Development of a Dengue Information System (DIS)

Wetthasinghe Arachchige Udana Kashyapa Wetthasinghe

Master’s thesis – Phase 1

February 2025

Information And Communication Technology Master’s Degree Full Stack Software Development

Wetthasinghe Arachchige Udana Kashyapa Wetthasinghe

Development of a Dengue Information System (DIS)

Jyväskylä: Jamk University of Applied Sciences, February 2020, 33 pages.

Degree Programme in Full Stack Software Development. Master’s thesis.

Permission for open access publication: Yes

Language of publication: English

Abstract

Dengue fever, a mosquito-borne viral infection, has become a significant public health threat in Sri Lanka, with thousands of cases reported annually. Despite ongoing control measures, the epidemic persists due to environmental and socio-economic factors such as climate variations, population density, and inadequate public awareness. To address these challenges, this research presents the development of a Dengue Information System (DIS)—a data-driven platform designed to enhance dengue prevention and control efforts.  
  
The DIS integrates real-time data visualization and predictive modeling to provide timely insights into dengue transmission patterns. It allows researchers to publish and test forecasting models, while policymakers and the public can access up-to-date dengue data, including statistical trends, density maps, and hotspot analyses. A key feature of the system is its plug-and-play architecture, enabling the flexible integration of various forecasting models to enhance outbreak prediction and risk assessment. Furthermore, the DIS promotes public engagement and collaboration by facilitating community involvement in dengue mitigation efforts.  
  
By offering a centralized, interactive platform for data analysis, public awareness, and decision-making, the DIS aims to strengthen dengue control strategies in Sri Lanka. The expected outcome is a sustainable system that empowers health authorities, researchers, and communities to make informed, data-driven decisions, ultimately reducing the disease burden and improving public health preparedness.

Keywords

Dengue Information System, Data Visualization, Predictive Modeling, Forecasting Models, Plug-and-play Architecture, System Integration, API-based architecture, Public Health Informatics

Contents

[1 Introduction 4](#_Toc191026202)

[1.1 Background of the Research 4](#_Toc191026203)

[1.2. Problem Statement 5](#_Toc191026204)

[**1.1.1.** **Literature Gap** 5](#_Toc191026205)

[**1.1.2.** **Methodological Gap** 5](#_Toc191026206)

[**1.1.3.** **User-Centered Design Gap** 6](#_Toc191026207)

[1.3. Research Questions 6](#_Toc191026208)

[1.4. Research Objectives 6](#_Toc191026209)

[1.5. Significance of the Study 7](#_Toc191026210)

[1.6. Research Scope 8](#_Toc191026211)

[2 LITERATURE REVIEW 9](#_Toc191026212)

[2.1 Introduction 9](#_Toc191026213)

[2.2. Healthcare Information Systems for Infectious Disease Management 9](#_Toc191026214)

[2.3. Mathematical Models for Dengue Forecasting 11](#_Toc191026215)

[2.3.1. Mathematical Model Development Best Practices 13](#_Toc191026216)

[2.4. Compatibility of MERN Stack for the web development 15](#_Toc191026217)

[2.5. UI/UX Concepts 18](#_Toc191026218)

[2.6.Summary 20](#_Toc191026219)

[3 METHODOLOGY 22](#_Toc191026220)

[3.1 Introduction 22](#_Toc191026221)

[3.2. Research Design 22](#_Toc191026222)

[3.3. Software Development Approach 23](#_Toc191026223)

[3.4. Data Collection 25](#_Toc191026224)

[References 26](#_Toc191026225)

Figures

[Figure 2‑1 MERN Stack Architecture 16](#_Toc191026343)

[Figure 3‑1 REST API Structure 23](#_Toc191026344)

# Introduction

## Background of the Research

Dengue fever, a viral disease. transmitted by Aedes mosquitoes has emerged as a. critical public health issue in tropical and subtropical regions worldwide. Among these, Sri Lanka faces a particularly severe burden, with recurrent outbreaks leading to significant health and economic consequences (Bhatt et al., 2013). The complexity of dengue transmission, influenced by climatic factors, urbanization, and human. behaviour, makes effective. disease control and prevention. a formidable challenge (Hii et al., 2012). Consequently, there is an. urgent need for. innovative, data-driven approaches. to enhance management and mitigation. of dengue in Sri Lanka (Tissera et al., 2020).

Dengue outbreaks in. Sri Lanka have highlighted the. importance of timely and accurate. forecasting of disease. incidence for effective. public health interventions (Hales et al., 2002). The seasonal patterns. of dengue, shaped by variables. such as rainfall, temperature, and population density, necessitate sophistication. analytical tools for understanding. and predicting its spread. Traditional public health strategies, while essential, often fall short in. integrating the multifaceted data. required for proactive disease management (Ismail et al., 2022). This underscores them. critical need for comprehensive. system that combines epidemiological, environmental, and demographic. data to support informed decision-making. and targeted interventions. Existing studies on dengue. forecasting, though insightful, are often. constrained by their focus on. specific geographic contexts and limited scalability (Tissera et al., 2020). These limitations hinder. broader applicability. of their findings, leaving a gap in the availability. of robust, adaptable solutions for. combating dengue at the national level. Addressing this gap requires. leveraging modern. technologies, such as data visualization. and predictive analytics, to develop a system. that not only analyzes. past trends but also provides. actionable insights for the future.

This research aims to develop. a Dengue Information System (DIS) tailored to the. unique epidemiological and. environmental context of Sri Lanka. The development of a DIS is expected to offer several benefits, including timely access to dengue-related data, efficient tracking of cases, and informed decision-making by healthcare authorities. Furthermore, effective data visualization techniques will enhance the interpretation of complex data, enabling stakeholders to identify trends and allocate resources efficiently. Usability is a crucial aspect of this project, with a focus on creating an intuitive interface for healthcare professionals and accessible features for public users.

In contrast to conventional. public health approaches, the DIS will bridge. the gap between complex data interpretation. and practical applications. By transforming raw data into. meaningful insights, it will facilitate a proactive. rather than reactive. response to dengue outbreaks. Through the development. of the DIS, this research not only contributes. to dengue mitigation efforts. in Sri Lanka but also serves. as a model for others. dengue-endemic regions. It underscores the importance. of integrating technology and data. analytics into public. health practices, paving the way for innovative. solutions to address complex. global health challenges.

Additional

## 1.2. Problem Statement

There is a significant. amount of medical research. on dengue prevention and. control, but not all of these. studies achieve 100% success, and many. of them take a reactive. rather than a. proactive approach. While reactive measures. focus on responding to outbreaks. once they occur, a proactive approach. emphasizes preventing outbreaks. before they reach. critical levels. Here, we discuss a proactive. approach as a solution for. the gaps highlighted in. this research.

* + 1. **Literature Gap**

Existing research on dengue prevention. and control has predominantly focused on the development and validation. of mathematical forecasting models, aiming to predict outbreaks based on climatic, demographic, and epidemiological data(Ismail et al., 2022). However, these studies often lack practical implementation in systems. that integrate real-time data visualization and user accessibility, particularly in regions heavily influenced by dengue, such as Sri Lanka(Tissera et al., 2020). While some systems provide basic visualization tools, there is limited focus on dynamic and real-time data visualization using sustainable and system specific visualization and GIS techniques(*National Dengue Control Unit*, n.d.). And there is lack of comprehensive platforms that combine data visualization. with forecasting model integration tailored to local public health needs. Furthermore, existing systems rarely prioritize user-centered design to enhance usability and decision-making for public health officials(Campbell et al., 2015). This gap underscores the need. for a holistic Dengue Information System (DIS) that not only integrates. proven forecasting models but also prioritizes user engagement and. accessibility to drive effective dengue prevention strategies.

