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Integration of AI and Big Data Analysis with Public Health Systems for Infectious Disease Outbreak Detection

Hamidreza Rasouli Panah
Auckland University of Technology, New Zealand, mww4881@autuni.ac.nz

Samaneh Madanian
Auckland University of Technology, New Zealand, Sam.madanian@aut.ac.nz

Jian Yu
Auckland University of Technology, New Zealand, jian.yu@aut.ac.nz

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Hamidreza Rasouli Panah
Department of Computer Science and Software Engineering
Auckland University of Technology (AUT)
Auckland, New Zealand
Email: hamid.rasoulipanah@autuni.ac.nz

Samaneh Madanian
Department of Computer Science and Software Engineering
Auckland University of Technology (AUT)
Auckland, New Zealand
Email: sam.madanian@aut.ac.nz

Jian Yu
Department of Computer Science and Software Engineering
Auckland University of Technology (AUT)
Auckland, New Zealand
Email: jian.yu@autuni.ac.nz

Abstract

In an increasingly interconnected world, disease spread has increased, posing devastating consequences for public health. However, emerging technologies like wearable devices, social media, Big Data Analysis (BDA), and Artificial Intelligence (AI) offer promising solutions for aiding public health authorities in coping with Infectious Disease Outbreaks (IDOs). Through a systematic literature review, this study highlighted the improved outbreak control achieved through AI and BDA but also emphasized the need for standardized methods and datasets for detecting IDO trends and patterns. To bridge this gap, this study introduces an integrated framework combining AI and BDA with the public health system, aiming to provide valuable insights for prevention, preparation, and response to outbreaks. This integration has the potential to detect IDOs effectively before escalating to a larger scale and also offers crucial insights for better control and management of the situation at hand. However, successful implementation requires the public health sector to maintain AI development and healthcare workers to stay well-informed about the expanding AI capabilities.

Keywords infectious disease outbreaks, AI, big data analysis, public health system, pandemics

1 Introduction and Background

The modern world is characterized by profound interconnectivity through travel, trade, and communication, enabling unprecedented global collaboration and growth. However, this connection has the unforeseen consequence of swiftly spreading infectious diseases, possibly leading to catastrophic worldwide outbreaks (Mak et al. 2022). The pathogens may easily spread across continents due to the volume of travel around the globe, and international trade serves as a conduit for disease vectors. Also, the following factors enable the swift transmission of pathogens and have a significant impact on disease patterns: urbanization, population growth, climate change, the ease of crossing borders, the complexity of the global economy, and human interactions (Haileamlak 2022). Such outbreaks can have far-reaching consequences on economies, healthcare systems, and international relations, necessitating unprecedented coordination to contain and mitigate the impact of diseases (Mak et al. 2022).

As an example, nearly 770 million people were affected, with 7 million cumulative deaths due to the COVID-19 pandemic globally (WHO 2023). The pandemic also had an impact on the global prevalence of anxiety and depression. According to the WHO, anxiety and depression increased by 25%, highlighting another dimension of the pandemic's devastating impact (WHO 2022). To overcome these concerns, the world must invest in robust global health systems, collaborative research, and preparation measures, all while using the same interconnection to create shared information and effective solutions to protect humanity's well-being (Bloom and Cadarette 2019; Haileamlak 2022). According to data from the Emergency Events Database (EM-DAT), the world has witnessed a concerning and continuous increase in the number of Infectious Disease Outbreaks (IDOs) from 1900 to 2023 (EM-DAT 2023). Over this span of time, various factors have contributed to this growing trend. **Figure 1** clearly illustrates the growing trend of IDOs in the past recent decades.

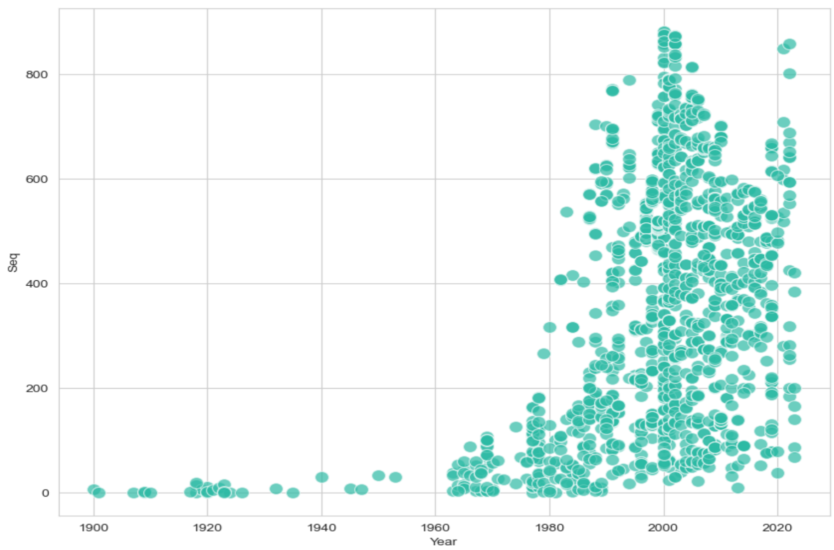

Figure 1 IDOs growing trend from 1900 to 2023 (data source: EM-DAT)

