Optimizing the Internet of Things adoption for pandemic management using digital technology and collective intelligence

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Abstract

In the midst of global health emergencies like pandemics, effective administration of healthcare systems becomes crucial. This scholarly article investigates the fusion of the Internet of Things (IoT) with digital technology and collective intelligence to enhance pandemic management within the healthcare framework. The study delves into the capabilities of IoT-enabled devices and sensors for real-time data collection, transmission, and analysis to facilitate prompt and accurate decision-making. Employing a multidisciplinary approach that integrates insights from healthcare, information technology, and data science, the research aims to improve the connectivity and interoperability of healthcare devices through digital technology. This enhancement facilitates seamless communication and collaboration among various elements of the healthcare infrastructure. Additionally, the incorporation of collective intelligence methodologies ensures that diverse stakeholders, including healthcare professionals, researchers, and policymakers, contribute valuable insights for a comprehensive understanding of the pandemic landscape.

The article explores specific applications of IoT devices, such as wearable health monitors, smart thermometers, and environmental sensors, to monitor and predict the spread of infectious diseases. It also delves into the role of data analytics and machine learning algorithms in processing the extensive data generated by IoT devices, enabling predictive modeling and optimization of resource allocation. Using recent pandemics as a case study, the research analyzes the adoption of IoT, drawing lessons from successful implementations and identifying challenges that need to be addressed. The article underscores the significance of privacy and security measures to ensure the responsible and ethical use of healthcare data.

Keywords: Internet of Things, IoT adoption, pandemic management, digital technology, collective intelligence, healthcare ecosystem, data analytics, machine learning, interdisciplinary research.

Introduction

In today's global health landscape, effective pandemic management necessitates innovative and agile approaches. The convergence of technological advancements, particularly the Internet of Things (IoT), digital technology, and collective intelligence, has the potential to revolutionise pandemic management within the healthcare ecosystem. The integration of IoT into healthcare systems has gained increasing attention due to its ability to improve real-time data collection, analysis, and decision-making, providing a dynamic and interconnected framework for addressing public health crises. The deployment of IoT-enabled devices, ranging from wearable health monitors to environmental sensors, represents a paradigm shift in how healthcare professionals monitor and respond to the spread of infectious diseases. These devices can collect and transmit a wealth of real-time data, providing insights(Goodarzian et al., 2023).

The backbone of this interconnected healthcare ecosystem is digital technology, which enables seamless communication and interoperability among various healthcare devices. The integration of digital platforms allows healthcare professionals to remotely access and analyse data, promoting a collaborative and efficient decision-making process. Furthermore, the use of advanced data analytics and machine learning algorithms improves the ability to extract meaningful patterns from the massive datasets generated by IoT devices, enabling predictive modelling and proactive response planning(Chui et al., 2021). Collective intelligence, a collaborative approach that taps into the expertise and insights of various stakeholders, emerges as a critical component in pandemic management optimization. A more comprehensive and nuanced understanding of the pandemic landscape is possible by involving healthcare professionals, researchers, policymakers, and even the general public in the decision-making process (Gupta et al., 2021).

The purpose of this research paper is to delve into the complex interplay between IoT adoption, digital technology, and collective intelligence in the context of pandemic management. The article aims to contribute a comprehensive framework for leveraging these technologies by synthesising insights from multidisciplinary studies in healthcare, information technology, and data science. This study aims to provide valuable guidance for policymakers, healthcare practitioners, and technology developers in navigating the complexities of implementing IoT for pandemic preparedness and response by analysing successful case studies and identifying challenges (Yousif et al., 2021).

Literature review

Concept Of IOT & Collective Intelligence In Healthcare Systems

The year 2020 should have marked the beginning of an exciting decade in medicine and science, with the development and maturation of several digital technologies capable of tackling major clinical problems and diseases. The Internet of Things (IoT) with next-generation telecommunication networks, big-data analytics, artificial intelligence (AI) that uses deep learning, and blockchain technology are among these digital technologies (Abubakari & Mashoedah, 2021). The International Telecommunication Union (ITU) presently characterizes the Internet of Things as a worldwide framework supporting the Information Society, facilitating advanced services through the interconnection of physical and virtual objects using established and developing interoperable information and communication technologies (Akpan et al., 2021).

