Systematic Review of the Literature on Transmissible Epidemiological Diseases

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ARTICLE HISTORY
Compiled May 22, 2023

ABSTRACT
This article aims to review research that has been conducted in the literature, to identify works that use ubiquitous models to assist in the prevention of communicable epidemiological diseases. To this end, a general search was conducted, whose processes employed for its conception are based on a research methodology known as Systematic Literature Review (SLR). The SLR has a series of steps that assist in the literature review of an area of interest, i.e., it assists in identifying articles that contain similar subjects to the research topic.

KEYWORDS
Internet of Things; Context Awareness; Situational Awareness; Data Analysis

1. Introduction

Transmissible epidemiological diseases are caused by infectious agents such as viruses, bacteria, fungi, and parasites and can be transmitted from human to human or from animal to human. These diseases represent a global challenge for public health, as they can cause outbreaks and epidemics that impact the population's health. Examples include COVID-19, influenza, HIV/AIDS, tuberculosis, malaria, dengue, and Zika. Prevention measures such as vaccination, hygiene, sanitation, isolation of suspected cases, and adequate treatment are necessary for transmissible epidemiological disease prevention. With technological advances, solutions have emerged that allow the use of sensors and actuators in people's daily lives in an imperceptible way that can help in disease prevention. These technologies collect accurate information about human behavior, enabling an adequate approach to prevent outbreaks and epidemics.

Thus, this article aims to identify studies and research that explore prevention models of transmissible epidemiological diseases. The analysis of these researches can provide valuable support for more effective strategies to combat these diseases and assist in comprehensive public health policy implementation.

This paper is structured as follows. Section 2 presents the theoretical bases of this work, the collective subject's discourse, and the serious and strategic games, respectively. Section 3 presents the methodology adopted in our work. Section 4 gives the speeches resulting from this research and the discussions on the found statements.

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Section 5 presents conclusions and future work.

2. Theoretical Foundamentations

The Internet of Things (IoT) is a concept that involves interconnected devices, enabling activities without the need for configuration and maintenance of computational resources. IoT emerged with the idea that objects equipped with identifiers and wireless connectivity could communicate with each other. Kevin Ashton's lecture in 1999 was a milestone in popularizing the term IoT, presenting the idea of a system composed of thousands of connected devices capable of exchanging information and commands. IoT exhibits characteristics such as device heterogeneity, scalability, transparency in data exchange, energy efficiency, location awareness, interoperability, security, and privacy.

Major technology companies are interested in leveraging the resources offered by IoT, but there are challenges to overcome, such as Big Data management and security. Context Science, also known as Context-Awareness, is a field of study that focuses on the circumstances surrounding an event or situation. It emerged in the 1990s and is present in various areas, such as computer networks and pervasive computing. The increasing use of mobile devices has enabled the acquisition and processing of context-aware data with greater precision, which is essential for applications that require contextual actions.

Therefore, Context Science involves the ability of a computational system to perceive the characteristics of the environment it is embedded in and act according to its interests. Context-aware systems collect relevant information, store historical data, identify trends, and drive actions that affect the user's environment. The lifecycle of Context Science consists of four main phases: context acquisition, context modeling, context reasoning, and context distribution. Context Science implementation faces challenges such as acquiring contextual information from heterogeneous sources, processing that information, and disseminating the data to interested consumers. Middleware systems recreate a role in context management by providing the necessary components to deal with the different phases.

Situation Science is a model presented to interpret contextual data collected by sensors. The model is based on three levels: perception, comprehension, and projection. The communication between these levels is not linear, and identifying a situation involves answering questions like who, what, when, where, why, and how. Situation-aware applications use situation-awareness methods to obtain semantic interpretations of low-level data. The data collected by sensors is transformed into contextual information at different levels of abstraction, enabling situation identification and decision-making in a situation-aware system. Situations can be generalized, composed, contradictory, dependent, or occur in temporal sequences.

