel management to monitor the health of guests and staff. The framework will detect and check the various vital signs of body and then report to the admin about health status of persons. The paper focuses on use of Internet of Things technology involving wearable sensors for monitoring the health status, detecting the disease and providing online health services for medical tourism sector.*

Keywords: *Medical Tourism, COVID-19, Internet of Things (Iot), Smart Healthcare, Pandemic*

INTRODUCTION

World, now a days, is facing a large problem of pandemic created by coronavirus, Covid-19. A lot of people are getting infected by the virus and being highly contiguous, this virus spreads at a very rapid rate. Early study estimated that one person can infect 2 to 2.5 people [1]. One recent study found that one person may infect 4.2 – 6.49 people [2]. So there are infected people all around the surrounding imposing extra burden on healthcare industry. According to WHO, the number of infected person are 6,663,304 and deaths are 392,802 globally [3]. Due to unprecedented load, it becomes difficult for the healthcare system of any country to cope up with large number of patients requiring the medical aid. Many developed Countries like America, China, Russia, England etc. are facing the shortage of medical facilities like ventilators, ICUs, PPE kits etc. that can be provided to all the patients of Corona virus. In this scenario, it is quite obvious that a developing country like India having a large population and less medical facilities, is going to face an extreme shortage of healthcare facilities. COVID-19 doesn't only threatens the global health but also severly affected the economy of world. Every sector is effected adversely may it be automobile industry, aviation industry, tourism, oil industry, food industry, health care industry etc. IoMT (Internet of Medical Things) can play a big role in this critical environment. Wearable health sensors and remote monitoring techniques may provide large potential of removing the burden from hospitals to quarantine centers or homes. IoT based healthcare facilities (called as IoMT) allow for remote access to patients by monitoring the data provided by the sensors of WBAN with the help of internet. If there is any kind of system that can diagnose the disease in its early stage based on symptoms and can provide the data to doctors or hospitals, then treatment can be recommended to the patient without physically visiting to the hospitals.

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WHO report says that nearly 58% of countries globally are using telemedicine in place of physical visit of patient to hospitals. [4]

This paper presents a framework of Internet of Things based healthcare for Indian medical tourism. The framework would help the medical facility providers to combat the masses of patients approaching to hospitals for testing of coronavirus. The paper is organized in following sections: section I briefs about the COVID-19 disease, its symptoms and precautionary measures, section II introduces about health tourism in India, section III introduces Internet of Things, section IV briefs healthcare architecture in IoT and its significance in COVID environment, section V presents the proposed framework, section VI is dedicated to discussion about the framework, section VII concludes the paper.

SECTION I

Coronavirus is a kind of virus that causes infection in nose, sinuses and upper throat. Caused by SARS coronavirus 2, COVID-19 may cause illness like causing illness like common cold, pneumonia, Severe Acute Respiratory Syndrome and Middle East Respiratory Syndrome alongwith cardiogenic shock. Some patients also showed symptoms like sore throat, headache, myalgia and breathlessness. Very rare patients show symptoms like nausea, nasal congestion, hemoptysis, diarrhea, and conjunctival congestion (Chamola, 2020). According to WHO, coronavirus is transmitted from one person to another from the spread of droplets during sneezing and coughing [6]. These droplets can cover a distance up to 1.8 meters (or 6 feet). According to WHO, most of the infected people experience mild to moderate respiratory problems and recover without any special treatment. Small children, pregnant ladies and older people with some medical problems like diabeties, heart problem, respiratory problem or cancer are more susceptible to the COVID-19 [7]. Patients of COVID 19 may be grouped into five categories: asymptomatic, mild, moderate, severe, and critical. In most of countries, to combat the healthcare facility challenges, only the patients with severe illness due to disease are admitted to hospitals while patients having mild or no symptoms may be taken care at home, and these patients will not require intervention unless rapid deterioration of health occurs [9,10]. According to data collected by WHO from China, only 15% are severe infection, requiring oxygen and 5% are critical infections, requiring ventilation. Rest 80% of infections are mild or asymptomatic [11]. In Italy and Spain, around 40-50% of COVID-19 cases were hospitalized, with 7-12% required admission to ICUs [12]. COVID-19 can quickly overburden the health care systems of any country, undermining their capacity to provide services not only to COVID patients but also to those with some other health problems.

