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Wearable Technology to Improve Health Care Infants in the Yomibato Peruvian Community

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Abstract

The research arises from the need to face the health problems of the infants in one of the poorest and most remote areas of Peru who may die from diarrhea or some other disease which in a city would be easily treated. The objective is to reduce the waiting time and increase the satisfaction level of the patient's medical care by implementing a remote Health Monitoring System using wearable technology. Users will be able to view and manage the monitoring system simply and quickly way. The research is carried out in the community of Yomibato, located in the center of the Manu National Park, where the information was collected. A Health Monitoring System using wearable technology and sensors to measure physical and biological parameters, and that is a more comfortable and non-invasive response appropriately to solve the issue. LoRa technology is proposed because of its capacity to send data collected over several kilometers in real-time to track the physical and biological patient's data. This solution works even without internet access as well as the absence of radios in place, which would increase the availability and satisfaction level of children's medical care.

Keywords; *Medical care, health monitoring system, wearable technology, sensors, LoRa technology.*

I. INTRODUCTION

Following the provisions of the Manu Development Plan until 2021 [1], to ensure adequate quality of the health service, it must be considered that the users of the localities are satisfied with the medical care they receive, the establishments are in good condition and are adequately equipped, medications are available and sufficient, and that they have basic services like water and energy. At the district level, there are six health establishments with categories between I-1, I-2, I-3, and I-4, the latter combine functions and are located in the Micro Network Manu, the others are located in the populated rural centers. As detailed in Figure 1, the Micro Network is located in Salvación, which is category I-3 with technical personnel and medical specialties. Still, in rural communities, the Health Posts are category I-1 predominate in Gamitana, Native Community Shipetiari, except in Itahuania and Shintuya, which are category I-2. These health facilities provide health services to the population of local communities and their scope of influence.

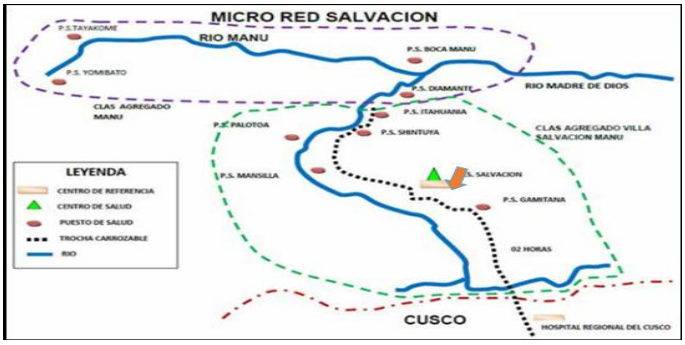

Figure 1: Map of Micro Network Manu (Source: Sexual and Reproductive Health Strategy - MicroRed Manu, 2015)

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According to the Yomibato Native Community Life Plan [2], despite all of those above, the Yomibato community does not have access to a quality health service. It is necessary to increase the number of professionals and expand the attention of health facilities. For instance, due to the lack of a bed, the members of the community do not adequately care for. Furthermore, when families make initial contact for any pain or disease, they arrive from the headwaters of the Cumerjali, Sotileja, Fierro, and Maestrón rivers, the facilities of the Primary care center are not enough to attend to all those who need it. On the other hand, there is an epidemiological risk for the population during initial contact when some of those who have remained in Yomibato and return to the places where they came from. Thanks to the NGO, Casa de Los NiñosIndígenas, drinking water is now consumed in Yomibato, through a sink in each home. Therefore, in 2015, intestinal infectious diseases in children decreased by 21% compared to 2014, and by 25% compared to 2013. But parasitosis could not be controlled, which has grown by 421% in 2015 compared to the year 2014 and 369% compared to 2013 (DIRESA, 2016). This is probably because any hygiene habits campaign has not been carried out to take better advantage of the drinking water service. According to Madre de Dios Regional Directorate of Health, this is now a priority for the community, as shown in Figure 2; malnutrition and anemia rates have increased alarmingly in children (between 36.3% and 73.8%), who are almost always sick with diarrhea.