A typical IoT system comprises several functional components that specialize in data collection, data transferring, data analytics, and data storage (Wortmann & Flüchter, 2015). Data is acquired most of the time by a variety of IoT sensing devices. Following the data collection, the data is transferred to cloud storage for data analytics, which is subsequently used to make decisions (Azizy et al., 2020).

The Massachusetts Institute of Technology (MIT) defined collective intelligence as "a group of individuals doing things collectively that appear intelligent," which includes the various stakeholders involved in the healthcare Ecosystem such as physicians, epidemiologists, supranational institutions, ministries, hospitals, device suppliers, and so on (Bai et al., 2020).

The Convergence of IoT, Collective Intelligence, and Digital Technology in Healthcare

The term Internet of Things (IoT) describes a system of physical objects containing sensors, software, and other technologies designed to connect and share data with other devices and systems via the Internet (Radanliev et al., 2020). Within the healthcare sector, IoT devices are utilized for tracking patients' vital signs, ensuring they adhere to their medication routines, and gathering information about their daily routines and surroundings. This collected data can be harnessed to enhance patient care in various ways (Budd et al., 2020).

IoT gadgets can play a role in overseeing patients' well-being from a distance, potentially minimizing the necessity for hospital visits and enhancing the daily lives of individuals with persistent health issues. For instance, these devices can oversee aspects such as blood pressure, heart rate, blood sugar levels, and oxygen levels (Rahimunnisa, 2022). Additionally, they can also monitor how consistently patients are following their prescribed medication regimens. This kind of monitoring can enhance the treatment's efficacy and lower the chances of negative health outcomes. As an illustration, IoT devices can be utilized to confirm if patients are adhering to their medication schedules correctly (CACOVEAN et al., 2020).

Utilizing IoT to improve the battle against the COVID-19 pandemic necessitates the complete integration of a network throughout the hospital facility. This intelligent integrated network will enable rapid communication and responses between patients, doctors, nurses, and other healthcare professionals on the front lines, ultimately improving the management of cases through automated procedures (Rahman et al., 2020). The gathered information about patients' everyday routines and surroundings can be employed to pinpoint potential disease

risk factors and create individualized preventive strategies. As an illustration, IoT gadgets can monitor patients' sleeping habits, dietary choices, and physical activity levels (Chaiyapong et al., 2023).

In the healthcare field, collective intelligence can enhance patient care in various ways. It can enhance the diagnostic and treatment planning stages by harnessing the collective wisdom and skills of multiple healthcare experts. For instance, it can be utilized to create algorithms that can make precise disease diagnoses by considering a patient's symptoms and medical background (Chamola et al., 2020). By leveraging the power of crowdsourcing, collective intelligence can be used to accelerate drug discovery and development. Also can be used to identify new drug targets as well as design and test new drug candidates (Chaudhari et al., 2020).

Identifies and tracks emerging disease outbreaks, as well as develops and implements effective prevention and control strategies, to improve public health surveillance and response. Collective intelligence can be used to analyze social media data to identify potential disease outbreaks and track disease spread (Dash, 2020).

Digital technology encompasses a broad spectrum of tools that involve the use of computers, software, and other electronic devices for the collection, storage, and processing of data. Within the realm of healthcare, digital technology finds multiple applications(Secundo et al., 2021). Electronic Health Records (EHRs) represent digital versions of patients' medical histories, simplifying the access and exchange of patient data among healthcare professionals, and ultimately enhancing the quality and coordination of healthcare services (Vishnu & Jino Ramson, 2021). Additionally, a wide array of health-related apps are readily available for monitoring health, managing chronic conditions, and promoting healthy lifestyles. These applications empower patients to take charge of their well-being and remain actively involved in their healthcare (Elhoseny et al., 2021).

