CHAPTER 1 INTRODUCTION TO THE STUDY

Background of the Study and Theoretical Framework

In the recent few years, the Philippines has witnessed numerous outbreaks of infectious diseases whose incidence or the geographical range of prevalence is increasing rapidly and has the threat to continually re-emerge in the near future spreading across regions causing countless morbidities and mortalities to people (Lo, 2021). It gives a massive challenge to public health policies and contributes substantially to the ever-escalating costs of healthcare.

It is observable that the public health facilities need to be more capable due to low quality of data collection and insufficient preparation on data management of information to oppose the threats of today's emerging and re-emerging infectious diseases. These infectious diseases can emerge and re-emerge unpredictably at any moment in any part of the region that can continuously challenge the progress that has been made in the area of the medical sector and remains an enduring problem in human health (Abebe, 2020).

Covid-19 (formerly known as novel coronavirus, 2019-nCoV) is an infectious disease defined as illness caused by a novel coronavirus 2 (SARS-CoV-2) that has first been identified amid an outbreak of respiratory illness cases in Wuhan City, China in December 2019 (Cennimo, 2021), wherein its original source of viral transmission to humans remains unknown (Maxmen, 2021). It is classified as an emerging infectious disease of probable animal origin (Haider et al., 2020).

According to the Department of Health, the first novel coronavirus case in the Philippines was confirmed on January 30, 2020, a 38-year-old Chinese national woman arrived from Wuhan, China. She had symptoms of cough and sore throat, an asymptomatic. 2 days later, marking as the first death case outside China was recorded on February 1, 2020, in the Philippines (Schnirring, 2020), a 44-year-old Chinese national male with symptoms of fever, cough, and chills (Edrada et al., 2020).

From January 3, 2020, to June 17, 2022, 5:24 pm CEST (Central European Summer Time), there have been 3,694,529 confirmed cases with 60,461 deaths in the Philippines (World Health Organization, 2022), which shows a massive impact on communities leaving its marks of sufferings on rural livelihoods, loss of income and millions of job opportunities exacerbating difficulties in poor communities due to restrictions imposed (de Lara-Tupio, 2022).

In the thick of growing threat of Covid-19, it revealed the lack of strain on the country’s health resources and its weak healthcare system (Lim, 2020) where relevant and accurate data and resources the country has in fight is very vital and should be of top priority amidst the phenomenon as it is the basic requirement in managing any situation that requires urgent and targeted response (UP COVID-19 Pandemic Response Team, 2020).

On the other hand, dengue, described as hemorrhagic fever or infectious acute thrombocytopenic purpura (Agrupis, 2019), has become the most pervasive re-emerging infectious disease in the Philippines, generating considerable concern in the country's public health due to its alarming outbreaks that are largely seasonal caused by arbovirus specifically, Aedes mosquitoes (which includes A. aegypti and A. albopictus) infected with a dengue virus (Mood, 2016). The virus is transmitted to humans through the bites of the infected mosquitoes entering the bloodstream as source of infection indicates that direct spread of dengue from one person to another does not occur (Bassett, 2017).

Dengue is considered as a major public health problem in the country by the cause of its widespread endemicity in all regions (Undurraga, 2017). Sudden severe flu-like illness, vomiting, skin rashes, aches, and pains are some of the symptoms that are usually visible within a week afterwards of infection and may last for up to ten days (Dunkin, 2021) and specific treatment to cure the viral infection is still remains unknown (World Health Organization, 2022). Patients are advised to take a rest, drink plenty of fluids, and seek medical advice to prevent fatalities.

In 2018, according to the Department of Health, there were 216,190 dengue cases, with 1,083 deaths. In 2019, the country recorded 146,062 dengue cases with 622 deaths from January up to July in the same year, which is 98% higher than the same period in 2018, justifying for the government to declare a national dengue epidemic due to the alarming rise of indices (Dyer, 2019). In 2020, the Philippines recorded a substantial decrease in dengue manifestations, with 59,675 confirmed cases and 231 deaths (Seposo, 2021). In 2021, there were a total of 79,872 dengue cases with 285 deaths reported from January 1 up to December 31 (Herriman, 2022). Later this year, there were approximately 34,938 dengue cases and 180 deaths within the first five months of 2022 from January 1 up to May 21 besides it is 23% higher than the cases were recorded during the same period in 2021 (Mendoza, 2022). It is evident from the numbers of cases shown that it is significantly lower as compared to previous years except from the period of March 20 up to April 30, a period known as morbidity weeks 12 to 17 which has an amount of 11,435 dengue cases recorded, 94% higher than the cases as compared to the same period in 2021 (Department of Health, 2022).

Despite the huge number of indices, only a proportion of dengue cases can only be captured and large episodes may not be reported, thus impeding measures that can reveal the true catastrophe of dengue in the country (Edillo et al., 2015).

Amidst the devastation, having accurate and reliable estimates of its burden had dispense plays a significant role in health policy and research, but it is unfortunate to say that the management systems are not designed to actively capture all the symptomatic infections (Undurraga, 2017) where the epidemiological metrics are vital for monitoring the state of the country during manifestations.

Moreover, tuberculosis is a potentially serious infectious disease that may occur when a bacterial infection caused by Mycobacterium tuberculosis spreads in one's lungs through inhaling tiny droplets released into the air, usually from coughs and sneezes of someone that has been infected (Khatri, 2020) where some of the symptoms may include a persistent cough that lasts more than 2-3 weeks that brings up phlegm with blood, night sweats, and swelling in the neck (Biggers, 2021). Although curable, it is still considered as the deadliest and number one killer among infectious diseases (Weiler, 2019) and is endemic in the Philippines, creating a major disruption to public health.

In 2019, the country had an estimate of 554 cases of tuberculosis per 100,000 people, considered the highest incidence in Asia and fourth worldwide, and there are roughly 74 deaths every day due to severe infection (World Health Organization, 2020). On March 25, 2022, there were

311,000 reported cases which is an 18% increase as compared to 263,000 cases in 2020 (Department of Health, 2022).

Approximately, there are about 1 million Filipinos with active tuberculosis at the present moment, with about 70 deaths every day (Flores et al., 2022); where most of those affected by this disastrous endemicity are millions of people residing in urban slums showing how vulnerable the populations are.

Beyond these cases, the country has also reported outbreaks of leptospirosis, diphtheria, meningococcemia, and measles as of November 5, 2019 (Department of Health, 2019) that creates frequent challenges due to resource limitations, inactive access of incidences, numerous barriers in controlling and managing data, and limited staff capacity (Dobler, 2018). It impedes the need for improving the capacity to develop centralized health policies, advancing the quality and effectiveness of public health systems management and operational research.

With the aforementioned situation, it is evident how the Philippines has seen frequent outbreaks of emerging infectious diseases in the recent past (Department of Health, 2017), and the risks visibly shows that they continue to be susceptible to the threat of re-emerge in any possible place at any time emphasizes the urgency to highlight the needs of improving preparedness against future pandemics (Arellano, 2017). Hence, infectious diseases remain a leading cause of morbidity, disability, and mortality in the country (Agrupis et al., 2021) as new pathogens will continue to re-emerge across regions signifying consequences and burdens they may provide that cause gaps in creating plans that can prioritize necessary measures and urgent action.

In order to efficiently achieve the aim of solving these gaps, there is a need for high authorities to come up with a flexible and dynamic system that can respond to the demand of patients and infectious diseases-related data and ensure preparedness foreseeing the possibilities of negative repercussions may be brought by the infectious diseases (Murray & Cogen, 2017) reducing their impact of casualties and costly health problems to the public safety.

As the Philippines is mainly dependent on Disease Reporting Units (Edillo, 2015), Rural Health Unit, along with the Barangay Health Workers, have the most significant role in promoting health and safety by implementing effective health policies and services, formulating plans and strategies in preventing disastrous occurrences of infectious diseases, and preserving the comfort and convenience of the inhabitants within the community, especially during a public health emergency that needs to be given attention and prioritize targeted intervention to control the spread of infectious diseases, man-made or natural.

Nevertheless, as researchers can observe, at the present moment, it is evident that health policy is currently facing provocations of keeping the standard of health care systems highly dynamic due to inadequate data management systems as they continuously use manual processes of collecting, compiling, and disseminating data which contributes to the expanding challenges. However, no matter how crucial, these challenges need to be addressed efficiently at the soonest possible time and should be of top priority.

There is a need for Health Agencies to improve their infectious diseases information management systems in order to easily adapt to the demand of critical public health-related data that need to be recorded, monitored, and managed to come up with a solution that may favor in maintaining a safe and healthy community.

Thereby, the proponents of this study aimed to develop a comprehensive infectious diseases information management, a web-based system that is an efficient and responsive tool that enables successful collection, management, and monitoring of patient’s data affected by infectious diseases.

This system allows the Barangay Health Workers to have significant information on the current status of their barangay’s public health, particularly on infectious diseases to timely react and come up with urgent preventive measures in reversing the outbreaks saving lives and resources as immediate response is crucial for infectious diseases, to immediately respond and come up with urgent preventive measures to reverse the outbreaks and save lives.

The proposed system has developed a conceptual framework based on input-process-output (IPO).

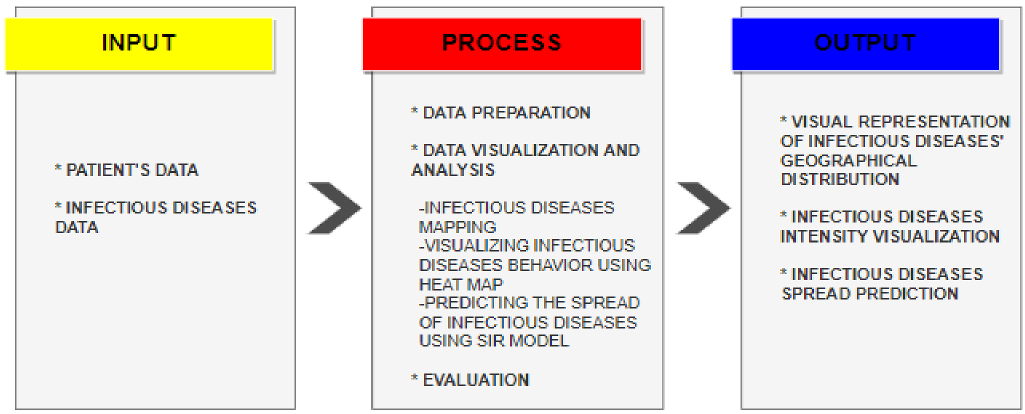


Figure 1. Conceptual Framework of the Study

As shown in Figure 1, the model emphasizes the illustration of the proposed system structure wherein the input box captures the data of patients and infectious diseases. These data will be administered for processing as shown in the second box that include data preparation were accessing and managing of raw data occurs for visualization and analysis. Furthermore, data visualization and analysis contain mapping of infectious diseases, visualizing their behavior using heat map, and predicting their spread using the SIR model. This also aids for evaluation by finding patterns on the data.

These processes comprise outputs that involve a visual representation of infectious diseases' geographical distribution within a population, its intensity indicating specific areas with the highest interaction, and infectious diseases spread prediction.

Objectives of the Study

Generally, this study aimed to develop an Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction.

Specifically, it aimed to:

1. Develop a web-based system that allows the Barangay Health Workers to record the patient's data and infectious diseases data.
2. Develop a Geographic Information System that allows the Barangay Health Workers to map the infectious diseases occurrence to evaluate their interaction and analyze their intensity using heat maps.
3. Develop a system that predicts the spread of Covid-19, Dengue, and Tuberculosis using the SIR model.
4. Evaluate the usability and effectiveness of the system using ISO 25010 standard.

Significance of the Study

This study is beneficial to the following:

Barangay Health Workers (BHW). Since they are responsible for recording infectious diseases data in the barangay, this study may be beneficial to the BHW as the system reduces the manual administrative processes overhead associated with collecting, monitoring, and managing infectious diseases data. The system may efficiently effectuate data analysis and visualization, which allows them to be well-aware of the current infectious diseases status and its threats in the barangay. It may provide an integrated mechanism to enhance efforts in data-driven decisions based on the information recorded in the system through the data it has collected. Through this, it may allow them to enhance efforts in prioritizing urgent measures of intervention and control to prevent epidemic occurrence.

Local Government Unit (LGU). The system may be beneficial to the LGU as it will provide them a comprehensive, real-time, and efficient system for visualizing and analyzing infectious diseases data as compared to manual processes. The significant findings will aid them to improve health policies, ensure health care system in compliant with standard, and flexible enough to adapt the demand of crucial infectious diseases. It supports the efforts of data-driven planning, decision-making, and evaluation of health programs for the benefit of the community.

Department of Health (DOH). This study may be beneficial to the DOH as it allows them to highlight the significant factors that create gaps in preventing infectious diseases outbreak. By regulating these gaps, it can help reveal the significant areas in the healthcare system that need improvements to adequately control public health threats caused by emerging and re-emerging infectious diseases. Thus, this system will aid in the provision of an integrated program that supports Disease Reporting Units across the nation that can administer a better response at all levels.

Rural Health Unit (RHU). This study may be beneficial to the RHU as it will motivate them to efficiently implement programs that can provide quality of services for primary healthcare and evaluate preventive plans in preventing the spread of infectious diseases that can benefit the community.

Future Researchers and developers. This study may also support future researchers and developers as it will serve as their foundation, guidance, and reference for further information they could include in their research that is similar to this study.

Definition of Terms

For clarity and better understanding, the following terms were defined conceptually and operationally:

Infectious diseases -- are illness caused by any type of harmful organisms (pathogens) such as bacteria, parasites, viruses, or fungi that get into human's body and damages health which later on may arise and can be spread from person to person through either direct or indirect contact (Christie, Feigin, & Garg, 2020).

In the study, "*infectious diseases*" referred to the human cases that the system intends to be collected and managed by the Barangay Health Workers to monitor, perform analysis and visualization, which allows them to be informed on the current situation of infectious diseases incidences in the barangay.

Geographic Information System -- is a computer system that helps users explore, capture, store, and display the everyday world space particularly in data-related positions to earth's surface where the representations are experienced in the context of a realistic god-like perspective from above (Cover, 2016).

In the study, "*GIS*" served as a valuable tool in managing the mapping of infectious diseases data by pinpointing the location where the incidence happened in the barangay. This enables the BHWs to monitor the geographical distribution of infectious diseases through visual representation that identifies areas of greatest risk due to its high interaction.

Heat maps -- are two-dimensional representations known as a data visualization technique for depicting and unraveling the hidden behavior of data in a graphical representation and utilizing a variety of colors that display different values for analytics (Gu, Eils, & Schlesner, 2016).

In the study, "*heat maps*" were used for data monitoring and visualization applied in the infectious diseases data from a GIS perspective to determine its intensity and behavior indicating specific areas with highest interaction for immediate visual summary of information with the help of various colors.

Visualization -- refers to the visual representation such as map or graph that displays statistical data and interpreting the simple summaries to come up with concurrent data-driven information (Unwin, 2020).

In the study, "*visualization*" referred to the translation of infectious diseases data into a visual context by using heat maps that incorporate various colors to determine the intensity and spatial prevalence of the data which can give immediate information to adequately associate the current status of infectious diseases in a particular area.

Monitoring -- refers to a regular systematic observation and checking of activities or situations for a period of time in order to routinely determine the progress or quality of a thing which allows gathering and discovering information carefully (Bartle, 2011).

In the study, "*monitoring*" was the process of determining the behavior of infectious diseases data by regularly observing its prevalence and intensity using heat maps and is also a mechanism that allows describing the current burden and epidemiology of the infectious diseases in the barangay.

Prediction -- is a statement that directly concerns what one thinks that has a great chance will happen in the future (Cambridge Dictionary, 2022).

In the study, "*prediction*" referred to the systematic use of infectious diseases data that has been recorded in the system with an application of a mathematical model to predict its spread causing frequent emerging and re-emerging epidemics that allows for the Barangay Health Workers to perform proper measures of interventions effective for controlling and preventing outbreaks.

SIR Model -- is one of the most well-known and commonly used mathematical model often applied to predict the spread of infectious diseases computing the number of susceptible, infected, and recovered individuals that are highly based on the number of contacts, fatality, incubation, and transmission (Carcione, Santos, & Ba, 2020).

In the study, the "*SIR model*" was utilized as a mathematical model in the infectious diseases data collected in the system and will be applied particularly in Covid-19, Dengue, and Tuberculosis data structured on the numbers of Susceptible, Infected, and Recovered individuals to predict their spread.

Cloud -- is a fast and low-cost computing model that allows the storing of data on the internet securely, that can be easily retrieved anytime at any place and anyone can have an immediate access to it provided that the permission is granted (Frankenfield, 2022).

In the study, "*cloud*" is a very crucial tool that allows storing and retrieving of patients' data and infectious diseases data conveniently that will be recorded in the system and will serve as a backup storage solution to avoid loss of valuable data and facilitates an efficient data recovery solution off-site at the same time.

Delimitation of the Study

This study entitled, "Barangay Infectious Diseases Information Management with GIS for Mapping and SIR model for Prediction" is generally designed with an intent to develop a web-based system which focuses on collecting and managing patients' data and infectious diseases data that can significantly support on presenting timely data-driven infectious diseases information that can aid immediate response in planning and deploying necessary measures to prevent outbreaks. This is mainly designed for Barangay Health Workers of Balabag, Santa Barbara, Iloilo as the system was supported through the information gathered in the said locale to aid their current manual operations in collecting, managing, and analyzing infectious diseases data which are discernible and that were not completely different from other Barangays.

Geographical Information System, statistical tools, and algorithm was carried through by the researchers in this study to fulfill the declared objectives.

Furthermore, this study did not offer complete resolution to the problem, but solely as a means to help the current processes of collecting infectious diseases data in barangay Balabag, Santa Barbara, Iloilo.

However, the study focused on the following:

- The proposed system must allow Barangay Health Workers to record infectious diseases data in a technology-based process to reduce the overhead manual administrative procedures of acquiring the data.
- The system should display the active cases of infectious diseases in Geographical Information System perspective to allow the Barangay Health Workers to have a significant understanding in its spatial scales.
- The system must display the graphical representation of the simulated future cases of COVID-19, Dengue, and Tuberculosis through the use of SIR model.

CHAPTER 2 REVIEW OF RELATED LITERATURE

Review of Existing and Related Studies

Infectious Diseases

As defined by the WHO, infectious or communicable diseases are caused by microorganisms such as fungi, bacteria, parasites, and viruses that are carried in the mouth, nose, throat, and respiratory tract. It can be transmitted through direct and indirect contact of a person from another, some are transmitted through bites of insects, and some are due to contaminated food or water intake. Some could have minor complications once infected, and some are life-threatening and deadly.

The study entitled “The challenge of emerging and re-emerging Infectious Diseases” of Morens et al. (2014), examined the burden of morbidity and mortality associated with infectious diseases emphasizing the factors of emergence from dynamic interactions and its impact on the human population.

According to the figures published by the WHO used in the study, there are about 15 million or less than 50% of 57 million annual deaths, 3 million of which are children worldwide due to rapidly evolving infectious pathogens and spread across geographical areas creating major challenges to human progress and survival.

The study suggests that infectious diseases information management, naturally occurring or deliberately engineered, which provides effective analysis is the significant element for immediate response and coordinated preventions to manage the increased threat of outbreaks.

However, the study concludes that the activities aren't sufficient to adequately address the challenges brought by infectious diseases which remain as the leading cause of mortality worldwide, and will continue to emerge and re-emerge, deriving unpredictable outbreaks and bringing burdens to public health.

In the study, the researchers aimed to develop a web-based system intended for barangay infectious diseases information management. The system allows an operative management of infectious diseases data that provides real-time data-driven information for immediate response in reducing the transmission of infections and possible outbreaks.

Infectious Diseases Analysis using Geographic Information System

The study entitled "Global mapping of Infectious Diseases" of Hay et al. (2013), aimed to evaluate the significance of geographic information systems in knowledge of spatial distributions of infectious diseases to humans and establish sets of minimum information requirements for epidemiology to make an informed decision.

Mapping the infectious diseases data incidence allows an immediate visualization of the particular places predisposed to the possible origin and emergence of the outbreak.

