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Community-Based Child Nutrition Projection and Monitoring

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Abstract

It is vitally important to monitor the nutrition status of the children living in the community to provide input to the City Health office personnel in designing desirable intervention programs. However, with the varied reasons for malnutrition and its related mortality, nutrition program planners and implementers find it difficult to decide what programs to design for a certain locality, considering fewer efforts to generate concrete interpretations of previous nutrition data. Hence, the study designed a prediction simulator for community-based nutrition status monitoring for children under five years old, with trend analysis and prediction. The study used time series analysis and Autoregressive Integrated Moving Average (ARIMA) for trend analysis and prediction. The development of the system follows the iterative process model. Moreover, the developed system generates trend analysis and prediction utilizing historical data showing outstanding functionality, reliability, usability features, and specifications. However, having a portable system version will help provide easy mobility. Furthermore, a wider scope of prediction and visualization to cover a province-wide scope is a help.

Keywords: classification algorithm, data mining, teaching performance, teacher brand model, policy enhancement

Introduction

New trends and technologies surround the children of the "digital generation," which expose them to televisions, computers, video games, and mobile devices. And one way to globalize the development of research is to recognize the fast phase of the advancement of technology. Hence, it played an important role in sustaining and advancing the spread of information around the globe (Sala & Trivin, 2018). Moreover, technology plays a vital role in conducting research involving time series forecasting. Time series forecasting aims to develop a mathematical model to forecast future observations based on available data (Khandelwal, Adhikari, & Verma, 2015). One of the most important and widely used time series models is the autoregressive integrated moving average (ARIMA) model. The popularity of the ARIMA model is due to its statistical properties and the well-known Box–Jenkins methodology in the model-building process. Visualization, on the other hand, helps in presenting research outputs. In addition, visualization helps present predictions of the future and enhances one's skills in understanding an image based on past data (Vassakis et al., 2018; Wang et al., 2018). Also, visualization is an important tool in developing a strategy to help an organization plan ahead, projecting current and future conditions to guide the organization in making decisions (Vassakis et al., 2018; Wang et al., 2018).

Similarly, malnutrition is one of the many pieces of information that require projection. Malnutrition means more than feeling hungry or not having enough food to eat. Inadequate intake of protein, calories, iron, and other nutrients makes up different types of malnutrition (Ruiz et al., 2019). Poor nutrition occurs in developing countries and progressive areas, affecting many persons worldwide to malnutrition (Akhtar, 2016; Dewan, 2016). Moreover, malnutrition contributes to more than half the childhood deaths in developing countries (Amare et al., 2019). Worldwide, millions of children die from preventable and treatable illnesses despite effective health interventions, and at least half of these deaths are from malnutrition (Akhtar, 2016; Fadel et al., 2019). Besides, maternal and child malnutrition is also a problem in low and middle-

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income countries (Jaacks et al., 2019), showing millions of children younger than five years have undernutrition, and billions of people are at risk of nutritional deficiency. Child and maternal undernutrition were responsible for millions of deaths, and the global disability-adjusted life (Troeger et al., 2018), and maternal and paternal education is a big factor in these consequences (Vollmer et al., 2017). Soil-Transmitted Helminths (STH) are a major public health problem in the Philippines, particularly among school-aged children, who, if infected, suffer from profound physical deficits, including anemia and malnutrition, stunted growth, reduced fitness, and cognitive delays (Ross et al., 2017). An extensive study showed that malnourished children have lower resistance to infection (Ibrahim et al., 2017); therefore, they are more likely to die from common childhood ailments such as diarrheal diseases and respiratory infections (Walson & Berkley, 2018). Besides, malnourished children who survive are likely to suffer from frequent illnesses, adversely affecting their nutritional status and locking them into a vicious cycle of recurring sickness, faltering growth, and diminished learning ability (Tsedeke et al., 2016). Disease-related malnutrition in hospitalized patients is a major public health issue in industrialized and emerging countries worldwide. Malnutrition in the hospital setting can develop due to insufficient nutrient intake, impaired absorption or loss of nutrients due to illness or trauma, or increased metabolic demands (Correia, Perman, & Waitzberg, 2017). Also, the malnutrition problem, in India, for instance (Sahu et al., 2015), is a relatively small number of states, districts, and villages account for a large share of the malnutrition burden — only five states and 50% of villages account for about 80% of the malnutrition burden. There are approximately 2.3 million malnutrition-related deaths among 6-60 months aged children in developing countries, about 41% of the total deaths in this age group (Sahu et al., 2015).