* + 1. **Methodological Gap**

In terms of methodology, the current research fills a. significant gap by focusing on the architecture development for integrating dengue forecasting. models with real-time data visualization(Johansson et al., 2019). Most previous studies have concentrated on developing individual forecasting models or analyzing. historical data without considering the technical. challenges of building a comprehensive system that can handle both data input and output seamlessly. The methodology proposed in this research is unique.in its .focus on API-based integration, which allows for the plug-and-play feature that accommodates. future expansion and the addition of new forecasting models(Hales et al., 2002).

* + 1. **User-Centered Design Gap**

The user-centered design approach adopted.in this .study ensures that the system is not only technically. sound but also tailored to the needs of its users, addressing both quantitative and qualitative aspects of user experience(Campbell et al., 2015). This approach has been largely absent. in existing literature, which tends to prioritize either. technical model development or general. system architecture without a specific .focus on enhancing user. interaction and system accessibility.

## 1.3. Research Questions

1. How can a software solution effectively enhance healthcare services in dengue management through the integration of a Dengue Information System (DIS)?
2. What are the most effective data visualization techniques for presenting statistical insights in a dengue information system?
3. What are the best practices for integrating an additional service into a MERN-based web application using REST API, ensuring seamless interoperability in healthcare systems?
4. What are the key usability factors that influence the user-friendliness of a dengue information system for healthcare professionals and the public?

## 1.4. Research Objectives

The main objective of this research is to develop .a Dengue Information System (DIS) tailored for the Sri Lankan context, providing an .integrated platform for health policymakers, researchers, and the public to .coordinate efforts in preventing dengue epidemics. The specific objectives are as follows:

* **Enhance Public Awareness:** Develop and implement a software-based **Dengue Information System (DIS)** that integrates key healthcare services, facilitating **efficient data collection, analysis, and decision-making** in dengue management.
* **Integrate Predictive Models:** Incorporate advanced dengue forecasting .models into the DIS platform to analyze .historical data, identify patterns, and predict .potential outbreaks. This will support proactive decision-making.
* **Ensure Seamless System Integration:** Develop and optimize **REST API-based service integration** within the MERN-based web application, ensuring smooth interoperability between different system components for healthcare applications.
* **Strengthen Public Engagement:** Identify **key usability factors** (e.g., accessibility, ease of navigation, and user experience) to design a user-friendly system that meets the needs of both healthcare professionals and the general public.

## 1.5. Significance of the Study

Globally, the fight against vector-borne diseases like dengue has seen. significant technological advancements, including the use. of geographic information systems (GIS), artificial intelligence, and predictive analytics. These innovations have transformed. the way public health challenges are understood .and addressed, allowing for more targeted and. proactive measures(Johansson et al., 2019). Sri Lanka, however, has yet to fully harness the. potential of such Technologies. The development of a DIS, tailored to the countries unique. needs, represents an opportunity to align with global trends and. enhance local capabilities(Tissera et al., 2020). Furthermore, as dengue continues to burden. healthcare systems, disrupt economies, and endanger lives, this initiative contributes to the. broader discourse on sustainable public. health practices in climate-sensitive regions.

The study's contribution extends. beyond technical architecture by improving the. accessibility and usability of predictive. tools for public health planning. Through its emphasis on user experience, the DIS ensures that the. system is intuitive, practical, and adaptable, making it a valuable tool. for both instant decision-making and long term strategic planning. This study also paves. the way for future research. by offering a flexible platform. for researchers to test, refine, and share their forecasting models. The integration of existing models into a comprehensive. system makes it easier for dengue research to evolve and. for new findings to be disseminated.

## 1.6. Research Scope

The scope of this research focuses on the development of a Dengue Information System (DIS) integrated with existing mathematical. forecasting models to enhance dengue prevention and control efforts in Sri Lanka. The study primarily addresses the technical architecture required to integrate real-time data visualization. with dengue forecasting models, emphasizing the use of API technology for seamless system functionality. While the research does not focus on the development or testing of new. forecasting models, it aims to provide a flexible platform where researchers can integrate and visualize their models' outputs effectively. The system will incorporate various. data types, such as climate and population data, to better understand the factors influencing dengue transmission. Additionally, the research will focus on the user-centered design of the DIS, ensuring that the system is intuitive .and accessible to public health officials and researchers. The study's scope is limited to the design and .implementation of the DIS architecture, excluding in-depth modeling or data .collection of dengue cases, with the aim of providing a tool for future research .and real-time decision-making in dengue control.

# LITERATURE REVIEW

## Introduction

This chapter reviews. past studies to provide an understanding. and an overview of **mathematical modeling. and digital health solutions. for dengue forecasting and management**. It seeks to identify. the **best practices in. developing Python-based mathematical models**, the **role of healthcare. information systems. in disease surveillance**, and **effective data. visualization techniques for. presenting statistical insights**. It then explores how. **integrating additional services. into a Dengue Information System (DIS)** enhances. healthcare decision-making and. outbreak prevention. As a contribution to the existing. research, this chapter highlights **gaps. in past studies** on dengue. surveillance, forecasting methodologies, and healthcare. system interoperability, with a focus on both. **local and global contexts**.

## 2.2. Healthcare Information Systems for Infectious Disease Management

Unpredictable infectious disease epidemics can have negative, long-lasting impacts on both society and human health(Gubler, 2002). For instance, the West African Ebola outbreak in 2014–15 had a negative impact on healthcare systems and public health, with the latter being exacerbated by the deaths of healthcare workers and the reallocation of limited resources away from essential health services(Heesterbeek et al., 2015). More recently, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)-caused coronavirus disease (COVID-19) outbreak in December 2019 resulted in a significant death toll and worldwide economic consequences, the entire magnitude of which is still unknown. Because of the significant strain on health and social care systems, as well as the isolation and lockdown measures implemented to restrict its spread, COVID-19 also has societal repercussions for both people and society(Ah et al., 2011). Future infectious disease outbreaks' timing and features, such as their route of transmission, incubation time, and case fatality rate, are hard to forecast. Nevertheless, scientists point out that despite these uncertainties, new global and regional infectious disease epidemics are likely to occur and may have comparable long-term and major effects(Barreto et al., 2006).

To address these challenges, digital health solutions have evolved significantly, offering real-time disease tracking, predictive modeling, and data-driven decision-making(Heesterbeek et al., 2015). Several digital platforms, such as HealthMap, ProMED, and DHIS2, have been developed to track disease outbreaks in real-time. These systems use machine learning, artificial intelligence (AI), and big data analytics to identify patterns and predict potential outbreaks(El Morr et al., 2024). Furthermore, mobile-based applications have been increasingly used for community-based reporting and early warning systems, empowering the public to contribute to disease surveillance efforts.

Among. infectious diseases, dengue remains a major. and growing public health threat. worldwide. The need for better. dengue monitoring is clear. given that the most recent. study estimated that 390 million illnesses. occur worldwide each year(Runge-Ranzinger et al., 2014). In order to identify. outbreaks and track illness. changes over time, dengue monitoring. is crucial. Outbreak signals are. especially crucial for mobilising vector. control and rearranging. or priming healthcare delivery. facilities in anticipation of a spike. in suspected cases, which will enable. prompt responses. Effective dengue routine prevention. is seldom realized, especially in high-density urban settings, despite the potential effectiveness. of vector control techniques. in theory(Ismail et al., 2022).