In the face of the increasing number of IDOs, new technologies have become vital in preventing and managing these situations. Some of these technologies include wearable health devices, sensor networks, and social media. Wearable health devices and sensors help collect real-time data on environmental conditions and individual health, aiding disease surveillance and response efforts (Madanian and Parry 2019; Madanian and Parry 2021). Social media platforms play a significant role in information dissemination, raising awareness, and engaging communities during outbreaks (Aggarwal et al. 2022). Other technologies that have the potential to further enhance public health are Big Data Analysis (BDA) and Artificial Intelligence (AI). BDA involve examining datasets to find valuable insights and correlations, informing strategic decision-making, often utilizing advanced computational techniques and algorithms (Chopra et al. 2022). AI replicates human intelligence in machine, enabling tasks like learning, problem-solving and decision-making by processing massive amounts of data quickly (IBM 2023). They are also able to identify patterns and predicting disease outbreaks with remarkable accuracy (Khan et al. 2022). Together, BDA and AI can revolutionise public health, enable evidence-based preventive measures and facilitate swift and efficient responses to infectious disease threats.

Building upon these technological advancements, BDA and surveillance systems are powerful tools for risk analysis, and managing IDOs, benefiting public health authorities in various ways including IDOs control and management. BDA helps to identify outbreak hotspots, enabling targeted interventions to stop localized outbreaks from becoming widespread (Alsunaidi et al. 2021). Surveillance systems with real-time data collection detect disease clusters, leading to quick responses that limit the impact on communities. During outbreaks, BDA and surveillance aid in monitoring disease spread (Morse 2012), tracing contacts (Nazayer et al. 2021), and improving communication strategies (Aggarwal et al. 2022). By using these technologies, authorities can take data-driven actions to control outbreaks and protect public health more efficiently.

On the other hand, AI models are powerful tools for public health authorities to predict and prevent IDOs. It can analyse large and complex data sets, finding early warning signs and patterns that might go unnoticed by traditional methods (Vaishya et al. 2020). By acting quickly, AI helps in stopping or reducing the chance of local outbreaks becomes national concern or pandemics. By using AI models it is possible to improve the current public health system to become prepared for and even respond more efficiently to IDOs, by extracting useful insights from different sources of data (Noorbakhsh-Sabet et al. 2019). Furthermore, AI can predict details of outbreaks, such as time and the location where they might happen and what type of disease could emerge (Vaishya et al. 2020). This valuable information enables authorities to take preventive measures, protecting communities from the impact of infectious diseases. Utilizing AI's capabilities can significantly strengthen public health systems, ensuring better prevention and management of outbreaks.

Harnessing the potential of AI, and BDA for IDOs, the integration of diverse data types, including epidemiological, environmental, mobility, and social media data, with AI models creates a powerful early warning system within the current public health systems. AI models can continuously monitor and analyse disease trends, enabling early outbreak detection and swift response measures. By identifying unusual patterns of infections, health authorities can implement targeted interventions, and communicate accurate information to the public, preventing outbreaks from escalating. The aim of this study is to introduce a framework for AI integration with the current public health system, optimizing prevention, preparedness, and response efforts, and fostering a proactive approach to disease surveillance and management. This transformative synergy empowers public health authorities to protect their communities more effectively, mitigating the impact of IDOs and ensuring a more resilient and proactive health landscape. According to the objective of the study, the research questions can be formulated as follows:

- How can AI models help to monitor and analyse disease trends, enabling the early detection of outbreaks?
- What key indicators signify unusual patterns of IDOs in the datasets?

To address the research questions, the study starts with a literature review of how AI models are used in IDOs, looking at existing research and applications. Using the findings, the study proposes a framework that seamlessly combines AI and BDA with the current health systems. This framework focuses on gathering various types of data, such as information on the disease's spread, environmental factors, population movement, wearable devices, and social media insights. By training AI models with this data, continuous monitoring and analysis of disease trends become possible, allowing for early detection of outbreaks. The framework also emphasizes the importance of AI models being interpretable and accountable to build trust and help health authorities make confident decisions.

2 Research Method

We conducted a Systematic Literature Review (SLR), spanning from January 2022 till May 2023 with specific focus on the utilization of AI techniques within the context of IDOs. To ensure a thorough exploration of the topic we used PlosOne, IEEE, ScienceDirect, and Google Scholar databases with the keywords "outbreak", "machine learning" to retrieve relevant studies. **Table 1** indicates the inclusion/exclusion factors that were considered in this SLR.