3. Methodology

For the research design, it is considered adequate to use a methodology of Systematic Literature Review, following the basic process proposed by Petersen et al. (2008). The author states that, as a research area matures, there may be an increase in articles and other publications available, generating a large volume of related publications that may not be useful for the research. Therefore, the Systematic Literature Review becomes a secondary study method. A systematic review goes through existing initial reports, in-depth analysis, and description of their methodology and results Petersen et al. (2008).

Compared to other literature reviews, the SLR stands out for its well-defined methodology, which allows for the determination of related works step by step. Utilizing the resources offered by the SLR amplifies the search for studies with the related theme using defined terms with broad situations and contexts in the researches. Furthermore, the SLR allows for more general conclusions in conjunction with the use of statistical meta-analysis, thus detecting more than isolated individual studies, and with the recording of the steps taken, the search performed can be reused. Following the methodology proposed by Petersen et al. (2008), the following steps are defined: define the main research questions, search for articles, and choose and classify them.

As a first step, following the processes mentioned by Petersen et al. (2008), the following questions supporting the research were developed:

- *(QP1)*: How does the context in which a person is embedded influence the prevention of epidemiological diseases?
- *(QP2)*: What motivates people to protect themselves against transmissible epidemiological diseases?
- *(QP3)*: What methods and structures IoT are used for transmissible epidemiological diseases prevention?

We established some definitions to improve the accuracy of searches for relevant articles. In this sense, we defined the initial search parameters for articles in recognized digital libraries that allow the use of advanced filters. The filters included boolean operators and strings to find papers that contain the keywords or their synonyms.

In this research, a process of execution was followed as defined by Machado (2019), in which an associated and restricted string was developed by including the following keywords: "e-epidemiology," "situation," "context-aware," and "Internet of Things." These keywords were believed to represent the relevant concepts of the research, as they were initially derived from a search for synonyms that were relevant to the topics of interest. Furthermore, an effort was made to make the string more comprehensive by using similar words to incorporate more variations in the terms. About the concepts, the following keywords were used: "epidemiology," "situation," "context-awareness," "contextualization," and "contextual." The order of the words in the string was also changed ("context-aware" and "aware context") to observe if it would alter the search results. Based on the possible variations to compose the search term, it was possible to construct the string shown in Figure 1.

epidemiology* AND context OR situation* AND ("internet of things"OR iot)

Figure 1. Keywords used in digital libraries.

After identifying the keywords, the search sequence for Figure **??** was applied to the following academic databases: ScienceDirect, ACM, IEEExplore and MedPub. The databases were chosen due to their relevance in the academic environment, allowing the use of tools such as logical operators or special characters. Some other platforms do not allow this use, such as the Scopus platform, which allows special characters and Boolean operators in search queries, but limits the number of operators that can be used in a single query.

Using words with logical operators such as ”AND” (intersection), which returns articles whose titles or topics contain all the search words/terms, and the “OR” operator (union), which brings articles or topics that have any of the search terms or words, the libraries returned records that include one or more of the terms. These digital libraries also allow the use of wildcards, which are special characters representing one or more characters, such as an asterisk (*). In addition to applying the string for more precise selection, the following exclusion criteria were used in this research:

- *Researchs published between 2017 and 2022;*
- *Duplicate articles;*
- *Articles not written in English;*
- *Article that does not present a model or framework for the prevention of epidemiological diseases;*
- *Articles that do not contain the words from the search string in their titles, keywords, or abstract.*

Some adaptations were necessary for the searches depending on the selected database. Among them, we highlight the adoption of filters or advanced search options to use the search string. In the search for articles, we observed that a high number of articles were returned, so we added the keyword “transmissible.” As the initial search returned other epidemiological diseases types, such as migraine, bronchitis, asthma, and other chronic diseases, and we desire to work with transmissible diseases, we added the term “transmissible” to the search string. Therefore, adaptations were made to the search string by adding other terms that would restrict the results to improve precision in the search.