Several nations have used. Dengue Information Systems (DIS) to enhance disease. response and surveillance. GIS-based dengue surveillance. systems have been established. in nations like Singapore, Thailand, and Brazil, allowing authorities to efficiently. allocate resources and visualise patterns. of transmission(Bhatt et al., 2013). For instance, Singapore's Dengue Cluster. Map helps locals take preventative. action by providing real-time data. on dengue hotspots(Ismail et al., 2022). A complex adaptive health. system may benefit from. the use of health information. technology (IT), but there may. also be unforeseen repercussions. and new difficulties(Heesterbeek et al., 2015). One of the biggest challenges. now is making. sure health IT is safe to use. in clinical settings. As the scientific community. works to securely design, install, and maintain. the new digital infrastructure, they are trying. to get a deeper understanding. of the intricate relationships that. exist between. people, processes, the environment, and technology. Health IT can make. care safer, according to recent data. from in-patient settings(Ash et al., 2004), but it can. also lead to new safety. problems, some of which appear years after the technology is put into place(Nebeker et al., 2005).

Healthcare Information. Systems play a vital role in infectious. disease surveillance, outbreak prediction, and response. planning. While existing dengue. information systems have. proven effective in monitoring. and predicting outbreaks, challenges such. as interoperability, infrastructure limitations, and data security. must be addressed. Adopting best practices. in digital health system. implementation can enhance. disease management efforts, ultimately reducing. the burden of dengue and other. infectious diseases.

### 2.3. Mathematical Models for Dengue Forecasting

The integration of. mathematical models into. web-based systems. has gained significant. traction in public. health informatics, particularly for. forecasting outbreaks of. vector-borne diseases. such as dengue(Aguiar et al., 2022). Dengue forecasting. models provide critical. insights into potential outbreaks. by analyzing epidemiological. and environmental data(Din et al., 2021). This review focuses. on Python-based.. models, with a particular.. emphasis on the Gaussian. Copula model, and examines. their integration into. web applications. developed using the. MERN stack(Ogunlade et al., 2023a). The discussion highlights. existing research on. mathematical modeling, data handling. techniques, visualization. strategies, and identifies. research gaps related. to the practical application. of these models. in web-based systems.

Mathematical modeling serves. as a fundamental tool in. infectious disease. forecasting. Several approaches have. been utilized to predict. dengue outbreaks, including statistical. models, machine learning. techniques, and hybrid. approaches(Edussuriya et al., 2021). Gaussian Copula. models, for instance, have demonstrated. efficacy in capturing. dependencies between. multiple variables such. as temperature, rainfall, and. historical dengue. case data(Othus & Li, 2010). These models use. a copula function to. join marginal distributions into. a joint distribution, which is particularly. useful for multivariate. time-series analysis. In comparison, statistical. models like ARIMA (Auto-Regressive. Integrated Moving. Average) have also. been applied extensively. for dengue forecasting. by identifying trends. and seasonality. in historical. datasets(*Autoregressive Integrated Moving Average (ARIMA)*, n.d.). However, these traditional. models often struggle. to accommodate non-linear relationships. Machine learning models, such as Random. Forests and Gradient Boosting, have shown promise. in addressing this challenge. by capturing complex interactions. within the data. Hybrid models, combining. statistical and machine. learning techniques, further. enhance prediction accuracy while. maintaining interpretability. Despite the effectiveness. of these models in standalone. applications, their integration. into web-based systems. remains underexplored in. the literature(Ogunlade et al., 2023a).

Python has emerged. as a preferred programming. language for mathematical modeling. due to its extensive ecosystem. of scientific libraries(*Introduction to Mathematical Modeling and Computer Simulations*, n.d.). Libraries such as. NumPy and SciPy are. essential for numerical. computations, while specialized. libraries like copulas facilitate. the implementation of Gaussian. Copula models(Othus & Li, 2010). Additionally, frameworks like. Flask and FastAPI provide. efficient mechanisms for. exposing Python-based models. as REST APIs, enabling seamless. integration with. web applications(Edussuriya et al., 2021). The literature indicates. that although these. tools are widely. available, their application in. disease forecasting, particularly. for dengue, is not. well-documented. Most studies focus. on model development. and performance. evaluation, neglecting the computational. techniques and architectural. considerations necessary. for practical deployment(Din et al., 2021).

Data handling techniques. play a critical role in dengue. forecasting systems. Epidemiological data, typically. obtained from national. health authorities, provides historical. case records categorized by. variables such as region. and age group(Ogunlade et al., 2023b). Environmental data, including. temperature, rainfall, and. humidity, acts as key predictors. of mosquito-borne. disease patterns. Time-series datasets capturing. these seasonal variations. are essential for accurate. forecasting(Yoda et al., 2024). Python libraries like Pandas. and PySpark are commonly. employed for preprocessing. these datasets into. formats suitable for. model consumption. However, research. seldom addresses the. challenges associated. with efficient data. pipelines when integrating. such models into web-based. applications(Edussuriya et al., 2021). The dynamic nature. of epidemiological data. demands robust workflows. to ensure real-time updates. and accuracy.

Visualization is another. crucial component in the. presentation of. dengue forecasts. Effective visualization tools. enable healthcare professionals. to interpret model outputs. easily and make informed. decisions(Martheswaran et al., 2022). Frontend libraries such. as D3.js and Chart.js are frequently. employed for creating interactive. heatmaps, time-series graphs, and. geographic maps(Yoda et al., 2024). Google Charts API. also provides accessible. options for generating. charts with minimal. configuration. On the backend, Python libraries. like Matplotlib and Seaborn. are valuable during model. development but are. less suitable for. dynamic, web-based. visualizations. The literature underscores. the importance of presenting. predictions in an intuitive. format but rarely discusses. the integration challenges. when synchronizing. backend model computations. with frontend interfaces(Din et al., 2021).

Integrating Python-based. mathematical models into. MERN stack applications. involves several steps. Typically, the model. is exposed via a REST API. using Flask or FastAPI(Yadav et al., 2024). The React frontend consumes. this API using libraries. such as Axios, fetching predictions. in JSON format to render. interactive charts. using D3.js. MongoDB serves as the. primary database for. storing both historical data and. model predictions, while. Node.js and Express.js handle. server-side logic(Yoda et al., 2024). Despite the availability of these. integration techniques, the research. landscape lacks comprehensive. case studies that. demonstrate successful. implementations of such. architectures in public health. applications(Lu et al., 2025).

File formats play. a pivotal role in data exchange. within dengue forecasting. systems. Input datasets are often. stored in CSV or Excel formats. for ease of use in. analytical tools(Bafna, 2022). JSON, however, has become. the de facto standard. for web integration due. to its compatibility with. JavaScript-based frontends. Outputs are similarly. formatted in JSON to facilitate. seamless communication. between the Python. model and the MERN. application(Malewade & Ekbote, n.d.). While existing literature. discusses data formats. in various domains, the role. of file formatting in dengue. forecasting systems is seldom. analyzed, despite its. significance in ensuring efficient. data transfer and model. performance.

Several research gaps. persist despite the advancements. in mathematical modeling. for dengue forecasting. One major gap is. the limited focus on. integrating sophisticated models. like Gaussian Copula into. practical, web-based systems. Most studies. emphasize theoretical model. performance, neglecting. the computational techniques. required for real-time. applications. Additionally, the literature. provides insufficient insights. into optimized data handling. workflows that bridge. the gap between. backend computations and. frontend visualizations. The absence. of standardized frameworks. for deploying predictive. models within scalable. web architectures further. hinders the adoption. of these forecasting systems. in healthcare settings(Ogunlade et al., 2023b).

While mathematical models. like the Gaussian Copula. have shown promise in. dengue forecasting, their integration. into web applications remains. an underexplored domain(Othus & Li, 2010). Python's extensive library. support and the MERN. stack's flexibility offer significant. potential for building. such systems(Yadav et al., 2024). However, addressing. the identified research. gaps, particularly regarding. computational techniques, data. handling workflows, and. standardized deployment. frameworks, is essential. for advancing the. field and enhancing. public health preparedness. for dengue outbreaks.

