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Digital Dashboard Technology for Spatial-Based Disease Distribution Mapping: Systematic Mapping Studies of Indonesia's Garuda Database

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Abstract
The utilization of Digital Dashboard Technology in disease spatial mapping offers a more interactive and insightful approach to present health data. This study employs a Systematic Mapping Studies (SMS) to examine the technologies applied in disease mapping dashboard development over the past five years. The findings reveal that digital mapping tools, including Geographic Information Systems (GIS) software such as QGIS and ArcGIS, as well as Leaflet.js, are widely used for spatial data visualization. Furthermore, the integration of advanced technologies like big data analytics, machine learning, and the Internet of Things (IoT) significantly enhances the dashboard's capability for in-depth analysis and real-time data processing. The most commonly mapped diseases in the reviewed studies include dengue fever, tuberculosis (TB), and stunting, highlighting the critical role of digital dashboards in monitoring and controlling infectious diseases and public health issues. However, challenges such as data validity and system interoperability remain significant obstacles. This study provides valuable insights into the evolution of digital dashboard technology and its potential in supporting evidence-based decision-making in the healthcare sector.

1. Introduction

In Indonesia, mapping the distribution of diseases plays a crucial role in public health systems, as it enables a more comprehensive understanding of transmission patterns and supports timely and effective decision-making. In a country with diverse geographical and demographic conditions, the ability to visualize health data spatially is vital for anticipating outbreaks and allocating resources effectively. With the advancement of digital technology, the use of digital dashboards has emerged as an innovative solution for dynamic and interactive health data visualization. Through this platform, information on disease distribution can be presented in a more informative and interpretable manner, allowing policymakers to respond more quickly and strategically to potential health threats. Due to the ongoing era of digitalization, data is now stored in a wide variety of formats[1], creating both opportunities and challenges for health data management and integration across platforms.

In the post-COVID-19 era, the demand for responsive and real-time public health information systems has intensified, particularly in countries like Indonesia that face both endemic and emerging infectious diseases. Digital dashboards provide a timely solution by enabling decision-makers to monitor, analyze, and communicate disease trends efficiently.

Recent advancements in technologies, such as Geographic Information Systems (GIS) for spatial analysis; big data for large-scale data processing; and machine learning for predictive modeling, have been widely utilized in the development of digital dashboards for more accurate and efficient disease mapping. These technologies facilitate deeper spatial analysis and a more integrated presentation of health data. For instance, a study conducted by Waskito and colleagues (2017) demonstrated the use of GIS in mapping the ten most prevalent diseases in the Mojosongo Primary Health Center area, significantly enhancing the understanding of disease distribution patterns in the region [1]. Another example is a health information dashboard used to support disease control initiatives at the Kulon Progo District Health Office, which underscores the significance of data integration and user-friendly data visualization in facilitating evidence-based public health policy development [2]. However, challenges such as data validity and system interoperability remain obstacles in the development of digital dashboards for disease mapping. A study identified both functional and non-functional requirements, as well as the challenges associated with dashboard implementation in hospitals, emphasizing the importance of user-friendly design and seamless system integration [3].

To address these issues, this study conducts a systematic mapping study (SMS) to provide a comprehensive overview of the existing literature on technologies used in the development of digital dashboards for disease distribution mapping. Rather than directly solving technical challenges such as data integration, system interoperability, user interface design, and data accuracy, this study aims to identify how these issues have been addressed across various implementations. By categorizing and analyzing the types of technologies, tools, and frameworks reported in prior research, this mapping study highlights current trends, gaps, and best practices in the field. The insights gained are expected to inform future system development and guide researchers and practitioners in selecting appropriate technological solutions to overcome the aforementioned challenges.

To guide the systematic mapping study, we address the following research questions: (1) What types of technologies, tools, and frameworks are used in the development of digital dashboards for disease mapping, and how are they applied to address technical challenges such as data integration, system interoperability, and real-time analytics? (2) What diseases are most commonly represented in digital disease dashboards, and how does the type of disease influence dashboard design and data requirements? (3) What are the key challenges in implementing these dashboards?

