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Home Health Monitoring: A Review of Recent Advancements

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ABSTRACT

Now-a-days the whole world is witnessing significant changes in healthcare facilities. Its role is extending from treatment to prevention and remote patient monitoring. As we know that "Prevention is always better than Cure" it is the need to monitor the health of an individual staying at home so that a person is prevented from the danger of fatal diseases. There has been an exponential increase in health care costs in the last decade. Patients have to make frequent visits to their doctor to get their vital signs measured. A system must be developed which will help in reducing the frequent visits to the clinic and also help in early diagnosis of dangerous diseases and is targeted both for monitoring elderly and for monitoring rehabilitation after hospitalization period. The aim of this review paper is to summarize different approaches towards remote patient monitoring.

Keywords : Health monitoring, fatal diseases, remote patient monitoring, vital health parameters.

1. INTRODUCTION

Healthcare is approaching a very critical situation. The ageing of population is increasing the prevalence of chronic diseases. Cardiovascular and respiratory diseases not only kill hundreds of thousands of people each year around the globe but also cost billions of dollars. It is economically and socially advantageous to reduce the burden of disease treatment by enhancing prevention and early detection [1]. People are becoming more conscious about healthcare and there is a growing demand for better quality of care. The move from a "clinical care" (hospital, ICU, speciality clinic) to a "residential care" (nursery facility, assisted living, etc.) and up to "home care" will result in a reduction of the healthcare costs and at the same time in a higher comfort of the patient and enhanced quality of life [2].

Patients have to make frequent visits to their doctor to get their vital signs measured. Telehome care and home monitoring are attractive options to allow elderly rural residents to stay in their own homes and communities and receive necessary healthcare. This care is defined as remote care delivery or monitoring between a health care provider and a patient outside of a clinical health facility in the patient's place of residence[3] .

Provision of ubiquitous healthcare solutions anytime anywhere continues to be a major challenge, with an ever increasing need for efficient remote healthcare systems. With the rise in the number of chronic diseases and symptoms across all age groups of the world population, the familiar face-to-face clinic interaction between patients and physicians is not a sustainable healthcare delivery model. Family-based healthcare services allow patients full mobility at their homes, where health-care providers can monitor their health data remotely. Such family-based connected healthcare systems besides reducing the waiting time for face-to-face contact with physicians are capable of generating alerts being sent to the patients or to the informal care-taker by the physician [4]. Such healthcare systems can be useful for the elderly and terminally ill patients confined within their homes and at the same time helpful to the pregnant women for their regular checkups without personally visiting to the clinic.

2. VITAL HEALTH CARE PARAMETERS

Health is defined by the world health organization (WHO) as "a state of complete physical, mental and social well-being and merely the absence of disease and infirmity". The vital health care parameters are the fundamental and important indicator of health. These include blood pressure, temperature, oxygen saturation, heart rate, breathing rate.

2.1 Blood pressure

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of Blood vessels and is one of the principal vital signs. During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure. The mean BP, due to pumping by the heart and resistance to flow in blood vessels, decreases as the circulating blood moves away from the heart through arteries. Blood pressure drops most rapidly along the small arteries and arterioles, and continues to decrease as the blood moves through the capillaries and back to the heart through veins. A person's BP is usually expressed in terms of the systolic pressure and diastolic pressure (mmHg), for example 120/80.

Understanding the Medical Terms

- Blood pressure is the force of blood against the walls of the artery.
- Hypertension means high blood pressure.
- Hypotension means low blood pressure.

- Brachial artery is a blood vessel that goes from your shoulder to just below your elbow. You measure the pressure in this artery.
- Systolic pressure is the highest pressure in an artery when your heart is pumping blood to your body.
- Diastolic pressure is the lowest pressure in an artery when your heart is at rest.
- Blood pressure measurement is made up of both the systolic and the diastolic pressure. It is normally written like this: 120/80, with the systolic number first.

Blood pressure can be easily measured with the help of digital blood pressure monitor as shown in the figure1 below.