In the Philippines, the country is still battling serious malnutrition problems requiring proper solutions as it affects the country's economy in the future if not given attention. However, the malnutrition situation in the Philippines has not substantially improved in the last 15 years (UNICEF Philippines, 2019). The death rates related to malnutrition are high for children five years old and below belonging to the poorest sectors of the

community (Gamelong, 2018). This scenario makes it impossible for nutrition program planners and implementers to design a more focused program. Hence, the researchers propose Community-based Child Nutrition Status monitoring and projection, piloting the City Nutrition Office of Ozamiz City to help them decide where to conduct immediate programs related to malnutrition in every barangay. With the information provided by the system, the City Nutrition Office can easily monitor the trends of the nutritional status of children, under five years old, per barangay and the city. The Office can use this information in their decision-making, project proposals, and other pertinent programs relevant to the nutritional welfare of the children under their care.

Theoretical Framework

Forecasting and Visualization

Forecasting is a planning tool to develop assumptions or premises about future uncertainty based on analyzing the present and past data available, predicting the future based on analyzing the most common trends of past and present (Martinez et al., 2014). There are two types of forecasting: qualitative and quantitative forecasting. Qualitative forecasting is useful in developing forecasts with a limited scope. The models are highly reliant on expert opinions and are most beneficial in the short term (Wang et al., 2019). On the other hand, quantitative forecasting excludes expert opinions and utilizes statistical data based on quantitative information (Meluzín et al., 2018). Quantitative forecasting models include time series methods, discounting, analysis of leading or lagging indicators, and econometric modeling (Emrouznejad et al., 2016).

On the other hand, visualization is the process of representing an abstract business or scientific data as images that can aid in understanding the meaning of the data (Iriarte, Hoveskog, Justel, Val, & Halila, 2018). Besides, the visualization systems are tools designed for the explicit purpose of data visualization, employing abstractions and mathematical models suited to this task. Furthermore, such tools also commonly support data management, layout algorithms, interaction, and animation.

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Furthermore, data visualization tools can automatically create visualizations, enable you to create your own, or offer both capabilities (Venier, Lehman, Salamova, & Hites, 2018).

Malnutrition Monitoring and Forecasting

Nutrition Monitoring and evaluation aim to determine and measure the amount of progress made for nutrition intervention and meet nutrition-related goals or expected outcomes, promoting a uniform goal within the dietetics profession to provide a more effective nutrition intervention (Andersen et al., 2018). This effort enables meeting the challenges for sustainable efforts of combatting micronutrient malnutrition. Achieving this objective requires an adequate supply, access, and consumption of various foods. There is also a program in the Philippines in line with the current government's efforts to fight undernutrition. These efforts include the Pantawid Pamilyang Pilipino Program (4Ps), a social protection and poverty reduction scheme that provides conditional cash grants to poor households. The program is actively and directly coordinated with the National Nutrition Council, the highest coordinating and policy-making body for nutrition in the Philippines, together with many government departments and agencies (Acupido et al., 2020). However, local government units are also mobilizing efforts to combat malnutrition (Herrin et al., 2018).