Unlike previous studies that often focused on specific tools or isolated local implementations, this research provides a broader synthesis of various technologies, disease types, and implementation challenges, offering a more comprehensive perspective on the current state and future direction of digital dashboards for disease mapping. It is expected that the findings will support researchers and practitioners in understanding the state-of-the-art, identifying gaps in the literature, and proposing directions for future development.

2. Literature Review

2.1 Spatial-based Digital Dashboard

A digital dashboard is a tool used to display summarized data outputs that can be quickly and accurately interpreted. Its interface typically includes tables, charts, and maps, enabling users to easily understand information visually [4]. In various sectors, particularly public health, digital dashboards play a crucial role in presenting complex data in a concise and interactive manner, thereby supporting efficient monitoring and decision-making processes [5].

One of the developments of digital dashboards is the spatial-based dashboard, which integrates data with geographic location elements. In this context, spatial data plays a vital role. Spatial data refers to information about geographic objects or features that can be identified and have a specific location reference based on coordinates. This type of data consists of two main components: graphic data, which depicts the shape and location of objects, and attribute data, which provides descriptive information about those objects. Spatial data, referenced by a coordinate system, integrates both location-based (spatial) and descriptive (attribute) information, distinguishing it from other data types. In other words, spatial data indicates the geographic position where each characteristic has a unique and specific location [6].

In public health, spatial dashboards are particularly valuable for visualizing the distribution of diseases digitally. These dashboards enable healthcare professionals and stakeholders to identify high-risk areas, monitor the spread of disease trends, and develop targeted intervention strategies based on geographic distribution. Dowding et al. (2015) emphasize that such dashboards deliver real-time information, which improves workflow efficiency, facilitate monitoring of key performance indicators (KPIs), and enable rapid response to patient needs. This real-time capability is critical in managing health crises and ensuring timely interventions [44].

Moreover, Carroll et al. (2014) found through a systematic review that spatial dashboards not only enhance communication within public health systems but also significantly improve their analytical capacity [45]. This dual role supports both the interpretation and practical use of complex spatial data in decision-making processes. However, as Rushton (2003) points out, the integration of spatial analytics in public health is not without challenges; issues such as data quality, access restrictions, and ethical considerations must be carefully addressed to maintain the reliability and integrity of the system [46].

The technologies used in developing spatial dashboards include [14][16][17] Geographic Information Systems (GIS) such as QGIS and ArcGIS; Google Maps API and Leaflet.js for interactive mapping; and web frameworks such as Laravel, Vue.js, or React for building responsive and dynamic application interfaces.

2.2 Disease Distribution Mapping

Mapping is the entire process carried out to create a map. This process can be conducted in various ways, one of which is through digital means. Digital mapping utilizes modern technology to reduce potential sources of error, such as human factors or media distortion [7]. In the context of public health, digital mapping has become an important approach in modern epidemiology, as it enables the accurate and efficient presentation of spatial information.

By utilizing spatial data, digital mapping allows for the visualization of disease case locations within a region, making it easier to identify patterns, clusters, and disease trends over a specific period. This mapping not only supports the analysis of disease distribution but also accelerates decision-making based on geographic data.

The main benefits of disease mapping include the identification of high-risk zones, monitoring of spatial-temporal trends, more efficient resource allocation, and the strengthening of policies based on geographic information. Various visualization approaches such as heatmaps, spatio-temporal analysis, and clustering methods (e.g., K-Means, DBSCAN, Getis-Ord Gi*) are commonly used in previous studies, particularly for infectious diseases such as dengue fever, tuberculosis (TB), and diarrhea. Unfortunately, mapping of non-communicable diseases (NCDs) such as diabetes, hypertension, and cancer still receives limited attention, even though spatial analysis of environmental and socioeconomic factors can significantly support preventive and promotive health efforts in a more targeted manner. Furthermore, the integration of real-time data from sensors or IoT devices, as well as the application of spatial analysis using machine learning, remains a challenge that needs further development in the context of digital disease mapping.