Furthermore, it measures the infected fraction of a population in an area and represents an accurate endemicity of the infectious diseases. The study concludes that mapping incidences has astonishingly determined the global burden given by infectious diseases and has the ability to visually present information to understand geographical determinants of disease emergence.

In the study, the researchers aimed to develop a Geographic Information System that allows Rural Health

Units to map the infectious diseases incidence to determine its geographical distribution using heatmap.

The study entitled "Mapping populations at risk: improving spatial demographic data for infectious disease modeling and metric derivation" of Tatem et al. (2012), acquired Geographic Information System for spatial modeling of infectious diseases enabling an efficient understanding of spatial epidemiology as an effective tool in gathering urgent information for immediate informed decisions.

Through mapping infectious diseases occurrence, its primary goal is to estimate the dynamics, risks, and burden by visually showing specific areas with uncertainty to outbreak.

In the study, the GIS serves as an effective tool for data analysis and visualization which is undertaken through mapping of infectious diseases data occurrence to determine its intensity through its population distribution using heat maps. This allows an advanced understanding of epidemiology and guides as a data-driven information for immediate response.

Infectious Diseases Prediction using the SIR model

According to Espinosa (2020), the SIR model aims to predict the number of individuals who are most likely susceptible to the infection, number of infected individuals, and individuals recovered with the infection.

The model is composed of three compartments (Tolles et al., 2020). (1) Susceptible individuals with high risk to become infected through direct or indirect contact with infected individuals; (2) Infected individuals are assumed to have contagious state and is able to transmit pathogen to another; and (3) Recovered individuals represents the individuals with immunity or who are no longer contagious.

The study entitled "A SIR model assumption for the spread of COVID-19 in different communities" of Cooper et al., deliberated the effectiveness of SIR modeling approach to predict the spread of Covid-19 within a community. The mathematical model is intended to provide data-driven insights and predictions about the infectious disease for intervention and strategies to control its transmission.

The study concludes that the mathematical model is an effective and significant tool to observe patterns and predict infectious diseases outbreak, thus, providing a theoretical framework to systematically observe the spread of Covid-19 in the community.

The study entitled "An SIR-Dengue transmission model with seasonal effects and impulsive control" of Chavez et al. (2017), making use of the SIR Model as a mathematical approach is significant to describe the transmission of dengue through data modeling. It is a fundamental epidemiological tool in understanding the dynamics of infectious diseases transmission.

The study emphasizes that the SIR model provides efficient and useful predictions of infectious diseases outbreak and comes up with urgent insights that impacts interventions in minimizing the numbers of infected-susceptible incidence rates of dengue.

The study entitled "Modeling the Transmission Dynamics of Tuberculosis in the Ashanti Region of Ghana" of Mettle et al. (2020), applied the SIR mathematical model that intends to aid in explaining the epidemiology and discussed the numerical solution of the model on the spread of tuberculosis and its dynamics among high-burden districts in the Ashanti Region of Ghana.

The study emphasizes the successful application of the model in predicting the infection dynamics of tuberculosis and concludes further that by early implementation of necessary informed action, the prevalence of the infectious disease can be effectively reduced to control the spread.

In the study, the SIR model is utilized in the Infectious Diseases Information Management System as an epidemiological model in Covid-19, Dengue, and Tuberculosis data structured on the numbers of Susceptible, Infected, and Recovered individuals to predict their spread for adequate informed interventions.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

Description of the Proposed Study

The primary objective of this study was mainly to develop a web-based system intended for barangay infectious diseases information management that can aid the current manual processes of BHWs in Balabag, Santa Barbara, Iloilo in collecting and managing patients' data, and analyzing infectious diseases data which provides timely information to immediate respond and control infectious diseases outbreak.

The system utilized the Geographic Information System as a significant tool in managing the mapping of infectious diseases which is vital in understanding their interaction, and analyze their intensity using heat maps. The system utilized the SIR model as a mathematical tool generated to predict the spread of infectious diseases, particularly, in Covid-19, Dengue, and Tuberculosis.

Methods and Proposed Enhancements

This study was prescriptive in nature and utilized the Design Science Research (DSR) approach (Hevner & Chatterjee, 2010) as the research design. The approach emphasized the problem-solving paradigm that intends to enhance human knowledge in science and technology bases through developing innovative artifacts to construct a new reality (i.e., solve problems) instead of explaining existing ones (Brocke, 2020).

This sought to successfully develop accurate and reliable knowledge of an existing problem by designing innovative artifacts as a solution to achieve the desired set of goals (Aken, 2014).

The method generally includes six core processes for constructive planning and communicating Design Science Research projects (Brocke & Maedche, 2019). (1) Identification of the problem involves identifying the specific social phenomenon and to understand its prevalence; (2) definition of objectives to describe concisely the aims to achieve in solving the problem; (3) design and development of artifacts that seeks to provide systematic models and comprehensive methods that are requirements to structure the artifact; (4) demonstration requires the use of the structured artifact; (5) Evaluation of the solution includes the processes of comparing the established objectives to observe the actual results in the developed artifact; (6) communication seeks to effectively meet the problem, the usability of artifact, and its significance to other studies.

In the study, the method was used to ascertain the main objective which was to develop an artifact that seeks to define ideas and practices of an organization from which the management, analysis, design, and use of information systems can be effectively and efficiently implemented. By generating prescriptive knowledge through DSR artifacts, it had a significant ability to contribute in alleviating the society's challenges and solving real-world problems using innovative solutions.

The proposed enhancement of this study was the implementation of an epidemiological model known as an SIR calculates the theoretical number of cases of a contagious disease in a closed community over time. The name of this class of models comes from the fact that they use coupled equations to relate the number of susceptible individuals (S), infected individuals (I), and recovered individuals R.

These compartments exist in the mathematical modeling of infectious diseases that can be used to explain the transmission of a disease within a population. The model will be utilized in the proposed system that aimed to predict the spread of Covid-19, Dengue, and Tuberculosis.

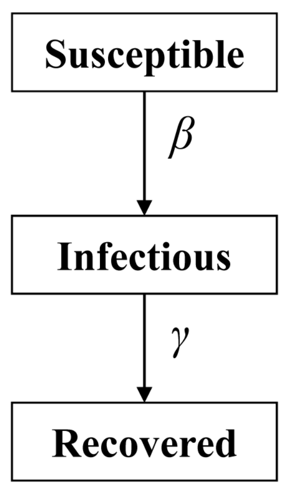


Figure 2. SIR Model for Spread of Infectious Diseases

S = S(t)is the number of susceptible individuals, I = I(t) is the number of infected individuals, and R = R(t) is the number of recovered individuals. However, according to McKendrick (2021), the R in Recovered in SIR Model could be replaced as Removed since Deceased in the population also has a significant part. Therefore, the R as Removed is the total number of Recovered added to the total number of Deceased so that N=S+I+R.

The initial step for the equation of the SIR model for susceptible, infected, and recovered are as follows:

$dS/dt = - \beta SI / N$

The susceptible over time is determined through the product of beta, susceptible, and infected divided by the total population.

$dI/dt = \beta SI/N - \gamma I$

The infected over time is determined through the number of beta multiplied to susceptible and infected divided by the total population and subtracted to the product of gamma and infected individuals.

$dR/dt = \gamma I$

The recovered over time is determined through the product of gamma and the number of infected individuals.

$t = 0$

Wherein, time denotes as 0

$N = S(t) + I(t) + R(t)$

These denote the fraction in each compartment where N (total population) = S(t) + I(t) + R(t).

According to Chu (2021), It would seem reasonable to employ the SIR model in analysis at the city, province, or national level because it "examines just the temporal dynamics of the infection cycle and should thus be appropriate for the description of a well-localized epidemic outburst."

Which, therefore, concludes that the SIR model is not suitable for a barangay scope. The model's dynamics in the aforementioned form are managed by the parameters S to I (susceptibility to infection) or beta (infection rate) and I to R (infection to recovery or death) or gamma (recovery rate), respectively, represent the rates of transition.

Measuring these parameters in real life is very complicated as countless factors affect its value (Diez & Zaborowska, 2021) such as the rate of contacts in the host population, the probability of infection being transmitted during contact, and the duration of infectiousness.

Typical modifications such as social isolation, stricter hygiene guidelines, or the usage of face masks are also factors that delays the spread of the illness.

To support the related studies aforementioned, Mr. Alexander J. Balsomo, Ph. D., a faculty of College of Arts and Sciences – West Visayas State University Main Campus and an epidemiologist had validated the application of the SIR Model and its compatibility to the proposed system.

The epidemiologist suggests that the model is not applicable to the barangay scope as it requires a daily transmission of the infection rate as well as recovery rate.

Furthermore, he also highlights that the value of the population in the model must be static which contradicts the dynamic mechanism of the proposed system. He emphasizes that the SIR Model should be an independent feature.

Therefore, the researchers conclude that the proposed system, specifically, in its scope, can't support the SIR Model as there are numerous requirements that need to be methodically carry off accordingly for the model to be successfully attained. The SIR model shouldn't be associated with other features for the reason that its methodology is independent and should execute standalone.

Components and Design

System Architecture

The system architecture shows the conceptual model that defines the structure, illustrates movement, and presents how major components of the system interact.

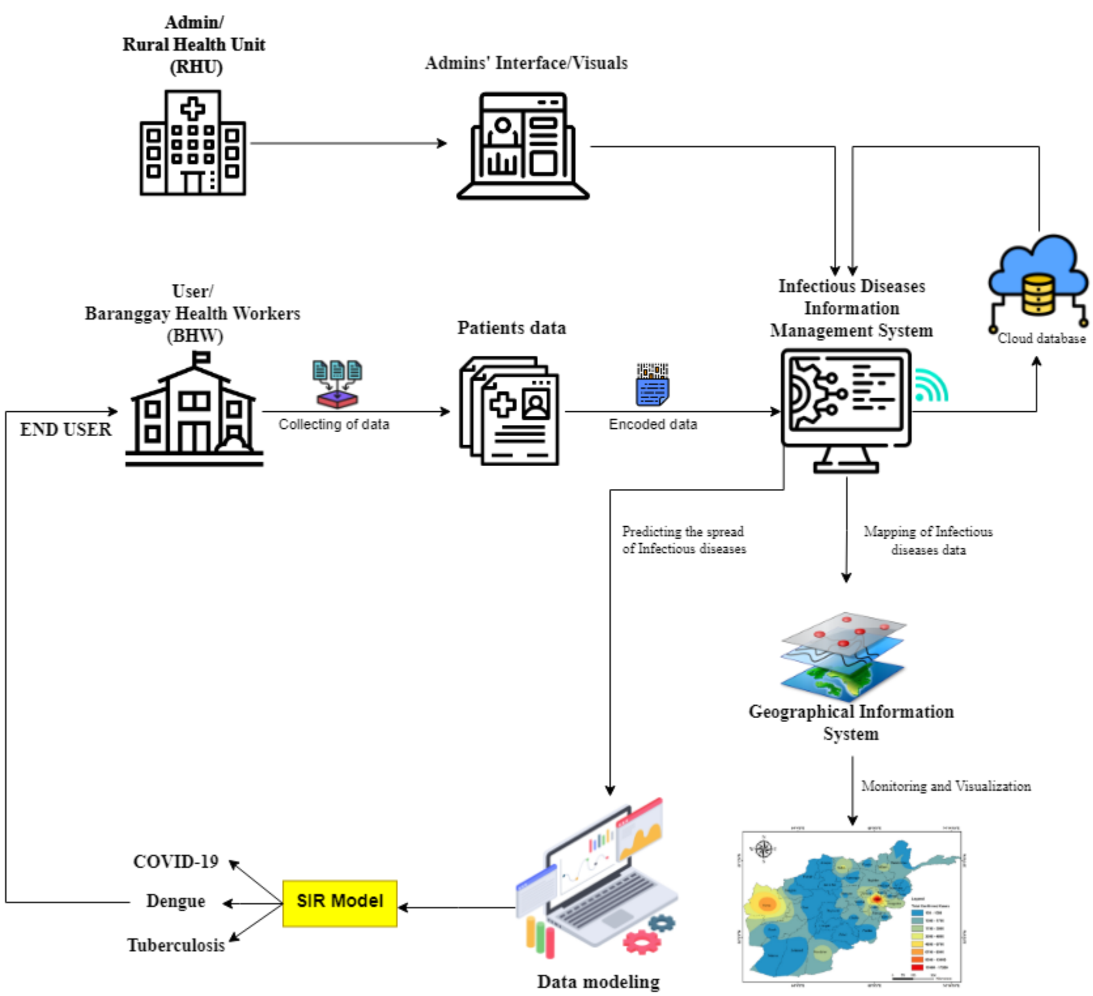


Figure 3. System Architecture of the Proposed System

Figure 3 illustrates the conceptual structure and behavior of the proposed system which highlights the Barangay Health Workers as the main user and the Rural Health Unit as admin. Barangay Health Workers are certain individuals designated to effectively collect valuable patient data and infectious diseases data.

The recorded data will be gathered in the Infectious Diseases Information Management System and will be directly stored in cloud storage to back-up the data which facilitate recovery off-site and make them available to the user over a network.

The infectious diseases data will be mapped using a Geographical Information System. The BHWs will pinpoint the location of incidence that aims to provide a visual representation of geographical distribution and intensity of infectious diseases within a population in a particular area of the barangay.

The Rural Health Unit can view the Patients data and the dashboard which gives them the authority to generate the patients’ data and summarized insights, download and/or print.

Furthermore, the system utilized the SIR model as a modeling technique generally designed for epidemiology to predict the spread of infectious diseases, particularly, in Covid-19, Dengue, and Tuberculosis.

Database Design

The database design of the proposed system is illustrated using an Entity Relationship Diagram. As shown in Figure 4, the database consists of five tables, namely, Household, Individual, Case, CaseMonitoring, and InfectiousDisease. The relationship between entities and corresponding cardinalities were also presented in the diagram using Crow’s Foot notation.

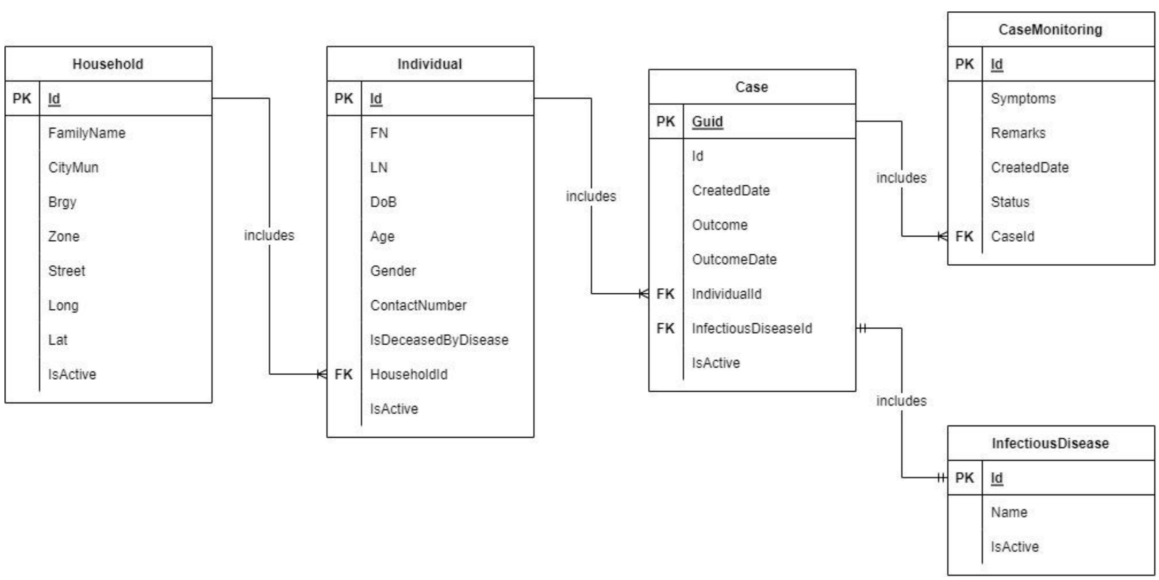


Figure 4. Entity Relationship Diagram

Procedural and Object-Oriented Design

Figure 5 specifies the procedural details of the proposed system utilizing the structured flow chart.

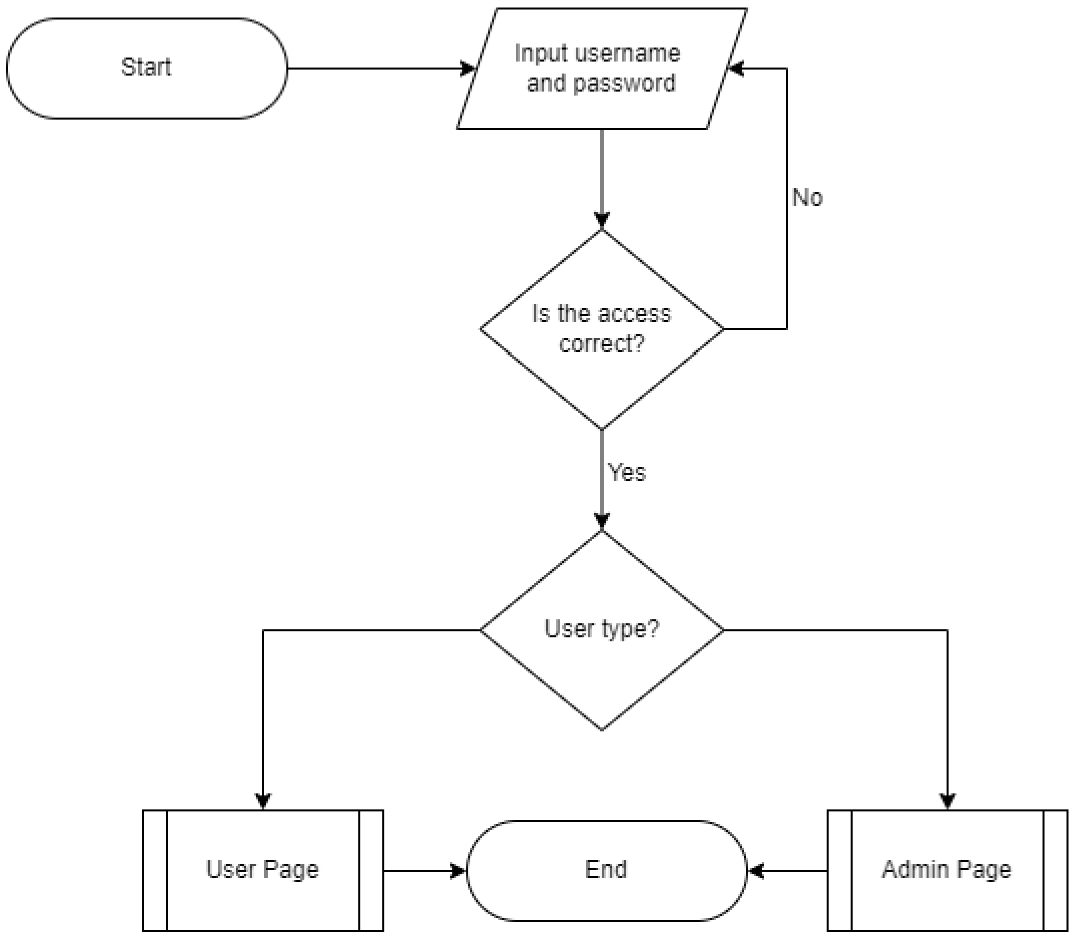
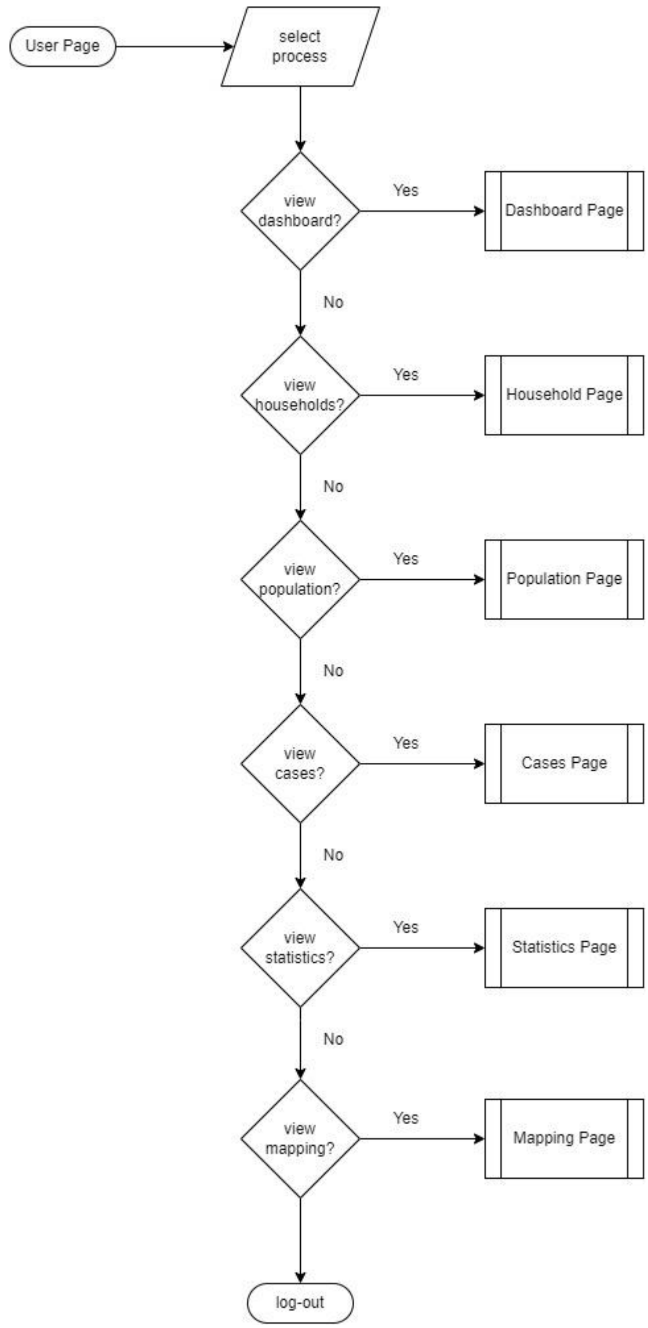
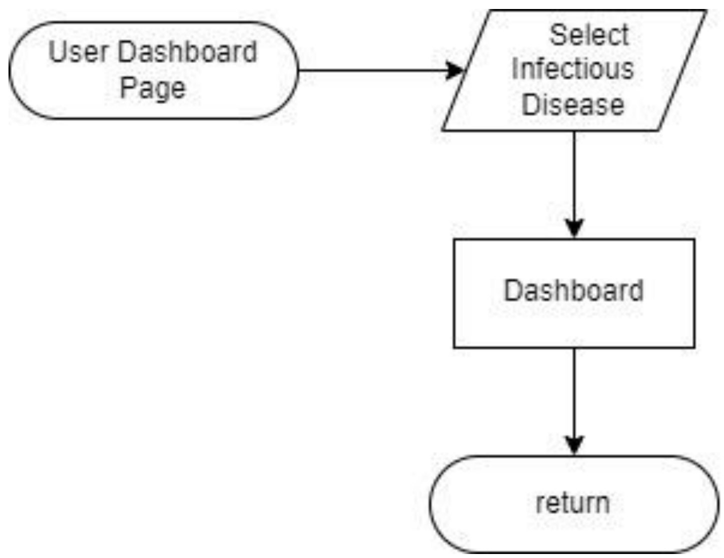