Thus, the possibility of using synonymous terms that could be part of the string, such as ”transmission” and ”transmissible,” was analyzed. This variation in terms yielded different results, returning articles relevant to the theme of this research. The term that provided the highest accuracy was “transmissible,” forming the modified search string shown in Figure 2.

epidemiology-transmissible AND context OR situation* AND ("internet of things"OR iot)

Figure 2. Modified search String to understand *t*ransmissible

As a result of the search, 1437 articles were found after applying the exclusion criteria and the reformulated search string. In Figure 2 tem que arrumar o numero da figura we can see that the criteria vary according to the analyzed library, with the reduction referring to the year filter and the addition of the word “transmissível.”After searching the databases, the exclusion criteria were analyzed. For this, We analise the titles, keywords and abstracts reviewed based on each exclusion criterion.

Finally, 29 articles remained, which were examined for the presence of any model type that assists in the prevention or treatment of transmissible epidemiological diseases. Five articles were selected for further discussion in the next section. Based on the stages of the systematic literature review (SLR), similar papers were chosen, considering their aspects, reasoning procedures, as well as their applicability in models with IoT techniques for the control of transmissible diseases.

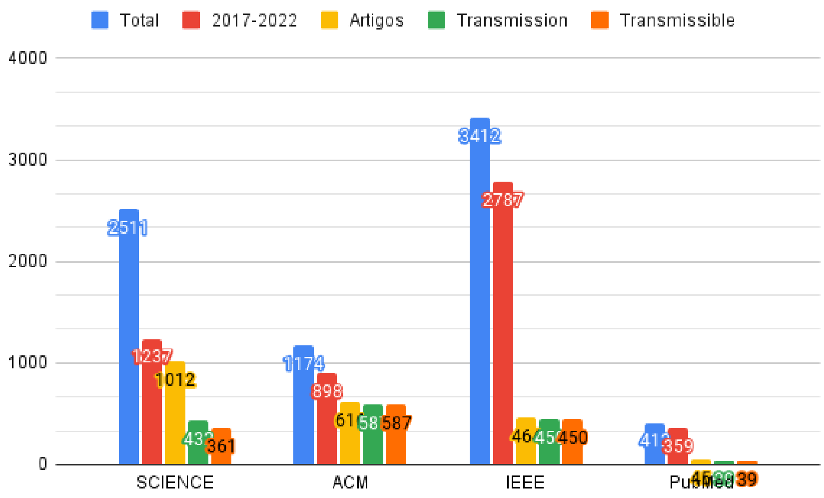

Figure 3. Number of articles found in the bases with the addition of one more keyword.

4. Results

In this section, selected papers using RSL will be discussed. The main characteristics, functionalities, and achieved results will be characterized.

An IoT-Based Healthcare Platform for Patients in ICU Beds During the COVID-19 Outbreak

Filho (2021) propose the use of an IoT-based healthcare platform called PAR (Platform for Intelligent Remote Monitoring of Patients) to provide remote monitoring for critically ill patients. The main objective of the work is to extend the platform proposed by Filho (2018), which was initially designed for patient dehospitalization through wearable sensors to monitor patients with COVID-19.

Additionally, the authors report the deployment of their platform in a environment, specifically in Intensive Care Unit (ICU) for COVID-19 patients in Brazil. Figure 4 presents a fragmented visualization of PAR and its services. The PAR software architecture was designed considering the requirements identified during the evolution of its methodology, instantiating services from the Reference Architecture for IoT-based Healthcare Applications (RAH), which was used as a reference architecture and proposed in Filho (2019, 2018).

The data flow of the platform starts with the raw data from the devices being sent to the gateway. The gateway packages the data, sets the packet headers, and sends them to the IoTDataCollector (IDC) in the upper layer, which receives, persists, and processes the data packets. The next component applies inference rules to the sensor data to understand them semantically and provide information about the patient's health status. The sensor in the service layer (Body and Environment Monitoring) act as interfaces that abstract requests for information about patients' health and in the environment they are in. Finally, this information reaches the applications and is presented to the end users of PAR Filho (2021).