Disease mapping is useful for identifying high-risk areas and improving health interventions. For example, Eisen and Lozano-Fuentes (2009) demonstrated how spatial and temporal modeling significantly enhanced dengue control operations [41]. Similarly, Hay et al. (2013) highlighted the potential of big data and spatial mapping for improving global disease surveillance and vaccine distribution [42]. In addition, Chaturvedi and Upadhyay (2020) emphasized the role of GIS-based disease mapping in enhancing decision-making processes for public health planning and resource allocation [43].

3. Research Method

To conduct the systematic mapping study (SMS), we adopted the methodology proposed by Petersen et al. [8], which provides a structured process to classify and analyze research literature within a specific domain. The process involves five main steps: (1) defining research questions to determine the scope and objectives of the study; (2) conducting a comprehensive literature search using search strings constructed using Boolean operators and keywords relevant to digital dashboards and disease mapping; (3) applying inclusion and exclusion criteria to filter relevant studies; (4) performing keywording of abstracts to extract key terms and concepts that contribute to building a classification scheme; and (5) extracting data and mapping the studies into categories based on multiple facets, such as research focus, contribution type, and research type.

In this study, the Garuda database was selected as the primary source of literature, as it offers comprehensive indexing of Indonesian scholarly publications and aligns with the national focus of this research.

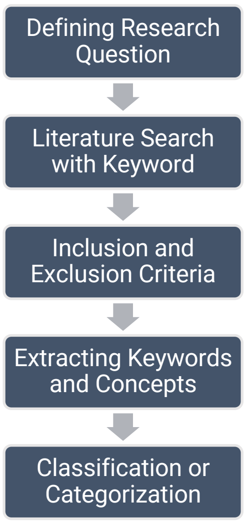

Figure 1. Systematic mapping studies steps

The classification scheme is iteratively refined during data extraction, and the final mapping is visualized using frequency tables or bubble plots to illustrate the distribution of research across categories. This systematic approach enables identification of research trends, gaps, and the maturity of specific subfields, thereby supporting strategic directions for future research [8].

4. Results and Discussion

A systematic search of the Garuda database retrieved 50 articles. Titles and abstracts were screened according to predefined inclusion and exclusion criteria, leading to the elimination of 8 articles and leaving 42 for further review. The next stage involved downloading the full-text articles in PDF format, from which 38 articles were successfully accessed, while 4 could not be retrieved in full. A final selection was made by thoroughly reviewing the 38 accessible articles, resulting in 32 articles eligible for further analysis. The selection process is illustrated in Figure 2.

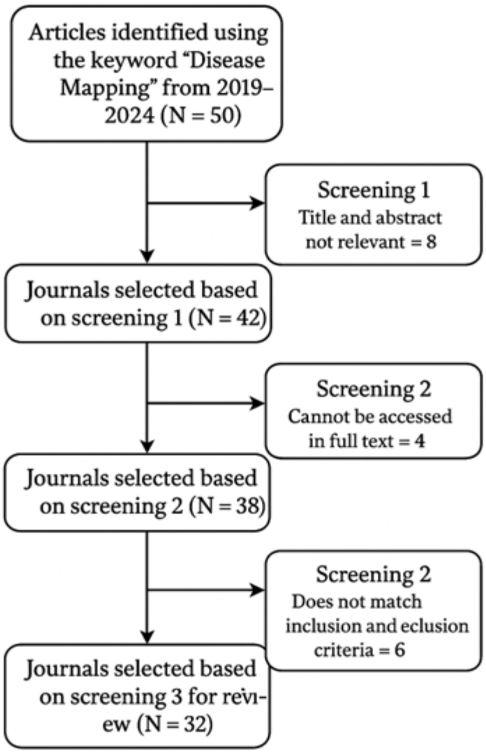

Figure 2. Journal Selection Stages

The articles selected and reviewed are then categorized according to the aspects previously determined, namely digital map visualization platforms, human disease objects, and technologies used for visualization. The overall results of the article review, which can be downloaded in full text, are presented in the form of a table, as shown in Table 1.

