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Malnutrition Causal Modeling Analytics For Mandaluyong City's Nutrition Committee

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Abstract

The prevalence of malnutrition among children in the Philippines is alarming. According to the Philippine Plan of Action in Nutrition 2017, the prevalence rate of stunting children is 33.4% and 21.5% for underweight in the year 2014. In 2016, there were six hundred and seventy-eight (678) pre-school children who were identified to be malnourished in the city of Mandaluyong during their Operation Timbang. However, the determinants of child malnutrition in the city have not been fully analyzed and identified. Solving problems regarding malnutrition entails properly assessing the nutritional status of the city. To do this, necessary data of the children must be analyzed. With insights backed up by quantitative evidence, managing interventions and programs to address malnutrition; and formulating their problem analysis or the creation of causal model would be more objective. This research aims to identify the determinants of malnutrition by applying statistical and forecasting techniques using data from the different available sources to come up with objective insights, evidences and findings.

Keywords: *Analytics, Children, Intervention, Malnutrition*

I. INTRODUCTION

Health has been a priority in the Philippine development agenda since the adoption of the Millennium Declaration. Among the eight Millennium Development Goals (MDGs), the goal for reducing poverty (MDG1) includes nutrition targets, which directly impacts health. The occurrence of communicable and non-communicable diseases can be caused by undernutrition and early stunting, which occur when children are deprived of the proper nutrients from the time of conception through the first two years of life. Up to now, one in four children under five years is underweight and undernourished. Undernourished and stunted children are less likely to complete schooling, join the workforce, or have future incomes equivalent to children who are not stunted. They are more likely to suffer later in life from NCDs, such as heart and Kidney disease and diabetes. Stunted girls are themselves likely to be mothers to underweight babies, potentially transmitting ill health and poverty across generations [1]. One of the Key Actions to Address the Health Agenda is the use of "Information and Communication Technology for Health".

This means that proper steps should be taken quickly to improve the quality and scope of data collection, recording, analysis and application. It has been identified that at present, there is not a lot of confidence found on the data that is collected and used. The timeliness of the data also leaves much to be desired. Cabral states that appropriate information and communication technology is the game changer that will facilitate timely, quality data and the monitoring of health-related outcomes [1].

In 2011, National Nutrition Council came up with a program to address malnutrition in the country and they called it the Philippine Plan of Action for Nutrition (PPAN) which is an integral component of

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

their Philippine Development Plan (PDP). Its primary aim is to address malnutrition in the different LGUs. Hence, it provides a guide for targets, directions, and priority actions among others. Consequently, a human resource development strategy called the Barangay Nutrition Scholar (BNS) Program that allows volunteer workers to supervise and monitor the nutritional status of the people as mandated in the Presidential Decree No.1569.

For the city of Mandaluyong, each of their twenty-seven (27) barangays has its own respective BNS. They are the ones who administer the different barangay level nutrition related projects as well as the accomplishment of the monthly nutrition-related reports to be submitted to the Nutrition Committee of Mandaluyong. Consequently, NNC requires the Nutrition Committee of the different LGUs to come up with their project plan for the upcoming year.

II. REVIEW OF RELATED STUDIES

A. Review of Related Cases

Several countries have implemented information systems to address issues and increase awareness towards nutrition- specifically countries in Europe where in a mandate from the European Nutrition for Health Alliance (ENHA) calls for an "Optimal Nutrition Care for All" using health care systems. One of its applications was a case study conducted by Endevelt, et. al., whose study was towards creation of better nutrition for Israel. Then, policy implementations and nutrition interventions were difficult for various stakeholders in Israel, thus, an intervention study comprising of four sub-committees were formed to develop a central system to collect patient health status concerning obesity and malnutrition, factoring in socio-economic status and geographic locations. With the aid of big data and analytics, results concluded that malnutrition was significantly associated to low income communities that reside far from hospitals and care homes. With immediate results and management of malnutrition data, patient intervention is now timely which in effect, reduces budget costs towards health for both government and patience in terms of reduced mortality, and decrease in hospital billing [2]. Another similar case using big data analytics is the use of social media which allowed healthcare personnel to provide timely intervention for surveillance disease conditions such as heart diseases, strikes, diabetes, diarrhea, flu, cancer, etc. A big data analytic system was set up in order to collect health related tweets, which were cleaned and clustered using natural language processing, and visualized through charts and graphs. Keywords relating to surveillance disease conditions were clustered and mapped against a geo-location to identify which areas the diseases were most rampant. In effect, this proved to be useful for health policy-makers to identify which areas had specific disease outbreaks or increasing number of cases towards a certain illness. This allowed preventive and timely action for effective disease management and surveillance [3].

B. Analytics for Causal Modeling

Adoption of data analytics in health allows healthcare organizations to become data-driven and evidence-based, allowing a more informed decision to improve the quality of healthcare at the lowest possible cost. Additionally, analytics is a process of creating meaningful insights out of diverse data with the use of supporting technologies to acquire, store, access, and process/analyze data that drives strategic decision making. Lastly, it is the utilization of statistical techniques, information system software, and operations research methodologies in order to investigate, visualize, and come up with patterns or trends in data [4]. However, more than associations and visualizations of health care related data, causal modeling is also another modeling method that can be applied to further develop analysis towards root causes of evidence-based health care reports. In medical literature, the degree of applying interventions should not just be reactive, but moreover, preventive by understanding patterns in order to assess the validity and repeatability of the health-related cases, and the factors the cause the

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

health problem. Similarly to the case of Repa, where in evidence-based medical data were modelled using object life cycle modeling and unified modeling language within the business process of evidence based healthcare to determine recurring day-to-day clinical problems and what related disease causes them, the nutritionists of the barangay also deemed this as an important component of the software to address their problem on malnutrition analytics and management [5].