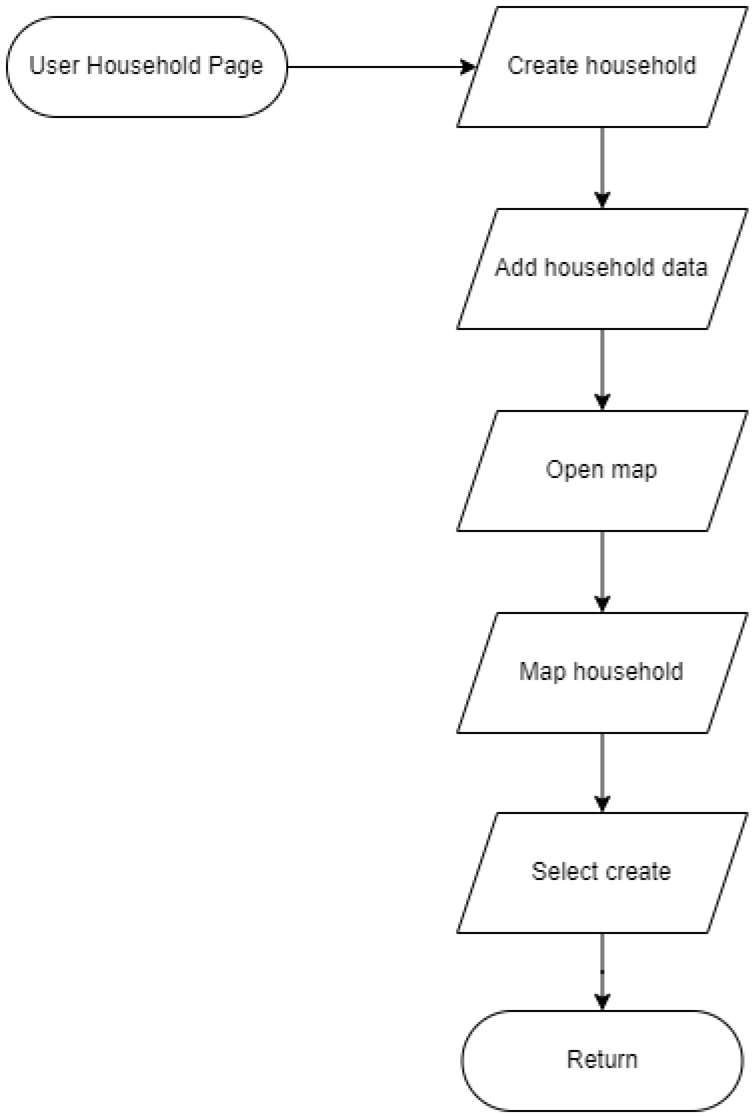
Figure 5. Procedural Design of the Proposed System


User Page
select process
view dashboard?
Yes
Dashboard Page
No
view households?
Yes
Household Page
No
view population?
Yes
Population Page
No
view cases?
Yes
Cases Page
No
view statistics?
Yes
Statistics Page
No
view mapping?
Yes
Mapping Page
log-out

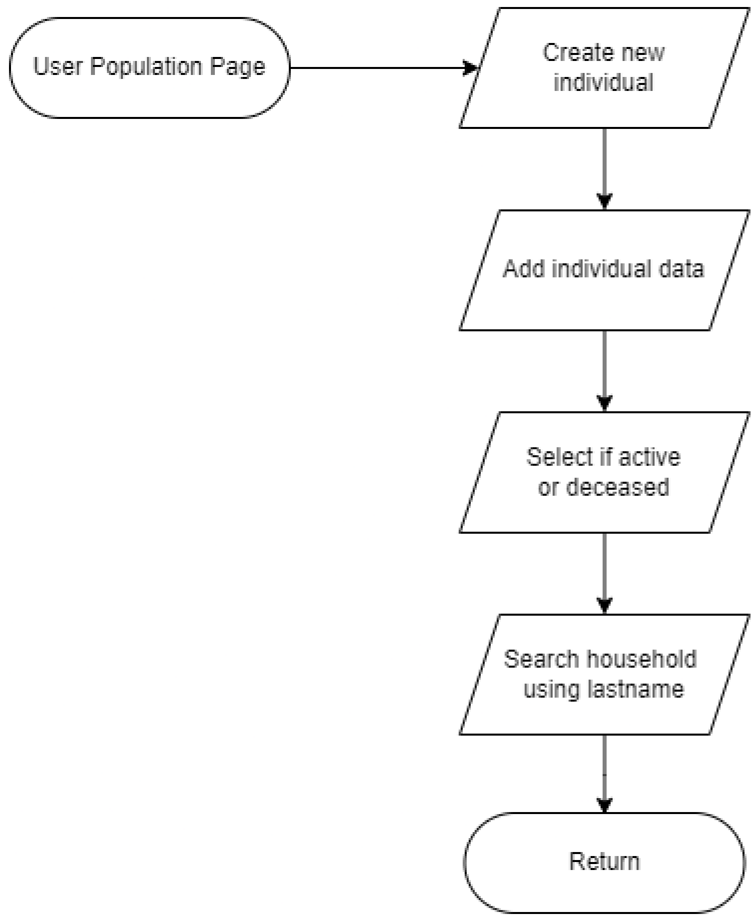
(cont.)


User Dashboard Page
Select Infectious Disease
Dashboard
return

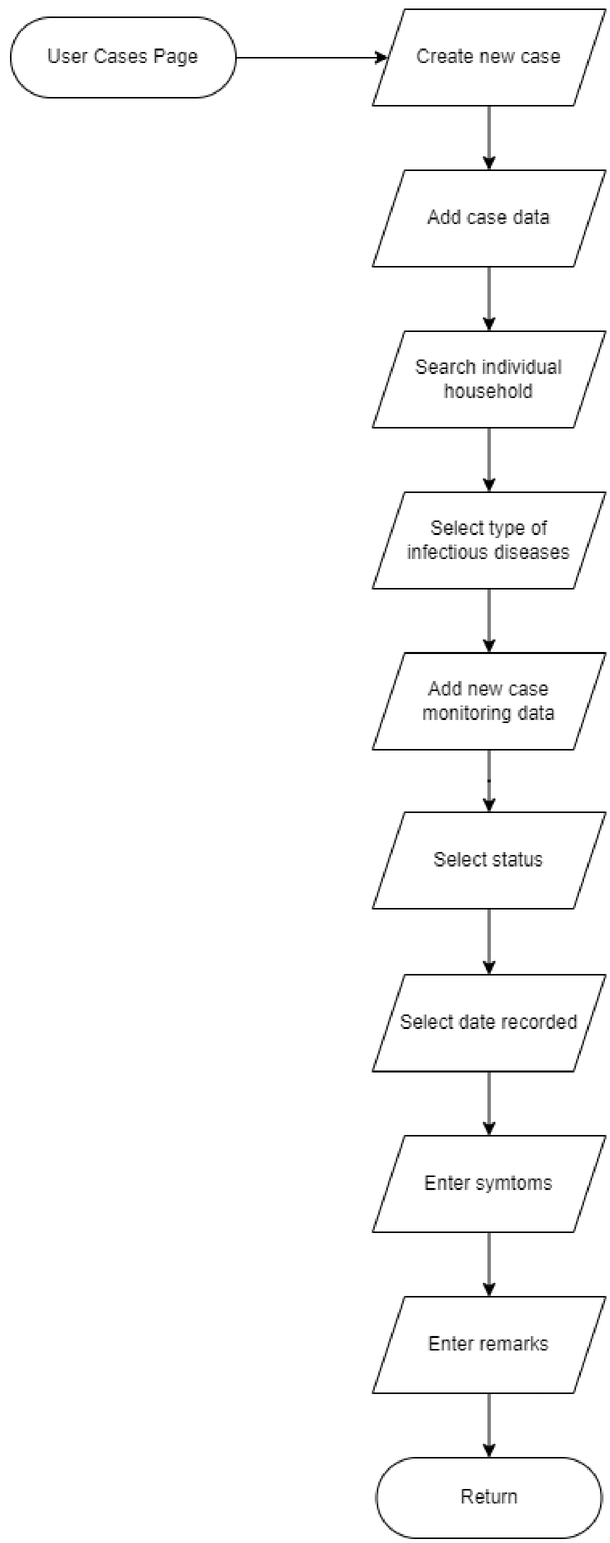
(cont.)


User Household Page
Create household
Add household data
Open map
Map household
Select create
Return

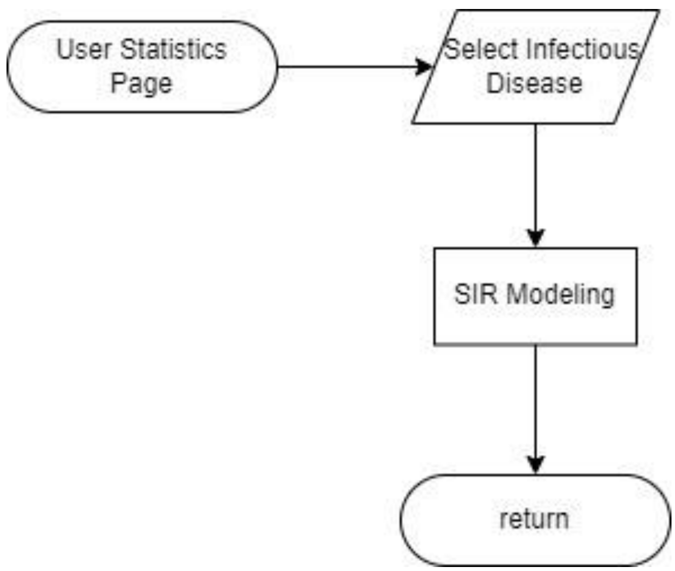
(cont.)


User Population Page
Create new individual
Add individual data
Select if active or deceased
Search household using lastname
Return

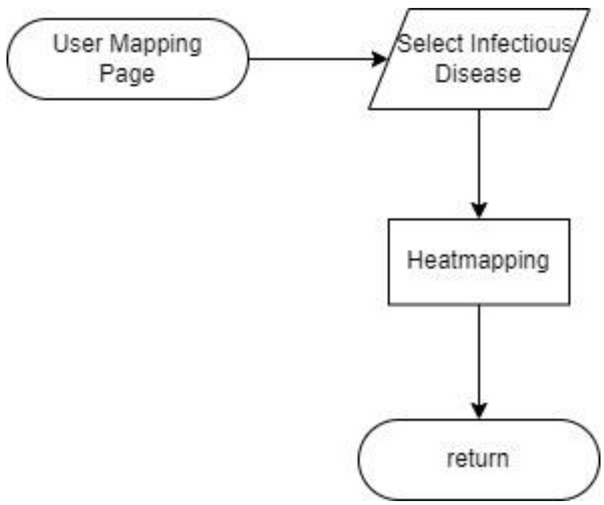
(cont.)


User Cases Page
Create new case
Add case data
Search individual household
Select type of infectious diseases
Add new case monitoring data
Select status
Select date recorded
Enter symtoms
Enter remarks
Return

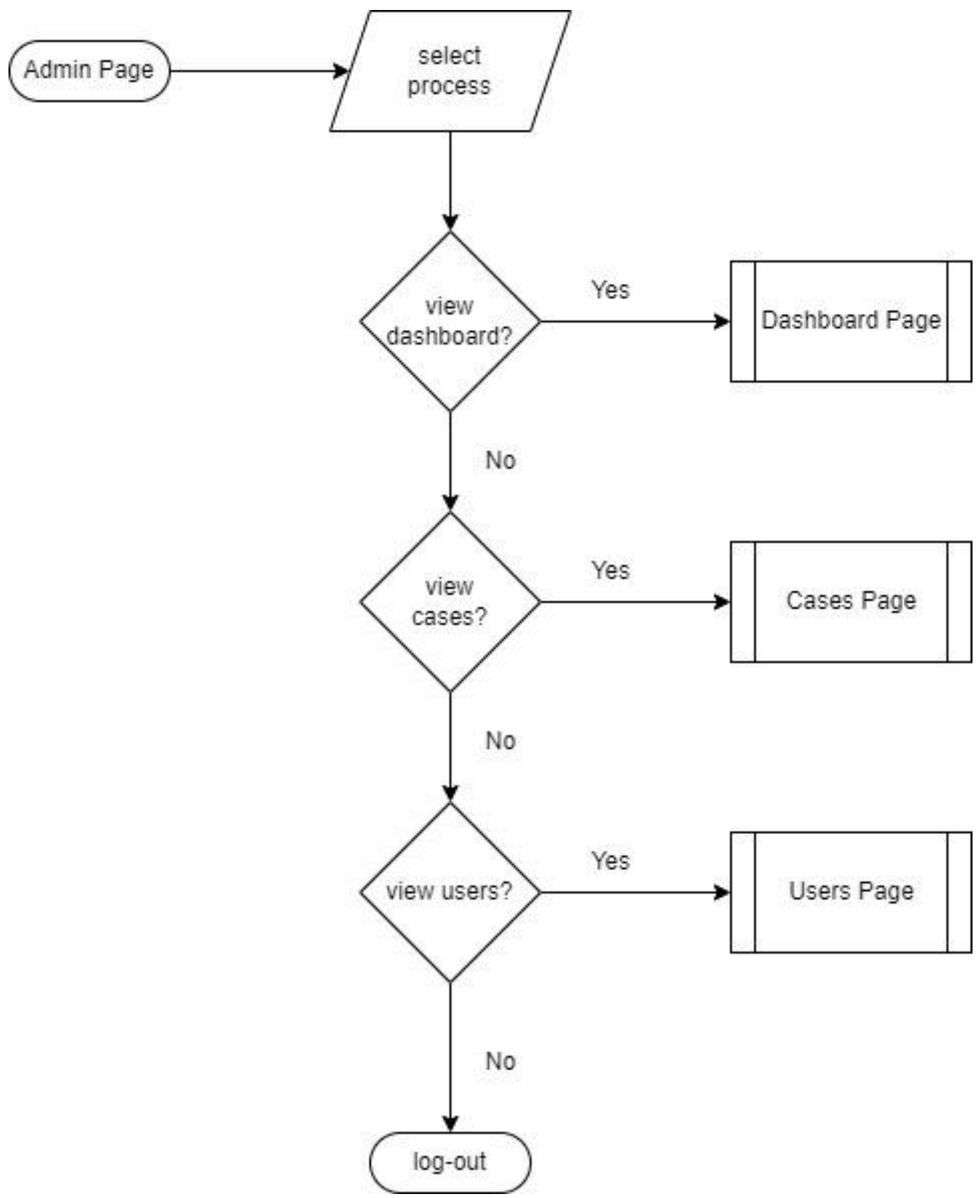
(cont.)


User Statistics Page
Select Infectious Disease
SIR Modeling
return

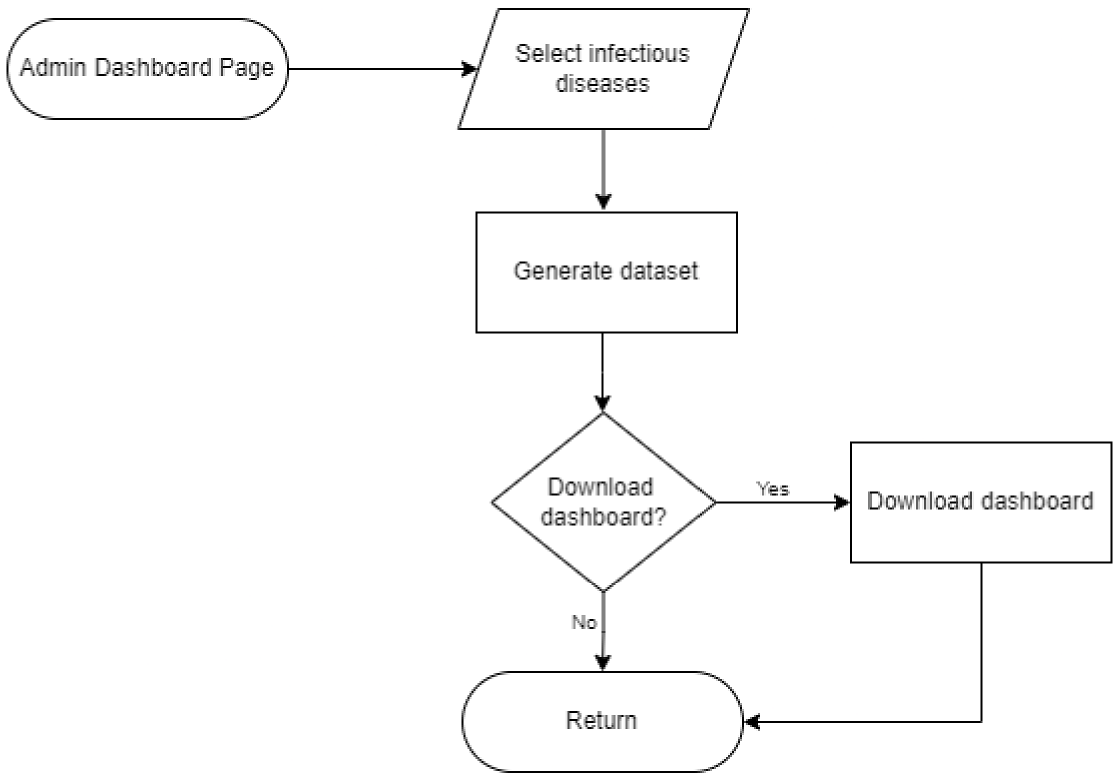
(cont.)