Table 1. Review of disease mapping journals

Article	Platform	Object	Technology
[9]	Webapp	Stunting	leaflet js + QGis
[10]	N/A	Diarrhea	N/A
[11]	N/A	Dangue Fever	N/A
[12]	N/A	Tuberculosis	N/A
[13]	N/A	Dangue Fever	N/A
[14]	N/A	Diarrhea	QGis
[15]	N/A	Tuberculosis	QGis
[16]	N/A	Tuberculosis	ArcGis
[17]	N/A	Social Diseases	Google Map API
[18]	N/A	Dangue Fever	N/A
[19]	N/A	DM + Tuberculosis	QGis
[20]	Webapp	Asthma, ISPA, Hypertension	N/A
[21]	N/A	Periodontal	ArcGis + GPS
[22]	Webapp	Dangue Fever	N/A
[23]	N/A	Tuberculosis, AIDS, Dengue Fever, STIs	N/A
[24]	N/A	Tuberculosis	QGis
[25]	N/A	ISPA	QGis

Article	Platform	Object	Technology
[26]	N/A	Typhoid Fever	ArcGis
[27]	N/A	Malaria	ArcGis
[28]	Webapp	Covid-19, Dengue Fever, Tuberculosis, Diarrhea, ISPA	Personal Extreme Programming
[29]	Webapp	Dengue Fever, Diarrhea, Tuberculosis	Google Map API
[30]	Webapp	Stunting	N/A
[31]	Webapp	Malaria, Leprosy, Dengue Fever	N/A
[32]	N/A	Dengue Fever	QGis
[33]	N/A	N/A	Google Map API
[34]	Webapp	Dengue Fever	N/A
[35]	N/A	HIV/AIDS	N/A
[36]	Webapp	Dengue Fever	N/A
[37]	N/A	Dengue Fever	N/A
[38]	N/A	Environtmental Sanitation Disease	N/A
[39]	N/A	Dengue Fever	N/A
[40]	N/A	Non-communicable Diseases	N/A

From the results of the analysis of 38 articles, several findings were obtained:

1. Digital Geographic Maps:
   - Of the 38 articles analyzed, 32 generated digital geographic maps, though some lacked detailed descriptions of the platforms or methodologies used.
   - Frequently mentioned technologies include QGIS, Leaflet.js, and ArcGIS, while several articles only referred to the use of Geographic Information Systems (GIS) in general.
2. Mapped Diseases:
   - The reviewed articles covered a variety of diseases, such as stunting, diarrhea, dengue fever (DF), tuberculosis (TB), and non-communicable diseases (NCDs).
   - While at first glance the type of disease may seem unrelated to dashboard implementation, in practice, it plays a significant role in shaping the system design and technological requirements. For example, mapping infectious diseases like dengue or TB requires real-time data integration and rapid response features, whereas dashboards for non-communicable diseases may focus more on trend analysis and long-term monitoring. Thus, understanding the types of diseases mapped provides insight into the functional demands and implementation challenges specific to different health contexts.
3. Use of Technology:
   - A number of articles merely mentioned the use of GIS without integrating additional technologies.
   - Several articles implemented more advanced analytical methods, such as clustering for disease distribution or epidemiological data visualization using Leaflet.js.

Despite these efforts, challenges remain in the implementation of digital dashboards. These include incomplete datasets, inconsistent spatial reporting, and limited system interoperability due to heterogeneous formats and incompatible systems. These issues significantly reduce the usability of the data and can hinder informed decision-making. Each component technology plays a vital role in addressing these gaps. For example, Geographic Information Systems (GIS) improve the spatial accuracy and visualization of disease spread, while big data technologies enable the integration and processing of large-scale, heterogeneous health data in near real-time. Meanwhile, machine learning enhances predictive analytics, allowing for early detection and targeted interventions.