Symptoms of COVID-19

The main symptoms include:

- Fever (moderate or high temperature)
- Cough
- Breathlessness
- Fatigue
- Chills (sometimes with shaking)
- Body aches
- Headache
- Sore throat
- Loss of smell or taste
- Nausea
- Diarrhea

Precautionary Measures

Functioning of immune system of a person is very critical. This is the immune system only that prevents a human body from being effected by illness. As long as we keep our digestive system strong, immunity will also be strong and illness would not happen. So, this is one way in which we can prevent ourself from being affected by Coronavirus. Ayurveda has the potential to increase body's immunity and maintain health. India's Ministry of AYUSH and CSIR are studying the use of ashwagandha, along with other Ayurvedic herbs like Guduchi, Yasthimadhu and Peepli, as a preventive treatment to front line workers and infected patients [12]. The holistic approach of AYUSH system focuses on improving immunity through change in lifestyle, diet and prophylactic interventions [13]. Ministry of AYUSH recommends some guidelines, summarized in fig. 1, that may help in preventive health measures and boosting immunity with special reference to respiratory health [15,16].

General Preventive Measures

- Drink warm water throughout the day.
- Practice of Yogasana, Pranayama and meditation daily for at least 30 minutes.
- Consume spices like Haldi (Turmeric), Jeera (Cumin), Dhaniya (Coriander) and Lahsun (Garlic) in cooking daily.
- Ayurvedic Immunity Boosting Measures:
- Have some amount of Chyavanprash in the morning. Sugar free Chyavanprash should be preferred more.
- Take herbal tea / decoction (Kadha) made from Tulsi, Dalchini, Kalimirch, Shunthi and Munakka - once or

twice a day. Add jaggery (natural sugar) and / or fresh lemon juice if needed.

- Drink Golden Milk or Haldi Milk - once or twice a day.

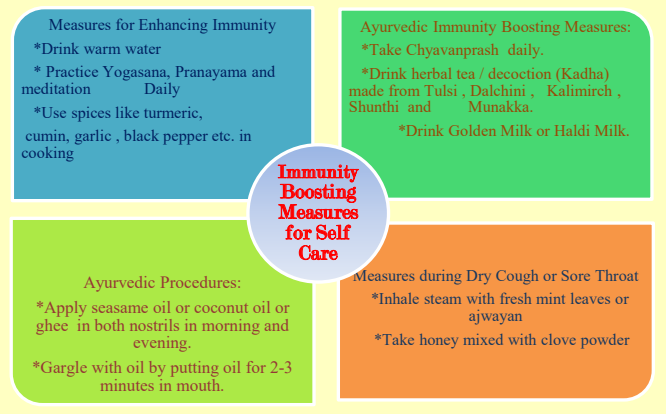

Fig. 1: Immunity boosting measures, as recommended by Ministry of AYUSH

YOGA

Various random studies show that practice of Yoga increases the immunity of human body. Yoga has also been shown to be useful in vulnerable population such as elderly, children. Yoga practices like Kriya, Yogasana and Pranayama specially reduce airway reactivity in elderly subjects with asthma and COPD(12) [17]. There are sufficient evidences in various studies that justify testing of YOGA can reduce susceptibility to illness.

Fig. 2: Yoga Helps in Building Immunity

SECTION II: HEALTH TOURISM IN INDIA

COVID-19 has affected almost all the sectors of economy very adversely crushing it all over the world. Tourism industry is the one that has been affected worstly, both international and domestic tourism. Tourism can be classified as tourism for entertainment (including leisure, adventure, heritage, cruise, corporate etc.) and tourism for medical (including medical and wellness tourism). According to a report of WHO, India was the third most preferable destination for medical tourism in 2019. A report of Ministry of Tourism, India states that nearly 1.5 lac patients travel to India for medical treatment from all over the world. Every tourist has to produce mandatorily a 'Fitness certificate' issued from authority of his/her country to get visa [18]. But because of coronavirus, medical tourism is paused completely. Patients are facing double problems: medical problem and pandemic of COVID-19. So they are restricting themselves to their countries only.

SECTION III: INTERNET OF THINGS

The Internet is a worldwide network of interconnected computer networks, based on a standard communication protocol (TCP/IP). Internet of Things is the technology that combines the analog and digital worlds, changing association and relationship of man with objects and their properties keeping the 'objects' in the center. Internet of Things is not a single novel technology; but many different complementary technical developments are combined together to bridge the gap between the virtual and physical world (Whitmore, Agarwal & Xu, 2014). Internet of Things doesn't only connect different 'things' (instruments, devices, and sensors) using wires or wireless technology, but it merges real and virtual worlds together whose communication is controlled by users (Deepu, Heng & Lian, 2017). IoT is believed to have embedded artificial intelligence. The IEEE IoT Community defines IoT as: "... a self reconfigurable and adaptive system that consisting of various networks of sensors and smart things interconnecting 'all things', that includes different objects used in everyday life and in industries, so as to make them more intelligent, programmable and capable of interacting with humans" [20]. IoT has a lot of applications amid which healthcare is most beneficial application.