User Mapping Page
Select Infectious Disease
Heatmapping
return

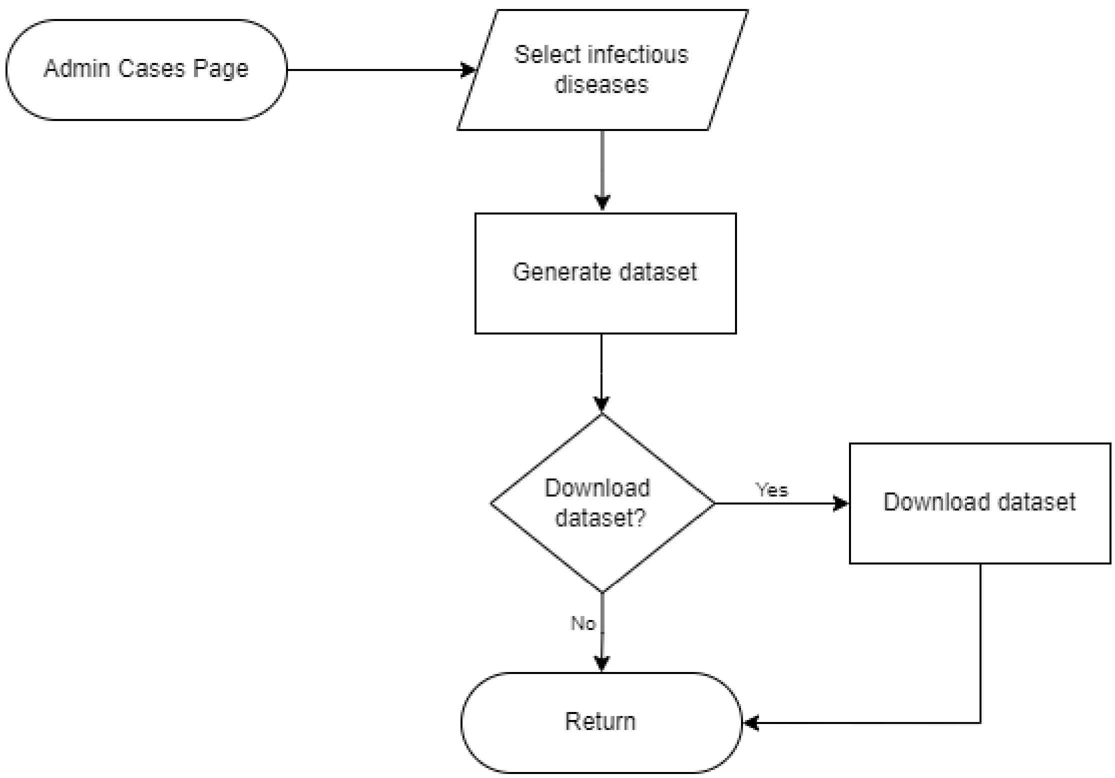
(cont.)


Admin Page
select process
view dashboard?
Yes
Dashboard Page
No
view cases?
Yes
Cases Page
No
view users?
Yes
Users Page
No
log-out

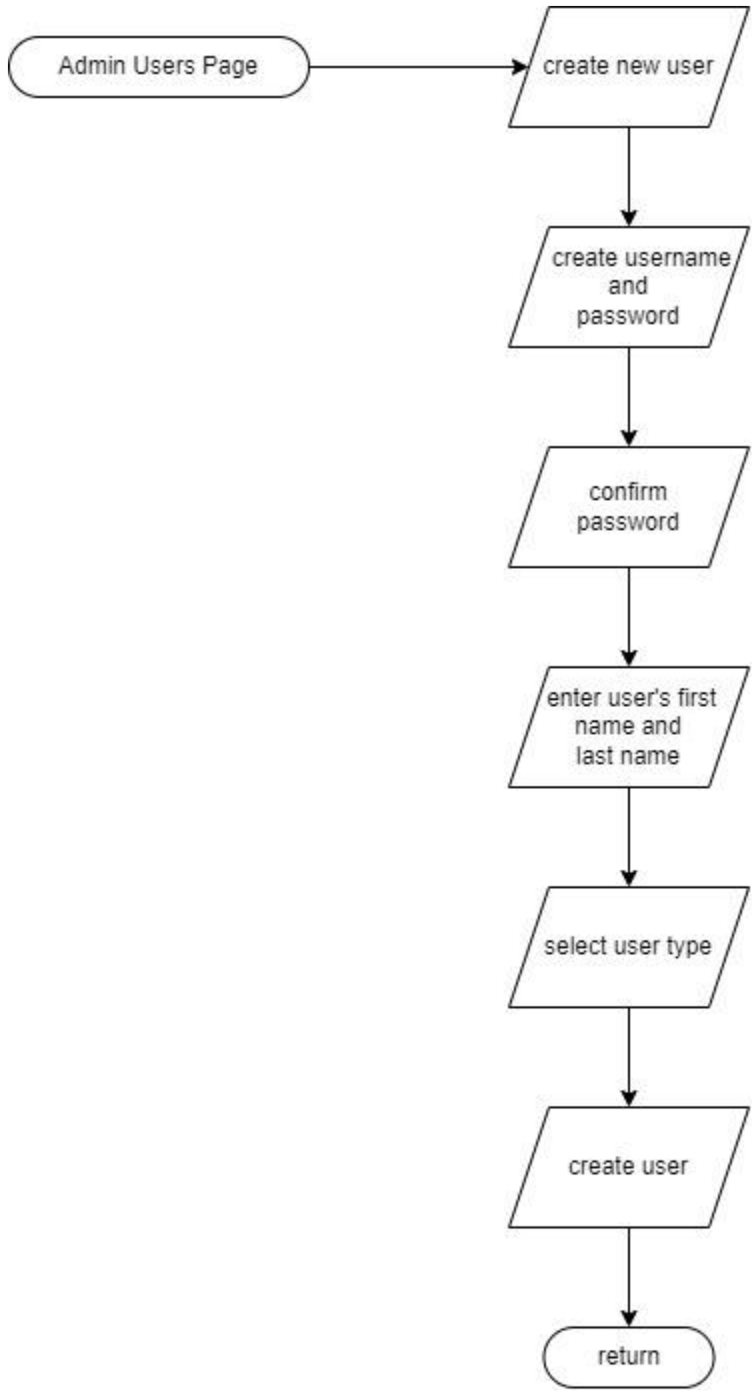
(cont.)


Admin Dashboard Page
Select infectious diseases
Generate dataset
Download dashboard?
Yes
Download dashboard
No
Return

(cont.)


Admin Cases Page
Select infectious diseases
Generate dataset
Download dataset?
Yes
Download dataset
No
Return

(cont.)


Admin Users Page
create new user
create username and password
confirm password
enter user's first name and last name
select user type
create user
return

(cont.)

The UML class diagram is provided in Figure 6 showing the structure of the system's classes, their attributes, operations, and relationships between objects.

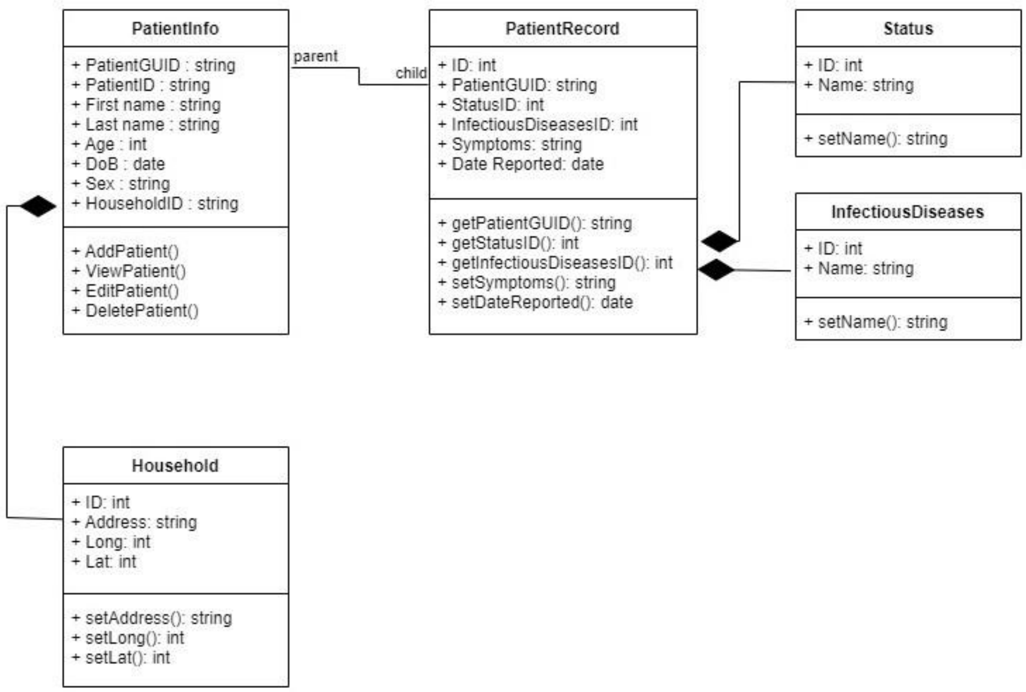


Figure 6. UML Class Diagram of the Proposed System

Process Design

The process design of the proposed system is illustrated using the Data Flow Diagram (DFD). The highest level DFD in the form of Context Diagram is presented in Figure 7. This figure shows how external entities, RHU (as Admin) and BHW (as user), interacts with the Barangay Infectious Diseases Information Management.

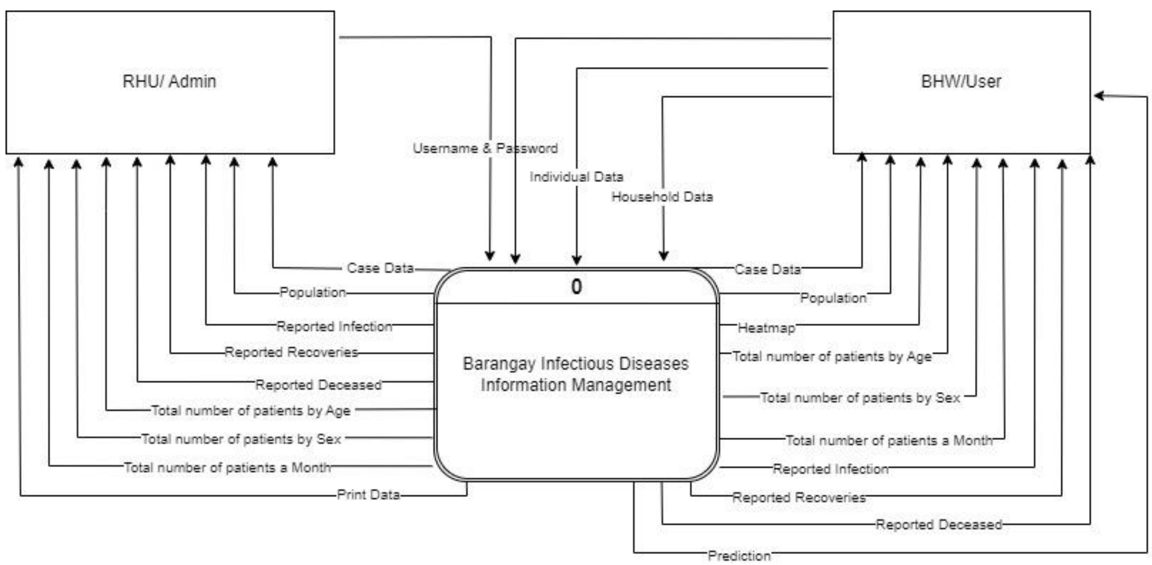


Figure 7. Context Diagram of the Proposed System

The detailed view of the proposed system is also presented in Figure 8 using the Level 0 diagram. The major processes are further broken down into sub-processes. These are presented using the Level 1 diagram shown in Figures 8-17.

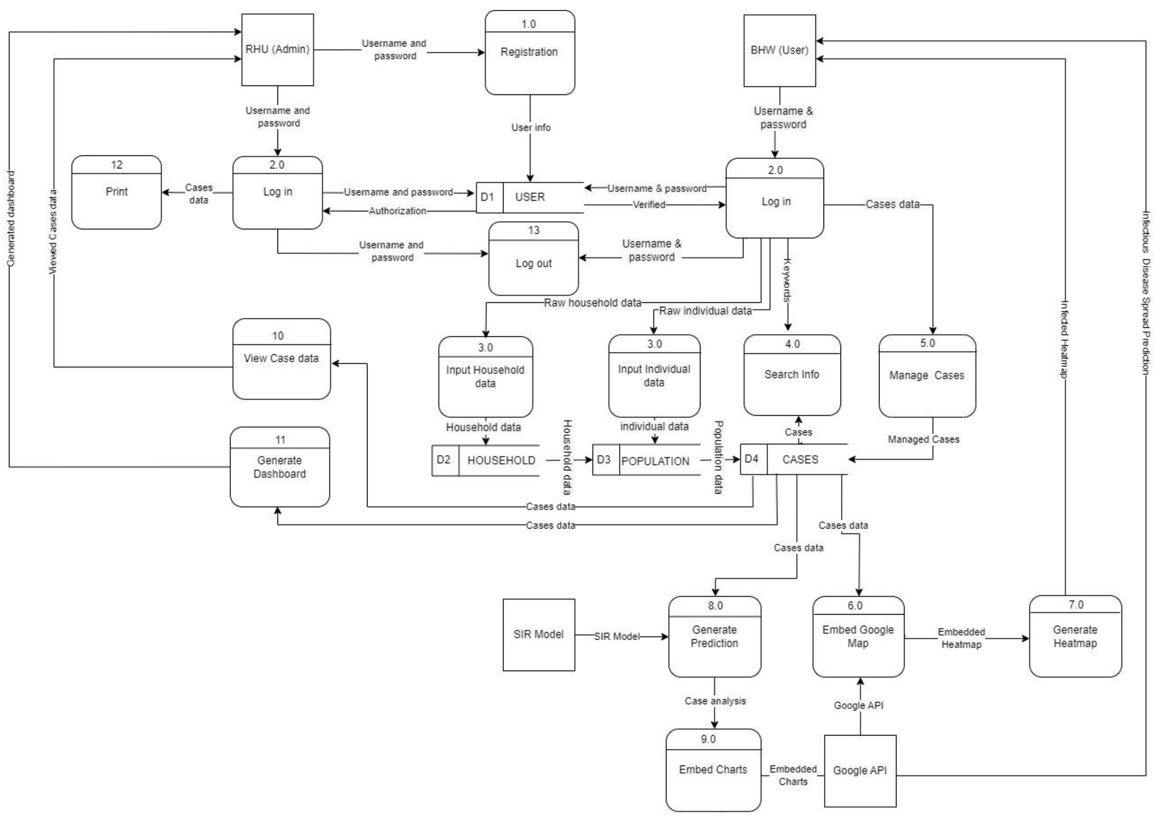


Figure 8. Level 0 Diagram of the Proposed System

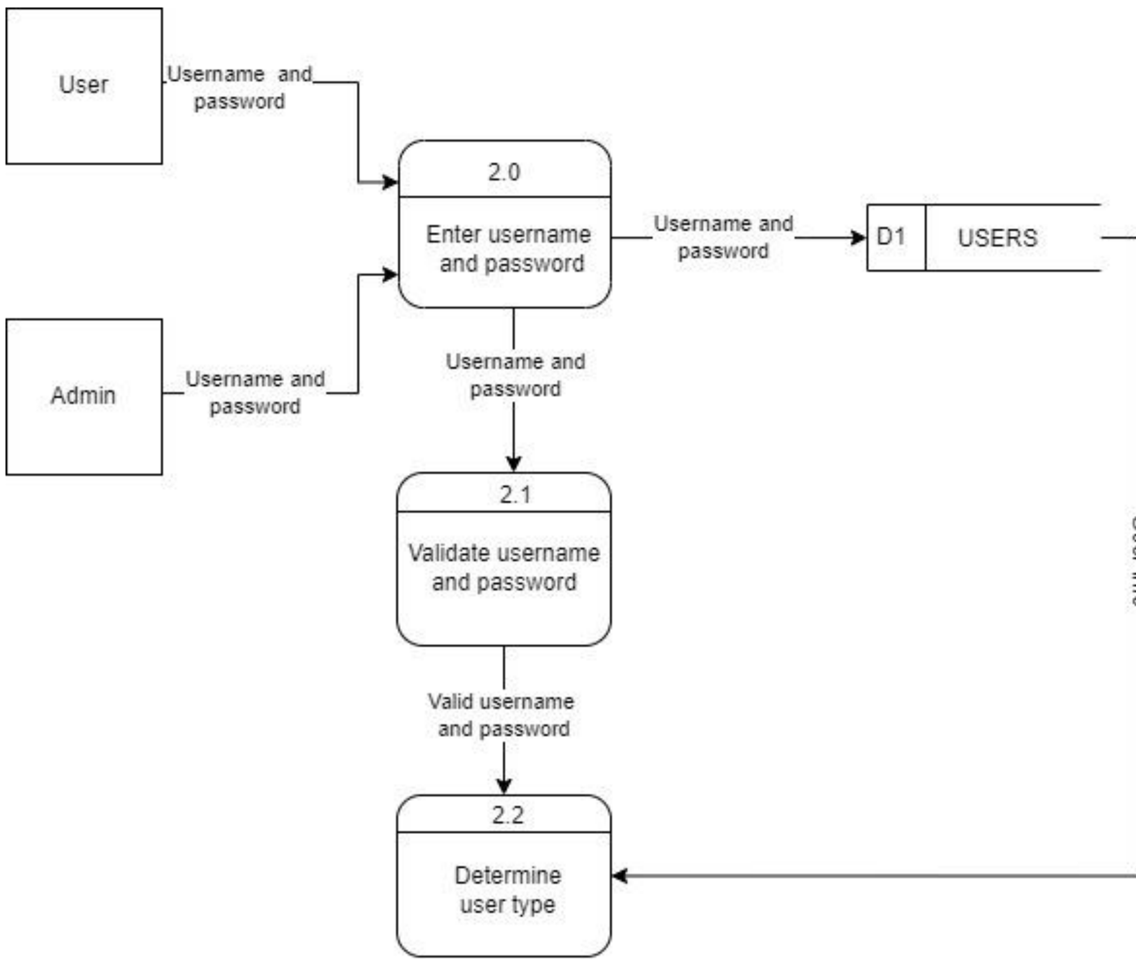


Figure 9. Level 1 DFD (Log-in)

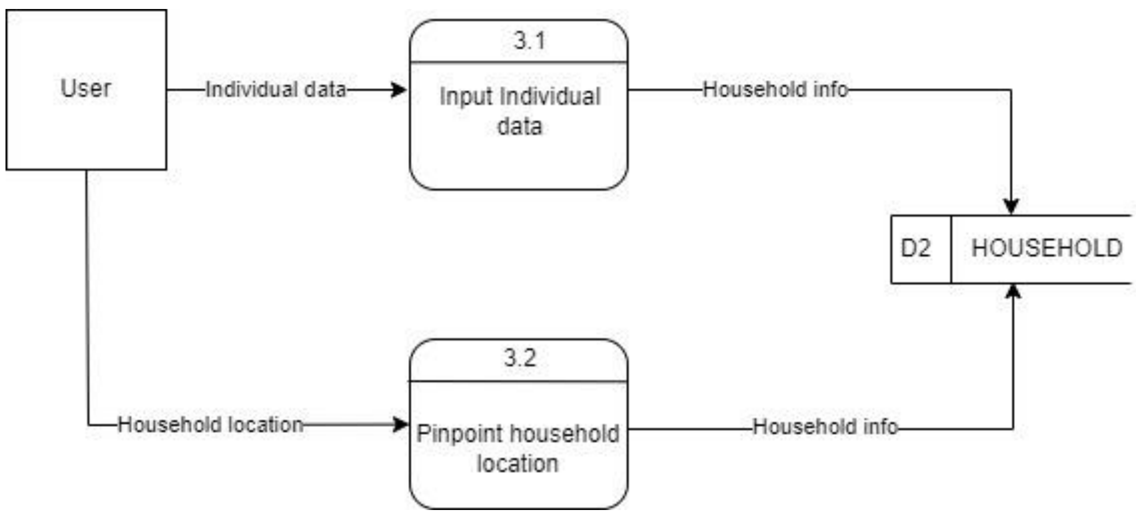


Figure 10. Level 1 DFD (Input Households)