Inclusion Criteria	Exclusion Criteria
Full text available	Books / Organisation Reports / Thesis / Abstract
English	Studies with a pure technological focus
January 2022 - May 2023	No AI for IDO management
Within the scope of AI in IDO management	

Table 1 Inclusion / Exclusion Criteria

The process of the SLR is illustrated in PRISMA **(Figure 2)**. Following a systematic literature search, 3,431 articles were identified and retrieved. Through a rigorous process of applying inclusion and exclusion factors and removing duplicates, books, organisation reports, thesis and abstracts were excluded. Also, studies solely focused on developing new AI methods, without addressing IDO management and control aspects, were eliminated from the dataset. Additionally, studies that failed to mention any AI approach for managing IDO were excluded from the analysis. Therefore, the extensive collection was refined to 327 articles. Following a detailed evaluation to align studies with the research aim, 45 relevant articles were chosen for a comprehensive review, allowing us to uncover important insights that directly help us analyse the research aim we have set for the study. In the subsequent section, the study will present a detailed assessment of these selected papers, highlighting their methodologies, findings, and contributions to the field of IDOs prediction and management using AI and BDA.

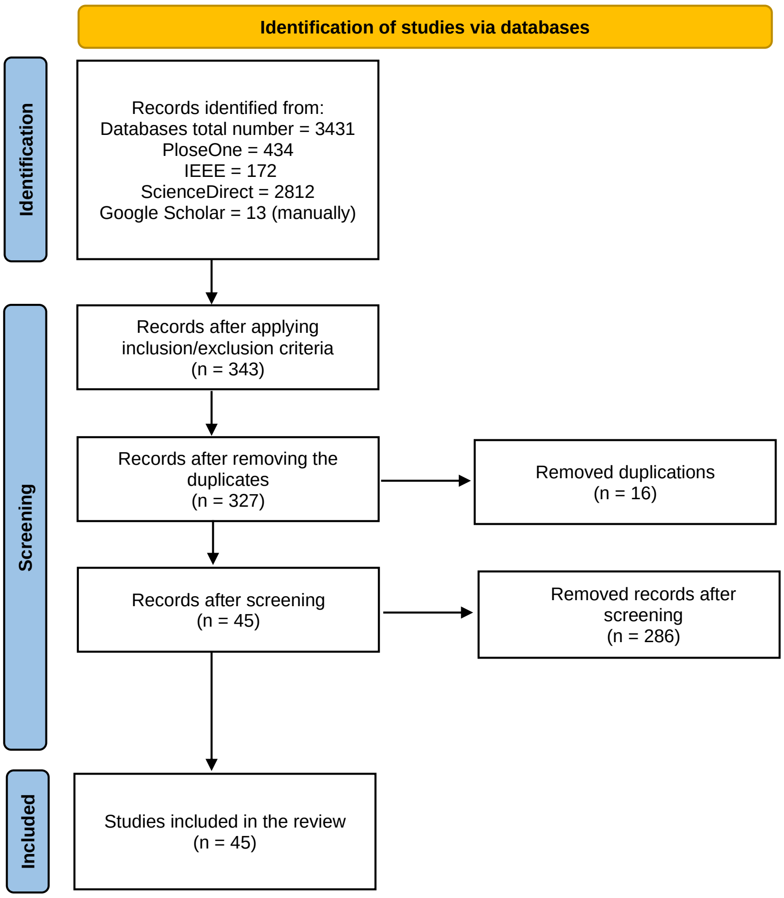

Figure 2 Identification of studies process

3 Results and Findings

From 45 papers, **Figure 3** shows the distribution of the included research papers in this study. In the area of the research, IEEE is the leading source with 44% of the papers. Google Scholar is also important, providing 29% of the papers. PlosOne and ScienceDirect are smaller sources but still significant, making up 18% and 9% of the papers respectively.

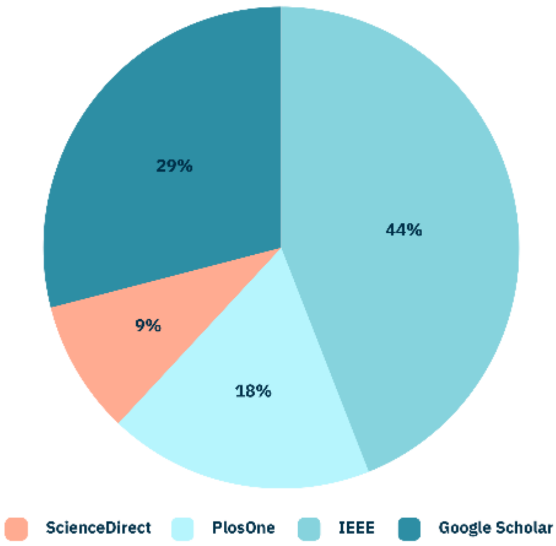

Figure 3 Proportion of selected papers per database

3.1 Characteristics of the Included Studies

Most of the studies of the dataset followed a quantitative approach while some studies used qualitative method. Only one study used a mixed method approach. **Figure 4** shows the number of studies based on their research methodology. The studies in the dataset were distributed across different regions, with a significant majority conducted in the Asian region. The distribution of the number of studies in each region is presented in **Figure 5**.