Telemedicine is the use of technology to provide healthcare services from a distance. Telemedicine can be used to give patients access to healthcare services in underserved areas or to provide care in the comfort of their own homes (Xu et al., 2021). Overall, the interconnection of IoT, collective intelligence, and digital technology within the healthcare system is a critical relationship with the potential to transform healthcare delivery (Ghaleb et al., 2021)

The obstacles in digital technology concerning pandemic control

One of the primary obstacles to employing digital technology for pandemic control lies in the unequal accessibility it offers. This issue is commonly referred to as the "digital divide." The digital divide can be attributed to various factors, including economic disadvantages, limited educational opportunities, and geographical isolation (Sestino et al., 2020). Those without access to digital technology may find it challenging to obtain vital information about the pandemic, including symptoms, prevention methods, and treatment options (Vargo et al., 2021). Additionally, they may face difficulties accessing essential services like healthcare and education. To address this, governments and businesses should allocate resources to enhance digital infrastructure, which involves improving broadband internet availability, providing devices, and offering digital literacy training (Golinelli et al., 2020).

Cyberattacks on digital technology are a risk to public health and safety during a pandemic. Cybercriminals could compromise healthcare systems to steal patient data or disrupt essential services (Shah et al., 2020). Cyberattacks could also be used to disseminate misinformation and disinformation about the pandemic. This could lead to people making poor decisions about their health and safety. To strengthen cybersecurity measures, implement robust security protocols, train employees on cybersecurity best practices, and monitor systems for suspicious activity. Educating people on how to identify and avoid misinformation, as well as removing false content (Gupta et al., 2021)

To enforce lockdowns and quarantine measures, governments have used digital technology to track people's movements. However, this raises privacy and surveillance concerns (Thilakrathne et al., 2021). Furthermore, there is a risk that digital technology will be used to discriminate against specific groups of people, such as people with disabilities or members of specific ethnic or religious groups. Obtaining informed consent before collecting and using personal data, implementing data encryption and access controls, and having a data breach response plan in place are all examples of best practices. (He et al., 2021). To address issues such as privacy, surveillance, and discrimination, ethical guidelines must be developed. We can ensure that digital technology is used in a safe, secure, and ethical manner by taking these steps(Javaid & Khan, 2021).

The significant challenge arises from the diverse mix of data collection devices that contribute to the same IoT network. The presence of varied device types and the specific technologies used by different manufacturers can make the management of the network less adaptable (Siddiqui et al., 2021). This can create problems when introducing new network rules or installing applications on an existing platform. For example, wearable location and temperature sensors, thermal imaging devices, and smartphones may all come from different companies, yet

they all need to connect to the same IoT network. To address this issue, solutions based on software-defined networking have been suggested. These solutions aim to enhance management flexibility, allowing for more seamless integration of COVID-19-related applications within the network (Jena, 2020)

According to WHO data, the age group most at risk is those over the age of 65. People with heart disease and diabetes are also at a higher risk in this pandemic situation caused by Covid-19 (Q. Wang et al., 2021). It is difficult for these people to handle IoT devices at this age. They require the person's assistance to read correctly (R. P. Singh et al., 2020). This will be the most difficult challenge for IoT. In this case, in sectors such as electricity, Only 30 to 40% of people are in charge of power supply. Any type of power outage will take some time to repair. The internet connection will be lost if the power goes out. As a result, it is possible that data will not be uploaded or communication will be delayed (Jiang, 2020).

The potential to utilize digital technology

Digital technology enables us to gather and assess up-to-the-minute data regarding the transmission of diseases, the efficacy of interventions, and the pandemic's effects on individuals and communities. This data can serve as a basis for decision-making on a global and local scale (R. P. Singh et al., 2020). Digital technology is capable of monitoring the mobility of people and products, pinpointing areas with high infection rates, and evaluating the efficiency of public health strategies. This data can be utilized to create more precise and efficient responses, like localized lockdowns and isolation protocols (Kamal et al., 2020).