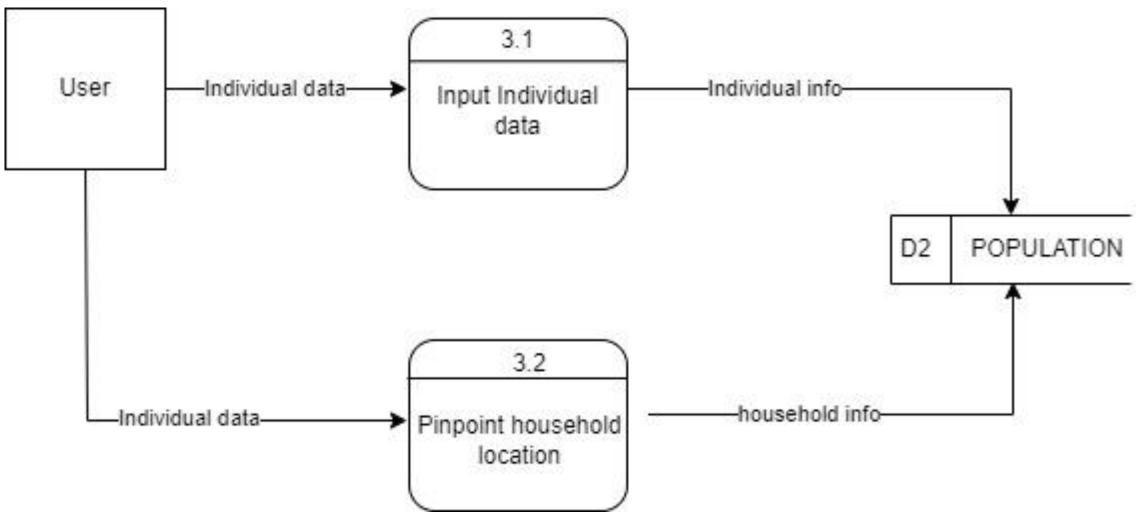


Figure 11. Level 1 DFD (Input Population)

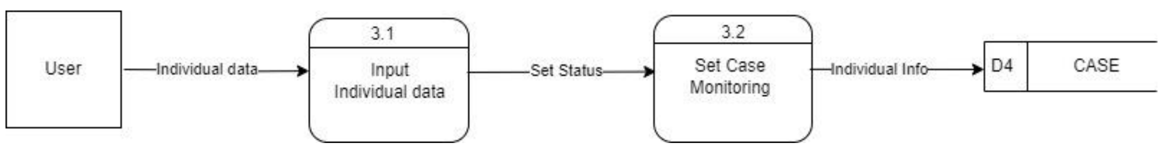


Figure 12. Level 1 DFD (Input Cases)

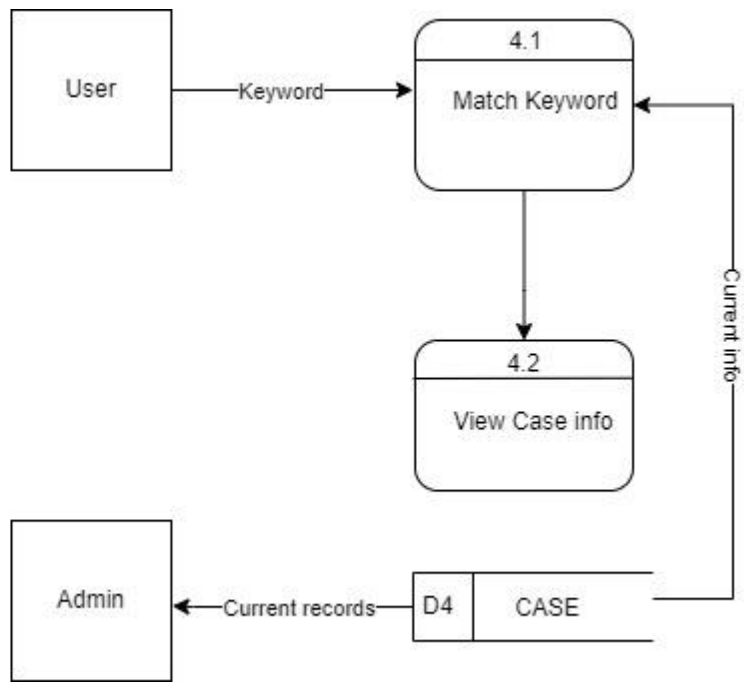


Figure 13. Level 1 DFD (Search)

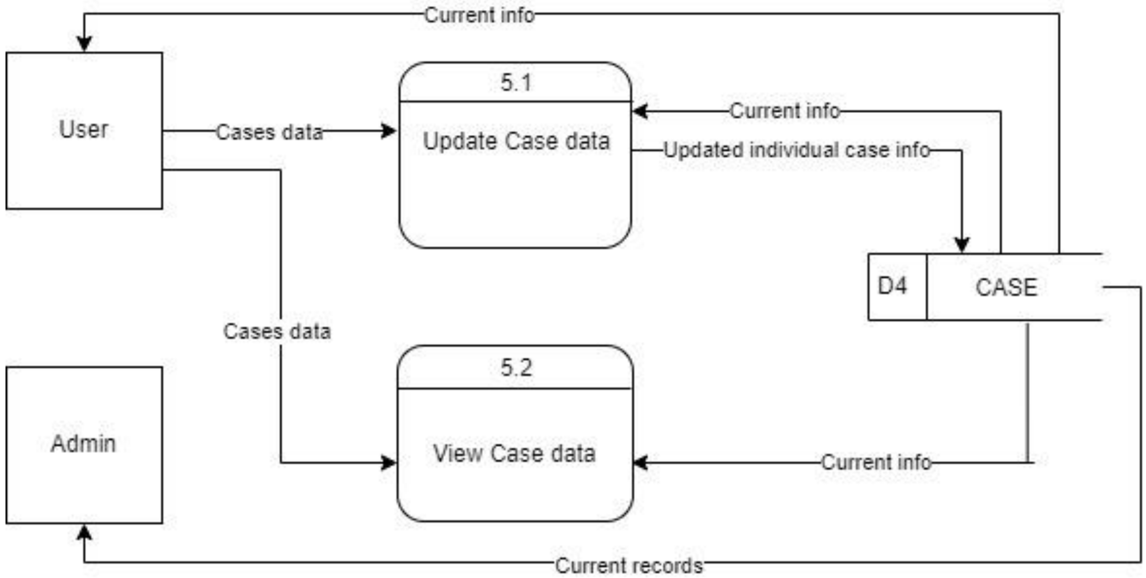


Figure 14. Level 1 DFD (Manage Cases)

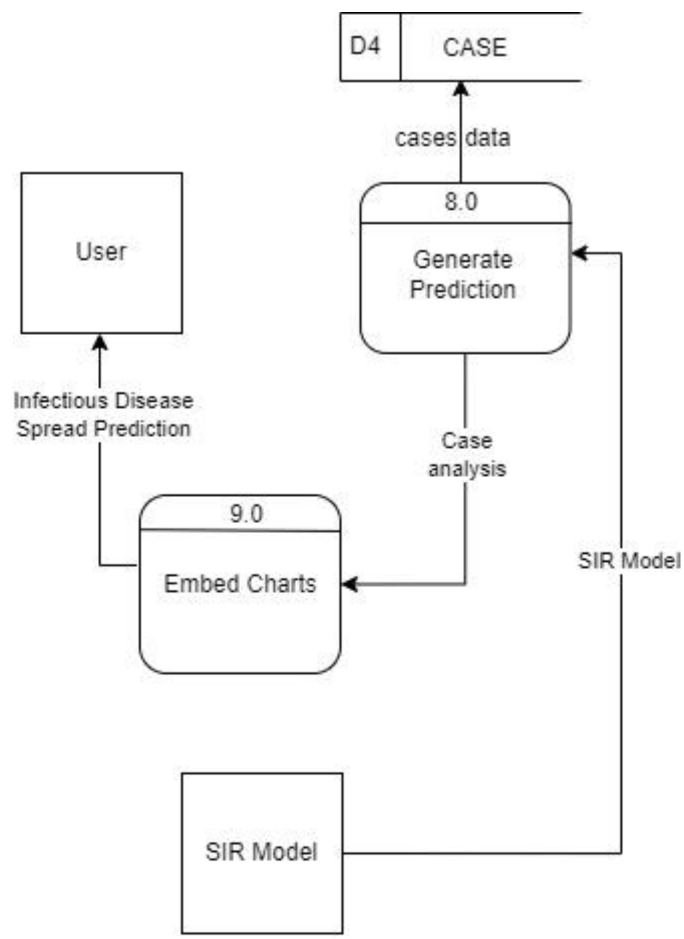


Figure 15. Level 1 DFD (Generate Infectious disease Prediction using SIR Model)

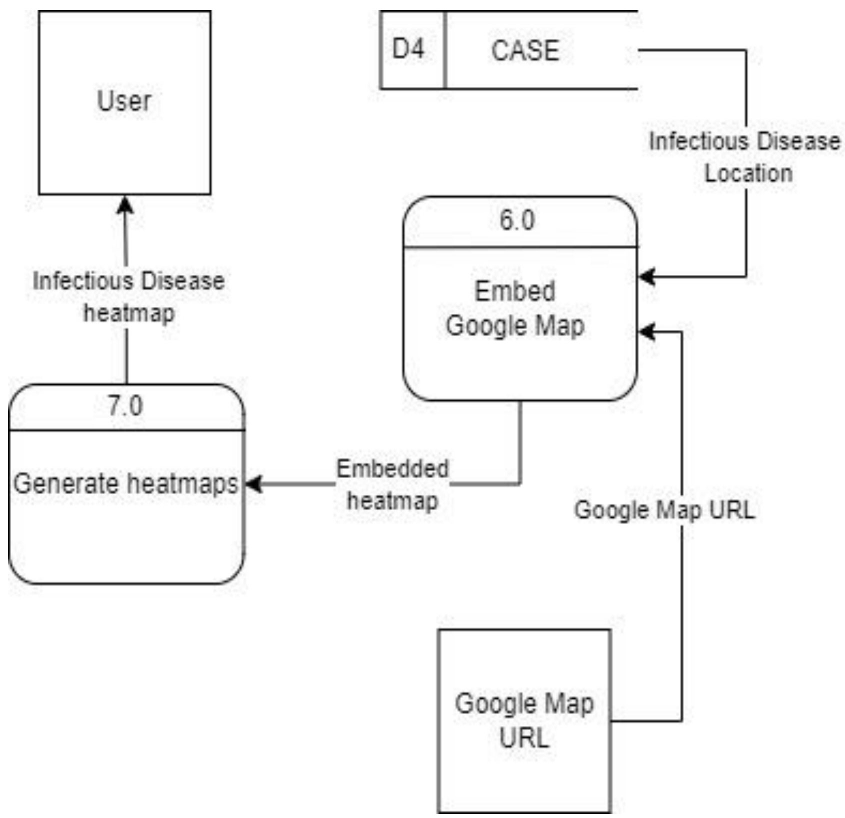


Figure 16. Level 1 DFD (Generate Infectious disease heatmap)

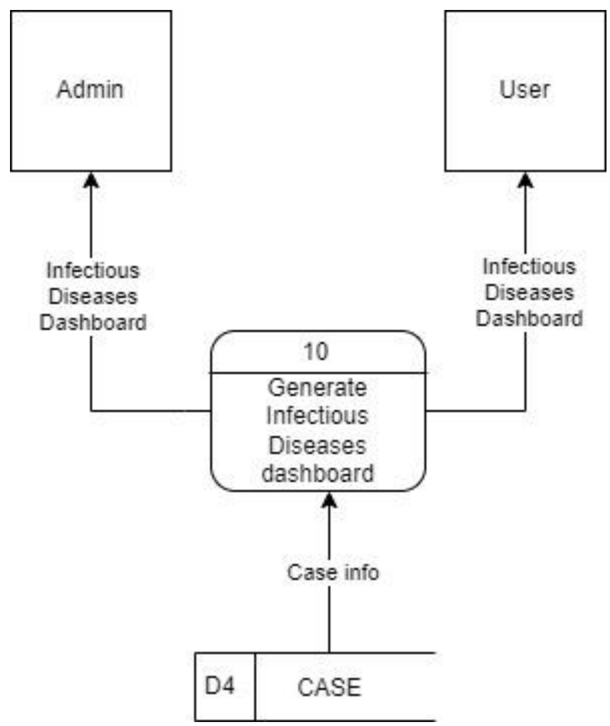


Figure 17. Level 1 DFD (Generate Infectious disease Dashboard)

Methodology

Systems Development Life Cycle

An organized procedure known as the Software Development Life Cycle (SDLC) provides the fastest possible production of high-quality, low-cost software. It establishes and outlines a thorough plan with stages, or phases, each of which includes its own procedure and outputs. Following the SDLC reduces project risks and costs and speeds up development while increasing the efficiency of production.

Similar to how traditional software is developed, an infectious diseases information management system can be divided into different life cycle stages. The techniques employed in the study can be utilized to achieve this. In this study, the web-based infectious diseases information management system used Agile Model SDLC.

Delivering a functional software allows the Agile Model to mix real-time and interactive models.

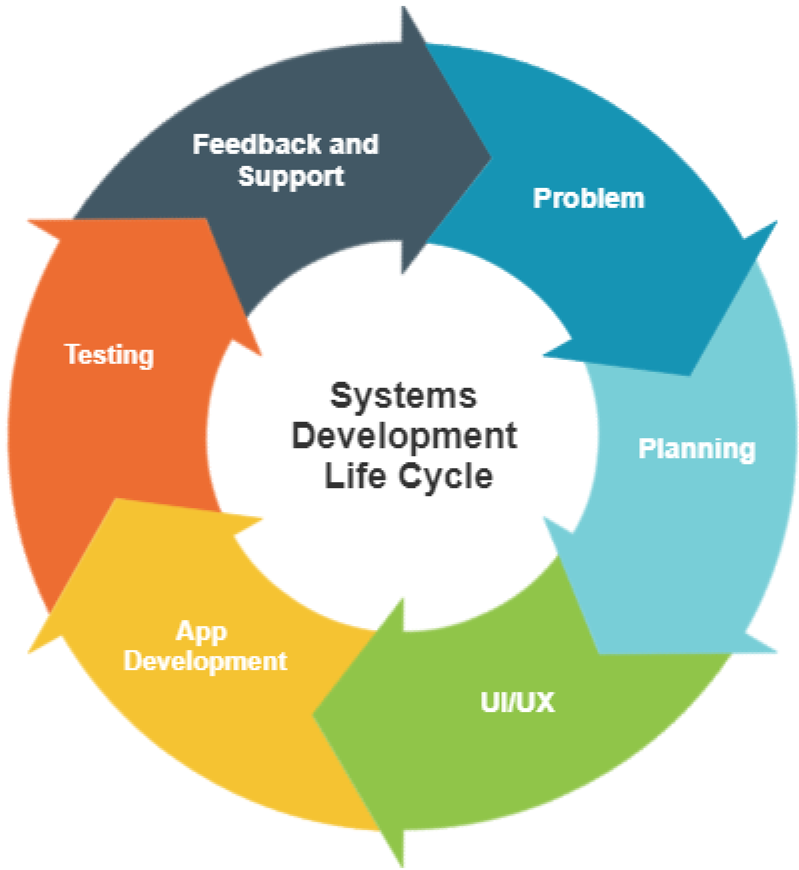


Figure 18. Agile Model SDLC of the Proposed System

The present manual processes of gathering data on infectious diseases are effectively aided by software that focuses on process adaptability. A flexible change process is another feature of the Agile methodology. Agile SDLC comprises of a development phase for each iteration, which progresses from requirements analysis and collection to designing the requirements, development, testing, deployment, and feedback.

The Problem phase includes by defining itself and determining the target users. Planning phase is where brainstorming of ideas, review of related literatures regarding to the study, and identifying the requirements. UI/UX or designing phase is where the wireframes and prototyping takes place. App development phase is where the development of front and back-end and API happens. This also includes the development of web application following the system development life cycle.

Furthermore, Testing phase includes the evaluation of application and usability of the system using ISO 25010 labeled scale-response questionnaire. Lastly, the Feedback and Support phase includes the support application for future revisions regarding feedbacks.

CHAPTER 4 RESULTS AND DISCUSSION

Implementation

The system was implemented to improve data-based decision making in relation to infectious diseases in the barangay. The Rural Health Unit will be the one to create and enroll an account for the Barangay Health Workers. In that case, the Barangay Health Workers are authorized to input all the necessary patient’s data. They are required to have an internet connection to access the site.

The system is tested several times to secure its usability, functionality, and operability. This will ascertain various instances that can affect the system during the run as anticipated. It is then followed by debugging to find and fix mistakes in the system code—also referred to as "bugs" that may cause it to behave erratically or crash.

The researchers gathered Covid-19 data for 3 years and were loaded in the system to ensure if the system meets its objective.

Although, some of the Covid-19 data are synthesized in order to test the usability of the SIR model.

These processes are being done repeatedly for numerous amounts of time to ensure the there are no bugs or errors that can affect the run of the system.

The study is composed of specifications that are needed in order to employ and install the proposed system. These are crucial requirements that must be complied to ensure the functionality and successful operability of the proposed system.

Software Specifications

The BIDIM Web Application was implemented to make use of the SIR model, which predicts the spread of infectious diseases. Also, an implementation of GIS that pinpoints and highlights active cases. The UI/UX design was originally made by the researchers and is user friendly both visually and experientially.

The development process was performed using Visual Studio 2022, Visual Studio Code, and Azure Data Studio with SQL Server for database handling. On the other hand, the researchers used Figma, which is a UI/UX prototyping tool, and Bootstrap v5 for designing and interacting with the system.

Hardware Specifications

The web application was deployed with minimum requirements using Windows 7 and above (x64bit operating system), with at least a CPU speed of dual core 1.2Ghz, and 4GB RAM.

As the web application is online dependent, the device connection should be able to work with the requirement of an internet connection via Wi-Fi.

User Specifications

The main user of the proposed system is assigned to the Barangay Health Workers, while Rural Health Units, on the other hand, is the admin. They must have considerable amount of knowledge in handling computers and technological tools so that they can use the system effectively.

Inputs and Outputs

The preceding figures are a collection of user interfaces for the application. These interfaces served as the front-end design of the application. The screenshot are as follows:

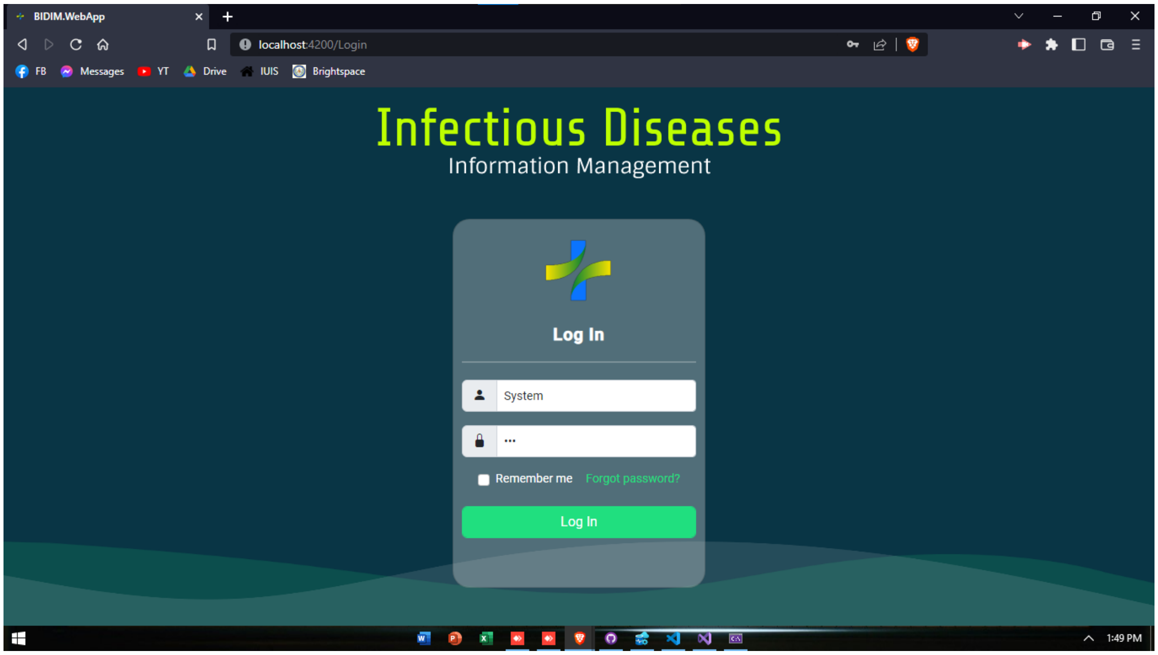


Figure 19. User and Admin Log-in Interface

Figure 19 exhibits the starting screen, having the initial preview and impression for the user and admin. The start screen flaunts its major logo of a cross placed in the center of the page and the signature of shades of color green that are visible across the entire page. Below the logo are the log-in buttons prompting the user/admin to input their username and password in order to gain access.