The primary care centers are driven by doctors who perform rural and urban marginal health services (SERUMS in Spanish). They generally meet a schedule from 7:00 am to 2:00 pm for one year. The health technicians (nursing technicians) are under the responsibility of these doctors, and they are the ones who attend the primary care centers until 7:00 pm. According to the category of these medical establishments, medical staff must carry out "external consultations" or "ambulatory care," surveillance and attention to emergencies, prevention, promotion, etc., undoubtedly, have been carrying out these tasks but during working hours.

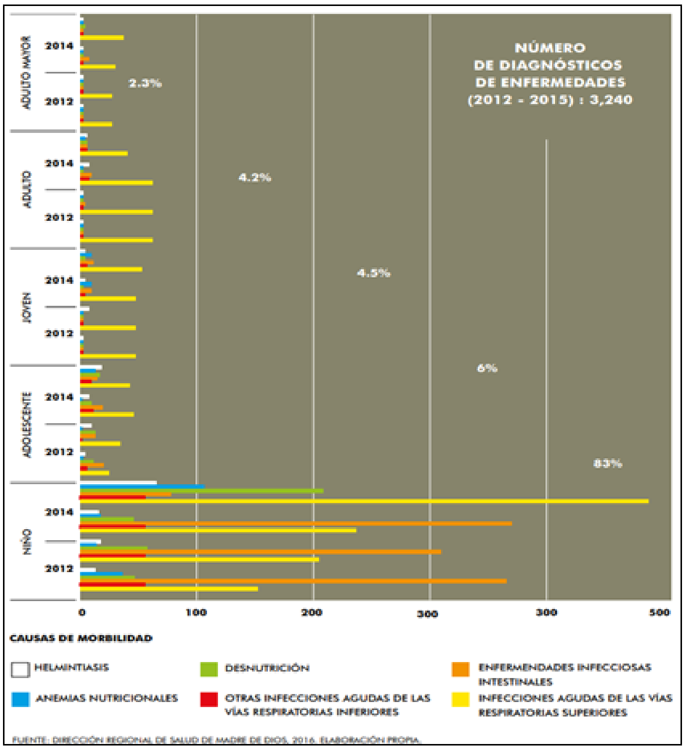

Figure 2. Morbidity of the Yomibato Community

That's why none of the Health Posts are open 24 hours. In case of an emergency, patients are transferred to the Salvage Micro-network (RCM). They may take between 1 and 4 hours of travel, depending on the primary care center location, ambulance availability, and the weather conditions are favorable.

What is the Rural and Urban Marginal Health Service (SERUMS in Spanish)?, It is a community service program that is oriented to develop preventive - promotional activities in MINSA health centers and primary care centers, or in equivalent establishments of other institutions of the National Health System, mainly in rural and urban - marginal areas considered less develop in the country.

II. PROBLEM STATEMENT

In Peru, the government is not capable of ensuring basic services for communities in rural areas that are difficult to access since it generates a high cost of time and resources if the personnel is sporadically

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sent or a health module is permanently installed to perform these monitoring functions. That way, the health of all inhabitants is a problem, especially for children who are the most vulnerable in these areas,

One of the communities with these described conditions is the community of Yomibato in the heart of Manu. To take a patient with an emergency, it takes more than two days on the way to the nearest civilization that has a health center, this being many sometimes fatal. All these factors generate a deficiency in the time and quality of response in the care of infants in the Yomibato community, which can have a series of unfortunate outcomes from unidentified anemia or loss of life due to lack of timely care.

Variable 1: Waiting time for patient care. According to [1], value: 4 hours plus

Variable 2: Degree of satisfaction with medical care. According to [1], value: Bad

III. THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 Smart Health Monitoring Systems

According to [3], the development of these systems is a possible solution to reduce the costs of hospitalization that is increasing, because in most countries there is an increase in the elderly population and also an increase in the useful life, thus generating an increase in the number of patients that need to be monitored.