The intelligence module utilizes machine learning techniques for analysis based on the vast amount of received data to generate knowledge about the patient's health behavior. This knowledge is then stored in this module, and users turn to the platform to obtain specific advice on the patient's health data as needed, seeking further data to complement the diagnosis. The platform can make inferences and reach conclusions about the patient's condition, such as critically ill patients experiencing hemodynamic instability. When a critical value is detected, this intelligence module automatically generates an alert message to the hospital module and clinical team, support for a specific decision on when and how to intervene. Another example is if the sensor-collected data indicate that the patient's heart rate is zero, it can be interpreted as a heart attack, and the module notifies the hospital module.

The intelligence module also provides an Application Programming Interface (API) to make patient information available to authorized third-party systems, considering privacy and ethics. Thus, the main contribution of the PAR platform is to provide healthcare professionals with access to patient data. The limitations of the platform proposed by the authors are limited to the lack of disease prevention functionality, which would enable quick action to maximize treatment effectiveness.

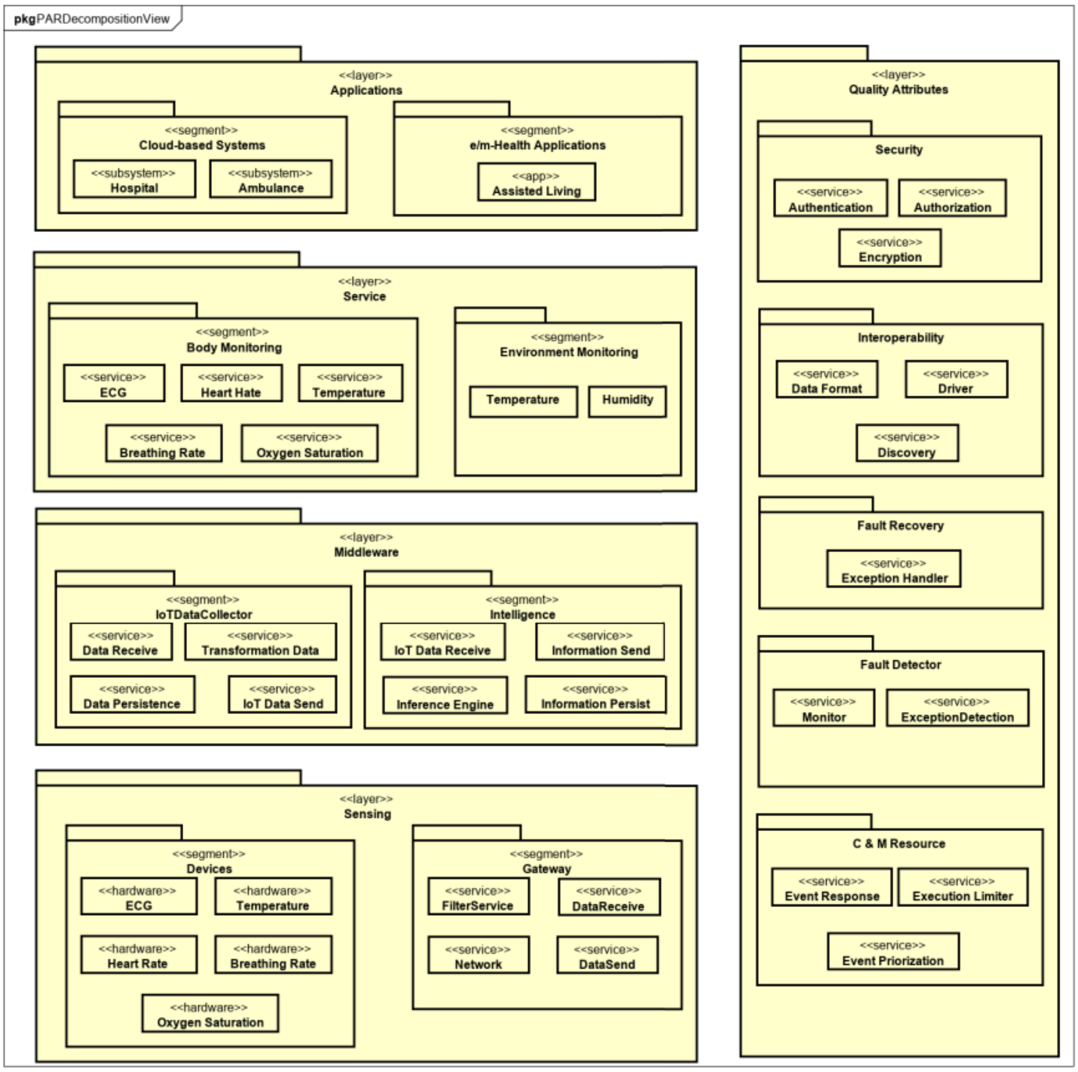

Figure 4. PAR architecture.
Source: Adapted from Filho (2019)

COVID-SAFE: An IoT-based System for Auto- mated Health Monitoring and Surveillance in Post-Pandemic Life

In the research developed by Vedaei (2020), an IoT application called Covid-Safe is presented, which provides remote healthcare and monitoring for pandemic situations. The proposed framework consists of three parts, including a low-cost IoT node (RPIZ), a smartphone application, and cloud-based machine learning tools for data analysis and diagnosis. The authors developed a remote radio frequency (RF) monitoring method that works in environments and notifies users about physical distancing. The system can assist participants in monitoring their daily activities and minimize the risk of exposure to the Coronavirus.