Figure 1. Digital blood pressure monitor

Digital blood pressure monitors have a cuff and a digital gauge (called a digital sphygmomanometer). The cuff will inflate automatically when it is started, by an electric motor. The digital monitor will determine your blood pressure and heart rate by measuring the vibrations (also known as oscillations) as the pressure is slowly released from the cuff. It works in a similar manner as the manual blood pressure monitor with the stethoscope.

2.2 Temperature

Normal human body temperature, also known as normothermia or euthermia, is a concept that depends upon the place in the body at which the measurement is made, and the time of day and level of activity of the person. There is no single number that represents a normal or healthy temperature for all people under all circumstances using any place of measurement. . The commonly accepted average core body temperature (taken internally) is 37.0 °C (98.6 °F). The typical oral (under the tongue) measurement is 36.8±0.7 °C, or 98.2±1.3 °F. From the home to the hospital and everywhere in between large number of people rely on digital thermometers to take fast, accurate reading of a patient's body temperature. The digital thermometer is shown in figure2 below.

Figure 2. Digital thermometer

The thermistor in a digital thermometer acts as a as a temperature-sensitive electric resistor. At low temperatures, a thermistor will not conduct electricity, but as its temperature rises, the thermistor's state changes and it becomes more and more conductive. Thermistors used in digital fever thermometers undergo this change in conductivity (resistance) at temperatures near 98° F.

2.3 Oxygen saturation

Oxygen saturation is defined as the ratio of oxhemoglobin to the total concentration of hemoglobin present in the blood. A hemoglobin molecule can carry a maximum of four oxygen molecules. 2000 haemoglobin molecules can carry a maximum of 8000 oxygen molecules; if they together were carrying 7200 oxygen molecules, then the oxygen saturation level would be 90%. An instrument called as pulse oxymeter as shown in figure3 measures the oxygen saturation level of a patient's body.

2.4 Heart rate

For an adult, a normal resting heart rate ranges from 60 to 100 beats per minute (bpm). For a well-trained athlete, a normal resting heart rate may be as low as 40 to 60 bpm. In healthy adults, a lower heart rate at rest generally implies more efficient heart function and better cardiovascular fitness. To measure your heart rate at home, simply check your pulse. Place two fingers on the thumb side of your wrist, or place your index and third fingers on your neck to the side of your windpipe. When you feel your pulse, look at your watch and count the number of beats in 15 seconds. Multiply this number by 4 to get your heart rate per minute.

Many factors can influence heart rate, including:

- Activity level
- Fitness level
- Air temperature
- Body position (standing up or lying down)
- Emotions
- Body size
- Medication use

Although there's a wide range of normal, an unusually high or low heart rate may indicate problems such as fainting, dizziness or shortness of breath. Pulse oxymeter is used to record the heart rate or pulse rate.

Figure 3. Pulse oxymeter

Pulse oximeters measure the absorption of red and infrared light by pulsatile blood. They are inexpensive, continuous and portable.

2.5 Breathing rate

Respiratory rate (i.e respiration rate, pulmonary ventilation rate or ventilation rate, breathing frequency (BF)) is the number of breaths a living being, such as a human, takes within a certain amount of time (frequently given in breaths per minute). There is limited research on monitoring respiratory rate. However it is not yet proven whether or not this is due to age or environment and these studies have focused on such issues as the inaccuracy of respiratory rate measurement and respiratory rate as a marker for respiratory dysfunction. The human respiration rate is usually measured when a person is at rest and simply involves counting the number of breaths for one minute by counting how many times the chest rises. However, a spirometer shown in figure4 is also of great use. Respiration rates may increase with fever, illness, or other medical conditions. When checking respiration, it is important to also note whether a person has any difficulty breathing.