The classification of HMS (Health Monitoring System), as shown in figure 3, is divided into 3: MHMS (Mobile Health Monitoring System) which refers to all those systems that can use a Smartphone, a Tablet or a PC to perform patient monitoring, we also have WHMS (Wearable Health Monitoring Systems) that use wearable sensors or biosensors to measure a patient's vital signs. Lastly, it has RHMS (Remote Health Monitoring Systems) that can remotely send patient data from wherever it is located, such as a home or hospital.

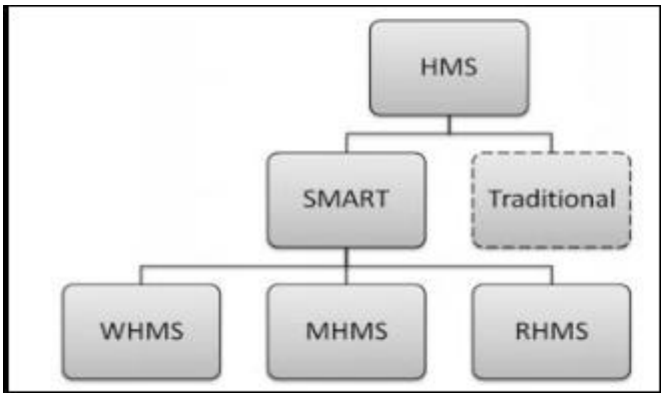

Figure 3. Classification of Health Monitoring Systems (HMS)

The architecture of the Intelligent Health Monitoring Systems, which has proven to be more efficient, is shown in Figure 4; it can be used for various scenarios applying some necessary modifications as required.

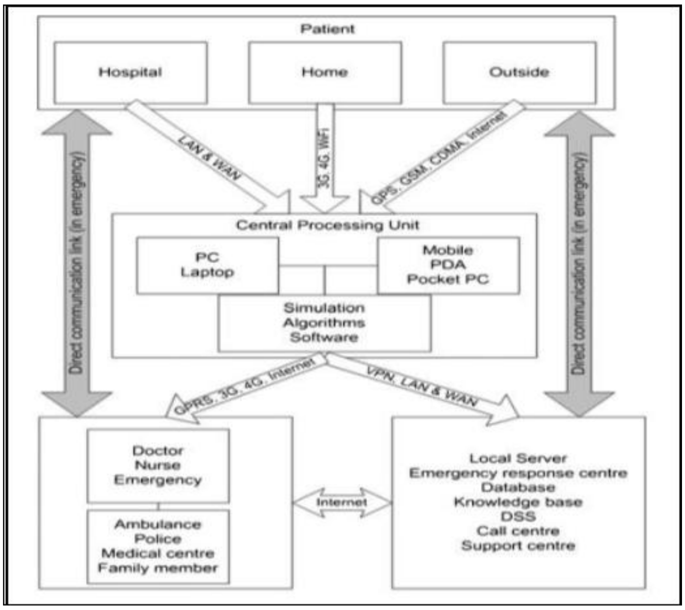

Figure 4. Smart Health Monitoring System Architecture

From a set of reviews made by the authors to this category of systems, the collection of patient data in a non-invasive and discreet way is highlighted as qualities, as is the case of a WHMS (Wearable Health Monitoring Systems), the system incorporated in a vest that can collect data from

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Electrocardiogram, photoplethysmography, heart rate, blood pressure, body temperature and the galvanic response of the skin. They even mention that electrocardiograms can be performed without the need for the gel and some other details. The validation results of the system confirmed the precision of the physiological measurements. A series of recommendations are recommended according to the categories of the HMS, as we can see in figure 5.

Area	Design Consideration
Wearable HMS	User comfort
	Data transmission rate power consumption
	Data quality
	Security and privacy
	Area of movement
	Context-awareness
Remote HMS	Secure data transmission
	Real-time availability
	Middleware design
	User-friendliness
	Security and Privacy
Mobile HMS	Power consumption
	Energy efficiency
	User-friendliness
	Scalability
	Mobility and Reliability
	Security and Privacy

Figure 5. HMS area considerations

3.2 Wearable Sensors for Remote Health Monitoring

According to [4], to be long-term, they must satisfy medical and ergonomic requirements such as: being comfortable, having flexible and small components, they must be chemically inert and hypoallergenic for the human body, it is also important to consider the lifetime battery life because long-term monitoring is required.