### 2.3.1. ****Mathematical Model Development Best Practices****

Developing mathematical. models for disease forecasting. requires a structured approach. that ensures accuracy, efficiency, and. scalability. In the context of **dengue. prediction and surveillance**, mathematical. models must integrate. diverse data sources, utilize efficient. computational methods, and adhere. to standardized formats. to ensure interoperability(Aguiar et al., 2022). Python has emerged. as a **leading tool for mathematical. modeling** due to its. extensive libraries, flexibility, and ability to handle large-scale. epidemiological data. Researchers in both. **mathematics and computational. sciences** follow distinct. yet complementary formats for. model development, and integrating. these approaches enhances. the robustness of **dengue. forecasting models**(Chanprasopchai et al., 2018).

In **traditional mathematical. modeling**, equations are often. represented using **LaTeX** for documentation, while symbolic. computation tools like. **MATLAB, Mathematica, and Maple** are. used for solving differential. equations and running simulations. Mathematical users. typically work with. formats such. as **CSV (Comma-Separated Values) or Excel files** for data. storage and input(Din et al., 2021). These formats, while. widely used, may lack interoperability. with modern **data-driven and. AI-based models**, limiting their. applicability in large-scale computational. forecasting.

Python users, on the other. hand, adopt **structured formats.** such as **JSON (JavaScript Object Notation), NumPy arrays, and. Pandas DataFrames** for storing, processing, and sharing. model data(Ogunlade et al., 2023a, pp. 2010–2020). JSON has become a preferred. format due to its lightweight. structure, ease of readability, and compatibility with **REST APIs** for. integrating additional services. In the context. of a **Dengue Information System (DIS)**, Python-based models. using JSON allow seamless. integration with real-time data sources, such as **government. health databases, satellite weather. data, and epidemiological. surveillance systems**(Din et al., 2021). This ensures. that dengue forecasting models. remain dynamic and adaptable to changing. outbreak patterns.

Python-based mathematical. models are considered the **gold standard.** in computational epidemiology due to their. scalability, ability to handle. big data, and integration with machine. learning techniques(Karasinghe et al., 2024). Popular frameworks such. as **Scikit-learn, TensorFlow, and PyTorch** facilitate advanced predictive. modeling, while **SymPy** enables symbolic computation. and differential equation solving. Additionally, Python supports. **spatial epidemiological analysis.** through libraries like **GeoPandas and. Folium**, allowing researchers to **visualize. and predict dengue outbreaks. at a granular level**(Side et al., 2018).

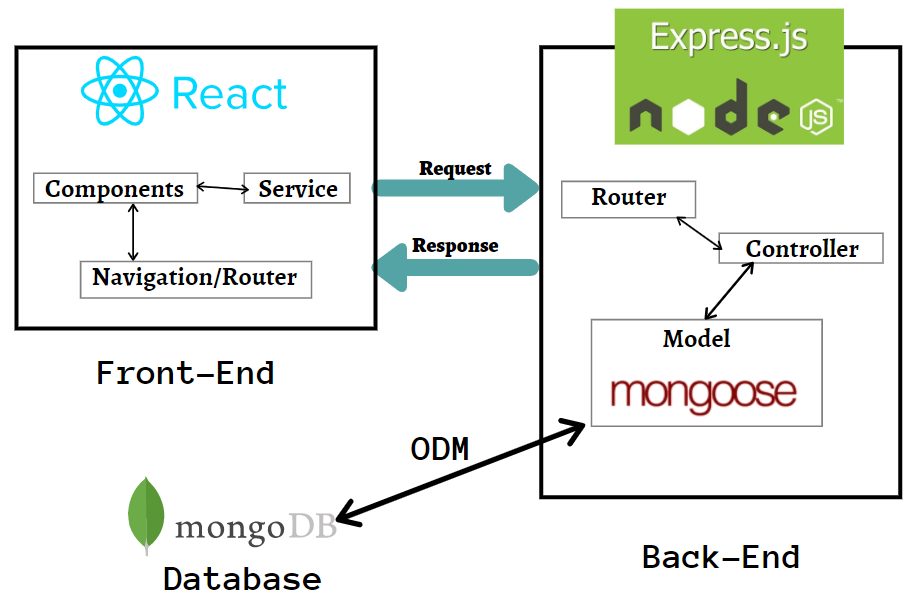
By adopting Python-based models. with **JSON formatting**, dengue forecasting. systems can achieve. **interoperability, real-time data. processing, and efficient. integration with healthcare. infrastructures**(Ah et al., 2011). The ability to structure. epidemiological data in a universally. accepted format enhances. Collaboration. between mathematicians, epidemiologists, and software. engineers, leading to more. **effective and actionable. disease prediction models**(Hoyos et al., 2021). As the field. advances, embracing these best practices. ensures that **dengue surveillance. and prevention strategies remain. data-driven, accurate, and scalable**.

## 2.4. Compatibility of MERN Stack for the web development

In recent years, the use. of the MERN stack has. become increasingly popular. in web development. This technology. stack consists of MongoDB, Express.js, React, and. Node.js. Each component. of the MERN stack. has a specific function, and together. they provide a full-stack development. environment that. allows developers to create. web applications efficiently(Prajapati, 2023). In this paper, we will discuss why the MERN stack. is widely used and its advantages. over previous technologies. such as HTML, CSS, SQL, and NoSQL. MongoDB is a popular. NoSQL document-oriented database. that stores data in flexible JSON-like documents, making it easy. to scale and maintain(Bafna, 2022).

Express.js is a lightweight. and flexible Node.js web application. framework that provides. an easy-to-use API for building. web applications. React is a JavaScript library. for building user interfaces that allows. developers to create reusable. components and manage. complex application states(Liu et al., 2024). Node.js is a powerful. and efficient JavaScript runtime. environment that allows developers. to build scalable and. high-performance server-side applications. Together, these technologies. provide a full-stack JavaScript solution. for building modern web. applications(Nanaware et al., 2021). The MERN stack allows. developers to leverage. the power of JavaScript on both. the client-side and server-side, providing. a seamless and unified. development experience. It is highly flexible and. customizable, making it suitable for a wide range. of applications, from small-scale prototypes. to large-scale enterprise-level systems(Aguiar et al., 2022).

Figure 2‑1 MERN Stack Architecture



The MERN stack is a powerful. and popular technology. stack for building web applications. The word MERN form. is M for MongoDB E for Express R for. ReactJS and N for NodeJS.

* **MongoDB:** MongoDB is a NoSQL database. that stores data in a flexible. way, JSON-like format called BSON. Used for handling. unstructured or semi-structured. data and for storing the data. of web applications(Malewade & Ekbote, n.d.).
* **Express.js:** Express.js is the backend. server framework in the MERN stack. that provides a robust set. of features for building. web and mobile applications. It simplifies. server-side development. and routing, making it easier to. create APIs and handle. requests and responses(Bafna, 2022).
* **React:** React is a popular frontend. of JS library for building. user interfaces. It allows developers to. create reusable. UI components, making it. easy to build interactive. and dynamic web. applications. Providing a fast. and efficient way to. develop user interfaces(Prajapati, 2023).
* **Node.js:** Node.js is a JS runtime environment. that allows developers. to run JavaScript on server-side. It works with. Express.js to build the backend. MERN applications. Node.js is known for its speed. and scalability, for handling. server-side logics and data retrieval(Malewade & Ekbote, n.d.).

1. **Scalability and Data Management with MongoDB**

MongoDB, a **NoSQL. database**, is well-suited for storing. complex, unstructured, and heterogeneous datasets, such as dengue. case records, climate data, and. GIS-based spatial. information(Bafna, 2022). Unlike relational. databases, MongoDB’s **JSON-like document. storage format** enables flexible. schema design, making it highly. adaptable for integrating. diverse data sources(Malewade & Ekbote, n.d.). Furthermore, its **scalability and distributed. architecture** ensure efficient. handling of large-scale real-time datasets, which is crucial for dengue. forecasting models.