The IoT node aims to track health parameters, including body temperature, cough frequency, respiratory rate, and blood oxygen saturation. This node operates with the user's smartphone, which collects proximity data using Bluetooth and communicates with the server using the device's own data network. The application notifies the user to maintain a physical distance of two meters, which is a key factor in controlling the virus spread.

Covid-Safe is based on the Mamdani fuzzy logic, which train associations and define inference rules. Covid-Safe runs on the server and considers the environmental risk and the user's health conditions to predict the risk of infection propagation in real-time. The platform's structure is demonstrated in Figure 5 and relies on three parts: i) Raspberry Pi Zero, temperature sensors, and photoplethysmogram sensors; ii) LoRa module for data communication in the absence of cellular or Wi-Fi data networks. The system is then synchronized with the software to monitor the user's behavior during their daily activities. iii) The application can notify people about new restrictions.

In the application, the user must create an account and answer some general questions such as gender, age, weight, height, and medical history. By receiving and storing this information, the system can provide an individual risk factor for the user. The application notifies the individual when a second node (person) approaches the specified distance range.The analysis of body parameters, risk assessment, and sending some useful tips for the user's well-being can help in decision-making. A decision-making system predicts the risk of virus transmission. The model estimates a risk factor using Fuzzy logic, containing three linguistic values (low, moderate, or high) that can help individuals determine if they are in a safe position without infected people nearby or if they may transmit disease.