After clicking the log-in button, it will lead the user/admin for their respective interfaces.

Figure 20. User Dashboard Interface

Figure 20 exhibits the screen of the user after logging in. It displays various data-based comprehensive overview of large-scales data illustrated in a graphical interface.

The user is permitted to choose any type of infectious diseases to be displayed and it will show the overall population of the barangay, the reported infectious, reported recoveries, and reported deaths. Cases per month, cases by sex, and cases by age are also illustrated graphically.

This will significantly provide the user with a glance view about the important metrics associated with the infectious diseases as its primary intention is to provide data-based information.

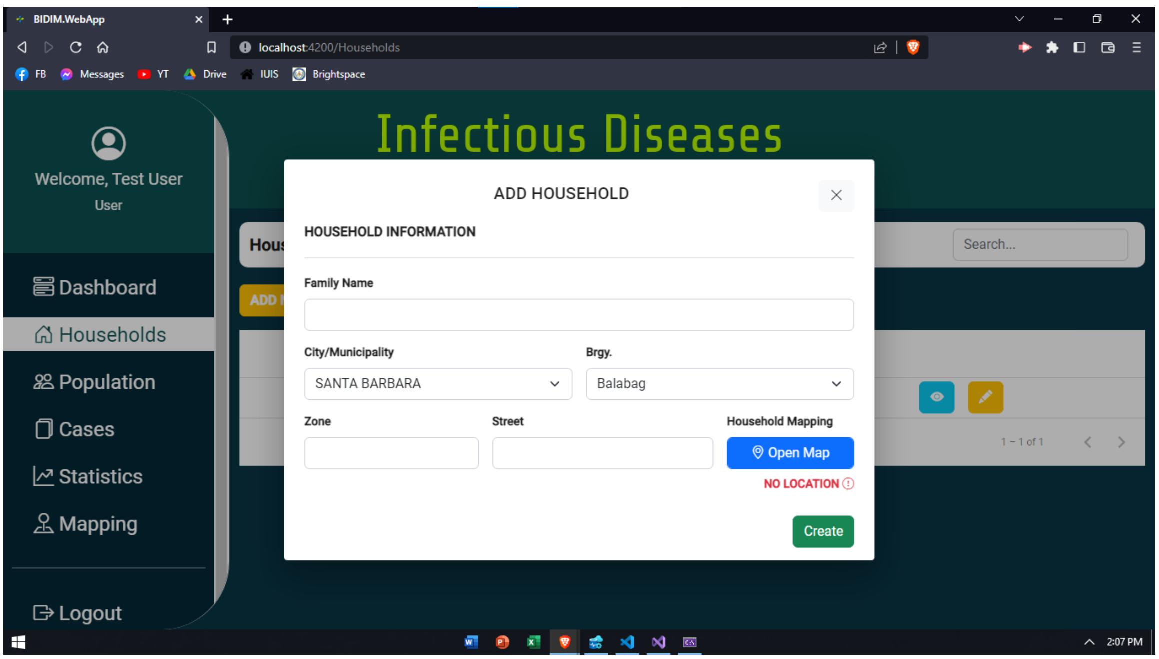


Figure 21. User Households Interface

Figure 21 shows the Households interface where the user can add new household by entering the household information. This includes Family name, City/Municipality, Barangay, Zone, and Street. Thenceforth, the user can map the location of the household. After encoding the necessary information, the user can now create the new household.

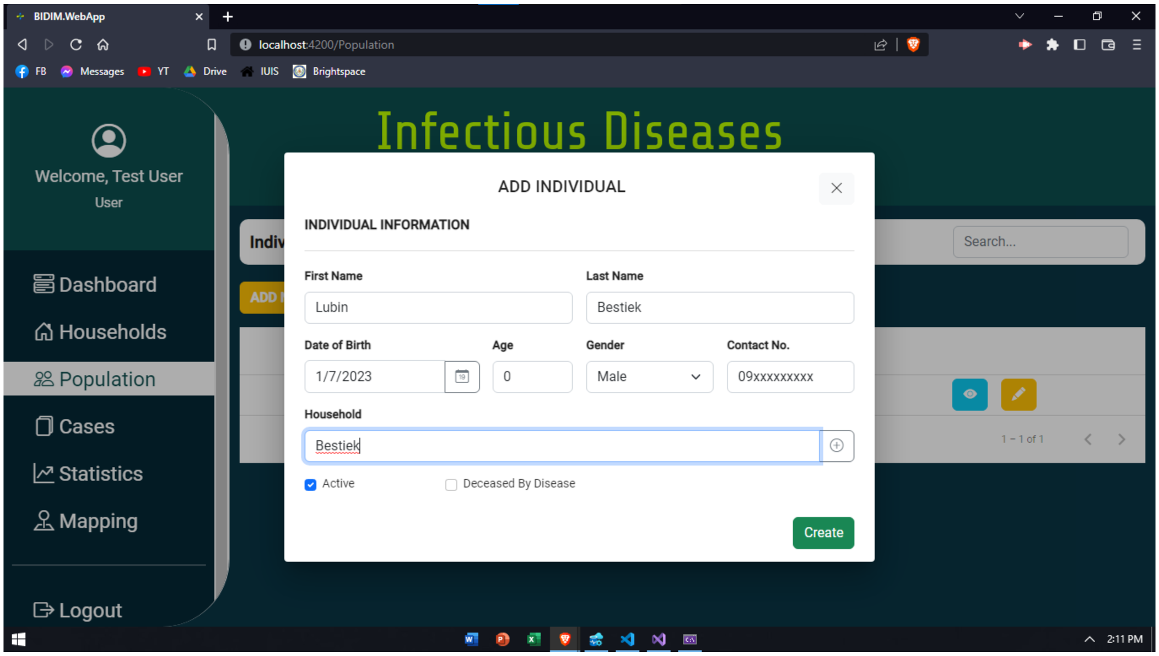


Figure 22. User Population Interface

The figure above exhibits the population page that allows the user to add an individual. The page demands the necessary individual information to be encoded such as the first name, last name, date of birth, age, gender, contact number, and selecting the individual's household by searching the last name. This is then followed, the user can select active if the individual is alive, otherwise, deceased by disease. The user can now create the new individual.

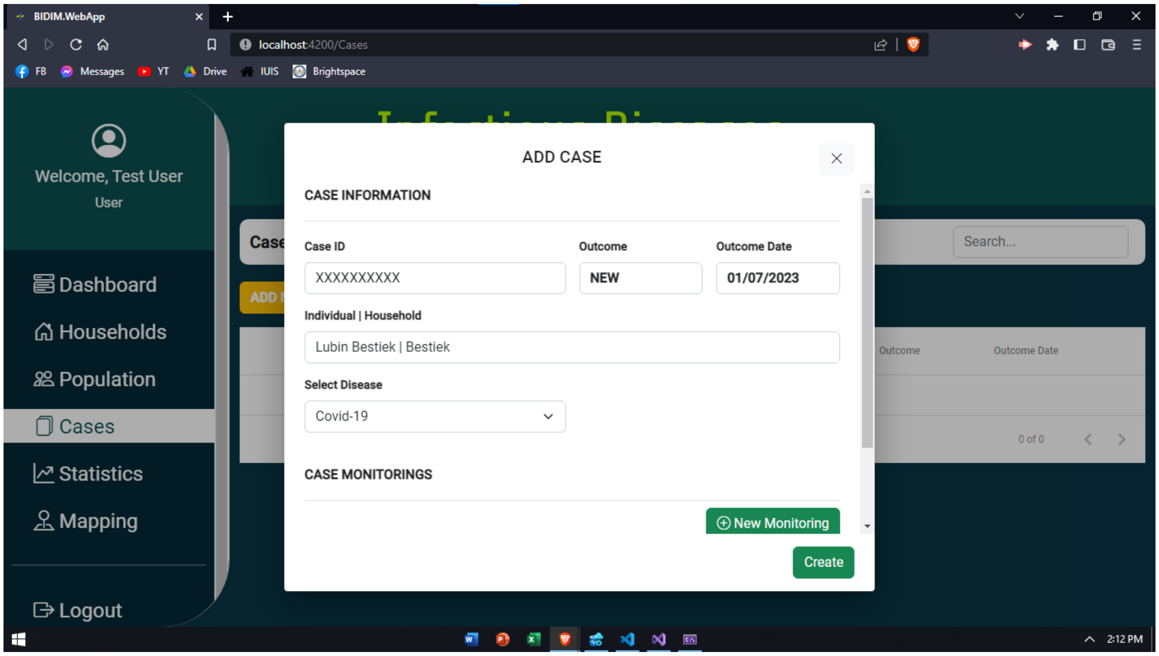


Figure 23. User Cases Interface

The figure above shows the interface where the user can add new case by entering the case's information such as case ID, outcome, Outcome date, household, and type of disease.

Aside from that, it also has necessary information that needed to be recorded such as the type of status, date recorded, symptoms, and remarks.

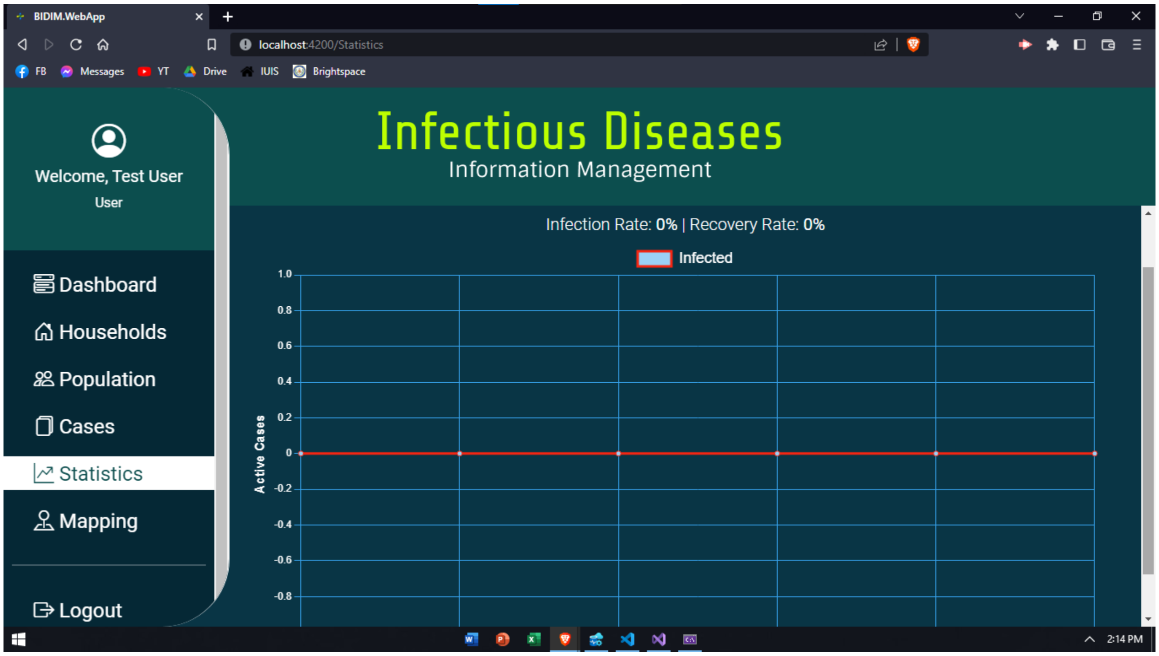


Figure 24. User Statistics Interface

Figure 24 exhibits the statistics that illustrates the prediction of infectious disease using SIR Model. The user is authorized to choose a type of infectious disease in the 3 infectious diseases that the SIR Model intended to predict that includes Covid-19, Dengue, and Tuberculosis.

Predicting the spread of the mentioned infectious diseases, through the numbers of susceptible, infected, removed, and recovered populations in the barangay.

Furthermore, the information displayed can aid possible outbreaks in the future.

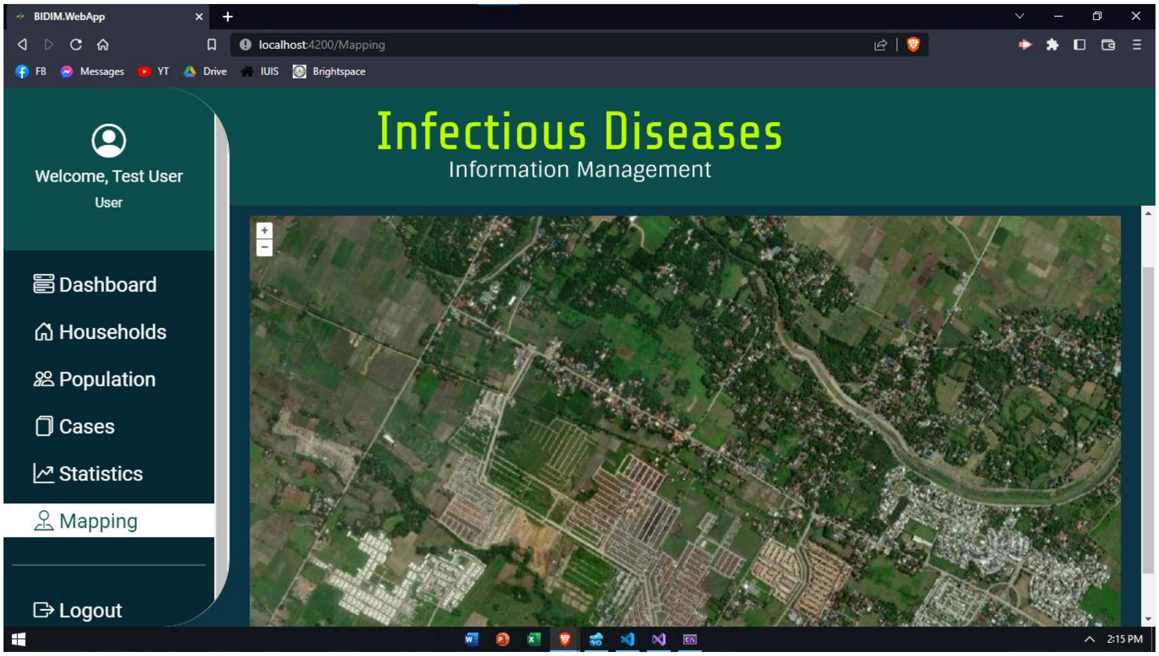


Figure 25. User Mapping Interface

Figure 25 displays the map of the Barangay Balabag Santa Barbara, Iloilo which is the locale of the study.

The barangay health worker, as the main user, can select any type of infectious disease to be displayed in the map to illustrate the location of the infectious disease occurrences that has been pinpointed upon creating case data.

Furthermore, the marker's color will automatically change showing it is slowly heating-up as soon as the area has a lot of pinpoints in its household location which signifies a possible outbreak, thus, the color will slowly cool down if the status of patient is changed to recovered.

Results Interpretation and Analysis

The researchers of this study proposed a web-based Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction which enables the BHW, as the main users, to record, manage, and map infectious disease cases; the RHU as the admin to have a real-time view of the infectious disease's cases data and dashboards with summarized insights which gives them the authority to generate, download and/or print.

To achieve the objectives of this study, the researcher utilized the System Development Life Cycle Model that includes Problem, Planning, UI/UX, App Development, Testing, and Feedback and Support which has a goal in reducing project risks and costs and speeds up development while increasing the efficiency of production.

Various Interviews in the Barangay Health Workers – Balabag, Santa Barbara and RHU – Santa Barbara was conducted in order to gather exact Infectious disease cases data in Covid-19, Dengue, and Tuberculosis 5 years ago to date.

Furthermore, data gathering for system testing has been conducted in the 10 Barangay Health Workers of Balabag, Santa Barbara to evaluate the usability and effectiveness of the system using ISO 25010 standard through survey questionnaires.

In the initial tests of the web-application, it was found out that the system is effective in recording population, creating infectious disease cases through households, mapping the active cases, and significantly display the dashboard that illustrates data-based comprehensive overview of large-scales data through graphical interface.

In terms of the algorithm used in the proposed system, the SIR Model, has effectively exhibits the cases of Covid-19, Dengue, and Tuberculosis.

Moreover, the R0, an epidemiologic concept of R naught, that expresses the typical number of instances of an infectious disease that result from transmission from a single infected person within a population that has never been exposed to the disease before, the beta (infection rate) which exhibits the interactions in a given time for the virus being transmitted, and the gamma (recovery rate)that exhibits the recovering rate of people infected in the given time has been successfully displayed in the User Statistics Page and are highly based on the cases data recorded in the system.

Moreover, to determine the effectivity of the SIR Model being utilized in the proposed system, the researchers of this study has conducted a further validation of the algorithm through the help of Dr. Alexander Balsomo, Faculty, College of Arts and Sciences, West Visayas State University – Main Campus.

The epidemiologist highlights that the SIR Model should be an independent feature whereby insinuates that the data being used in the algorithm requires a static environment which had made a huge contradiction on the objectives of our proposed study as our system has a dynamic and real-time environment.

Furthermore, the epidemiologist also stated that the SIR model can't efficiently support the system in its mechanism to predict the spread of three infectious diseases (Covid-19, Dengue, and Tuberculosis), specifically, in the number of data required by the model for it to effectively function, since the model is only applicable to large geographic scales such as countries and regions. Barangay, on the other hand, has a small scale which signifies that it can't support the requirements to systematically provide the needs of the model.

System Evaluation Results

The researchers used ISO 25010 standard questionnaires with rating sheets to systematically assess the evaluation of meaningful insights and measurable feedback from the audiences providing valuable information that are significant to determine the areas that work and what doesn't in the study and to assess the feasibility of the study.

The usability of the system was tested by the Barangay Health Workers of Balabag Santa, Barbara Iloilo to measure the final in-motion system and determine if its initial performance obtained the objectives of the study.

Composite weighted means were used to determine the evaluation of the proposed software.

Scales of Mean	*Description*
5 – 4.1	Very Good
4 – 3.1	Good
3 – 2.1	Fair
2 – 1.1	Poor
1	Very Poor

Functional Stability. The results as shown in Table 1 concluded that the web application has an overall functional stability mean value of 4.30. Specifically, Completeness has a mean value of 4.00, "Good"; Correctness has a mean value of 4.50, "Very Good"; and Appropriateness has a mean value of 4.40, "Very Good". Therefore, the results indicate that the web application is capable of offering functions that meet the implied needs.

Table 1

ISO 25010 - Functional Stability

Indicators	**Mean**	**Interpretation**
Completeness	4.00	Good
Correctness	4.50	Very Good
Appropriateness	4.40	Very Good
Overall Mean	**4.30**	Very Good

Reliability. The results as shown in Table 2 concluded that the web application has an overall reliability mean value of 4.78. Specifically, Maturity has a mean value of 4.70, "Very Good"; Availability has a mean value of 5.0, "Very Good"; Fault Tolerance has a mean value of 4.40, "Very Good"; and Recoverability has a mean value of 5.0. Therefore, the results indicates that it meets the reliability indicators and the quality of performing consistently well.