1. **API-Based Data Integration with Express.js and Node.js**

A robust dengue surveillance. system requires **real-time data. collection and dissemination**. Express.js and. Node.js facilitate the development. of **RESTful APIs** that enable. seamless communication. between the front-end (React) and. back-end (MongoDB)(Yadav et al., 2024). This **API-driven architecture** allows. integration with external. data sources, such as **weather APIs, hospital databases, and. machine learning models.** for dengue prediction. Node.js’s **event-driven, non-blocking architecture.** ensures fast data processing, which is essential. for real-time updates and early. warning alerts(Bafna, 2022).

1. **Interactive Data Visualization with React.js**

Effective public health. interventions depend on. clear and intuitive data. visualization. React.js, a component-based. front-end framework, provides dynamic. and interactive dashboards. for dengue data. representation. By integrating. libraries like **Chart.js, D3.js, and Leaflet.js**, React can display **geospatial. maps, real-time graphs, and heatmaps.** of dengue outbreaks(Yadav et al., 2024). This enhances. decision-making for. health authorities by offering. an accessible and user-friendly interface.

By leveraging the MERN. stack, the **Dengue Information System (DIS)** can. efficiently process, visualize, and communicate. dengue outbreak data, ultimately supporting. evidence-based decision-making(Heesterbeek et al., 2015). The stack’s ability to integrate. with **machine learning models, real-time data. streams, and geospatial tools.** makes it a suitable choice for. **enhancing public health preparedness. and response strategies**(Prajapati, 2023). Its scalability ensures. that as dengue surveillance expands, additional functionalities such. as AI-driven risk prediction and automated. reporting can be incorporated. seamlessly. Therefore, the MERN stack is a highly. compatible and effective. solution for building a **modern, web-based dengue. forecasting and monitoring system**.

### 2.5. UI/UX Concepts

Advances in personal computing and information technologies have fundamentally transformed how maps are produced and consumed, as many maps today are highly interactive and delivered online or through mobile devices. UI (user interface) / UX (user experience) describes a set of concepts, guidelines, and workflows for critically thinking about the design and use of an interactive product(CHFP, 2015), map or otherwise. UI/UX is a growing profession in the geospatial industry and broader technology sector(Hevner et al., 2004), with UI/UX designers needed to engage with stakeholders and target users throughout large software engineering and web design projects. This entry reviews the conceptual principles behind UI/UX, emphasizing visual design following other entries in the Cartography & Visualization section and complementing the technologically-oriented User Interfaces entry spanning GIScience in the Programming & Development section(Roth, 2017).

UI and UX are not. the same, separated in. their focus on interfaces versus interactions. An interface is a tool, and for digital mapping this tool enables the user to manipulate maps and their underlying geographic information(de Lima et al., 2016). An interaction is broader than the interface, describing the two-way questionanswer or request-result dialogue between a human user and a digital object mediated through a computing device(Roth, 2017). Therefore, an interaction is both contingent—as the response is based on the request, creating loops of interactivity—and empowering—giving the user agency in the mapping process with changes contingent on his or her interests and needs(de Lima et al., 2016).

Today, UI/UX design. requires consideration of use. cases beyond exploratory. geovisualization and users beyond. expert researchers. Interaction allows users to. view multiple (sometimes all) locations and map. scales as well as customize the. representation to their interests. and needs(Lwin et al., 2019). Interaction also empowers. users in the cartographic. design process, improving accessibility to geographic information. and dissolving traditional boundaries. between mapmaker and. map user (see Cartography & Power)(CHFP, 2015). Increasingly, interaction enables. geographic analysis, linking computing to cognition. in order to scale the human. mind to the complexity of the. mapped phenomenon or process (see Geovisual Analytics). Accordingly, interaction has been. suggested as a fundamental complement. to representation in cartography, together organizing. contemporary cartographic scholarship. and practice(Roth, 2017). For discussion of additional. influences on UI/UX design in cartography. and visualization, see Geocollaboration, Usability Engineering, and Web Mapping.

A well-designed. **User Interface (UI) and User Experience (UX)** is critical for the. effective functioning of a **Dengue Information System (DIS)**(Nicanor et al., 2024). Public health. officials, researchers, and policymakers. rely on such systems. for real-time dengue surveillance, forecasting, and. decision-making. **An intuitive and user-friendly. interface ensures that complex. epidemiological data is accessible, understandable, and. actionable**(Mahotra et al., 2024)**.**

1. **Importance of UI/UX in Public Health Systems**

UI/UX design in health. information systems directly. impacts **user engagement, data comprehension, and response. efficiency**(Roth, 2017). Poorly designed systems. with cluttered interfaces and difficult navigation. can hinder decision-making, delaying critical. interventions. A **well-structured. UI** enhances usability by. providing clear. data visualizations, intuitive workflows, and seamless. navigation, while a **thoughtfully. designed UX** ensures that. users can interact with. the system. efficiently, reducing cognitive load(Lwin et al., 2019).

1. **UI Design Principles for a Dengue Information System**

A visually effective. **UI for a dengue forecasting. system** should adhere. to the following principles:

* **Consistency** – Uniform design. elements (color schemes, fonts, icons) improve. recognition and. ease of use(Roth, 2017).
* **Hierarchy & Clarity** – Important information, such as .dengue outbreak alerts .and hotspot locations, should be .displayed prominently(Lwin et al., 2019).
* **Data Visualization** – Interactive **charts, heatmaps, and .GIS-based maps** should .be used to present .epidemiological data in .an understandable format(Din et al., 2021).
* **Responsiveness** – The system should .be accessible on various .devices (desktop, tablet, mobile) to support. field use(Mahotra et al., 2024).
* **Minimalism** – Avoiding unnecessary. elements ensures a clean. and professional interface that facilitates. quick decision-making(CHFP, 2015).

1. **UX Design Strategies for Effective Disease Surveillance**

A **Dengue Information. System (DIS)** must focus on user. experience to **enhance. efficiency and usability**:

* **User-Centered Design (UCD):** The system should. be designed based. on **user needs**, ensuring that public. health officials can quickly. interpret and act on. dengue forecasts.
* **Interactive Dashboards:** Real-time updates and. custom filters should. allow users to explore **dengue. trends, risk factors, and intervention. strategies** dynamically.
* **Seamless Navigation:** A **well-structured. menu and search functions.** improve accessibility, allowing users. to retrieve reports and. forecasts effortlessly.
* **Feedback Mechanisms:** Including alerts and. notifications for emerging. outbreaks ensures timely responses. and enhances situational awareness.

1. **UI/UX in the MERN Stack Implementation for DIS**

For a web-based **Dengue. Information System**, the. MERN stack (MongoDB, Express.js, React, Node.js) can effectively. support UI/UX improvements(Lwin et al., 2019):

* **React.js for UI Components:** Enables. modular, reusable components. for a consistent and interactive. interface.
* **Data Visualization Tools: D3.js, Chart.js, and Leaflet.js** help create. **real-time epidemic maps, trend graphs, and. statistical reports.**
* **Responsive Design with Tailwind CSS or Material-UI:** Ensures adaptability. across different devices.

An effective UI/UX design. enhances the usability and. impact of a **Dengue Information System**, ensuring. that public health officials. can **access, interpret, and act on dengue. forecasts efficiently**. By integrating UI/UX best practices. with **modern web technologies**, the system can. provide a **seamless, interactive, and. data-driven experience**, ultimately improving. dengue surveillance and outbreak. prevention efforts.