To address the identified challenges, researchers should adopt standardized spatial data protocols, incorporate robust data validation frameworks, and ensure system interoperability through the use of open standards and APIs. These strategies are particularly relevant to the Indonesian healthcare system, where variations in regional data collection practices and limited digital infrastructure can impede unified responses. By applying these technologies and approaches, the quality, reliability, and scalability of digital dashboard systems can be improved to better support public health interventions in Indonesia and similar settings.

In addition to being presented in a tabular format, the reviewed data are also visualized through graphs to provide a clearer and more informative overview of the distribution of articles that produced digital geographic maps.

4.1. Digital Geographic Maps

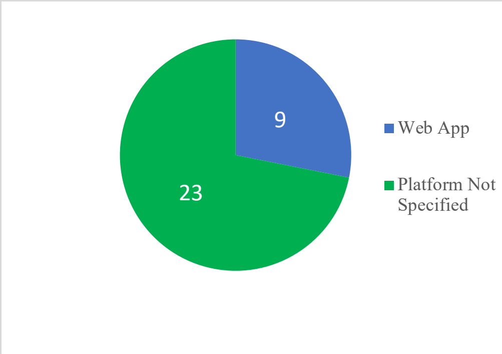

Figure 3. Distribution of digital geographic map platforms

The chart in Figure 3 illustrates the number of articles that produced digital geographic maps based on the review of 32 selected studies. Of the total articles reviewed, nine articles generated digital maps using a web-based application (Web App), while the remaining 23 articles did not specify the platform used to present the digital geographic maps. This lack of specification is likely due to a lack of standardized reporting guidelines or a primary focus on the results rather than on the technical tools and platforms employed. Such absence of detail can reduce the reproducibility and comparability of these studies. Therefore, it is important for future research to provide detailed information about the platforms used to enhance transparency and facilitate better comparisons across studies.

4.2. Human Disease Objects

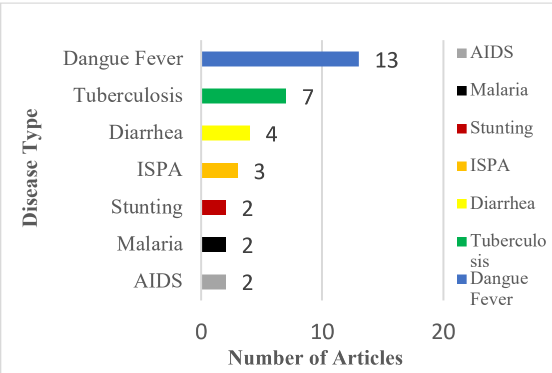

Figure 4. Diagram of human disease objects

Note: For clarity, diseases reported in only one article were excluded from this chart, including conditions such as asthma, hypertension, and other low-frequency communicable and non-communicable diseases.

The chart above illustrates the various human diseases that were the focus of the studies reviewed. Dengue fever (DBD) is the most frequently studied disease, appearing in 13 articles, followed by tuberculosis (TB) in 7 articles, and diarrhea in 4 articles. Acute respiratory infections (ARI), stunting, AIDS, and malaria were the focus of 2 to 3 articles each. In addition to these diseases, other conditions such as asthma, hypertension, other infectious diseases, and several non-communicable diseases were each addressed in only one article. Due to their limited representation, these diseases were excluded from the chart to maintain the effectiveness of the visualization. Nevertheless, the inclusion of studies on these diseases highlights that a wide range of both communicable and non-communicable diseases continues to receive attention in the development of digital geographic maps. The dominance of diseases such as dengue fever, tuberculosis, and diarrhea could be attributed to their high public health burden in Indonesia and their clear spatial transmission patterns. Infectious diseases are often prioritized in mapping efforts due to their epidemic potential and the need for spatial surveillance.