Digital technology enables video conferencing, electronic data, and resource sharing, as well as remote training and education. These applications enhance coordination and communication across diverse organizations and sectors while ensuring universal access to essential information and resources (Kerres & Buchner, 2022). Activities like screening and prioritizing, diagnosing and treating, as well as monitoring and reporting. Doing so can release healthcare workers and other resources to handle more crucial responsibilities (Thilakrathne & Samarasinghe, 2021). Utilizing digital technology, automated chatbots can be created to respond to people's queries regarding the pandemic, assess them for symptoms, and direct them to the appropriate level of care. In addition, digital technology can be employed to establish automated systems for monitoring and reporting instances of the disease, recognizing close contacts, and issuing alerts (J. S. Kumar & Patel, 2014).

Digital technology can be used to educate the public about pandemics and how to prevent them, as well as to provide access to resources and support services and to allow people to connect with others and share information. Online platforms for delivering education and training, as well as crowdfunding platforms for raising funds for research and development, can be used to develop innovative solutions to the challenges of pandemic management (K. Kumar et al., 2020)

Overall, digital technology has the potential to significantly improve pandemic management in several ways. By investing in digital technology and developing new and innovative applications, we can better prepare for and respond to future pandemics (Z. Wang & Tang, 2020). Contact tracing apps are being used in many countries to help track down people who have been in contact with an infected person. These apps typically use Bluetooth technology to identify and track close contacts (M. Kumar et al., 2021). Artificial Intelligence (AI) plays a crucial role in creating novel tools and applications for effectively managing pandemics. It is utilized for crafting predictive models to understand how diseases spread, pinpoint potential drug targets, and devise innovative diagnostic tests. In parallel, Blockchain technology is harnessed to establish trustworthy and clear-cut systems for monitoring and distributing pandemic-related data. Blockchain aids in tracing vaccine distribution and crafting digital health passports (Lavric et al., 2022).

Roles of Government & Insurance Policy in Digital Technology

Governments can allocate financial support to technology firms for the creation and implementation of digital health solutions, which can be utilized for monitoring and controlling the transmission of contagious illnesses (Paganelli et al., 2022). An illustration of this is the Indian government's funding of the Aarogya Setu contact tracing app. Governments also have the authority to enforce the utilization of digital health tools in specific environments, like medical facilities, to enhance the exchange of patient information and enable remote healthcare services. An example of this is the Australian government's requirement for the adoption of electronic health records (EHRs) in all hospitals in the year 2022. (Lee & Lee, 2021)

Offering financial assistance to facilitate the acquisition of wearable devices and other digital health instruments. Governments have the opportunity to extend financial aid to individuals for the acquisition of wearable devices and various digital health tools, which enable them to monitor vital signs and other health-related information (Whitelaw et al., 2020). As an illustration, the UK government extends financial support to individuals dealing with chronic conditions to facilitate the purchase of wearable devices. (Leila et al., 2020)

Collaborating with technology firms to create and introduce novel digital health initiatives. Governments can enter into partnerships with technology companies to design and introduce fresh digital health initiatives for the benefit of their populace (Malliga et al., 2021). For instance, the US government joined forces with Pear Therapeutics to create and make available the re-SET digital health program tailored for individuals with substance use disorder. Governments can help to ensure that digital technology is used to improve the quality and efficiency of healthcare delivery, reduce the spread of infectious diseases, and empower patients to take charge of their health by taking these steps(Mohsan et al., 2022).

Insurance plays a pivotal role in bolstering and expediting the integration of digital technologies. It serves as a means to offer financial security for investments in digital technology and can serve as a motivator for the advancement and application of novel technologies (V. Singh et al., 2020). Serves as a safeguard for investments in digital technology against various risks, including technological obsolescence, cyberattacks, and pandemics. This, in turn, enhances the appeal for businesses and governments to invest in digital technology, thus expediting the assimilation of these innovative technologies(Mora et al., 2021).

Insurance can also be used to encourage the development and application of new technologies. Insurance companies, for example, may offer lower rates to businesses that use digital technologies to improve their safety and security (Siriwardhana et al., 2021). Insurance can also make digital technology more accessible for pandemic management. Insurance companies could create new products and services to assist businesses and individuals in managing pandemic risks (Mukati et al., 2023).