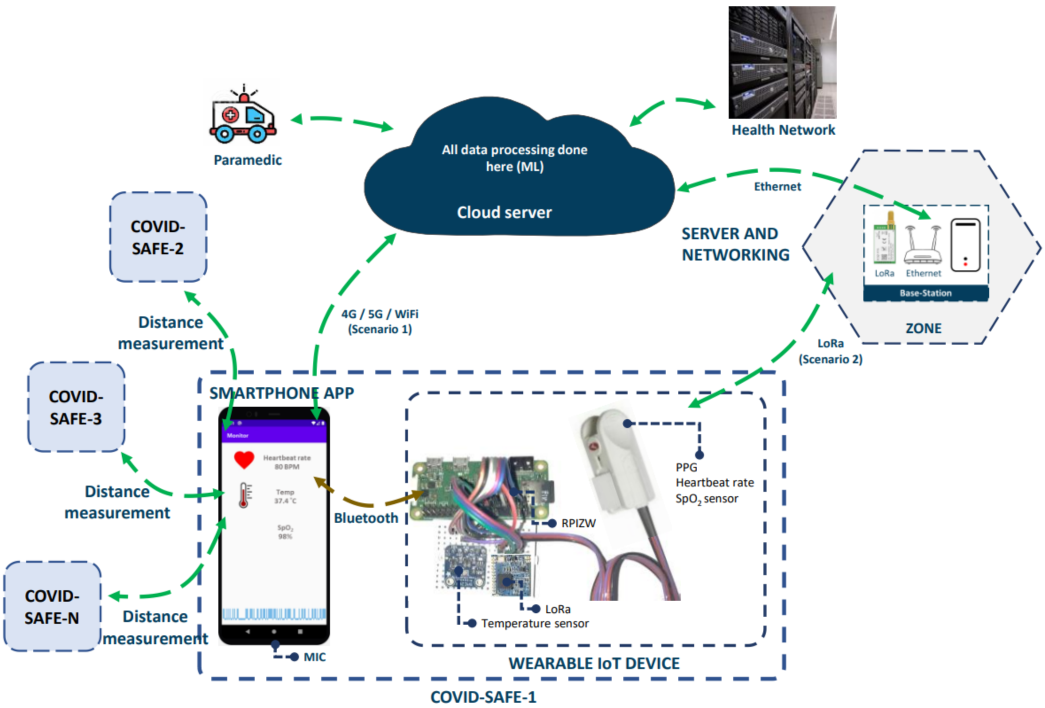

Figure 5. Covid-safe architecture.
Source: Adapted from Vedaei (2020)

Covid-Safe presents an architecture for disease prevention, such as COVID-19, with notifications to users, assisting in distancing control. However, it has some limitations, such as accessing the microphone of smartphones, which violates privacy concerns.

Additionally, it is limited to mobile use only, without providing alternative solutions for those who do not currently use a mobile device.

Tracking COVID-19 by Tracking Infectious Trajectories

According to Filho (2021), the transmission of the Coronavirus in China was driven by asymptomatic patients, meaning those who did not show signs of the disease. The authors emphasize that the official number of infections does not reflect the actual number of infected individuals, suggesting that asymptomatic patients were one of the main factors behind the rapid and extensive spread of the virus. In response to this critical situation, Filho (2021) proposed an investigation system called IoTa, specifically designed to detect asymptomatic patients and infectious locations. The goal is to assist authorities in disinfecting highly contaminated areas and facilitating the confinement of infected individuals, even when they don't show apparent symptoms. The system proposed by the authors also allows for determining all individuals who had close contact with infected or suspected patients. As a result, the swift isolation of suspected cases and more efficient control over the spread of the disease can be achieved.

The proposed system must include the coordinates of individuals in crowded public places, mainly using IoT devices that can identify people and continuously report their position, in order to operate effectively. The Big Data architecture is employed to archive the collected trajectories of individuals. The platform should be powered by IoT devices capable of determining people's coordinates during the outdoor activities and sending the collected data to the system. Individuals in residences or vehicles are considered isolated. The proposed architecture consists of three layers: data collection, storage, and data utilization, as illustrated in Figure 4.

Data collection is divided into two independent parallel tasks. The first task is related to collecting the necessary health data to create a user profile, while the second task is responsible for the individuals geolocation coordinates. The storage layer addresses issues related to data retention and processing of large volumes of data. The authors conducted extensive research and proposed several efficient solutions, including data ingestion, online stream processing, offline batch processing, distributed file systems, clustering, and more. These techniques enable efficient distributed storage and fast processing by dividing the data into smaller quantities, resulting in faster treatment and processing.

Lastly, the data utilization layer employs three algorithms: (i) Finding and classifying suspicious cases, i.e., people who had contact with confirmed patients or other suspected cases. (ii) Helping determine black areas, which are zones with a high probability of contamination. (iii) Enabling the all individuals identification who visited black areas, also considered as potentially infected individuals. Therefore, it can be observed that the primary objective is not to track individuals but to track the virus's propagation.