On the other hand, forecasting uses historical data to make informed estimates to determine future trends (Khan et al., 2016). Concerning nutrition, childhood malnutrition leads to poor mental and physical development and an increased risk of morbidity and mortality (Aheto et al., 2017). Likewise, assessing a patient's initial nutritional status and evaluation during the disease and treatment plays an important role in tailoring nutritional support. Malnutrition exposes an individual to disease and infections, leading to slower recovery from illness. Likewise, good nutrition enhances immunity and the ability to fight infections and diseases (Akhtar, 2016). Moreover, poor nutrition during childhood hampers children's physical and mental development, leading to a greater risk of a casualty from communicable diseases or additional critical

infections and ultimately ending in a bigger economic burden on society (Das & Gulshan, 2017).

On the other hand, malnutrition is a known contributing factor to disease and death (Bhutta et al., 2017). Wasting, a nutritional condition where a child suffers from rapid weight loss, exposes the child to an increased risk of mortality, putting 1/10 of the children in Asia and Oceania at this risk (World Health Organization, 2020). More than half of the malnourished under-five children in the world lived in the southern part of Asia (World Health Organization, 2020). However, malnutrition does not only focus on stunting and wasting conditions as it ranges from extreme hunger and undernutrition to obesity (Webb et al., 2018). Furthermore, undernutrition, overweight, obesity, or overnutrition are more common under inequitable socioeconomic situations like poverty, which reflects nutrition inequities (Perez-Escamilla et al., 2018).

Malnutrition Monitoring in the Philippines

With the government's effort to improve the country's economy, the national prevalence rates of chronic malnutrition remain one of the biggest challenges the country faces, with an alarming 3.4 million stunted children or short for their age and over 300,000 children under five underweight for their age or wasted as shown in the results conducted in 2015 (Villafranca, 2016). However, in the 2021 report of UNICEF, a significant number of about 3.5 million Filipino children under 5 years old are stunted, classifying these children to have chronic malnutrition (Ulep, 2021). Moreover, a significant fraction of Filipinos suffers from chronic malnutrition issues such as protein-energy malnutrition and micronutrient deficiencies (Capanzana & Aguila, 2020). The cost of undernutrition is a burden shouldered not only by one-third of Filipino children but by the entire nation (Save the Children, 2017). Many Filipinos suffer from malnutrition due to poverty, population, politics, pathology, production of food, and preservation of food from wastage and loss (Salvacion, 2017; Ramirez et al., 2019; Capanzana & Aguila, 2020). Moreover, the number of underweight pregnant mothers gives infants a high risk of low birth weight that will lead to malnutrition (Ulep, 2021).

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In addition, poor access to health care services, bigger family size, lack of nutrition education, and weak financial support from the government contribute to the rising problem of malnutrition (Gamelong, 2018). Moreover, social status, employment, education, poverty, war, disasters, and calamities affect the nutrition of the populace, hence leading to stunting (Ulep, 2021).

Although improving, the rate of decline of malnutrition is slow compared to other countries of the same income level (Ulep, 2021). With a national stunting rate of 30%, the Philippines ranked seven among East Asia and Pacific regions (Mbuya et al., 2021). In addition, the Philippines is among the Southeast-Asian nations facing the condition known as the double burden of malnutrition or the co-existence of under- and overnutrition (Vargas et al., 2018; Leyso & Palatino, 2020). Although, government and non-government organizations work together to combat malnutrition in the country.

Operational Framework

The child's nutritional information study focused on three major tasks: forecasting, monitoring, and visualization. Figure 1 shows the conceptual framework of the study.