Figure 4. Spirometer

Average respiratory rates, by age:

- Newborns: Average 44 breaths per minute
- Infants: 40-60 breaths per minute
- Preschool children: 20–30 breaths per minute
- Older children: 16–25 breaths per minute
- Adults: 12–20 breaths per minute
- Adults during strenuous exercise 35–45 breaths per minute
- Athletes' peak 60–70 breaths per minute

3. RECENT DEVELOPMENTS IN THE FIELD OF HEALTHCARE

Ibrahim Khalil et al., [1] developed an advanced prediction model to estimate the heart rates of selected patients in a mobile care system that would send alerts to a designated medical centre for appropriate action to be taken when estimated rates exceed a predefined threshold. The system was preventive as it was capable of predicting heart rate abnormality, and possibly
Tachycardia, well in advance. But only heart patients can be taken care of with this system. Koji Mukai et al., [5] developed a remote system for monitoring heart rate, respiration rate and movement behaviour of at-home elderly people who are living alone. The system consists of a 40 kHz ultrasonic transmitter and receiver, linear integrated circuits, a low-power 8-bit single chip microcomputer and an Internet server computer. However, the system could not be used for clinical diagnostic purposes, although its resting heart and respiratory rates are exceedingly reliable and accurate, as is its monitoring of general in and out of bed status and schedule.

Hiroshi Nakajima et al., [6] described a human health monitoring system by an air pressure sensor and an ultrasonic sensor system. The ultrasonic sensor system can obtain the state of a patient in bed by placing it under a bed frame. That is, we can determine whether or not a patient in the bed. The air pressure sensor system can detect heart beats by placing it to the mattress on the bed. The system of the two sensors complementary detects the state, heart beat, a behavior before getting out of bed. Thus, the system of the two sensor systems can noninvasively and unconsciously provide human health information with fuzzy logic. Even though this model is very effective in health monitoring but it monitors only the one vital sign of the human body. Also use of fuzzy logic does not produce very accurate results as compared to the neuro-fuzzy approach.

K. Kuwana et al., [7] have developed an implantable telemetry capsule for monitoring heartbeat with FM transmitter and power supply. The capsule has three main functions, monitoring vital signs, transmitting the vital signs, and receiving energy for driving the capsule without wires. They used two wavelengths of LEDs and a photodiode sensitive to the two wavelengths for heartbeat sensor. The arterial oxygen saturation is calculated from the amplitude of the heartbeat signal. A coil-based antenna was used for the transmitter. The capsule was capable of monitoring vital signs over the long term. However the whole system was a bit complex and economically inefficient. Mari Zakrzewski et al., [8] developed the system which was targeted both for monitoring elderly and for monitoring rehabilitation after hospitalization period. The paper presented the utilized sensor network implementation, chosen set of sensors for the first test trial, as well as other design choices for the trial.

Shoko Nukaya et al., [9] described a novel bed sensing method for noninvasive, constraint-free, subliminal detection of biosignals. The sensor system detects the heartbeat, respiration, body movement, position change, and scratching motion of a person lying or sleeping on the bed. These biosignals provide not only basic medical information but also sophisticated details about sleep conditions. Thus, the bed sensing method can be used to monitor the health condition of people sleeping at home, as well as that of patients in the hospital. Kyung-Ah Kim et al., [10] implemented a home self healthcare monitoring system which can monitor respiration, blood glucose, urinary flow, and temperature. The obtained bio-signal by the each sensing unit is transmitted to a monitoring station using Zigbee wireless communication in real time at home on the personal computer. But this type of system depends upon the doctor's decision. Also if some sort of problem occurs in transmission of data then the system may fail.

Dr. V. Vaidehi et al., [11] proposed health care monitoring system enables significant responsiveness and process optimization by integrating complex event processing that leverages context awareness in Service Oriented Architecture. The project is at an early stage, and significant work remains in order to completely develop the system and fully validate the
approach. A method using the combination of ZigBee and GPRS is presented by Hongzhou Yu et al., [12] which is a remote health monitoring system used to collect and transfer biosignal data from the patient to healthcare center. Two wireless technologies are integrated to support continuous biosignal monitoring in presence of patient mobility. Even if this system transfers the data effectively but is not capable of decision making.