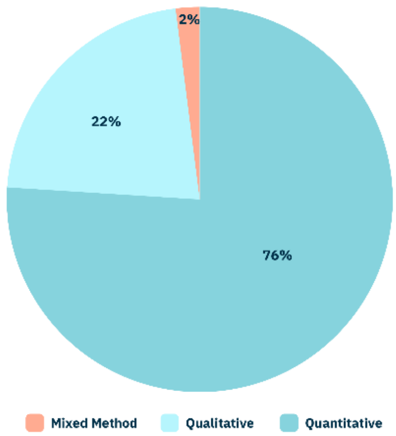

Figure 4 Proportion of the studies based on the research methodology

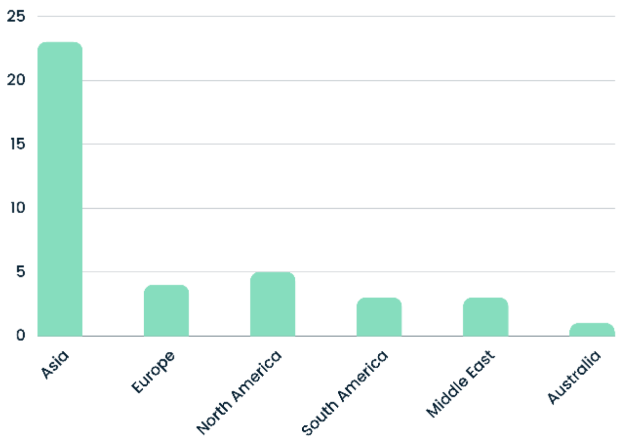

Figure 5 Proportion of selected studies as per region

The studies were published across a range of journals and conferences, and the specific area of each journal and conference are presented in **Table 2** and **Table 3**, respectively.

Area of the Journal	Journals
Tropical Medicine, Infectious Diseases	Trop Med Infect Dis
Sensor Technology	Sensors (Basel)
Public Health	Public Health
Multidisciplinary Research	PLoS One
Neglected Tropical Diseases	PLoS Negl Trop Dis
Computational Biology	PLoS Comput Biol, Comput Biol Med
Neural Computing and Applications	Neural Comput Appl
Materials Science	Materials Today: Proceedings
Intelligent Systems and Applications	Int'l Journal of Intelligent Systems and Applications, Intelligent Systems with Applications
Medical Informatics	Informatics in Medicine Unlocked
Infectious Disease Modeling	Infect Dis Model
Artificial Intelligence	IEEE Trans Artif Intell
Tropical Medicine, Infectious Diseases	Trop Med Infect Dis
Sensor Technology	Sensors (Basel)
Public Health	Public Health
Multidisciplinary Research	PLoS One
Neglected Tropical Diseases	PLoS Negl Trop Dis
Computational Biology	PLoS Comput Biol, Comput Biol Med
Neural Computing and Applications	Neural Comput Appl
General Engineering	IEEE Access

Table 2 The area of the journals

Area of the Conference	Conferences
Computer Science	2023 InCACCT, 2022 ICNGIS, 2022 ICDSIS, 2022 ICRAIE, 2022 CCGrid, 2022 ICCCNT, 2022 ICAST, 2022 ICECTE, 2022 ICAC3N, 2022 PRML, 2022 ICIEM
Information Technology	2022 ICITIIT
Electrical, Computer, Communications, Mechatronics Engineering	2022 ICECCME
Cluster, Cloud, Internet Computing	2022 CCGrid
Engineering, Technology	2022 CCET
Engineering, Innovations	2022 ICRAIE
Computing, Communication, Networking Technologies	2022 ICCCNT
Electrical, Computer, Telecommunication Engineering	2022 ICECTE
Computing, Communication, Control, Networking	2022 ICAC3N

Table 3 Area of the conferences

The studies included in this SLR placed an emphasis on different IDOs like COVID-19, dengue fever, monkeypox, Zika, measles, norovirus, Lassa fever, and malaria. Notably, COVID-19 emerged as the primary focused disease among the studies, reflecting its global significance and impact. **Table 4** provides an overview of the distribution of concentration among the studies on these various diseases.