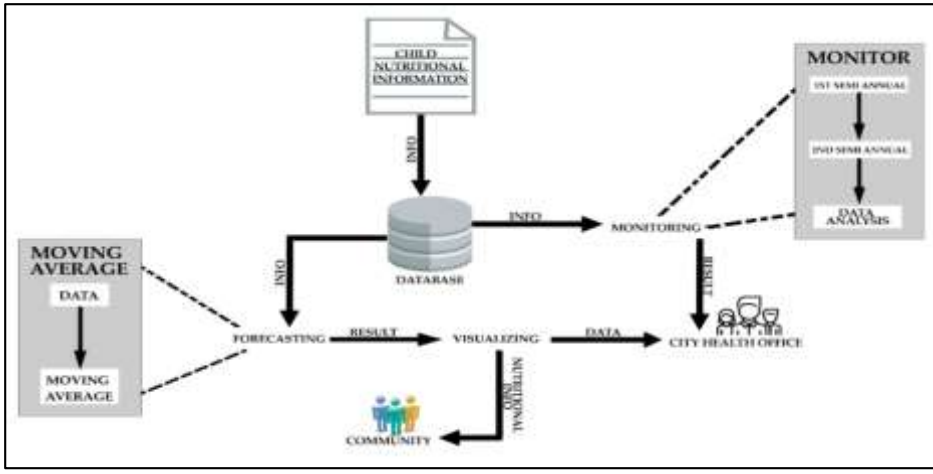


Figure 1. Child Nutrition Status Monitoring and Forecasting Architecture.

Figure 1 shows the flow of forecasting, monitoring, and visualizing the child's nutritional information, recording the important information in the database, and forecasting and monitoring the nutritional status. The forecasting process used the moving average and visualizing the result through graphs. On the other hand, the monitoring happens in a semi-annual schedule that analyzes the nutritional information of each child for the City Nutrition Office's use.

The development of the system follows the iterative process with three iterations covering the monitoring, forecasting, and visualization modules. The first increment focused on the monitoring module which kept track of the different information of the children under five years old. After polishing the monitoring module and making sure of the correctness of the data, the second increment commenced. The second increment created the forecasting module. This module used the nutritional data stored in the database backtracking several years of coverage as well as that of the current information used during the monitoring to generate the forecasted value as a result of the second increment. The third increment then developed the visualization of information necessary for the City Nutrition Office in the regular monitoring of the children under their supervision.

The Moving Average technique acts as the first step in getting a series of data from past to current. The process then divides the data by 3 to get the moving average used for forecasting. On the other hand, the monitoring module monitors the child's status every six months. Therefore, the analysis compared the first and the second half of the nutritional information of the child. On the other hand, the study used a database to record the nutritional information of each barangay. Figure 2 presents its database design through an entity-relationship diagram.

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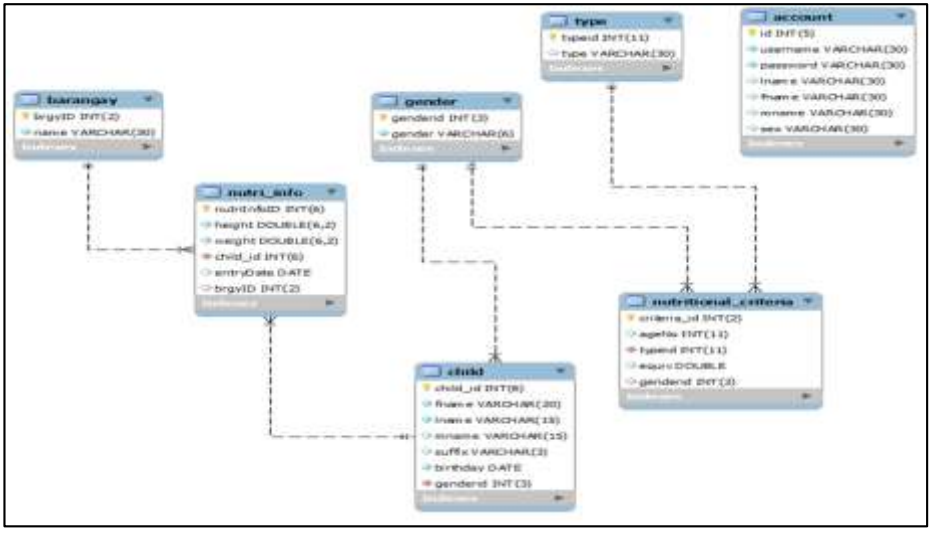


Figure 2. Database Design for Child Nutrition Status Monitoring and Forecasting.