Namrata Nawka et al., [4] presented "SESGARH", a scalable and extensible smart-phone based healthcare system, to provide realtime continuous monitoring of health conditions of individuals seeking professional healthcare. The system suggested an "anytime anywhere" health monitoring mechanism via an application providing rich contextual visualization of health data through easy-to-use interfaces. Using SESGARH, patients with chronic illnesses can send disease symptoms and other critical health information to a physician, who can analyze this data remotely and prescribe e-prescriptions. SESGARH can significantly minimize time taken for transmission of healthcare data from patient to physician and vice-versa, and improve the reach and quality of healthcare services. However this system is also incapable of decision making. A real-time system for detecting the fall of elderly people in smart home is presented by V. Dhivya Poorani et al., [13]. The proposed system confirms the fall based on measurements from accelerometer sensor and detects the abnormality in the patient using bio-sensors. Decision-making based on neuro-fuzzy logic, makes the fall detection system more accurate and reliable. The numbers of false predictions are greatly reduced using neuro-fuzzy technique. Also it involves, reasoning the event of fall using bio-sensors. The system is reliable but mainly focussed for detecting falls and not for monitoring the health of an individual.

4. COMPARATIVE ANALYSIS

In previous sections it is attempted to portray an elaborated review of various health monitoring techniques. It has been seen that each technique has its own advantages and drawbacks. For instance, an accelerometer sensor and biosensor based neuro-fuzzy system monitors health remotely and detects fall at the same time. Whereas, the bed sensing technique allows for investigating the heartbeat, respiration and body movement and position change & scratching motion of a person lying or sleeping on the bed. Although techniques like Advanced prediction method monitors only the heart rate of a patient, they help for preventing the risk of fatal heart diseases. A comparative summary of purpose and methods with related advantages and limitations for the various health monitoring techniques is tabularized in Table 1.

Table 1: Comparative Examination of Health Monitoring Techniques

Author	Purpose	Method	Limitations	Advantages
Ibrahim Khalil et al.,	To monitor Heart rate	Advanced prediction method	Only heart rate can be monitored	Predicts heart rate, tachycardia
Koji Mukai et al.,	Home health monitoring	Microcomputer and Internet server computer based system	system could not be used for clinical diagnostic purposes	monitors heart rate, respiration rate and movement behaviour
Hiroshi Nakajim et al.	health monitoring on bed	air pressure sensor, an ultrasonic sensor and fuzzy based system	fuzzy logic does not produce very accurate result	Very effective in health monitoring
K. Kuwana et al.	monitoring heartbeat & oxygen saturation	implantable telemetry capsule with FM transmitter and power supply	system was a bit complex and economically inefficient	capable of monitoring vital signs over the long term
Shoko Nukaya et al.	Detects heartbeat, respiration and body movement and position change & scratching motion of a person lying or sleeping on the bed	bed sensing method	system was a bit complex and economically inefficient	monitor the health condition of people sleeping at home, as well as that of patients in the hospital
Kyung-Ah Kim et al.	monitor respiration, blood glucose, urinary flow, and temperature	Zigbee wireless communication	Not reliable and depends on the doctor's decision	home self healthcare monitoring system
Hongzhou Yu et al.,	collect and transfer biosignal data from the patient	combination of ZigBee and GPRS	Not capable of decision making	continuous biosignal monitoring in presence of patient

	to healthcare center			mobility
Namrata Nawka et al.,	realtime continuous monitoring of health conditions	contextual visualization of health data through easy-to-use interfaces	incapable of decision making	improve the reach and quality of healthcare services
V. Dhivya Poorani et al.,	Fall detection and health monitoring system	accelerometer sensor, biosensor, neuro-fuzzy system	Mainly focussed for fall detection	The system is reliable and accurate

5. CONCLUSION

In this study, a review on various health monitoring techniques has been presented. On the basis of research papers, publications, web-sources, product manuals, interviews, formal discussions and other available literature, it can be concluded that the different approaches discussed are helpful for home health monitoring but at the same time have some limitations. These limitations range from complexity to cost. Hence there exist a gap between technologies and user requirement for a convenient, economical and reliable home health monitoring system. Thus, the future work for health monitoring can be implanted considering these few important parameters.

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