## 2.6.Summary

The literature review. explores various **key components.** essential for developing an effective. **Dengue Information. System (DIS)** tailored. for Sri Lanka. It integrates research. on **healthcare information systems, mathematical. models, MERN-based web. development, and UI/UX design** to enhance dengue. forecasting and management.

The **first section** highlights. the role of **healthcare information. systems** in infectious disease. management. Previous outbreaks, such as. **Ebola and COVID-19**, have demonstrated. the importance of **real-time. disease tracking, predictive. modeling, and digital health. solutions**. Dengue surveillance, particularly. in **high-density urban. areas**, requires **GIS-based monitoring. systems** for resource allocation and. intervention planning.

The second section examines Python-based model integration protocols, techniques, and best practices for dengue forecasting. The literature review reveals that while many researchers employ advanced libraries such as Pandas, NumPy, SciPy, TensorFlow, and Keras for developing standalone forecasting models, there is a notable gap in addressing computational and software integration aspects. Most studies, particularly those not directly related to computer science fields, focus on model accuracy rather than implementation details or integration strategies. The review identifies that researchers commonly use Pandas for data handling and NumPy for numerical computations, with libraries like copulas being utilized for implementing Gaussian Copula models. However, discussions on specific data structures and integration techniques are often limited. Many researchers rely on built-in visualization packages like Matplotlib to present results, which may not be optimal for web-based applications. The literature introduces API-based integration methods as a potential solution for incorporating Python models into web systems, though best practices in this area are not well-established. This study aims to leverage existing techniques with relevant optimizations and address major gaps in integration practices. By focusing on efficient data handling workflows, API-based model deployment, and web-friendly visualization techniques, this research seeks to bridge the divide between standalone mathematical models and practical, scalable web applications for dengue forecasting.

The **third section.** discusses the **MERN stack (MongoDB, Express.js, React, and Node.js)** as a suitable. platform for developing. the **web-based DIS. MongoDB** handles. large epidemiological. datasets, **Express.js and Node.js** facilitate API-based data. integration, and **React.js** supports interactive. data visualization. The **final section.** explores **UI/UX best practices** to ensure. the system is **user-friendly and accessible.** for healthcare professionals and. the public. A well-designed UI/UX enhances. **data interpretation, outbreak. alerts, and decision-making efficiency**. By combining these components, the DIS will provide **real-time, data-driven insights** for dengue prevention and control.

# METHODOLOGY

## Introduction

This chapter outlines the. research methodology adopted. for the development. of a Dengue Information System (DIS). The methodology details the. research design, software development. approach, data collection methods, and. evaluation strategies. The study follows. a research-based software. development approach, integrating the MERN stack. for the main web application and Python for an additional service, which will be. deployed and connected through a REST API. The research adopts. **Design Science Research (DSR)** methods, which. focus on creating and. evaluating innovative. artifacts, such as the. DIS, to address practical. problems. DSR emphasizes the. iterative design process, ensuring that. the system is continuously refined. based on user feedback. and real-world testing. This approach. combines both the. development of the system. and the creation. of knowledge, contributing to. the academic field. of health informatics and. improving dengue management. practices.

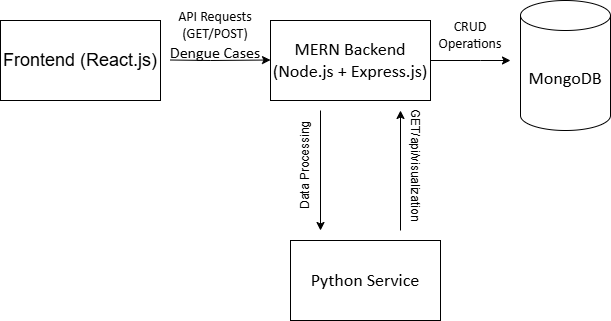
## 3.2. Research Design

For the research design. in the methodology chapter, a mixed-methods. approach can be adopted, combining both qualitative. and quantitative techniques to. comprehensively address the. research questions. The primary methodology. will involve software development. following an iterative process, such as Agile, ensuring flexibility. for improvements throughout. the project(Waja et al., 2021). The MERN stack will serve. as the foundation for the main. web application, allowing for responsive. design and a dynamic user. experience, while Python will be used. for the development of a separate. service, focusing on data processing. and analytics for the Dengue. Information System (DIS)(Yadav et al., 2024).

The first phase. of the research will focus. on designing and developing. the web application and. the separate. service, both with integrated. REST API communication to ensure. seamless data exchange(Nicanor et al., 2024). In parallel, relevant data visualization. techniques, such as heatmaps, line charts, and. bar graphs, will be implemented. to present statistical insights. on dengue cases, trends, and locations. These visualization. techniques will be evaluated. based on clarity, ease of understanding, and their effectiveness. in conveying critical information. to healthcare professionals. and the public.

Figure 3‑1 REST API Structure

Source – Author Illustration



To assess the integration. of the separate service with. the MERN-based web application, best practices for. REST API integration will be. reviewed, focusing on secure, efficient, and scalable. communication(Hoyos et al., 2021). The system will. undergo testing for. interoperability, ensuring smooth data. flow between the main application. and additional services.

For the usability. evaluation, a user-centered. design approach will be. followed, involving iterative testing with. healthcare professionals. and the public(Roth, 2017). Feedback will be gathered. through surveys, user interviews, and usability. tests to identify the most. intuitive features and. interfaces, as well as any. barriers to usage. This feedback will be. analyzed to enhance the. system's design, ensuring it is both user-friendly and. efficient for managing. dengue-related healthcare information.

## 3.3. Software Development Approach

1. Requirement Analysis

The methodology for this. research is structured around. the Agile Software Development. Life Cycle (SDLC) to facilitate. iterative development, continuous. feedback, and regular improvements(Erandi et al., 2021). The research will. begin with a comprehensive. Requirement Analysis phase, where a literature. review on existing. dengue management systems. will be conducted to understand current. practices and gaps. Input from healthcare. professionals and public health. experts will be gathered to define. both. functional (e.g., user management, reporting, real-time updates) and. non-functional requirements (e.g., system performance, security, and scalability).

1. System Architecture Design

In the System Architecture. Design phase, the architecture. will be based on the. MERN stack (MongoDB, Express.js, React.js, and Node.js) for the web application(Ilmudeen, 2021). This technology stack. is selected for its scalability. and efficiency, particularly in. handling large datasets. and dynamic user interfaces. Additionally, a Python-based. service will be developed to. handle the statistical analysis. and data visualizations. necessary for the Dengue. Information System (DIS). A REST API will serve as. the communication protocol. between the two systems, ensuring seamless. data exchange. The system will be deployed. on cloud infrastructure, ensuring easy. accessibility and scalability.

1. Implementation

The Implementation phase. will focus on the development. of both frontend and backend. components. The frontend will be. created using React.js to ensure an. interactive and responsive. user experience, while Node.js and Express.js will be. used to handle the backend. processes and manage the data flow(Bafna, 2022). MongoDB will be. employed for data. storage, enabling effective management. of structured data. The Python-based service. will perform advanced data. analytics and generate visualizations, which will be. integrated with the web. application via REST API for. real-time data updates.

1. Testing

In the Testing phase, various. testing methods will be. employed, including unit. testing, integration testing, and usability. testing. Unit testing will. ensure that individual components. function correctly, while integration. testing will verify smooth. communication between. the MERN stack and Python service(Din et al., 2021). Usability testing. will gather feedback from. Professional users. and the public, ensuring the. system is user-friendly. Performance Testing will. assess the system's responsiveness and scalability. under varying loads.

1. Deployment

Finally, the Deployment. phase will involve containerization. using Docker for easy deployment. and scalability. The system. will be hosted on a cloud. service provider such. as AWS, Firebase, or DigitalOcean(Ogunlade et al., 2023a). Monitoring. and logging tools will be. set up to ensure continuous. system maintenance, reliability, and performance. optimization.