The nutritional information includes the barangay information and nutritional criteria categorized into gender and type. Specifically, each barangay holds nutritional information for every child under its care. On the other hand, Figure 3 and Figure 4 present the process flows of the system, showing the interactivity of processes.

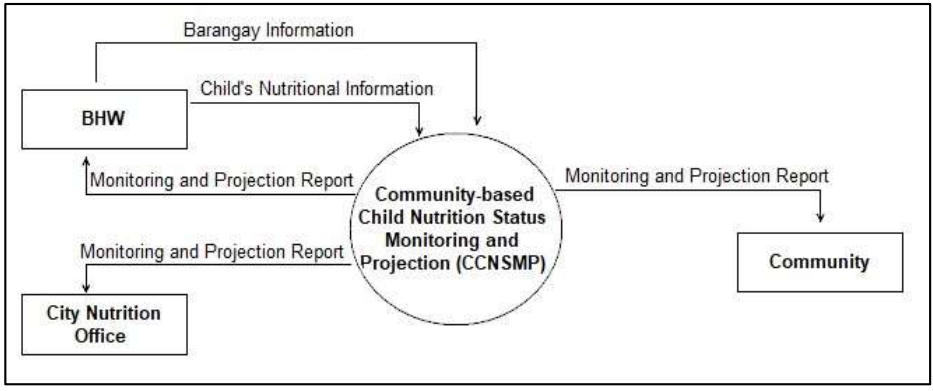


Figure 3. Context Diagram of the Child Nutrition Status Monitoring and Forecasting.

The Community-based Child Nutrition Status Monitoring and Projection System maintains each child's information under each barangay. The Barangay Health Worker (BHW) for each barangay obtained the child's information through periodic nutritional surveys and enumeration and provided the child's information to the system. As a result, the BHW, the City Nutrition Office, and the community can view the visualization results of the monitored and projected data for every barangay.

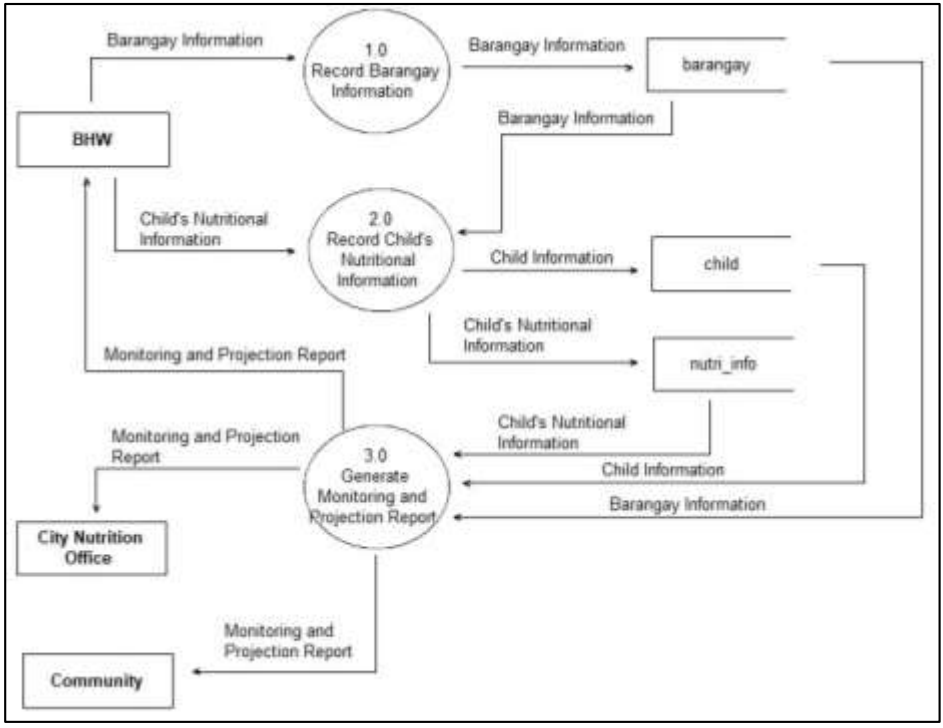


Figure 4. Top-level DFD of the Child Nutrition Status Monitoring and Forecasting.