There are several investigations of wearable health monitoring systems that only study a single type of vital sign, such as body temperature, blood pressure, and others; the authors highlight that this is not useful for patient monitoring because with a single measurement it is tough to determine if the patient suffers from any disease.

Therefore, it is vital to implement multi-sensor systems to have early detection of various diseases and even be able to prevent them. The great challenge of multi-sensor systems is to be able to achieve easy integration, with low energy consumption, having information security, and efficient data processing. From the analysis and discussion, it was determined that for the multi-sensor systems the set of critical physiological parameters to be measured and monitored are used using four sensors: ECG (Electrocardiogram), PPG (photoplethysmography), GSR (Galvanic Skin Response) and a temperature sensor, of which the other parameters necessary to mediate the vital signs of a patient can be defined. More details in Figure 6 and Figure 7.

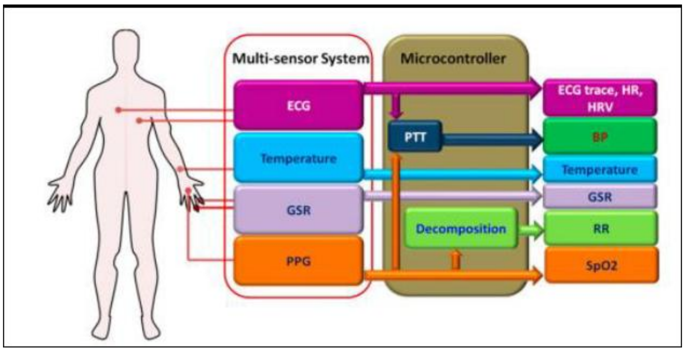

Figure 6. Four health monitoring sensors

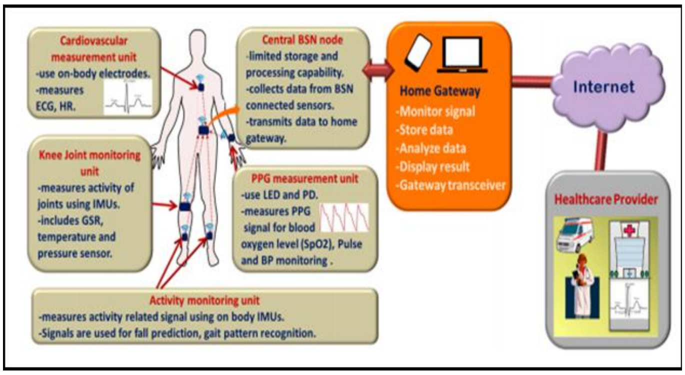

Figure 7. Health monitoring systems

Quantifying a patient's rehabilitation status allows a clinical team with feedback to define the rehabilitation strategy. The acuity degree quantifying patient status and reflex has evolved from physician-derived ordinal scale assessment to quantification systems reserved for a clinical setting

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with portable and wireless systems that can easily measure and quantify patient status patient and the characteristics of their reflexes through their inertial sensors, such as the accelerometer and gyroscope [6].

3.3 Low-Power Wide Area Network (LPWAN)

According to [5], the Internet of Things (IoT) is becoming increasingly relevant in the world and that this gives us the ability to collect data in new ways that is why this revolution must implement technologies of Low-Power and Wide Area and thus allow long periods of use without maintenance and human intervention.

As can be seen in Figure 8, LPWANs are wireless communication networks whose one of the most critical performance metrics for the low power extensive area networks (LPWAN) is the coverage. Indeed, there are some significant studies and papers that show the coverage of LoRa LPWAN technology via real-life measurements. Therefore, they observed the maximum communication range of over 15 km on the ground by a car and close to 30 Km on the water by a boat [7]. Besides, because of their deficient energy consumption and long battery life allows them to be connected for long periods. LoRa WAN technology stands out for this type of technology due to its characteristics, it's free, and encryption and the physical components compatible with this technology are low cost. The best use and where LoRa WAN is most efficient is in outdoor places where it can reach its full potential since, in urban areas, it is significantly reduced.