Diseases	Disease Description	Authors and Year	Study Proportion
COVID-19	A highly contagious respiratory illness caused by the SARS-CoV-2 virus.	(Chandra et al. 2022; Didi et al. 2022; Heidari et al. 2022; Islam et al. 2022; Kumar et al. 2022a; Kumar et al. 2022b; Kumari et al. 2022; Noak and Wang 2022; Rakhshan et al. 2023; Santra and Dutta 2022; Sharma et al. 2022; T.K et al. 2022; Vasudev et al. 2022; Vengateshwaran et al. 2022; Wan Mohamad Nawi et al. 2023; Yenkikar and Babu 2023)	48%
Dengue Fever	A viral infection transmitted by mosquitoes causes flu-like symptoms, including high fever, severe joint and muscle pain. In severe cases, it can lead to dengue haemorrhagic fever or dengue shock syndrome.	(Aleixo et al. 2022; Barboza et al. 2023; Cabrera et al. 2022; Dey et al. 2022; Nguyen et al. 2022; Panja et al. 2023; Sarder et al. 2022; Sarwar and Al Mamun 2022; Sylvestre et al. 2022)	27%
Monkeypox	A viral disease that causes skin lesions and fever. It is similar to smallpox but less severe and usually transmitted from animals to humans, and limited human-to-human transmission can occur.	(Bengesi et al. 2023; Bhosale et al. 2022; Mir et al. 2023; Ng et al. 2022; Priyadarshini et al. 2023)	15%
Zika	A viral infection transmitted by mosquitoes often causes mild or no symptoms but can lead to birth defects if contracted during pregnancy.	(Shinde et al. 2022)	3%
Measles	A highly contagious infection that primarily affects children. It leads to fever, rash and can cause serious complications like pneumonia and encephalitis.	(Lau et al. 2022)	3%
Norovirus	A gastrointestinal virus that causes vomiting and diarrhea. It is often associated with outbreaks in crowded or enclosed settings.	(Lee et al. 2022)	3%
Lassa Fever	A haemorrhagic fever can lead to severe bleeding, organ failure, and death. It is primarily found in West Africa and is transmitted through rodents.	(Oluwole and Nkonyana 2022)	3%
Malaria	A parasitic infection transmitted by mosquitoes. It causes fever, chills, and flu-like symptoms. Severe cases can lead to organ damage and death, particularly in young children.	(Singh et al. 2023)	3%

Table 4 The distributions of the diseases in the dataset

3.2 Methods and Datasets

In these research studies, the main goal of AI application was to develop prediction models for these outbreaks. Some studies used specific Machine Learning (ML) algorithms, while others combined multiple methods in hybrid models. The most commonly used ML algorithms were Support Vector Machine (SVM), Random Forest, Long Short-Term Memory (LSTM), Decision Tree, and K-Nearest Neighbours (KNN). Additionally, some studies conducted systematic reviews and surveys to analyse existing literature (Gamal et al. 2022; Pilipiec et al. 2023; Riswantini and Nugraheni 2022; Sylvestre et al. 2022). **Figure 6** presents the distribution of methods used in the dataset, grouped into nine categories. These categories include groups like Time Series Forecasting, Machine Learning, NLP, Statistical Analysis, Clustering, and different combinations like NLP and Machine Learning or Machine Learning and Time Series which comprise a significant proportion of the studies.

Moreover, the inclusion of NLP indicates a growing interest on analysing textual data, highlighting the increased integration of computational linguistics. It introduces a linguistic perspective with models like BERT and RoBERTa, enabling the analysis of textual content. Also, the significance of geospatial analysis becomes evident as it presents important methods for investigating connections and trends that appear within the data. Social media analysis and epidemiological models shows the relevance of social media and disease-related data for a broader understanding of the nature of the diseases. This categorization helps to see the variety of approaches used in the studies, including cases where methods are combined for more comprehensive insights.