The Barangay Health Worker (BHW) assigned to a specific barangay periodically obtains the nutritional information of each child under his care and stores this information in the system. The system then uses this periodic data for each barangay in the monitoring and prediction

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generation. The monitoring process enables the concerned entities to know the nutritional progress of each child, while the prediction generation provides a nutritional forecast for each barangay given a certain period.

System Evaluation

The system evaluation process determines the system's performance for both the client and server. In addition, the evaluation process allows target users to use the system and, at the same time, rate their perception as to the functionality, reliability, and usability of the system for both the client and server sides. Since the developed system is implemented in a client-server architecture, the evaluators who tested and evaluated the client side are the Barangay Nutrition Scholars (BNS) in rural areas of the city. Likewise, the evaluators for the server-side application are employees of the City Nutrition Office (CNO). The software quality assessment criteria used the 5-point Likert scale where 5 means Strongly Agree and 1 is Strongly Disagree. In addition, the study used an 0.8-continuum for interpretation with Excellent as the highest and Poor as the lowest.

Results and Discussions

Recording Nutritional Status per Barangay

The study monitors the nutritional status of each barangay by recording each child's nutritional information. The first step is to register the child's information in the system, as presented in Figure 5. Recording the child's nutritional information follows registering the child's personal information. Then, for every nutritional monitoring period, the system updates the nutritional information of the child. The system also provides basic functionalities for managing the child's information, such as updating the nutritional entries and editing some clerical errors, as presented in Figure 6. This interface also allows the user to search for specific child information. Also, the view button enables viewing the

child's nutritional information. Clicking the View button displays the trend of the nutritional information of the child. This trend provides information for the child's nutritional monitoring showing the information from the previous weighing session of the child up to the present.

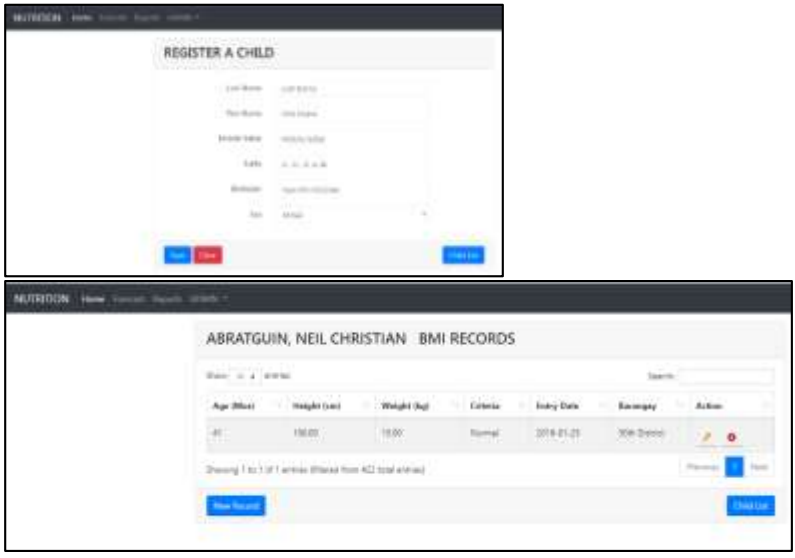


Figure 5. Recording Child's Nutritional Information.