IoT healthcare is the medical care that ensures healthy lifestyle by remote monitoring and supervising the health of patients, supporting chronical states and recommending preventive measures (Islam, 2015; Khanna & Misra, 2014). Healthcare IoT provides personal and customized services to patients according to their state and condition as monitored by different smart devices like body parameter sensors, smart phones or laptops etc. available with the patient. Government of India has also started various e-Health projects with a vision to provide better health facilities to people (Bhattacharya & Pandey, 2020).

SECTION IV: HEALTHCARE ARCHITECTURE IN IOT

The general architecture for healthcare services is proposed by many researchers as shown in Fig. 3. The architecture

comprise of mainly three layers: Sensor Network Layer, Gateway and Cloud data center (Jangra & Gupta, 2018).

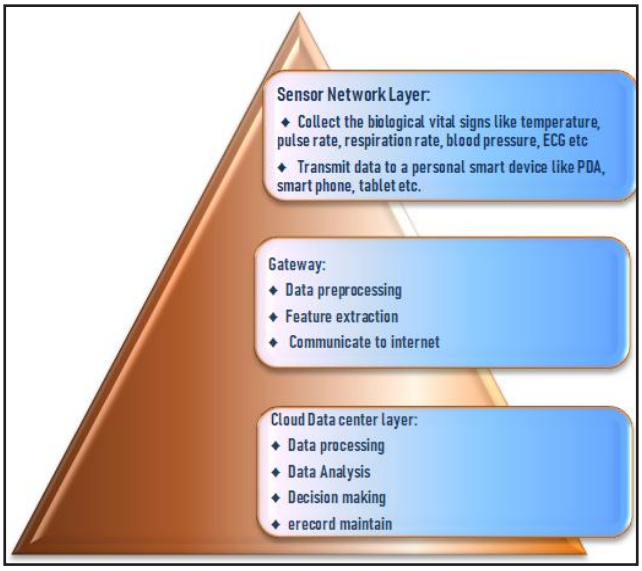

Fig. 3: General Architecture of Healthcare System based on IoT.

Sensor Network Layer: This layer comprises of various biomedical sensors that are either carried or worn by patient. These sensors combinely make personal Wireless Body Area Network(WBAN). The sensors collect the biological parameters like temperature, pulse rate, respiration rate, blood pressure, ECG, blood glucose etc. The sensors transmit their data to a personal smart device like PDA, smart phone, tablet etc. using low power transmission method like Bluetooth.

Gateway: The smart devices act as gateway. These receive data from sensors, process the data to extract meaningful information and analyze the data. Various machine learning algorithms may be used at this level to preprocess the data, extract features from it and develop a predictive model that can be trained to extract features from a training data set and realtime data lateron. The extracted features may be then communicated to doctors through internet.

Cloud Data Center Layer: The facilities provided by cloud enables to process the data obtained from gateway layer, store the information for analysis and decision making. Also erecord may be maintained at this layer.

Significance in COVID Environment

The sensor network layer comprises different sensors that may be used to monitor the physiological condition of people. The sensors may be wearable or can be carried with. Wearable sensors can monitor the patient in real time continuously (Ding, 2021). Various sensors that may be used to sense the vitals of human body are summarized in table 1. Report of Clinical Symptom Monitoring Studies says that the main clinical symptoms of COVID-19 are fever (90% of cases or above), cough (around 75%) and dyspnea (up to 50%) (Jiang, 2020). The wearable sensors can be used to measure these vital signs of patient related to symptoms.

Temperature: Temperature of human body determines whether the person is having fever or not indicating signs of illness. A wearable temperature sensor continuously monitors the body temperature and can detect the rise in temperature quickly (Abbasi, 2017).

Cough Monitoring: Cough signs are characterized by change in sound and voice of patient. A wearable microphone or a highly sensitive piezoelectric transducer near throat area (Drugman, 2013; Amoh, 2016; Elfaramawy et al., 2018) can be used to detect the variations in sound and vibrations produced by cough.

Respiratory Disorder: Respiratory rate is a major vital sign to detect COVID-19 (Huang et al., 2020). The respiratory disorders like shortness of breath can be measured using wearable chest straps or wavelet health wristband.

Also change in respiration rate can change Oxygen saturation in blood (Pan et al., 2020). This can be measured with the help of SpO2 that can tell the percentage of hemoglobin in blood. Due to COVID-19, the lungs get affected and amount of oxygen that can be carried by lungs also gets changed resulting in change in blood hemoglobin.