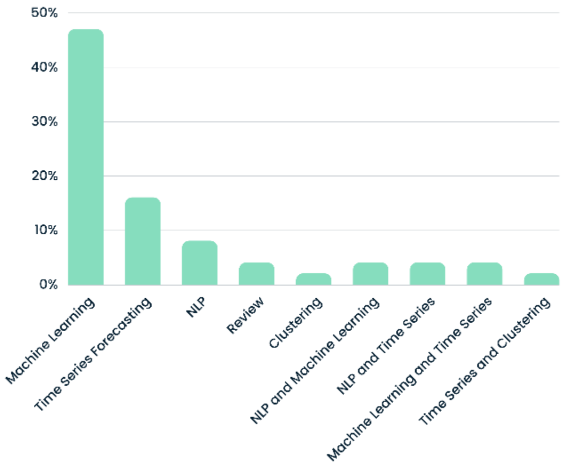

Figure 6 The distribution of the methods and combined methods

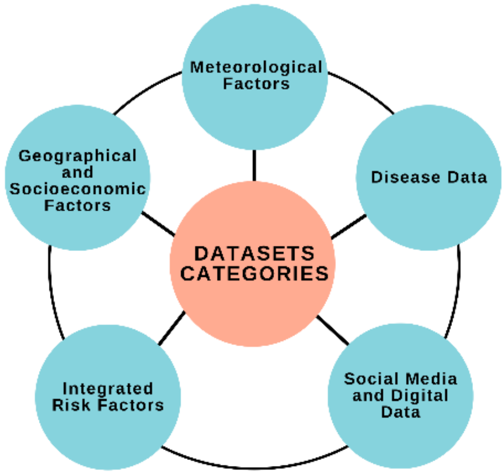

Figure 7 Used datasets categories

The studies explored various datasets and datatypes, including climate variables (Barboza et al. 2023; Nguyen et al. 2022; Sarder et al. 2022; Shinde et al. 2022), socio-economic information (Dey et al. 2022), hospitalized patients (Dey et al. 2022), medical risk factors (Zhang et al. 2022), GPS data (Vengateshwaran et al. 2022), environmental factors (Sarwar and Al Mamun 2022), social medial (Islam et al. 2022; T.K et al. 2022), X-Ray images (Kumari et al. 2022) symptoms and disease datasets (Allawadi et al. 2023; Kumar et al. 2022; Yenkikar and Babu 2023) to train specific AI models for predicting and managing IDOs. They found that SVM (Bengesi et al. 2023; Sarwar and Al Mamun 2022), and LSTM (Nguyen et al. 2022) algorithms consistently performed well in outbreak prediction. Temperature, rainfall, and humidity were identified as crucial factors influencing the transmission of diseases like dengue fever and malaria, highlighting the importance of considering climatic elements in forecasting IDOs (Singh et al. 2023). One of the studies also emphasized the effectiveness of forecasting over a longer time period to better manage the impact of IDOs (Yenkikar and Babu 2023). Additionally, researchers used social media data and Natural Language Processing (NLP) techniques to monitor public sentiments, detect outbreaks early, and keep track of the situation during outbreaks (Bengesi et al. 2023; Gamal et al. 2022; Ng et al. 2022; Pilipiec et al. 2023; Sharma et al. 2022).

Figure 7 shows how different types of datasets were used in the studies. We classified these datasets into five groups, each with a specific focus. The categories include Meteorological Factors, Disease Data, Social Media and Digital Data, Integrated Risk Factors, and Geographical and Socioeconomic Factors. Meteorological Factors which consider meteorological variables, are critical in providing context for infectious disease patterns. Disease data also provides valuable insights into disease prevalence and transmission dynamics. The utilization of social media and digital data offers opportunities for conducting real-time sentiment analysis and monitoring outbreaks. The incorporation of integrated risk factors combines economic, social, and medical dimensions to facilitate a comprehensive understanding. The interaction between geographical and socioeconomic factors illuminates the environmental and societal aspects that influence the spread of diseases. The utilization of these data types offers an overview of how they can contribute to IDO prediction and management. These comprehensive findings demonstrate the significant potential of combining diverse datasets with AI models, providing valuable tools to enhance IDOs management, and ultimately strengthen public health strategies and responses.

4 Discussion

The results of this review demonstrate a significant recent multidisciplinary (**Table 2** & **Table 3**) global (**Figure 5**) interest in the area. Advances in AI and ML approaches also has fuelled (**Figure 6**) this interest for predicting and managing IDOs. However, there remain critical gaps that require attention.

The complex nature of IDO dynamics has resulted in a lack of universal agreement on methods and data sources, as it is shown in **Figure 6** and **Figure 7**, hindering the establishment of a standardized approach applicable across different scenarios, diseases, and locations. This standardized approach is important for the public health system to allocate the resources appropriately for prompt and efficient disease control and management. To bridge this gap, it is imperative to develop a standardized procedure that can effectively address various IDOs contexts. Moreover, the significance of different data sources must be thoroughly evaluated, considering the possibility of combining correlated features from diverse datasets to create a more accurate predictive model. This necessitates a focus on data quality, availability, and validation, as these factors are pivotal in establishing a standardized model for seamless integration with the public health system. By addressing these challenges and advancing research in these areas, it is possible to enhance the capabilities of ML approaches in effectively predicting and managing IDOs.

AI models have proven to be highly capable of predicting and helping to manage IDOs, providing valuable insights to public health authorities. Integrating these AI models with the current public health system is of utmost importance to maximize their effectiveness. Real-time analysis and continuous monitoring enable rapid response measures and targeted interventions. In this framework, an ensemble AI approach will be adopted, allowing the utilization of the most suitable method based on the specific conditions of the situation at hand. This approach involves evaluating diverse data sources and analysing their features, relations, and correlations to create a standardized dataset containing all necessary information for the AI model. The key goal of this proposed framework is to seamlessly incorporate various AI methodologies into existing public health systems, enabling the selection of the most appropriate approach for each unique situation. By incorporating standardized procedures and integrating features from different datasets, the framework significantly enhances the reliability of predictive models, ensuring an adaptable system for addressing diverse public health challenges. This approach allows public health authorities to make more informed decisions and take proactive measures in preparing for, preventing, and responding to IDOs effectively. It also empowers them to better understand the complexities of IDOs and implement adapted strategies for outbreak management. **Figure 8** provides an overview of the framework that integrates AI and BDA with the public health system.