4.3. Mapping Technology

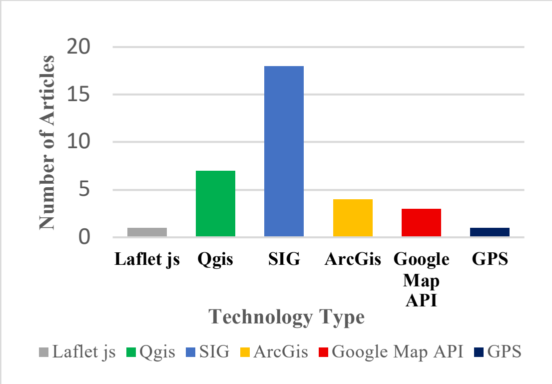

Figure 5. Bar chart using map technology

The bar chart above illustrates the various mapping technologies employed in the reviewed studies. Geographic Information Systems (GIS) is the most frequently used technology, with a total of 18 articles utilizing it. QGIS was selected in 7 articles, while ArcGIS was applied in 4 articles. Google Map API was also used in 3 articles. Meanwhile, Leaflet JS and GPS were each employed in only one article. This data indicates that GIS, QGIS, and ArcGIS are the dominant mapping technologies in geographic mapping research based on the articles reviewed. However, emerging technologies such as artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) have the potential to revolutionize disease dashboards by enabling predictive modeling, real-time anomaly detection, and automated data ingestion from sensors or mobile sources. Despite their promise, the adoption of these advanced technologies in Indonesian studies remains limited. This can be attributed to several underlying factors, including inadequate digital infrastructure in many regions, limited access to high-quality and real-time health data, and a shortage of skilled human resources with expertise in data science and advanced analytics. Additionally, institutional constraints, such as fragmented health information systems and budgetary limitations, further hinder the integration of cutting-edge technologies into public health initiatives. Addressing these barriers is essential for unlocking the full potential of digital dashboards in the Indonesian healthcare context.

Compared to international reviews such as Carroll et al. (2014), our findings align in highlighting the dominance of GIS-based tools. However, the relatively low adoption of real-time analytics or AI-based methods in Indonesian studies reflects a technological lag. This gap underscores the need for investment in newer technologies for more adaptive disease surveillance.

5. Conclusion

Based on the results of this Systematic Mapping Study (SMS), it is evident that digital dashboards play a significant role in spatial-based disease distribution mapping. This technology enables interactive and informative spatial data visualization, thereby supporting analysis and decision-making processes in the healthcare sector. Geographic Information Systems (GIS), especially tools like QGIS and ArcGIS, are the most commonly utilized technologies. Most dashboards are web-based, although many studies lack detailed information about the specific platforms used.

From the reviewed studies, several implementation challenges such as data validity, system interoperability, and user-centered design are indirectly addressed. For example, the use of GIS with integrated data layers helps improve data validity through geospatial verification. Meanwhile, some studies demonstrate efforts toward system interoperability by combining various data sources, although such practices are not yet standardized. The lack of platform transparency and technical documentation in many articles also reflects the need for improved dashboard implementation practices. Regarding user-friendly design, few studies discuss usability testing, indicating a gap that future research must fill to ensure dashboards are accessible to diverse stakeholders.

Additionally, infectious diseases like dengue, tuberculosis, and diarrhea are among the most commonly mapped conditions, emphasizing the importance of dashboards in supporting continuous monitoring for diseases with spatial-temporal dynamics. However, advanced technologies such as AI, IoT, and tools like Leaflet JS remain underutilized. There is also limited focus on non-communicable diseases, which represent a growing public health concern.

Therefore, we recommend the development of reporting standards that require authors to disclose platform specifications, spatial data validation methods, system integration strategies, and usability considerations. Such standards will enhance reproducibility, transparency, and innovation. Future research should also explore dimensions like geographic disparities, data source variety, and user experience to support a more context-aware, reliable, and user-centered disease mapping ecosystem.

While this ensures contextual relevance to Indonesian research, relying solely on Garuda may limit exposure to international advancements in technologies like real-time analytics or AI-driven dashboards. Therefore, future research is encouraged to complement Garuda with international databases such as PubMed or Scopus to enhance the diversity of perspectives and enable more robust cross-comparative analysis.

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