Table 2

ISO 25010 – Reliability

Indicators	**Mean**	**Interpretation**
Maturity	4.70	Very Good
Availability	5.00	Very Good
Fault tolerance	4.40	Very Good
Recoverability	5.00	Very Good
Overall Mean	**4.78**	**Very Good**

Portability. Table 3 illustrates the result that the application has an overall portability with a mean of 4.6, "Very Good"; Adaptability has a mean value of 5.0, "Very Good"; Durability has a mean value of 4.70, "Very Good"; Installability has a mean value of 4.60, "Very Good";

Replicability has mean value of 4.10, “Good”, and Affordability has a mean value of 4.60, “Very Good”.

Therefore, the results indicates that the web application is capable of being transferred from one environment to another.

Table 3

ISO 25010 – Portability

Indicators	**Mean**	**Interpretation**
Adaptability	5.00	Very Good
Durability	4.70	Very Good
Installability	4.60	Very Good
Replaceability	4.10	Very Good
Affordability	4.60	Very Good
Overall Mean	**4.60**	**Very Good**

Usability. The results shown in Table 4 displays that the usability if the system has an overall mean of 4.68 Appropriateness recognizability has a mean value of 4.80, "Very Good"; Learnability has a mean value of 4.60 "Very Good"; Operability has a mean value of 4.7, “Very Good”;

User error protection has a mean value of 4.30, "Very Good"; User interface aesthetics has a mean value of 5.0, "Very Good"; and Accessibility has a mean value of 4.8, "Very Good".

Therefore, the results indicates that the system achieved a defined goal effectively, efficiently, and satisfactorily.

Table 4

ISO 25010 – Usability

Indicators	**Mean**	**Interpretation**
Appropriateness and Recognizability	4.80	Very Good
Learnability	4.60	Very Good
Operability	4.70	Very Good
User error protection	4.30	Very Good Very Good
User Interface Aesthetics	5.00	Very Good
Accessibility	4.80	Very Good
Overall Mean	**4.68**	**Very Good**

Performance Efficiency. Results above have accumulated with an overall performance efficiency mean of 4.80. Time behavior has a mean value of 4.70, "Very Good"; Resource utilization has a mean value of 5.0, "Very Good"; and Capacity has a mean value of 4.70, "Very Good". Therefore, the results indicate that the application has satisfied the required performance related to the number of resources used.

Table 5

ISO 25010 – Performance Efficiency

Indicators	**Mean**	**Interpretation**
Time behavior	4.70	Very Good
Resource utilization	5.00	Very Good
Capacity	4.70	Very Good
Overall Mean	**4.80**	**Very Good**

Security. Table 6 has an overall mean security value of 3.34, "Very Good"; Confidentiality has a mean value 4.6, "Very Good"; Integrity has a mean value of 3.50, "Good";

Non-repudiation has a mean value of 2.70, "Fair"; Accountability has a mean value of 3.40, "Good"; Authenticity has a mean value of 2.5, "Fair". This generally means that the web application is somehow able to protect information and data from security vulnerabilities.

Table 6

ISO 25010 – Security

Indicators	**Mean**	**Interpretation**
Confidentiality	4.60	Very Good
Integrity	3.50	Good
Non-repudiation	2.70	Fair
Accountability	3.40	Good
Authenticity	2.50	Fair
Overall Mean	**3.34**	**Good**

Compatibility. The results shown in Table 7 revealed that the system has "Very Good" compatibility based on its overall mean value of 5.0. Co-existence has a mean value of 5.00, "Very Good"; and Interoperability has a mean value of 5.0 mean. This means that the system or component can share data with other goods, systems, or components and/or execute its needed functions while sharing the same hardware or software environment.

Table 7

ISO 25010 – Compatibility

Indicators	**Mean**	**Interpretation**
Co-existence	5.00	Very Good
Interoperability	5.00	Very Good
Overall Mean	**5.00**	**Very Good**

Maintainability. The results shown in Table 8 displayed that the system has an overall maintainability mean of 4.78. Modularity has a mean of 4.80, "Very Good"; Reusability has a mean value of 4.70. Same goes with the Analysability and Modifiability has a mean value of 4.70, "Very Good"; and Testability has a mean value of 5.0, "Very Good". This signifies that the system has attained the level of effectiveness and efficiency at which a product or system may be adjusted to improve, rectify, or adapt to changes in the environment and needs.

Table 8

ISO 25010 - Maintainability

Indicators	**Mean**	**Interpretation**
Modularity	4.80	Very Good
Reusability	4.70	Very Good
Analyzability	4.70	Very Good
Modifiability	4.70	Very Good
Testability	5.00	Very Good
Overall Mean	**4.78**	**Very Good**

The results as shown in Table 9 indicate that the barangay infectious disease information management with geographic information system for mapping and SIR model for prediction achieved an overall "Very Good" rating based on the ISO 25010 standard garnering an overall mean of 4.535.

Precisely, among the eight quality requirements, compatibility has the highest mean value of 5 conforming with a perfect mean of the "very good" rating. Moreover, the requirements which are functional stability, reliability, portability, usability, performance efficiency, compatibility, and maintainability have attained a “Very Good” rating wherein the overall mean is ranging between 4.3 and 4.8. On the other hand, security quality requirements have the lowest mean with a value of 3.3, yet, it is still proportioned as “Good”. Results have satisfied the conducted quality evaluation and therefore attest to the application’s quality for providing implied needs to its users.

Table 9

Summary of ISO 25010

ISO 25010 Criteria	**Mean**	**Interpretation**
Functional Stability	4.33	Very Good
Reliability	4.77	Very Good
Portability	4.60	Very Good
Usability	4.70	Very Good
Performance	5.00	Very Good
Efficiency	4.80	Very Good
Security	3.30	Good
Compatibility	5.00	Very Good
Maintainability	4.78	Very Good
Overall Mean	**4.54**	**Very Good**

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Proposed Study Design and Implementation

This study developed by implementing the SIR model for predicting the spread of diseases and incorporating GIS in the form of a heatmap, enabling the Barangay Health Workers to keep track of active cases.

BIDIM web application was able to operate effectively, able to add new patients with infectious diseases, showing the total population, total recovered, total infected, and total deceased and other metrics in the dashboard related to the infectious disease population. The user also allows the pinpointing of active cases with the implementation of heatmap. The study has been challenged as the SIR Model implemented in the system isn’t accurately working since the model is not applicable for the barangay scope.

This study will be beneficial to the BHW since they are in the role of recording infectious disease data in the barangay. The system reduces the manual administrative processes overhead associated with collecting, monitoring, and managing infectious disease data. The system will efficiently effectuate data analysis and visualization which allows them to be well aware of the current infectious diseases status and its threats in the barangay.

Through this, it will allow them to enhance efforts in prioritizing urgent measures of intervention and control to prevent epidemic occurrence.

Summary of Findings

The researchers conducted a thorough user-testing of the functional web-based infectious disease information management system on the ten (10) Barangay Health Workers of Barangay Balabag, Santa Barbara to evaluate its usability and effectiveness.

It was found out that the system can successfully record the barangay population by entering necessary personal data, create cases through households, map the active infectious disease cases, and illustrate the dashboard that displays the summarized data in categories using graphs as an observation for data-based information.

Due to the incapability of researchers in testing the SIR Model's quality assurance in terms of accuracy and compatibility upon implementing it in the system, an in-depth validation to the epidemiologist has been conducted.

Apart from the successful display of the R0, alpha, and beta, and statistically graphs the infected, and recovered individuals overtime, it was found out that the SIR Model can't sustain its accuracy due to the small scope of source of cases data.

This study only focuses on a barangay scope. However, according to Sir Alexander Balsomo, the epidemiologist, SIR Model requires a wide geographical range such as city, region, or country in order to systematically provide the needs of the model and to support in sustaining its accuracy.

Furthermore, the web-based infectious disease information management system is developed in a dynamic environment denoting that the cases that has been created through populations can affect the SIR Model which contradicts to the statement of Sir Alex that the Model should be an independent feature since it is designed for a static environment.

Conclusions

After implementation and testing, the results of the proposed system have shown and it was able to meet its objectives as follows:

1. The barangay infectious diseases information management system aided the barangay health workers to record the population, household, and infectious disease cases data.
2. The GIS for mapping allowed the barangay health workers to pinpoint the location of the household, and could be used for mapping the new case which signifies as the place where the incidence of infectious disease took place.
3. The pinpoint marker in GIS displays a color red which signifies that the barangay could be experiencing an outbreak in the near future since the infected individuals have occurred nearby one another.
4. Based on the statement of the epidemiologist, the SIR model can’t efficiently support the system in its mechanism to predict the spread of three infectious diseases (Covid-19, Dengue, and Tuberculosis) since

the model is only applicable to large geographic scales such as countries and regions. Barangay, on the other hand, has a small scale which signifies that it can't support the requirements to systematically provide the needs of the model.

5. The overall performance of the system evaluated based on ISO 25010 Standard feedback of the surveyed 10 barangay health workers was a mean of 4.535 which indicates a “Very Good” performance. Whereabouts, seven quality requirements have a scale of means that is described as “Very Good” and the other one has an overall mean that signifies that the system has a “Good” performance. Furthermore, the system was able to meet the needs and requirements of the end-users.

Recommendations

To further improve the system, the researchers recommend the following:

1. To include two-factor authentication for the user/admin to have a secured log-in by securing the online accounts and the data they contain. This means that the account must be connected to the phone number and/or to email as evidence to an authentication mechanism to grant access.
2. After logging-in, and before starting the operation with the web application, the system must include prompts that give overview and guides in navigating the interfaces by describing each section and buttons and explain their functions as most of the users do not have enough knowledge about handling and use of tools regarding the system.
3. Appropriate algorithm must replace the SIR model as its range is only applicable to large geographic scales in terms of simulation. It only applies to the range of city, province, or national level which means that it is its smallest scope. Barangay

scope on the other hand is not achievable due to the limited attributes that can support the requirements of the model.

4. The algorithm used must be applicable to all infectious diseases and not only limited to the three infectious diseases which are Covid-19, Dengue, and Tuberculosis. This will make the system flexible and its mechanism will be improved.
5. The GIS must have dates that allows filters to show the past incidence of infectious diseases. This includes the pinpoints of location of the infectious disease occurrence and its intensity.

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Appendices

Appendix A

Letter to the Adviser

	INVITATION LETTER FOR ADVISER	Document No.	WVSU-ICT-SOI-03-F03
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

February 24, 2022

DR. MA. BETH S. CONCEPCION
Dean
College of Information and Communications Technology – West Visayas State University
Luna St, La Paz, Iloilo City, 5000 Iloilo

Dear Ma'am,

The undersigned are BS Information Systems Research 1/Thesis 1 students of CICT, this university. Our thesis/capstone project title is *"Barangay Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction"*.

Knowing of your expertise in research and on the subject matter, we would like to request you to be our **ADVISER**.

We are positively hoping for your acceptance. Kindly check the corresponding box and affix your signature in the space provided. Thank you very much.

Respectfully yours,

1. Luvin B. Lara
2. Leslie Ann Grapes S. Novales
3. Emillen Joy M. Pascual
4. Mark Levi L. Sequio

PS:

Advisers, are task to work with the students in providing direction and assistance as needed in their thesis/capstone project. They shall meet with the students weekly or as needed to provide direction, check on progress and assist in resolving problems until such a time that the students passed their defenses and submit their final requirements, as well as, preparing their evaluations and grades.

Action Taken:

❍ I Accept.

❍ Sorry. I don't accept. ______________________ Signature over printed name of the Adviser

CC:

CICT Dean
Research Coordinator
Group
*To be accomplished in 4 copies

Appendix B

Request Letter for Interview

February 19, 2022

Arian Villaflor
President, Barangay Health Workers
Balabag Santa Barbara, Iloilo

Dear Ma'am,

We, the researchers of College of Information and Communications Technology from West Visayas State University – Main Campus, currently taking up bachelor's degree in Information Systems are proposing a research idea entitled, "Barangay Infectious Diseases Information Management with Geographic Information Systems for Mapping and SIR Model for Prediction".

Prior to this, we would like to request of your precious time to discuss about your current processes in acquiring infectious diseases data.

A great pleasure of having you as our locale of our study. Your ideas and suggestions will be a big help for the progression of our undergraduate thesis.

Thank you very much!

Respectfully yours,

Luvin B. Lara
Leslie Ann Grapes S. Novales
Emillen Joy M. Pascual
Mark Levi L. Sequio

Noted by:

Dr. Ma. Beth S. Concepcion
Thesis Adviser

Appendix C

Request Letter for Historical Data

May 2, 2022

DR. MARIA NEY E. MUCHO
MHO
Rural Health Unit - Santa Barbara, Iloilo

Dear Ma'am,

We, the researchers of College of Information and Communications Technology from West Visayas State University – Main Campus, currently taking up bachelor's degree in Information Systems are proposing a research idea entitled, "Barangay Infectious Diseases Information Management with Geographic Information Systems for Mapping and SIR Model for Prediction".

Prior to this, we need to acquire the patient's historical data in COVID-19, Dengue, and Tuberculosis of Balabag Santa Barbara, Iloilo from 2017 till date. These data are very much needed in our proposed system to perform analysis and visualization.

We are looking forward to your positive response from your good office about this matter.

Respectfully yours,

Luvin B. Lara
Leslie Ann Grapes S. Novales
Emillen Joy M. Pascual
Mark Levi L. Sequio

Noted by:

Dr. Ma. Beth S. Concepcion
Thesis Adviser

Appendix D

Request Letter for Data Gathering

February 19, 2022

Barangay Health Workers
Balabag Santa Barbara, Iloilo

Dear Ma'am,

In partial fulfillment of the requirements in thesis 1 and 2, we, the researchers of College of Information and Communications Technology from West Visayas State University – Main Campus, currently taking up bachelor's degree in Information Systems are conducting research entitled, "Barangay Infectious Diseases Information Management with Geographic Information Systems for Mapping and SIR Model for Prediction".

We are in the process of gathering data through ISO 25010 standard survey that will be used for the software quality evaluation of our system.

Regarding this matter, we would like to ask your permission to distribute our survey questionnaire to the Barangay Health Workers that will help us obtain information we need to determine the effectiveness of our system.

We are looking forward for your consent at our request.

Respectfully yours,

Luvin B. Lara
Leslie Ann Grapes S. Novales
Emillen Joy M. Pascual
Mark Levi L. Sequio

Noted by:

Dr. Ma. Beth S. Concepcion
Thesis Adviser

Appendix E

Letter of Request to the Epidemiologist

February 28, 2022

Dr. Alexander J. Balsomo
Faculty, College of Arts and Sciences
West Visayas State University

Dear Sir,

We, the researchers of College of Information and Communications Technology from West Visayas State University – Main Campus, currently taking up bachelor's degree in Information Systems are proposing a research idea entitled, "Barangay Infectious Diseases Information Management with Geographic Information Systems for Mapping and SIR Model for Prediction".

Prior to this, knowing your expertise and in the subject matter, we would like to request of your precious time to discuss about the SIR Model and its application to our proposed system.

We are positively hoping for your acceptance. Your ideas and suggestions will be a big help for the progression of our undergraduate thesis. Thank you very much!

Respectfully yours,

Luvin B. Lara
Leslie Ann Grapes S. Novales
Emillen Joy M. Pascual
Mark Levi L. Sequio

Noted by:

Dr. Ma. Beth S. Concepcion
Thesis Adviser

Appendix F

Endorsement Letter to the Technical Editor

	ADVISER'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F10
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Technical Editor**, the attached manuscript of the thesis entitled:

Barangay Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction.

Said manuscript has been presented to me for preliminary evaluation and guidance, and after a series of corrections/directions given which was implemented by the proponents whose names are listed hereunder and their thorough research, we have come to its completion.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the Technical Editor for **TECHNICAL EDITING**.

MA. BETH S. CONCEPCION, DIT
Adviser's Name & Signature

Date: May 25, 2023

Group Members:
1. Luvin B. Lara
2. Leslie Ann Grapes S. Novales
3. Emillen Joy M. Pascual
4. Mark Levi L. Sequio

Note: This form should be accomplished and signed if the corrections and changes made by the adviser have been implemented and a new copy of the document have been printed for checking and submission to the next editor

Appendix G

Endorsement Letter to the English Editor

	TECHNICAL EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F11
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	**April 27, 2018**
		Issued by:	**CICT**
		Page No.	**Page 1 of 1**

Respectfully endorsed to the **English Editor**, the attached manuscript of the thesis entitled:

Barangay Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction.

Said manuscript was presented to me and was reviewed and edited in terms of technical specifications, correctness of diagrams and other technical matters. The corrections and suggestions was carried and implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** the said thesis manuscript to the English Editor/Grammarian for **English Grammar Editing.**

MA. BETH S. CONCEPCION, DIT
Technical Editor's Name & Signature

Date: May 25, 2023

Group Members:
1. Luvin B. Lara
2. Leslie Ann Grapes S. Novales
3. Emillen Joy M. Pascual
4. Mark Levi L. Sequio

Note: *This form should be accomplished and signed if the corrections and changes made by the Technical Editor have been implemented and a new copy of the document have been printed for checking and submission to the next editor.*

Appendix H

Endorsement Letter to the Thesis Format Editor

	THESIS FORMAT EDITOR'S ENDORSEMENT FORM (For Thesis Manuscript)	Document No.	WVSU-ICT-SOI-03-F13
		Issue No.	1
		Revision No.	0
	WEST VISAYAS STATE UNIVERSITY	Date of Effectivity:	April 27, 2018
		Issued by:	CICT
		Page No.	Page 1 of 1

Respectfully endorsed to the **Thesis Coordinator**, the attached manuscript of the thesis entitled:

Barangay Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction.

Said manuscript was presented to me and has checked the preliminaries, thesis document convention and end matters, made some corrections which was implemented by the proponents whose names are listed hereunder.

Now therefore, I hereby **ENDORSE** said manuscript to the Thesis Coordinator for appropriate action.