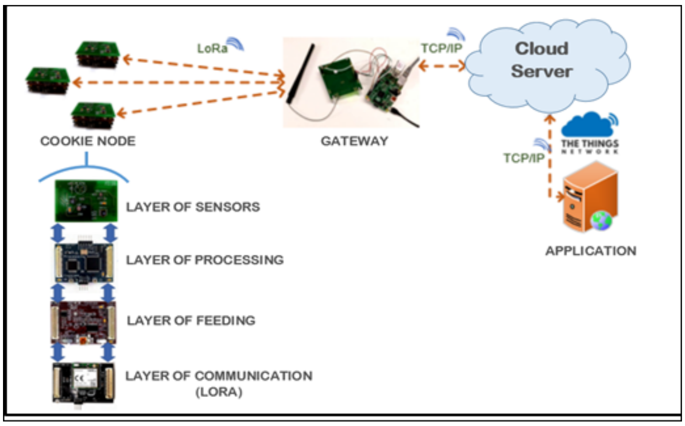

Figure 8. Scheme of a LoRa network

It is essential to mention that in the future, IoT applications would be applied for infrastructure, people, trash, bicycles, cars, boats, etc. are possibly monitored with LPWAN technologies, such as LoRa [8]. Besides, LPWANs can be employed for tracking data from the different king of vehicles; in this sense, medical personnel would be able to receive and transmit data during the trip to the place where the patient is located. This scenery would allow the patient´s family member to provide first aid and prepare him or her for rapid medical evacuation to the nearest medical center.

Further, over the years, a series of authentication protocols have been proposed for Wireless Medical Sensor Network (WMSN) to protect the transmitted data against unauthorized access from an attacker or malicious user because of sensitive patient´s data and legitimacy of a medical professional whose would receive information for a proper diagnosis and it is possible that attacker intercepts and modifies these physiological data, the doctor may make a wrong diagnosis; therefore, it is necessary to include protocols security during the wearable health monitoring system [9].

To solve a health problem, we must consider with particular emphasis that the causes must be detected early [10]. Based on this, we propose the following solution.

IV. MATERIALS AND METHODS

4.1 Software requirements

According to [11], the requirements model represents the fundamental basis on which a system focuses. Therefore, meetings are planned with business users and technicians, that there are greater access and knowledge of internal strategy reports and that the organization is analyzed in different contexts. After the analysis of the interviews, the main requirements obtained were:

- Register Monitoring Unit

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- Manage Monitoring Unit
- Update Patient Data
- Perform Monitoring
- Download report
- Coupling Monitoring Unit

4.2. Application design

The project proposes a solution with various profiles that have permissions and functionalities so that they can carry out their corresponding processes. Figure 9 shows the main processes that would be performed by the user, and Figure 10 shows the conceptual system model´s design for the logical and physical database.

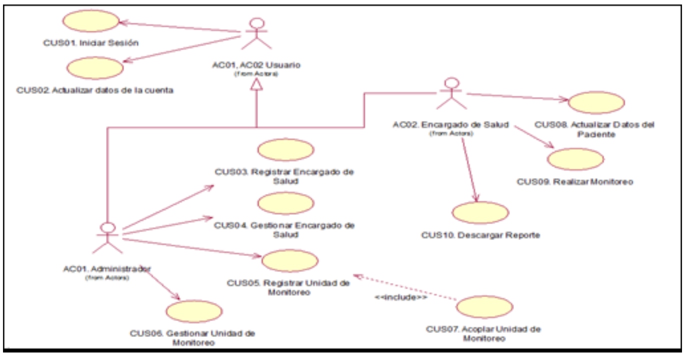

Figure 9. System Processes

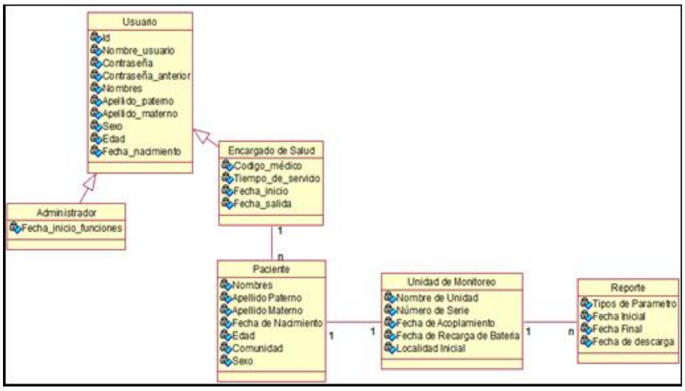

Figure 10.Conceptual System Model.