Cyber insurance offers a safeguard against the financial repercussions of cyberattacks, a vital consideration for businesses reliant on digital technology for their operations, given their heightened susceptibility to such attacks (Williamson et al., 2020). Similarly, business interruption insurance acts as a shield against financial losses stemming from operational disruptions, which is especially crucial for digitally-reliant businesses as they face a higher probability of being affected by events like pandemics (Naji et al., 2021). Pandemic insurance, on the other hand, aids both businesses and individuals in managing the financial uncertainties linked to pandemics. It may encompass expenses related to medical care, lost income, and business interruptions (Nasajpour et al., 2020).

Legal, ethical, and privacy barriers, as well as organizational and workforce barriers

There is a concern that the emergency measures currently in place may set a precedent and could persist even after the emergency has passed. This could result in the continuous collection of private citizens' information without any emergency-related justification (Sultana & Tamanna, 2022). All systems must be safeguarded to prevent privacy breaches and must adhere to the appropriate legal, ethical, and clinical standards. Data can only be shared under a legal agreement for a specific purpose and duration, with provisions for independent audits to ensure that the data is not used for purposes unrelated to the pandemic(Ndiaye et al., 2020).

Public health has historically received less funding when compared to other areas of healthcare. Achieving long-term changes will require investments in national and international centers of digital excellence, with the right mix of partners and predetermined access to digital datasets. Substantial investments in education and skills development for the workforce are crucial for the growth of leadership in digital public health (Oyeniyi et al., 2020).

Methodology

The literature search was limited to articles published from 2015 - 2022. The search for articles was done online by using the search words ‘’ IOT, Collective Intelligence, Digital technologies, Pandemic effect on healthcare system ‘’ in the title and keywords in research databases at Wiley, Elsevier, Taylor & Francis, ERIC, Springer, SAGE, Frontiers.

Analysis

The method used is the Preferred Reporting Item for Systemic Reviews and Meta Analytics (PRISMA) method. All articles that have passed the selection process were then reviewed and summarised based on the objectives, year of publication, number of citations, and suggestions for further research.

Inclusion & Exclusion criteria

The be included in the current study, studies have to meet some criteria

(a) Studies have included some kind of selection criteria (Content related to the topic). These criteria limited the number of studies.

(b) Accordingly excluded the studies in which based on irrelevant information there is no proper Title, Abstract & Review, or Citation below 50, Articles before 2015.