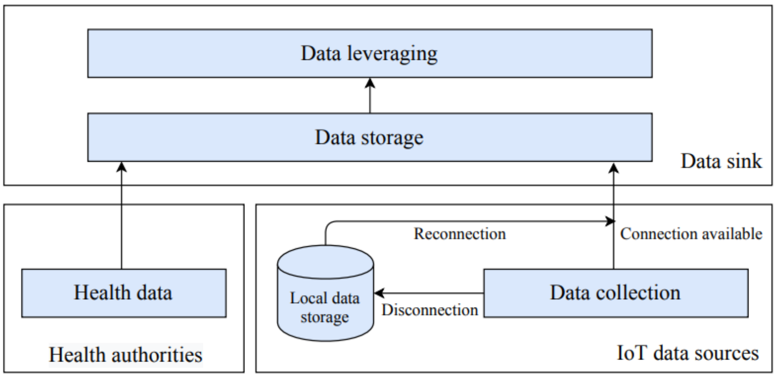

Figure 6. Tracking-covid architecture.
Source: Adapted from Benreguia (2020)

Home quarantine patient monitoring in the era of COVID-19 disease

In the article published by Sicari (2022), an IoT-based infrastructure is proposed for remote monitoring. It consists of heterogeneous devices such as wearable sensors, GPS, and air quality sensors. The infrastructure utilizes wearable sensors to monitor body temperature, blood pressure, oxygen saturation, heart rate, and respiratory rate. The GPS tracker ensures that the patient does not leave the allowed area during the quarantine period, thus helping to prevent the spread of the virus. The air quality sensors play a crucial role in monitoring the recovery of patients from the effects of COVID-19 on their lungs. All the values collected by the sensors are accessible to the patient, the doctor, and other authorized stakeholders using appropriate credentials. As a security measure, all measured values are encrypted before being sent to other nodes in the network, preserving the patient's identity.

The application stands out by providing sound notifications on its dashboard, pop-up, and SMS messages, especially in cases where vital measurements exceed or fall outside the normal range. It enables the medical team to take necessary actions, such as sending an ambulance or arranging an intensive care bed. It was designed, developed, and simulated using Node-RED, an open-source platform initially developed by IBM, defined as a flow-based programming tool. It stores data in MongoDB and transports information using the MQTT protocol.

For validation purposes, tests were performed on a Java-based simulator, as shown in Figure 7. The simulator window displays three screens with monitored sensors, totaling nine sensors. Field values were changed to trigger specific alerts based on pre-defined rules to test the system.

The approach presented in this article considers the scenario where countries struggle to accommodate all COVID-19 patients in hospital wards. The authors state that negligence could be avoided through home monitoring. Therefore, the work proposed by the authors helps to actively monitor the real-time statistics of remote patients by any medical team. However, for practical implementation, hardware technologies such as sensors connected to the platform where the NodeRED.

In the works Filho (2021); Vedaei (2020); Benreguia (2020); Sicari (2022) some limitations were identified related to prevention, notification, user privacy, and viability for use in production, that is, the ability of users to validate its effectiveness.in the real world or real-time?, OK.