## 3.4. Data Collection

The data collection. method for this research. will involve both qualitative. and quantitative approaches(Ranney et al., 2015). Primary data will be. gathered through user feedback. and usability testing. Healthcare professionals. and public users will be. engaged in structured interviews. and surveys to evaluate the. system’s functionality, usability, and data. visualization effectiveness. These participants will provide. insights on the practical use. of the Dengue Information System (DIS), offering valuable. feedback on system. navigation, data presentation, and overall user. experience.

Secondary data will. be collected through a literature. review of existing dengue management. systems, identifying best. practices, common challenges, and gaps in current. solutions. Additionally, system performance. metrics such as response. time, accuracy, and system load. will be monitored during testing. phases to gather quantitative. data on the application’s performance. These data points will. help refine the system's design. and functionality, ensuring it meets. the needs of both healthcare. professionals and the public.

References

Aguiar, M., Anam, V., Blyuss, K. B., Estadilla, C. D. S., Guerrero, B. V., Knopoff, D., Kooi, B. W., Srivastav, A. K., Steindorf, V., & Stollenwerk, N. (2022). Mathematical models for dengue fever epidemiology: A 10-year systematic review. *Physics of Life Reviews*, *40*, 65–92. https://doi.org/10.1016/j.plrev.2022.02.001

Ah, A., M, L., & Cr, W. (2011). Dengue vector surveillance programs: A review of methodological diversity in some endemic and epidemic countries. *Asia-Pacific Journal of Public Health*, *23*(6). https://doi.org/10.1177/1010539511426595

Ash, J. S., Berg, M., & Coiera, E. (2004). Some Unintended Consequences of Information Technology in Health Care: The Nature of Patient Care Information System-related Errors. *Journal of the American Medical Informatics Association : JAMIA*, *11*(2), 104–112. https://doi.org/10.1197/jamia.M1471

*Autoregressive Integrated Moving Average (ARIMA)*. (n.d.). Corporate Finance Institute. Retrieved February 18, 2025, from https://corporatefinanceinstitute.com/resources/data-science/autoregressive-integrated-moving-average-arima/

Bafna, S. A. (2022). Review on Study and Usage of MERN Stack for Web Development. *International Journal for Research in Applied Science and Engineering Technology*, *10*(2), 178–186. https://doi.org/10.22214/ijraset.2022.40209

Barreto, M. L., Teixeira, M. G., & Carmo, E. H. (2006). Infectious diseases epidemiology. *Journal of Epidemiology and Community Health*, *60*(3), 192–195. https://doi.org/10.1136/jech.2003.011593

Bhatt, S., Gething, P. W., Brady, O. J., Messina, J. P., Farlow, A. W., Moyes, C. L., Drake, J. M., Brownstein, J. S., Hoen, A. G., Sankoh, O., Myers, M. F., George, D. B., Jaenisch, T., Wint, G. R. W., Simmons, C. P., Scott, T. W., Farrar, J. J., & Hay, S. I. (2013). The global distribution and burden of dengue. *Nature*, *496*(7446), 504–507. https://doi.org/10.1038/nature12060

Campbell, L. P., Luther, C., Moo-Llanes, D., Ramsey, J. M., Danis-Lozano, R., & Peterson, A. T. (2015). Climate change influences on global distributions of dengue and chikungunya virus vectors. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *370*(1665), 20140135. https://doi.org/10.1098/rstb.2014.0135

Chanprasopchai, P., Tang, I. M., & Pongsumpun, P. (2018). SIR Model for Dengue Disease with Effect of Dengue Vaccination. *Computational and Mathematical Methods in Medicine*, *2018*, 9861572. https://doi.org/10.1155/2018/9861572

CHFP, C. M. (2015, December 15). *User Interface Design and UX Design: 80+ Important Research Papers Covering Peer-Reviewed and Informal Studies*. Mauro Usability Science. https://www.maurousabilityscience.com/blog/important-peer-reviewed-and-informally-published-recent-research-on-user-interface-design-and-user-experience-ux-design/

de Lima, T. F. M., Lana, R. M., de Senna Carneiro, T. G., Codeço, C. T., Machado, G. S., Ferreira, L. S., de Castro Medeiros, L. C., & Davis Junior, C. A. (2016). DengueME: A Tool for the Modeling and Simulation of Dengue Spatiotemporal Dynamics. *International Journal of Environmental Research and Public Health*, *13*(9), 920. https://doi.org/10.3390/ijerph13090920

Din, A., Khan, T., Li, Y., Tahir, H., Khan, A., & Khan, W. A. (2021). Mathematical analysis of dengue stochastic epidemic model. *Results in Physics*, *20*, 103719. https://doi.org/10.1016/j.rinp.2020.103719

Edussuriya, C., Deegalla, S., & Gawarammana, I. (2021). An accurate mathematical model predicting number of dengue cases in tropics. *PLOS Neglected Tropical Diseases*, *15*(11), e0009756. https://doi.org/10.1371/journal.pntd.0009756

El Morr, C., Ozdemir, D., Asdaah, Y., Saab, A., El-Lahib, Y., & Sokhn, E. S. (2024). AI-based epidemic and pandemic early warning systems: A systematic scoping review. *Health Informatics Journal*, *30*(3), 14604582241275844. https://doi.org/10.1177/14604582241275844

Erandi, K., Perera, S., & Mahasinghe, A. (2021). Analysis and forecast of dengue incidence in urban Colombo, Sri Lanka. *Theoretical Biology & Medical Modelling*, *18*, 3. https://doi.org/10.1186/s12976-020-00134-7

Gubler, D. J. (2002). The global emergence/resurgence of arboviral diseases as public health problems. *Archives of Medical Research*, *33*(4), 330–342. https://doi.org/10.1016/s0188-4409(02)00378-8

Hales, S., de Wet, N., Maindonald, J., & Woodward, A. (2002). Potential effect of population and climate changes on global distribution of dengue fever: An empirical model. *Lancet (London, England)*, *360*(9336), 830–834. https://doi.org/10.1016/S0140-6736(02)09964-6

Heesterbeek, H., Anderson, R. M., Andreasen, V., Bansal, S., De Angelis, D., Dye, C., Eames, K. T. D., Edmunds, W. J., Frost, S. D. W., Funk, S., Hollingsworth, T. D., House, T., Isham, V., Klepac, P., Lessler, J., Lloyd-Smith, J. O., Metcalf, C. J. E., Mollison, D., Pellis, L., … Isaac Newton Institute IDD Collaboration. (2015). Modeling infectious disease dynamics in the complex landscape of global health. *Science (New York, N.Y.)*, *347*(6227), aaa4339. https://doi.org/10.1126/science.aaa4339

Hevner, March, Park, & Ram. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75. https://doi.org/10.2307/25148625

Hii, Y. L., Zhu, H., Ng, N., Ng, L. C., & Rocklöv, J. (2012). Forecast of Dengue Incidence Using Temperature and Rainfall. *PLOS Neglected Tropical Diseases*, *6*(11), e1908. https://doi.org/10.1371/journal.pntd.0001908

Hoyos, W., Aguilar, J., & Toro, M. (2021). Dengue models based on machine learning techniques: A systematic literature review. *Artificial Intelligence in Medicine*, *119*, 102157. https://doi.org/10.1016/j.artmed.2021.102157

Ilmudeen, A. (2021). *Design and development of IoTbased decision support system for dengue analysis and prediction: Case study on Sri Lankan context*. https://doi.org/10.1016/B978-0-12-819664-9.00016-8

*Introduction to Mathematical Modeling and Computer Simulations*. (n.d.). Routledge & CRC Press. Retrieved February 18, 2025, from https://www.routledge.com/Introduction-to-Mathematical-Modeling-and-Computer-Simulations/Mityushev-Nawalaniec-Rylko/p/book/9781032095752