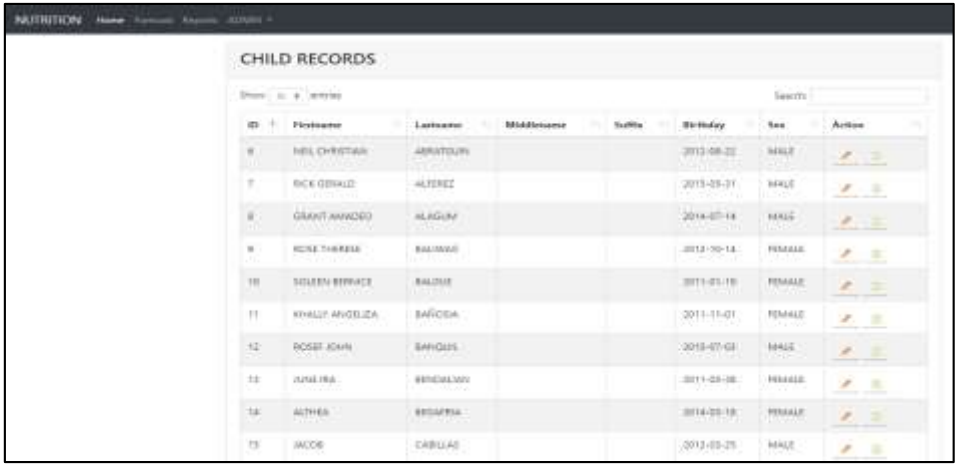


Figure 6. Managing Child's Information

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Monitoring and Visualizing the Nutritional Status per Barangay

The nutritional status of every child in a barangay provides information for the City Nutrition Office regarding prediction and forecasting for possible improvement of the nutritional status or worse nutritional status. The graph, as shown in Figure 7, presents the comparative distribution of children's nutritional classification as tall, severely stunted, normal, and stunted. This trend allows the user to select the year to monitor and the type of visualization to use.

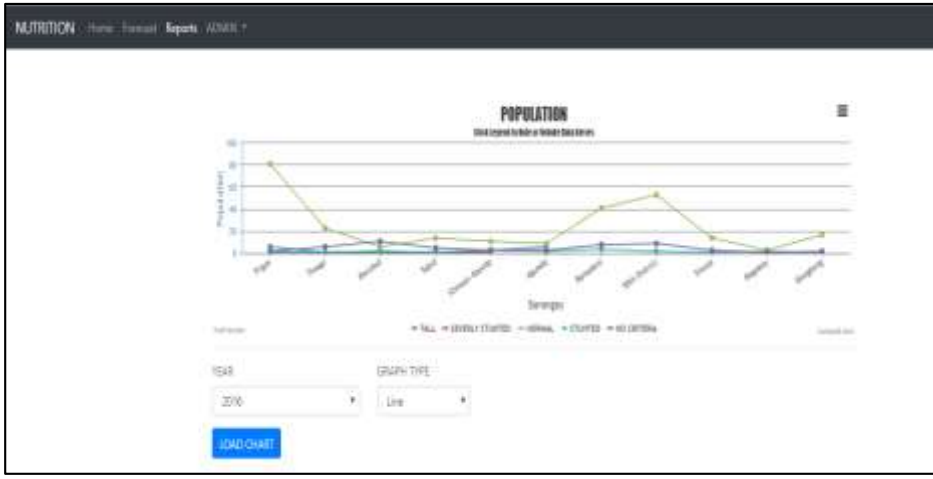


Figure 7. Child's Nutritional Classification per Barangay

Visualizing Nutritional Status Prediction

The system provides a forecasting feature to predict the possible improvement of the nutritional status to aid in planning and implementing nutritional programs for the target barangays. The visualized forecast, as presented in Figure 8, shows the nutritional status prediction of each barangay, given some criteria and the predicted trends of nutritional information for a specific range of years. This visualized forecast helps the City Nutrition Office plan for a more focused nutritional program to lessen malnutrition in the target barangay.



Figure 8. Nutritional Status Forecasted Data

System Evaluation

To justify the effectiveness and accuracy of the functions, the selected respondents evaluated the system's functionality, reliability, and usability for both the client side and server side. Figure 9 presents the overall result of the evaluation.