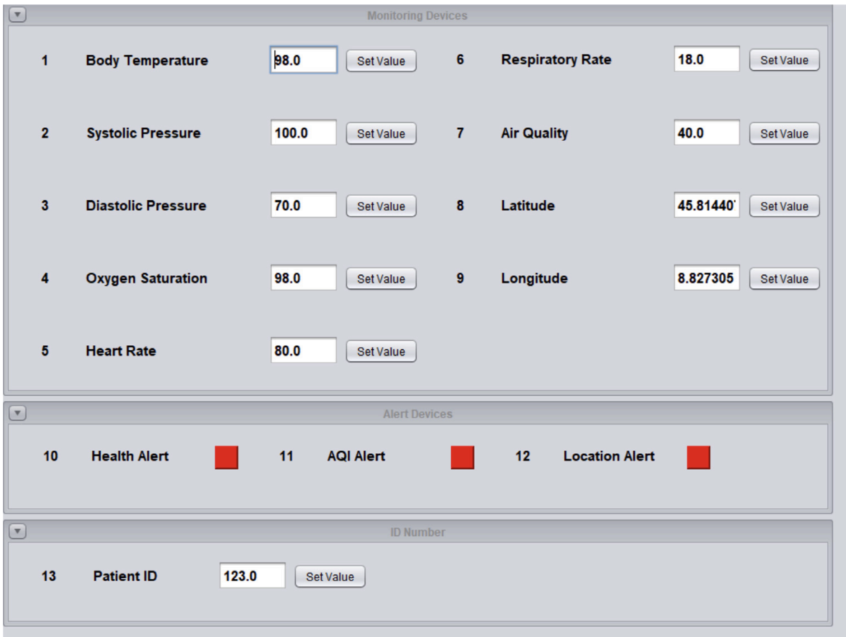

Figure 7. Sensor simulation screen.
Source: Adapted from Sicari (2022)

- C1 - Scalability of the Model or Framework
- C2 - Study Area
- C3 - Machine Learning
- C4 - Uses IoT-based sensors
- C5 - Used in prevention
- C6 - Applied in case of diseases
- C7 - Sending notifications and alerts

Table 1. Comparison of Articles, where Yes means it is present, No means it does not contain

	Filho, 2021	**Vedai, 2020**	**Berenguia, 2020**	**Sicari, 2022**
C1	Yes	Yes	Yes	Yes
C2	Health	Health	Health	Health
C3	Yes	Yes	Not	Not
C4	Yes	Yes	Yes	Yes
C5	Not	Yes	Not	Yes
C6	Yes	Not	Yes	Yes
C7	Yes	Yes	Yes	Yes

Observing Table 1 and also the peculiarities of the works, it is noted that two of them Filho (2021); Vedaei (2020) have as their main purpose patient monitoring while Sicari (2022) focuses on virus propagation control. Filho (2021) uses a model that applies a layer of intelligence to the received data, producing information about the patient's health behavior. After being stored, healthcare agents (doctors, nurses, among others) can use the platform to search for patient information, assisting them in understanding the patient's condition, with the main users being the medical team.

On the other hand, Vedaei (2020) mainly uses users' smartphones to collect data and send it to a server, which processes this information to monitor their behavior during daily activities and sends notifications with tips and restrictions. Registration allows the storage and processing of information to create an individual risk factor. Its main functionality is RF monitoring, which notify users about the distance between them. Sicari (2022) proposes an application that can assist in patient monitoring using sensors, with rules inferred from the collected sensor values, emitting alerts with patient statistics.

Benreguia (2020) proposes detecting people in infected areas. The system is continuously fed with the coordinates of people in public places, providing traceability of the user and indicating a possible contact zone. Unlike the other works, this one allows tracking virus propagation. In the study Sicari (2022), it is perceived that it could become the real application, but is used in simulation mode, it is difficult to understand whether it would be possible to monitor patients in remote locations in a real-life application, as it would be necessary to overcome some infrastructure barriers to validate the use of sensors.

5. Conclusions

This study searched and examined articles and research related to prevention models of epidemiological transmissible diseases. By analyzing these studies, we can gain valuable information to help develop more effective strategies to combat these diseases and implement comprehensive public health policies.

The Systematic Literature Review (SLR) method was chosen to search for articles, which differs from other literature review approaches due to its systematic and well-defined process. This process facilitates the systematic identification of relevant works, performing a comprehensive search using specific terms and considering different situations and contexts. The SLR allows for generalized conclusions through statistical meta-analysis, which makes it possible to identify patterns in several studies. Additionally, documenting the steps taken in the SLR allows for future replication of the research process.

After applying the RSL and analyzing the results obtained, we observed that the studies found in the literature have some limitations regarding user privacy, delivery of notifications, and applicability of the proposed software. As a result, a generic model is proposed for future work to help prevent transmissible communicable epidemics.

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