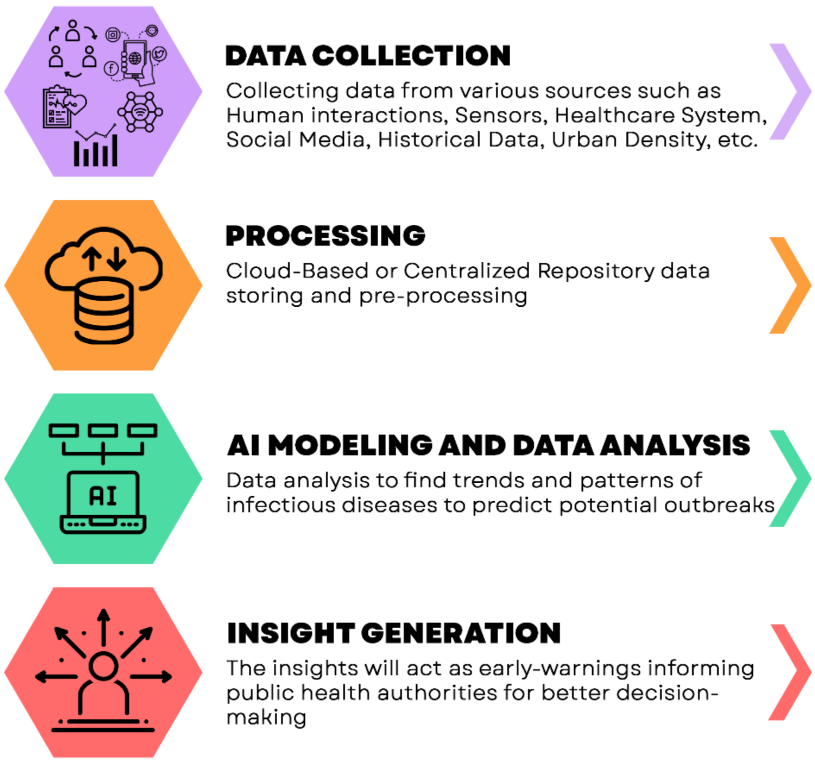

Figure 8 An overview of integrating AI and BDA with the public health system

In the first phase of the framework, known as **data collection**, an extensive and diverse range of data should be gathered from various sources to build a comprehensive understanding of IDOs for the public health sector. This involves constantly collecting data on human interactions, sensor readings, healthcare facilities, social media content, historical records, urban density, and other relevant information. To accomplish this data collection, accessing different sources becomes crucial (Singh et al. 2023), and collaboration between various organizations is essential (Guimón and Narula 2020). Health agencies, research institutions, government bodies, and technology companies may need to work together to pool their data resources and expertise, ensuring a comprehensive and robust dataset that captures various aspects of IDO dynamics. The success of this phase relies on efficient data-sharing mechanisms, and transparent collaborations (Gao et al. 2020), for accurate and timely data acquisition, which forms the foundation for subsequent phases of the framework.

In the second phase of the framework, known as **processing**, the data collected in the previous phase will be securely stored on cloud servers or a centralized repository and undergoes rigorous pre-processing to ensure data quality and compatibility. Techniques such as data cleaning, normalization, and integration of epidemiological knowledge are applied to rectify errors, missing values, and outliers, ensuring accuracy and reliability. Additionally, data transformation processes standardize formats and units, making the information consistent for analysis. At this level, the relationships between different datasets should be explored, employing statistical methods to identify intricate correlations crucial for early IDO detection. The objective is to identify relevant correlations and patterns among various data sources, facilitating the creation of a comprehensive dataset that captures the interconnections between different factors influencing IDOs. Enhanced through healthcare expertise and AI-driven analysis, this unified dataset becomes a powerful tool for early IDO detection, crucial for accurate prediction and management of IDOs.

The third phase of the framework, **AI modelling and data analysis** represents a fundamental stage where advanced AI models are deployed to thoroughly analyse the pre-processed data, aiming to unveil intricate trends and patterns associated with infectious diseases, ultimately facilitating the prediction of potential outbreaks. By leveraging the remarkable capabilities of AI, this phase can effectively detect complex and subtle relationships within the data that may not be readily discernible to human analysts. The selection of an appropriate AI approach depends on the nature and characteristics of the pre-processed data obtained in the previous phase. Depending on the specific objectives of the analysis and the complexity of the data, public health authorities can employ various AI models, such as ML algorithms, deep learning neural networks, or predictive analytics. Moreover, the ability to integrate an ensemble of different AI models in this phase adds an extra layer of robustness and accuracy to the outcome information. The ensemble approach allows for combining the strengths of multiple AI models, mitigating individual model limitations, and creating a more reliable predictive model. By integrating a diverse range of AI models, the framework gains the capacity to provide a complete and in-depth understanding of infectious disease trends, offering valuable insights. The AI modelling and data analysis phase represents a significant advancement in infectious disease surveillance and management, as it utilizes the power of AI to uncover hidden trends and patterns that might otherwise go unnoticed. Through this data-driven approach, the framework strengthens the public health system's capabilities, ultimately contributing to more effective, efficient, and proactive responses to infectious disease challenges.