SHEM DURST ELIJAH B. SANDIG
Thesis Format Editor's Name and Signature

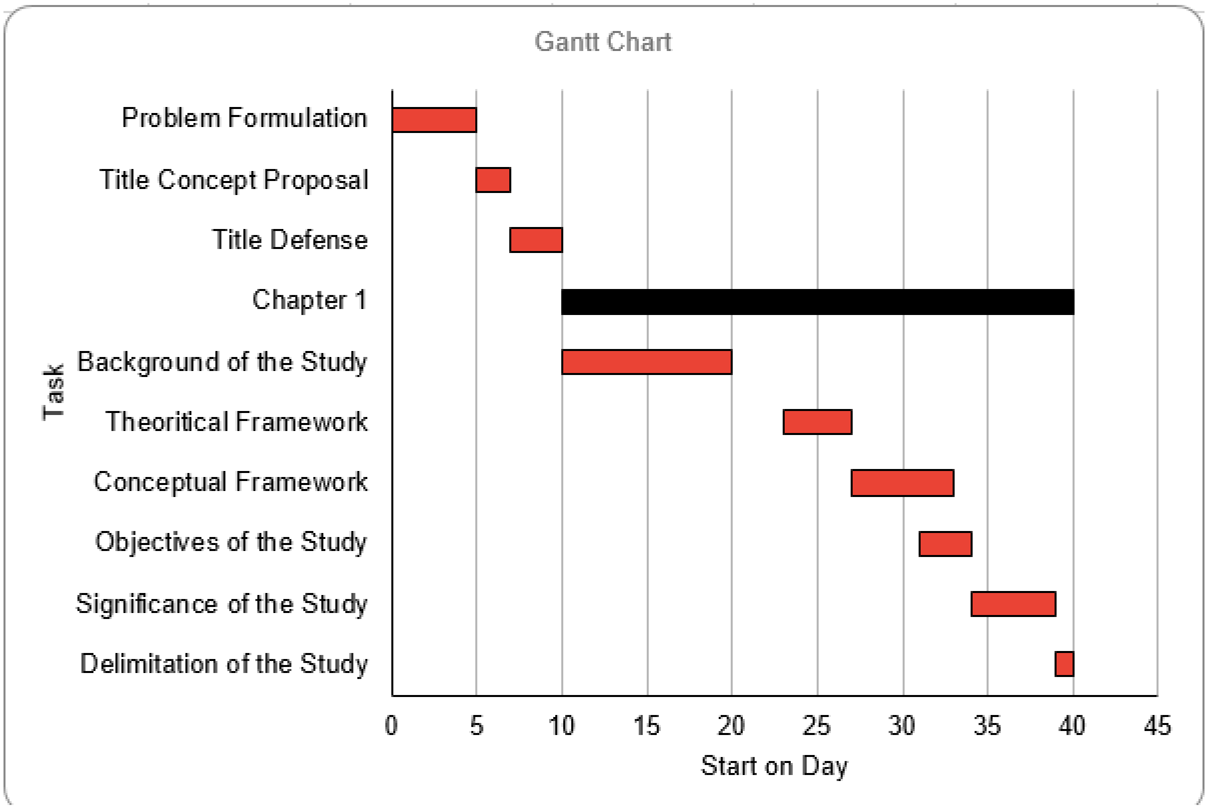
Date: May 26, 2023

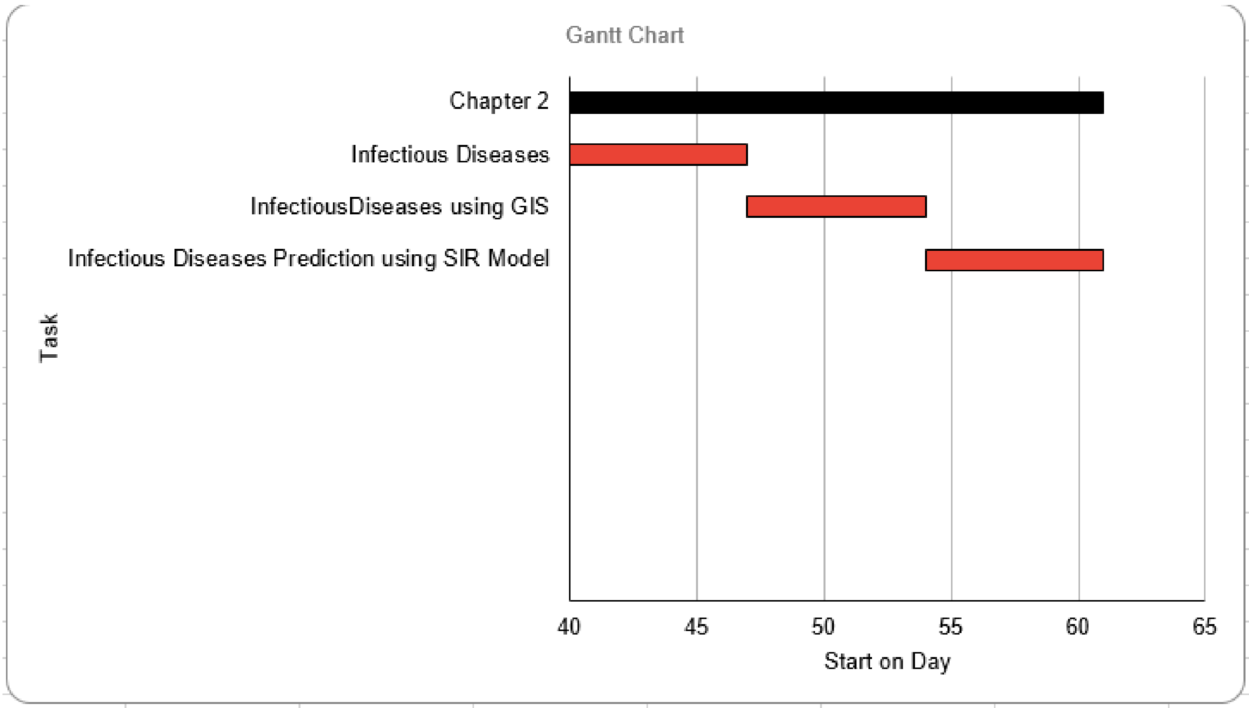
Group Members:
1. Luvin B. Lara
2. Leslie Ann Grapes S. Novales
3. Emillen Joy M. Pascual
4. Mark Levi L. Sequio

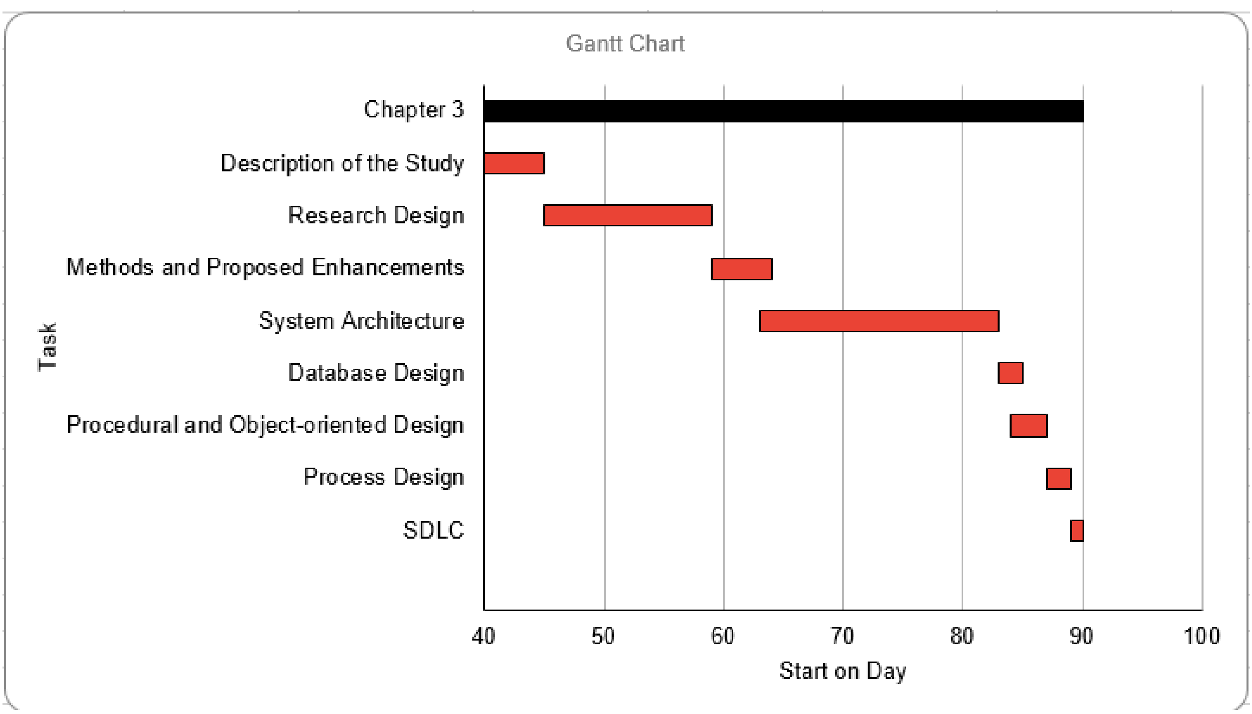
Note: This form should be accomplished and signed if the corrections and changes made by the Thesis Format Editor have been implemented and the four (4) new copies have been printed ready for bookbinding.

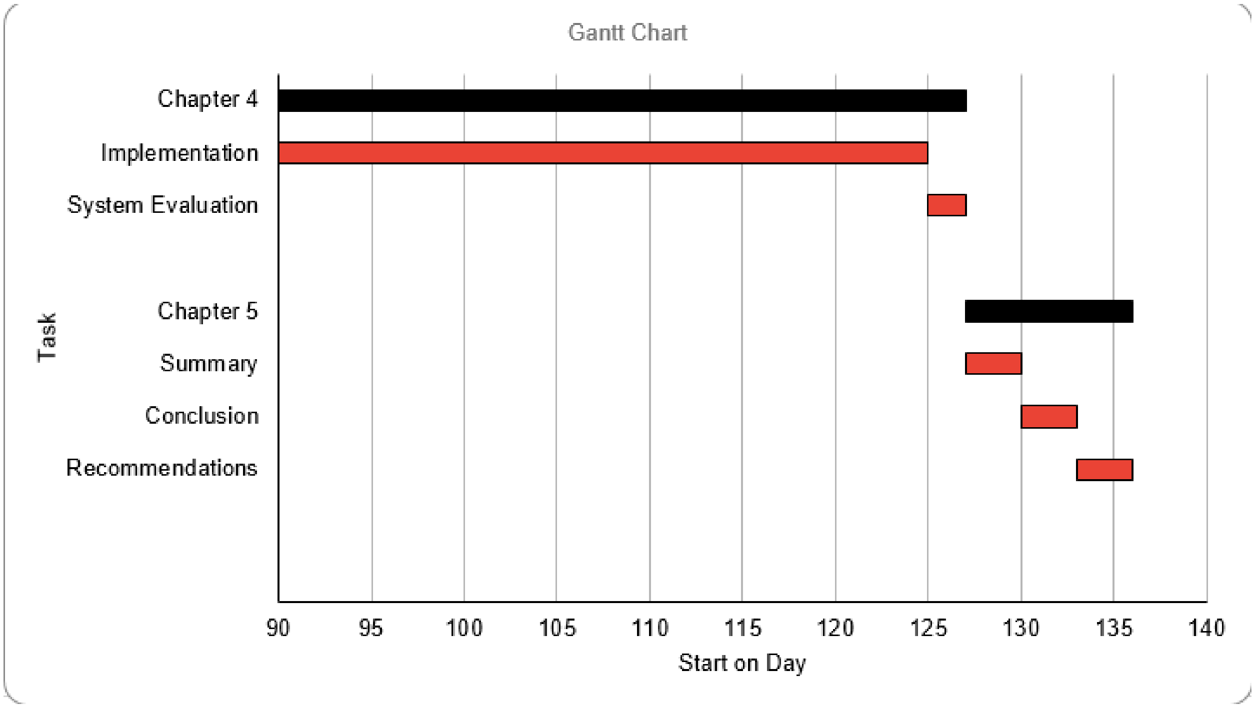
Appendix I

Gantt Chart



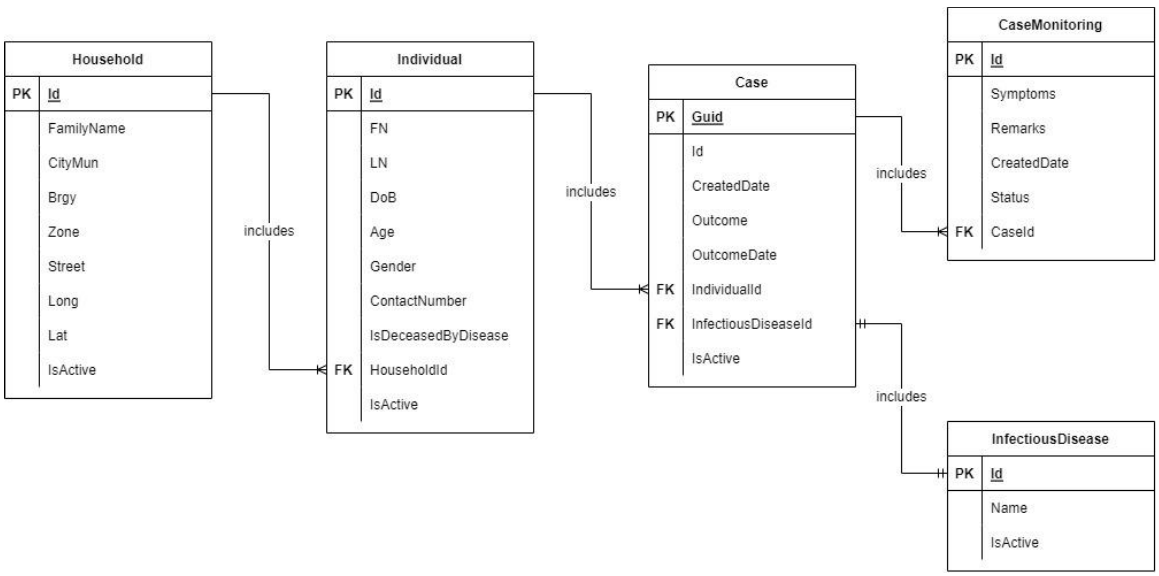

Gantt Chart
Chapter 2
Infectious Diseases
InfectiousDiseases using GIS
Infectious Diseases Prediction using SIR Model
Task
40
45
50
55
60
65
Start on Day


Gantt Chart
Chapter 3
Description of the Study
Research Design
Methods and Proposed Enhancements
System Architecture
Database Design
Procedural and Object-oriented Design
Process Design
SDLC
Task
40
50
60
70
80
90
100
Start on Day


Gantt Chart
Chapter 4
Implementation
System Evaluation
Chapter 5
Summary
Conclusion
Recommendations
Task
90
95
100
105
110
115
120
125
130
135
140
Start on Day

Appendix J

Entity Relationship Diagram



Appendix K

Data Dictionary

Infectious Disease	:	ID +
		Name [COVID-19 | Tuberculosis |...]
Population	:	ID
		FirstName +
		LastName +
		DoB +
		Age +
		Gender [Male | Female] +
		ContactNumber +
		IsActive +
		DeceasedbyDisease +
		HouseholdID
Case	:	GUID +
		ID +
		CreatedDate +
		Outcome [Dead | Recovered] +

OutcomeDate +

IndividualID +

InfectiousDiseaseID

Case Monitoring : ID

Symptoms +

Remarks +

Status [Active | Dead |...] +

CreatedDate +

CaseID

Households : ID +

FamilyID +

CityMun [Sta. Barbara| Cabatuan |...] +

Brgy [Balabag | Bolong Oeste |...] +

Zone [Zone 1 | Zone 2 |...] +

Street [Bermejo St.| Rizal St. |...] +

Long +

Lat

Appendix L

Sample Program Codes

```
#region > Statistics
        public async Task<StatisticsViewModel>
GetSIRData(int diseaseId)
        {
            List<Case> cases = await
_caseRepository.GetAllActive();

            var individuals = await
_individualRepository.GetAllIncludeInactive();

            return cases.Any() ?
                //ComputeSIRData(4000, cases.Where(c =>
c.InfectiousDiseaseId == diseaseId).ToList()) :
                ComputeSIRData(individuals.Count,
cases.Where(c => c.InfectiousDiseaseId ==
diseaseId).ToList()) :
                new StatisticsViewModel()
                {
                    SIRData = new List<object>(),
                    SIRMonthProjections = new
List<string>(),
                    InfectionRate = 0,
                    RecoveryRate = 0
                };
        }

        private StatisticsViewModel ComputeSIRData(int
population, List<Case> cases)
        {
            StatisticsViewModel retVal = new
StatisticsViewModel();

            retVal.SIRData = new List<object>();

            double N = population;
            double I = cases.Count(c =>
c.Outcome?.ToLower() == "infected");
```

```
            double R = cases.Count(c =>
c.Outcome?.ToLower() == "recovered");
            // Susceptible = population - (infected +
deceased)
            double S = N - (cases.Count(c =>
(c.Outcome?.ToLower() == "infected" || c.Outcome?.ToLower()
== "deceased")));
            double t = 0;

            double reproductionRate = 3;
            double a = 1.000 / 14.000; // gamma/recovery
rate
            double b = reproductionRate * a; //
beta/infection rate

            //double a = 0.5; // gamma/recovery rate
            //double b = 2.0; // beta/infection rate

            double scale = 0.1;

            retVal.InfectionRate = Math.Round(b, 2);
            retVal.RecoveryRate = Math.Round(a, 2);

            // Get last case date to get total days for 6-
months projection
            DateTime? latestCaseDate = cases.Any() ?
cases.OrderBy(c => c.CreatedDate).Last().CreatedDate :
null;
            var daysOfProjection = 0;

            // Month/Year text
            List<string> monthOfProjection = new
List<string>();

            if (latestCaseDate != null)
                for (int i = 1; i <= 6; i++)
                {
                    var nextMonth =
latestCaseDate?.AddMonths(i);

                    if(nextMonth != null)
                    {
```

```
monthOfProjection.Add($"{nextMonth?.ToString("MMMM")}
{nextMonth?.Year}");
                        daysOfProjection += new
DateTime(nextMonth?.Year ?? 0, nextMonth?.Month ?? 0, 1, 0,
0, 0).AddMonths(1).AddSeconds(-1).Day;
                    }
                }

            // Set months projected
            retVal.SIRMonthProjections = monthOfProjection;

            for (int i = 1; i <= 6; i++)
            {
                retVal.SIRData.Add(new { Data = new
List<double>() { S, I, R } });

                double dS = (-b * S * I) / N;
                double dI = ((b * S * I) / N) - a * I;
                double dR = a * I;
                double dt = 1;

                S = S + dS * scale;
                I = I + dI * scale;
                R = R + dR * scale;


                t = t + dt * scale;
            }

            return retVal;
        }
        #endregion
```

Appendix M

Software Quality Evaluation Form

Using the scale below evaluate the system by placing a check (✓) mark on the appropriate column.

5 — Very Good 4 — Good 3 — Fair 2 — Poor 1— Very Poor

1. Functional Stability

Indicators		5	4	3	2	1
Completeness	The set of instructions all the specified task and user objectives.					
Correctness	The system provides correct results with the needed degree of precision.					
Appropriateness	The system provides the accomplishment of specified tasks and objectives.					

2. Reliability

Indicators		5	4	3	2	1
Maturity	A system, product or component meets for reliability under normal operation.					

Availability	A product or system is operational and accessible when required for use.					
Fault tolerance	A system, product or component operates as intended despite the presence of hardware or software results.					
Recoverability	In the event of an interruption or a failure, a product or system can recover the data and establish the desired state of the system.					

3. Portability

Indicators		5	4	3	2	1
Adaptability	A product or system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments.					
Durability	A product or system can withstand technology evolution and changes without costly redesign, reconfiguration or recoding.					
Installability	A product or system can be successfully installed and/or uninstalled in a specified environment.					

Replaceability	A product can replace another specified software product for the same purpose in the same environment.					
Affordability	A product or system can increase efficiency and productivity by reducing the time and costs involved in delivering instruction.					

4. Usability

Indicator		5	4	3	2	1
Appropriateness Recognizability	Users can recognize whether a product or system is appropriate for their needs.					
Learnability	A product or system enables the user to learn how to use it with effectiveness, efficiency in emergency situations.					
Operability	A product or system is easy to operate, control and appropriate to use.					
User error protection	A product or system protects users against making errors.					
User interface aesthetics	A user interface enables pleasing and satisfying interactions for the user.					
Accessibility	A product or system can be used by people with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use.					

5. Performance Efficiency

Indicator		5	4	3	2	1
Time behavior	The response and processing times and throughput rates of a product or system, when performing its functions, meet requirements.					
Resource utilization	The amounts and types of resources used by a product or system, when performing its functions, meet requirements.					
Capacity	The maximum limits of the product or system parameters meet requirements.					

6. Security

Indicator		5	4	3	2	1
Confidentiality	The prototype ensures that data is accessible only to those authorized to have access.					
Integrity	A system, product or component prevents unauthorized access to, or modification of, computer programs or data.					

Non-repudiation	Actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later.					
Accountability	The actions of an entity can be traced uniquely to the entity.					
Authenticity	The identity of a subject or resources can be proved to be the one claimed.					

7. Compatibility

Indicator		5	4	3	2	1
Co-existence	A product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product.					
Interoperability	Two or more systems, products or components can exchange information and use the information that has been exchanged.					

8. Maintainability

Indicator	5	4	3	2	1

Modularity	The application is composed of discrete components such that a change to one component has minimal impact on other components.					
Reusability	An asset can be used in more than one system, or in building other assets.					
Analyzability	It is possible to assess the impact on a product or system of an intended change to one or more of its parts, or to diagnose a product for deficiencies or causes of failures, or to identify parts to be modified.					
Modifiability	The application can be effectively and efficiently modified without introducing defects or degrading existing product quality.					
Testability	Test criteria can be established for an application, product or component and tests can be performed to determine whether those criteria have been met.					

Appendix N

Disclaimer

The College of Information and Communications Technology at West Visayas State University has accepted this web-based system and its corresponding documentation, titled "Barangay Infectious Diseases Information Management with GIS for Mapping and SIR Model for Prediction", in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Systems. With the exception of the text that is indicated, it is our own creation.

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June 2023