Figure 11 presents the design of the implementation of the hardware; this solution will be based on a system composed of a LoRa communication node, a compiler node, and several sensor nodes.

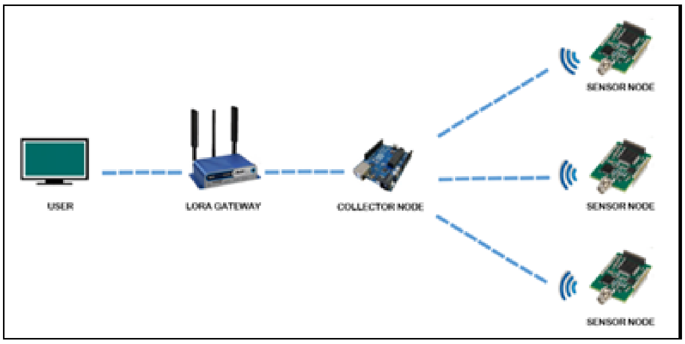

Figure 11. Hardware implementation design

4.3 Prototypes

Figures from 12 to 18 show the sequence of the main screens of the software implemented, the most important being Figure 17, which shows the process of how the monitoring process is carried out.

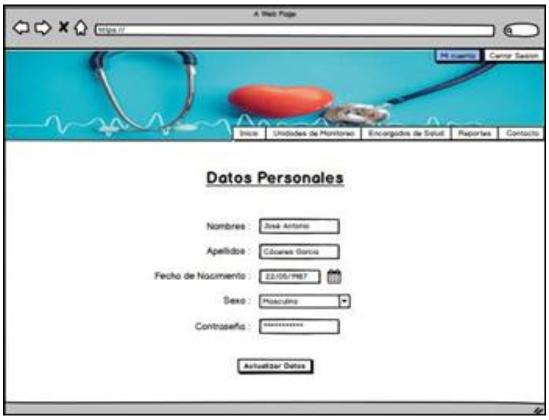

Figure 12. Update Account data

Figure 13. Register Manager

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Figure 14. Register Monitoring Units, Patient

Figure 15. Monitoring Units

Figure 16. Coupling Monitoring Unit

Figure 17. Perform Monitoring

Figure 18. Download Report

V. CONCLUSIONS

This system improves the quality and response time of medical care received by the most vulnerable babies and inhabitants in remote rural areas, such as the Yomibato community in the heart of Manú,

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providing real-time information about patients in various places at different distances, additional data from the area health manager is essential to improve the service and the future benefits of the system. Regarding this, LPWANs can be employed for tracking data from different kinds of vehicles; therefore, a node LoRa can be implemented on a car or a boat, and medical personnel would be able to receive and transmit data during the trip to the place where the patient is located. Response time would further decrease; likewise, it would be allowed high availability of the service.

Extensive and extensive testing needs to be emphasized because it could present erroneous readings and raise a false alarm, so the parameters in the algorithms were adjusted to increase the precision and quality of the data displayed by the system. Due to the modularity of the design, as we mentioned in the previous paragraph, it is possible to change certain technologies used in the future to obtain more benefits from each new technology available on the market, such as the use of other sensors, microcontrollers, communication technology, and others.

There are aspects to improve in the future, such as information security, by applying encryption techniques of authenticated protocols to access sensitive patient data, likewise, enhance communication security in LoRa technology individually when data is sent to the Internet which can be accessed anytime, anyone and anywhere. Furthermore, adding predictive algorithms with machine learning for better decision making by the decision-maker.

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