Table 1: Vital Signs and Sensing Technology for COVID-19 Patient Monitoring

Clinical Symptoms of COVID-19	Measurement	Sensing Technology be used	Area of Sensor imlementation	Maturity of Technology	Warning Values for COVID-19
Fever	Body temperature	Thermal sensing	Patch, headband	High	$\geq 38^{o}C$
Cough	Sound Signal	Piezoelectric or mechanical sensing	Patch, Microphone	Low	Dry Cough

Respiratory Disorder	Respiration rate	Respiratory airflow sensor, humidity sensor, Detection of movement of diaphragm via strain or accelerometer	Chest Strap, patch	Low	≥20 bpm
	SpO2	Optical Sensing	Wrist patch, ring or with smart watch	Low	≥94%

SECTION V: PROPOSED FRAMEWORK

In this section, a smart healthcare framework is proposed that is used to monitor the various physiological parameters of COVID patient for 24 hours continuously. Fig. 4 shows the proposed framework.

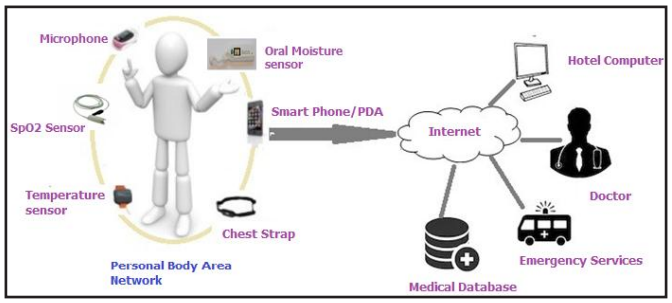

Fig. 4: Proposed Framework for Smart Healthcare System that may be used for COVID Patients

The proposed framework comprises of a personal body area network which has various wearable sensors like temperature sensor (to measure temperature of body), a chest strap consisting of respiratory sensor (to count the number of breaths) alongwith a microphone (used to detect sudden rise in voice amplitude due to sneezing or cough), oral moisture checking sensor(used to detect the moisture of mouth), SpO2 (used to detect the amount of oxygen level in blood). All these sensors monitor the vital signs to check the major symptoms of COVID-19 like high temperature, fever, cough, cold, shortness of breath, diarrhea etc. continuously round the day.

The data collected by the sensors is fed in real time to a edge device (which acts as gateway). This may be a smart phone, PDA, Tablet or a laptop/PC. The smart device preprocesses the data obtained and extract the information from the data. It may compare the obtained data with threshold values of vital signs recommended for a healthy person. The extracted information is transmitted to cloud through internet.

The cloud layer server performs processing and analysis over the data. It takes decision whether the data corresponds to a healthy person or it shows illness. Also, the cloud layer analyses the category of patient i.e. either it is mild, moderate, severe or critical. Some machine learning algorithms may also be used to design and develop a predictive model and it can be initially trained through available datasets and later on can be fed with realtime data obtained from user. The extracted information about the user may be then conveyed to medical practitioners/doctors, hospital management (for emergency services like ambulance), hotel management (whether the user is healthy or not and if not, what is category of patient-mild, severe). Also the data is stored at cloud to make a medical database which can be used by government of India to maintain records (for number of healthy or infected people).

SECTION VI: DISCUSSION

The framework helps in identifying healthy or infected (with severity of illness) people. The information is very useful for tourism department and hotel management. The ministry of tourism may ensure that the patients arrived for medical treatment to India are infected by coronavirus or not. Secondly, if the patient has COVID-19, then the patient may get isolated in isolation wards or identified hotels. The hotel management may also be informed about the details of the patient in advance such that the hotel administration may make proper arrangements.

Ayurvedic treatment can also be made available to the patients. Ayurvedic immunity boosting drinks and suppliments like golden milk, chyavanprash, herbal tea, decoction etc. can be customized according to patient. The hotel management can also manage sessions of Yoga and Pranayam for patients helping them to combat the disease early. Also alarm messages can be sent to patient's phone reminding for Yoga and drinks.

SECTION VII: CONCLUSION

Since outbreak of coronavirus has crumbled the entire working of whole world in almost all the sectors. Tourism sector is also affected badly due to COVID-19 pandemic. In this paper, we started with a brief review about coronavirus disease, its causes, transmission mechanism, symptoms alongwith the preventive measures suggested by ministry of AYUSH. Next we discussed IoT technology, its healthcare application and significance of healthcare using IoT in COVID environment. A remote monitoring smart healthcare framework is proposed in paper that would help the patient, hotel management, hospitals and lastly government also to maintain record and keep tracking the patient.

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