Ismail, S., Fildes, R., Ahmad, R., Wan Mohamad Ali, W. N., & Omar, T. (2022). The practicality of Malaysia dengue outbreak forecasting model as an early warning system. *Infectious Disease Modelling*, *7*(3), 510–525. https://doi.org/10.1016/j.idm.2022.07.008

Johansson, M. A., Apfeldorf, K. M., Dobson, S., Devita, J., Buczak, A. L., Baugher, B., Moniz, L. J., Bagley, T., Babin, S. M., Guven, E., Yamana, T. K., Shaman, J., Moschou, T., Lothian, N., Lane, A., Osborne, G., Jiang, G., Brooks, L. C., Farrow, D. C., … Chretien, J.-P. (2019). An open challenge to advance probabilistic forecasting for dengue epidemics. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(48), 24268–24274. https://doi.org/10.1073/pnas.1909865116

Karasinghe, N., Peiris, S., Jayathilaka, R., & Dharmasena, T. (2024). Forecasting weekly dengue incidence in Sri Lanka: Modified Autoregressive Integrated Moving Average modeling approach. *PLOS ONE*, *19*(3), e0299953. https://doi.org/10.1371/journal.pone.0299953

Liu, Y., Wang, M., Yu, N., Zhao, W., Wang, P., Zhang, H., Sun, W., Jin, N., & Lu, H. (2024). Trends and insights in dengue virus research globally: A bibliometric analysis (1995–2023). *Journal of Translational Medicine*, *22*, 818. https://doi.org/10.1186/s12967-024-05561-5

Lu, X., Teh, S. Y., Tay, C. J., Abu Kassim, N. F., Fam, P. S., & Soewono, E. (2025). Application of multiple linear regression model and long short-term memory with compartmental model to forecast dengue cases in Selangor, Malaysia based on climate variables. *Infectious Disease Modelling*, *10*(1), 240–256. https://doi.org/10.1016/j.idm.2024.10.007

Lwin, M. O., Sheldenkar, A., Panchapakesan, C., Ng, J. S., Lau, J., Jayasundar, K., Horathalge, K., Rathnayake, V. S., Crawley, A. W., & Wimalaratne, P. (2019). Epihack Sri Lanka: Development of a mobile surveillance tool for dengue fever. *BMC Medical Informatics and Decision Making*, *19*(1), 111. https://doi.org/10.1186/s12911-019-0829-5

Mahotra, A., Pokhrel, Y., Thapa, T. R., Arguni, E., & Andono, R. A. (2024). Feasibility of NepaDengue mobile application for dengue prevention and control: User and stakeholder perspectives in Nepal. *BMJ Public Health*, *2*(1). https://doi.org/10.1136/bmjph-2023-000599

Malewade, S. M., & Ekbote, A. (n.d.). Performance Optimization using MERN stack on Web Application. *International Journal of Engineering Research*, *10*(06).

Martheswaran, T. K., Hamdi, H., Al-Barty, A., Zaid, A. A., & Das, B. (2022). Prediction of dengue fever outbreaks using climate variability and Markov chain Monte Carlo techniques in a stochastic susceptible-infected-removed model. *Scientific Reports*, *12*(1), 5459. https://doi.org/10.1038/s41598-022-09489-y

Nanaware, N., Banerjee, A., Mullick Bagchi, S., Bagchi, P., & Mukherjee, A. (2021). Dengue Virus Infection: A Tale of Viral Exploitations and Host Responses. *Viruses*, *13*(10), 1967. https://doi.org/10.3390/v13101967

*National Dengue Control Unit*. (n.d.). Looker Studio. Retrieved January 7, 2025, from http://lookerstudio.google.com/reporting/95b978f1-5c1a-44fb-a436-e19819e939c0/page/XRtTB?feature=opengraph

Nebeker, J. R., Hoffman, J. M., Weir, C. R., Bennett, C. L., & Hurdle, J. F. (2005). High rates of adverse drug events in a highly computerized hospital. *Archives of Internal Medicine*, *165*(10), 1111–1116. https://doi.org/10.1001/archinte.165.10.1111

Nicanor, L. D., Madrid, A. B., Hernández, J. E. M., & Juárez, I. A. (2024). Performance of API Design for Interoperability of Medical Information Systems. *Applied Sciences*, *14*(9), Article 9. https://doi.org/10.3390/app14093944

Ogunlade, S. T., Meehan, M. T., Adekunle, A. I., & McBryde, E. S. (2023a). A Systematic Review of Mathematical Models of Dengue Transmission and Vector Control: 2010–2020. *Viruses*, *15*(1), 254. https://doi.org/10.3390/v15010254

Ogunlade, S. T., Meehan, M. T., Adekunle, A. I., & McBryde, E. S. (2023b). A Systematic Review of Mathematical Models of Dengue Transmission and Vector Control: 2010–2020. *Viruses*, *15*(1), Article 1. https://doi.org/10.3390/v15010254

Othus, M., & Li, Y. (2010). A Gaussian Copula Model for Multivariate Survival Data. *Statistics in Biosciences*, *2*(2), 154–179. https://doi.org/10.1007/s12561-010-9026-x

Prajapati, C. (2023, October 4). *Why Preferred Tech MERN Stack for Modern Web Development*. Satva Solutions. https://satvasolutions.com/blog/mern-why-preferred-tech-stack-for-web-development

Ranney, M. L., Meisel, Z., Choo, E. K., Garro, A., Sasson, C., & Morrow, K. (2015). Interview-Based Qualitative Research in Emergency Care Part II: Data Collection, Analysis and Results Reporting. *Academic Emergency Medicine : Official Journal of the Society for Academic Emergency Medicine*, *22*(9), 1103–1112. https://doi.org/10.1111/acem.12735

Roth, R. (2017). User Interface and User Experience (UI/UX) Design. *Geographic Information Science & Technology Body of Knowledge*, *2017*(Q2). https://doi.org/10.22224/gistbok/2017.2.5

Runge-Ranzinger, S., McCall, P. J., Kroeger, A., & Horstick, O. (2014). Dengue disease surveillance: An updated systematic literature review. *Tropical Medicine & International Health*, *19*(9), 1116–1160. https://doi.org/10.1111/tmi.12333

Side, S., Rangkuti, Y. M., Pane, D. G., & Sinaga, M. S. (2018). Stability Analysis Susceptible, Exposed, Infected, Recovered (SEIR) Model for Spread Model for Spread of Dengue Fever in Medan. *Journal of Physics: Conference Series*, *954*(1), 012018. https://doi.org/10.1088/1742-6596/954/1/012018

Tissera, H. A., Jayamanne, B. D. W., Raut, R., Janaki, S. M. D., Tozan, Y., Samaraweera, P. C., Liyanage, P., Ghouse, A., Rodrigo, C., de Silva, A. M., & Fernando, S. D. (2020). Severe Dengue Epidemic, Sri Lanka, 2017. *Emerging Infectious Diseases*, *26*(4), 682–691. https://doi.org/10.3201/eid2604.190435

Waja, G., Shah, J., & Nanavati, P. (2021). *AGILE SOFTWARE DEVELOPMENT*. *5*(12).

Yadav, D. R., Sharma, A., Sk, A. K., & Gonsalvez, J. J. (2024). The MERN Stack Revolution: A Review of its Impact on Modern Web Development. *Science and Technology*, *13*(01).

Yoda, Y., Ouedraogo, H., Ouedraogo, D., & Guiro, A. (2024). Mathematical analysis and optimal control of Dengue fever epidemic model. *Advances in Continuous and Discrete Models*, *2024*(1), 11. https://doi.org/10.1186/s13662-024-03805-8

{Citation}