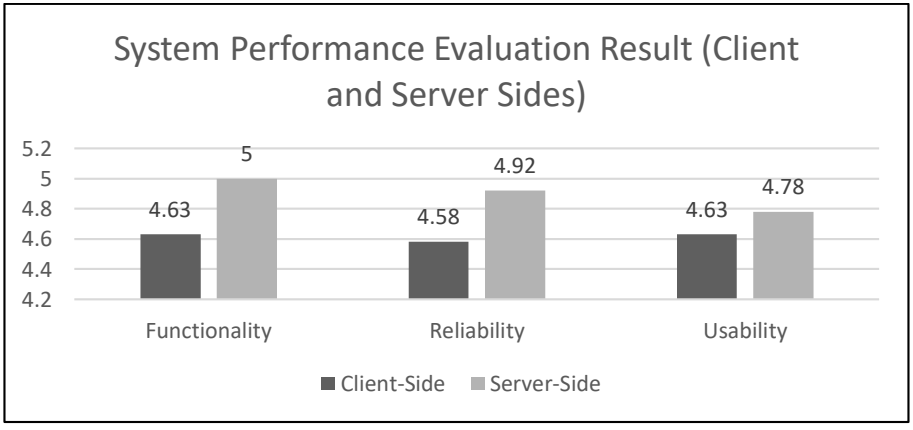


Figure 9. Overall System Performance for both Client and Server Sides.

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In the system functionality evaluation, the client-side result shows that users strongly agree that the system's functions are functional. Furthermore, the users exhibited a very satisfying impression of the system's functions. Although, there is a need for a more detailed description of the visualization for the users to understand the visualized reports holistically. However, on the server side, the result shows a very overwhelming acceptance of the users of the server side, demonstrating a very responsive system to their needs in managing the nutritional data. The result also implies that the navigational flow of functions is self-explanatory and easily understood.

Regarding the system's reliability, the respondents on the client side accepted the system's information as accurate and reliable, considering that the system provides the user with the exact output and visualizations of data. Likewise, the respondents strongly agree with the system's accuracy and reliability in managing the data and generating the needed information on the server side. The visualization of the monitoring and the predicted data exhibits a reliable source of information to help in planning nutritional programs for target barangays.

On the system's usability, the assessment result on the client side shows that the system provides the user with a very understandable navigational flow of the system. This result also implies that the overall aesthetics of the system is outstanding and were able to support the usability and learnability needs of users of varying ages. On the other hand, the server-side evaluation result shows that the system provides the users with a very smooth navigational flow of the controls in managing the data and generating the necessary visualizations. Although there is a very minimal concern found in the assessment, it is easy to address by changing the font and font style choices that could fit the users' varying ages.

Conclusions and Recommendations

Malnutrition is a burden to everyone. It hinders a child's capability to achieve their full potential as a learner and future productivity as a worker and a contributor to their country. With the varied reasons for

malnutrition and its related mortality, nutrition program planners and implementers find it difficult to decide what programs to design for a certain locality, considering that there are fewer efforts to generate concrete interpretations of previous nutrition data. Hence, the study designed and developed a Community-Based Child Nutrition Status Monitoring and Projection piloting all the barangays of Ozamiz City, Misamis Occidental, Philippines.

The study showed that the developed system for child nutrition status monitoring and projection was able to provide a set of modules that records the nutritional status of every child in a specific barangay where the system used the barangays of the pilot city. Also, the system developed a module that monitors the trends of the nutritional information of the children per barangay. Besides, a module also generates the visualized forecast of the nutritional information per barangay for a specific period, given varying criteria. Lastly, the system obtained commendable acceptance from the users on the client side and the server side for its functionality, reliability, and usability.

The system was able to monitor children's nutritional status in every barangay and visualized reports for the benefit of the City Nutrition Office in planning their programs to help lessen malnutrition. However, other features still need enhancement or development, such as developing a portable version of the system through a mobile application and expanding the prediction and visualization to multiple towns or a province-wide scope.

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