In the fourth and final phase of the framework, referred to as **insight generation** the valuable insights obtained from the AI modelling and data analysis phase play a critical role in equipping public health authorities with timely information to make appropriate decisions and take proactive measures to effectively address and mitigate potential IDOs. The insight generated in this phase serves as a fundamental early warning system, allowing authorities to anticipate and prepare for future IDOs by identifying trends and patterns in the data that may indicate potential outbreaks. Furthermore, the insights obtained during the outcome phase contribute to the continuous improvement of the AI models used in the previous phase, as the data-driven feedback loop ensures that the models evolve and improve over time, leading to more accurate and reliable predictions in the future. By leveraging these advancements, the framework further strengthens the public health system's capabilities, fostering a proactive and data-driven approach to infectious disease surveillance and management, ultimately enhancing health security and safeguarding communities from the impact of infectious disease outbreaks.

The integration of AI with public health will introduce a new era of possibilities, significantly improving response efforts through advanced data analysis and predictive modelling. By harnessing the power of advanced data analysis and predictive modelling, the framework offers a thorough approach. The framework considers not only medical factors but also human behaviour, social elements, and healthcare-seeking patterns, providing a holistic view of disease dynamics, empowering healthcare professionals to anticipate outbreaks, optimize interventions, and ultimately enhance the overall public health outcomes.

However, fully realizing AI's potential and seamlessly integrating it into existing public health systems come with its challenges. The public health sector must maintain and strengthen the technical expertise essential for AI development and implementation. This involves investing in the training and education of personnel in AI-related fields, fostering interdisciplinary collaborations between public health experts and data scientists and technology developers. Active engagement between these stakeholders is vital, bridging the gap between AI research and practical applications in public health. Establishing standardized protocols and ethical guidelines for AI implementation in healthcare settings is essential. These protocols ensure the accuracy and reliability of AI algorithms and safeguard patient data and privacy. Furthermore, ongoing research and development efforts are essential to keep pace with the evolving landscape of infectious diseases and technological advancements. Developing a culture of innovation, continuous learning, and adaptability within the public health sector is key. By doing so, the public health system can effectively harness the full potential of AI to address current and future health challenges.

In addition to technical expertise, building healthcare workers' proficiency in AI technologies is pivotal for the successful integration of AI into public health. It is essential to ensure that healthcare professionals are well-informed and trained in the diverse AI features and capabilities appropriate to their fields. This knowledge equips them to comprehend how AI can significantly enhance disease surveillance and early detection efforts. With a deep understanding of AI applications, healthcare workers can make informed decisions, enabling them to implement evidence-based strategies for patient care effectively. Furthermore, continuous training and updates in AI advancements enable healthcare professionals to adapt to the evolving landscape of technology, ensuring they remain at the forefront of innovative healthcare practices. This collaboration between technical expertise and healthcare professionals' knowledge forms a foundation for overcoming the challenges associated with AI integration in public health systems.

The COVID-19 pandemic works as a convincing example of the value of AI in public health response efforts. AI algorithms played a fundamental role in identifying strain areas, predicting disease spread patterns, and assessing training requirements for healthcare workers involved in future outbreak responses. The data-driven insights provided by AI models were instrumental in guiding public health interventions, informing policy decisions all of which were crucial in managing the pandemic's impact. Despite its vast potential, integrating AI into public health systems, ethical considerations, data privacy concerns, and ensuring the transparency and interpretability of AI models remain important aspects to address. Collaboration between public health authorities, researchers, and AI experts is also crucial in developing responsible and equitable AI applications that align with public health goals.

5 Conclusion

Due to the growing trend of IDOs in recent decades and the complex challenges they present, in our systematic review, we explored the use of AI approaches for IDO management and control. We aimed to interpret the methods and data sources employed by researchers. Our thorough analysis revealed a diverse landscape, where innovative approaches were employed to understand, manage, and control outbreaks. Through the examination of the dataset, it became evident that various techniques were utilized, reflecting the complexity and urgency of the task at hand. In spite of these efforts, we found the absence of a universal and standardized approach capable of detecting IDO trends and patterns before they escalate into full-scale epidemics and pandemics. This critical insight emphasized the pressing need for innovative solutions. Therefore, a framework for integrating AI into existing public health systems was introduced to assist authorities in making informed decisions tailored to the specific situation at hand.

In conclusion, the integration of AI with public health holds great promise in improving preventive, preparing, and responsive efforts. The potential of AI is undeniable, but it requires a determined effort from the public health sector to overcome challenges, maintain technical expertise, and ensure healthcare workers are well-prepared to utilize AI's capabilities. By providing comprehensive training programs and raising awareness among healthcare professionals and the general public, the health system becomes adept at harnessing AI's potential to its fullest extent. Additionally, informed decision-making through ongoing research and collaboration with experts in both healthcare and AI fields helps optimize AI integration. This leads to not only improved healthcare services but also enhance resilience in the face of future health crises. The interaction between AI technology and public health efforts, supported by continuous education and research, leads to a more robust and adaptable healthcare system capable of addressing the challenges of IDOs.

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