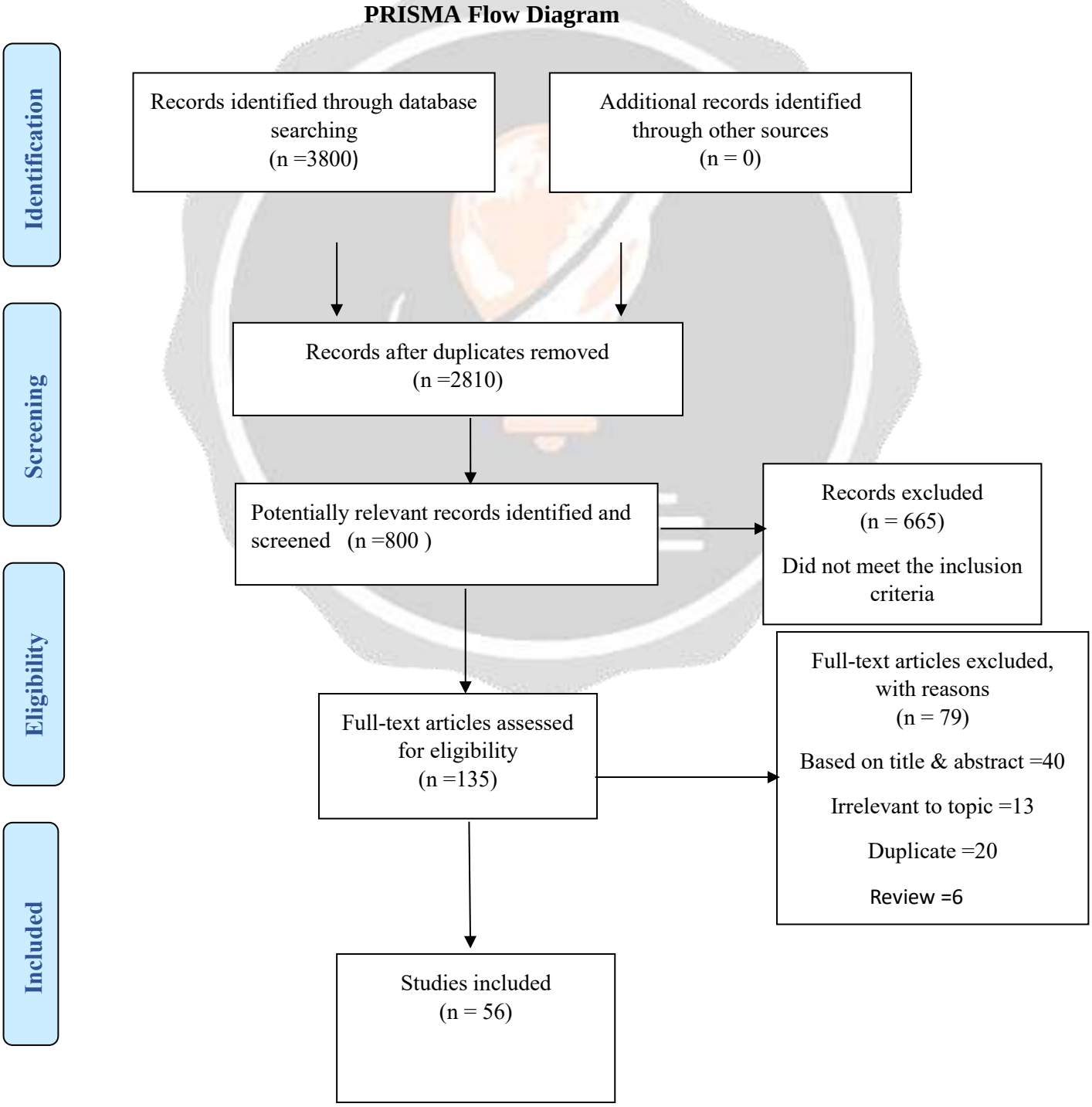
Final data set

The research database search resulted in all keywords search results obtained 3800 research articles. After scanning the title, there was the same article in two different databases. The results after deducting the duplicates are 2810 articles. A total of 800 articles were screened. 665 Articles excluded that they not meet the inclusion criteria.

Articles accessed for eligibility are 135 articles. A Total number of 79 articles excluded based on title and abstract (40) Irrelevant to topic (13) Duplicate (20) Review(6).

The final data set consists of 56 articles.

The oldest included study was published in the year 2015 and the most recent study was conducted on 2022. The Entire process is shown in figure



Discussion

The convergence of IoT, collective intelligence, and digital technology has enormous potential for pandemic management. Despite challenges such as data privacy concerns, cybersecurity threats, and a lack of standardisation, the benefits outweigh the drawbacks. IoT-enabled devices and collective intelligence platforms can provide real-time data and valuable insights. Governments and insurance policies can encourage adoption by providing funding, clear regulations, and coverage incentives. Legal, ethical, and privacy concerns, as well as organisational and workforce barriers, must be addressed to ensure successful implementation and optimise IoT adoption for pandemic management.

Conclusion

In summary, leveraging the Internet of Things (IoT) for pandemic management, coupled with digital technology and collective intelligence, has become a crucial resource within the healthcare ecosystem. This novel strategy not only improves data gathering, analysis, and decision-making but also enhances the capacity to respond to healthcare emergencies, including pandemics, with increased efficiency and flexibility. As we persist in harnessing the potential of IoT and digital innovations, the collaborative and collective intelligence aspects will play a vital role in constructing robust and adaptable healthcare systems capable of effectively tackling the complexities presented by pandemics and other health challenges, ultimately resulting in enhanced public health outcomes.

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