C. Bi-Variate Analysis and Pearson Correlation

Another technique used by the group is bivariate analysis which is a method of analysis used to identify and show the relationship of a dependent and an independent variable and up to what extent are those two variables correlates with one another. It shows how one variable changes with respect to the other variable which usually produces the correlation matrix. This is one of the simplest forms of statistical analysis that often uses x and y as the two variables for the purpose of determining the quantitative relationship between them. Although, this can only measure the effect of one independent variable to a dependent variable at a time. This technique was applied in the study of Hao, where in they examined the correlations among local health utilization, GDP, and online doctor reviews to examine geographical health analytics in China [6]. On the other hand, Pearson's Correlation is one of the widely used statistical methods, which uses a pair of sampled variables, x and y, in order to measure the strength of linear relationship, which is frequently measured over time. It is also frequently used in order to identify the influence of a time-based variable to another variable by using its distribution, over time, in order to identify the confidence interval. The confidence interval of the two variables can vary from -1, which shows a negative correlation, where as one goes up, the other goes down, and 1, which means that there is a positive correlation, where as one goes up, the other goes up. In which a 0-confidence interval means that there is no correlation between the two variables. This was used in the study of Raghupathi, et.al. on their empirical investigation on the correlation between a country's income level and public health delivery [7].

III. METHODOLOGY

A. Problem Analysis and Requirements Gathering

The proponents conducted an interview with the different target users of the system. From the interviews, the existing business process was identified as well as the different problem areas present in it. The proponents collected necessary forms that the Nutritionists of the Mandaluyong City's Nutrition Committee deemed necessary for their situational analysis of the city's nutrition landscape. These forms include data such as: the demographic profiles of the different households in the community, prevalence of illnesses in the city, and the number of malnourished children in the city.

B. System Design and Development

The system design framework of the system is composed of four main modules: data collection, data pre-processing, data analytics and data visualization. The data collection module is where data entry and validation occur in the system. It also includes automatic notification for information assets not yet uploaded in the system. On the other hand, the data-preprocessing module includes setting of thresholds for different metrics related to malnutrition which are monitored throughout the year. These metrics will later be used for the causal model generation and root cause analysis if they satisfy their threshold condition. The data analytics module is where the data uploaded is processed using different data analytics techniques such as predictive analysis using the weighted moving average formula, correlation techniques using Pearson's R and insight generation using various data aggregation techniques. Lastly, the data visualization module includes report generation (memos and annual reports), the causal modeling facility (root causes and causal model diagram) and different information visualizations (charts and dashboards).

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

C. Causal Modeling Facility, Insight and Report Generation

With the use of data analytics, the system generates a causal model of malnutrition in the city. This causal model contains the different root causes of malnutrition based on the different metrics that have been identified as critical for the year. By identify the different root causes, the Nutrition Committee will be able to plan the necessary interventions to be done to address malnutrition in the city. Reports are also generated by the system which contains insights of the different root causes of malnutrition. These insights include the areas which illnesses are prevalent and other metrics that are correlated with it.

IV. SYSTEM DESIGN AND RESULTS

A. Data Collection and Validation

The researchers implemented a data collection and validation module in the system to serve as a platform for the users to input the data that will come from different sources such as socio-economic and health reports. In addition, this module also comes with different validation checks to ensure that the data entered into the system is correct. Furthermore, this functionality also comes with an automatic notification system which sends notifications to the users who have not yet uploaded their respective reports based on the due date of the information asset.

B. Threshold Setting

In the beginning of the year, the nutritionists set thresholds for different metrics relating to malnutrition in the threshold setting module which are extracted from the different information assets. These metrics are monitored throughout the year and in the moment that these metrics satisfies its threshold condition (whether current value is greater than or less than the threshold set), such metrics are displayed in the nutritionists' and program coordinators' dashboards. These metrics that reached their thresholds may be possible causes of malnutrition which may be used for the generation of the causal model at the end of the year.

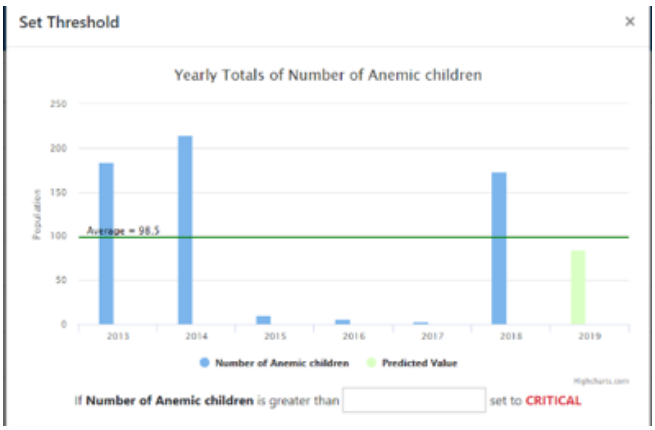

Figure. 1: Threshold Setting Facility

C. Data Visualization and Report Generation

Once data has been collected, it can be used for visualizations and reports generation. The malnutrition causal model is composed of blocks. These blocks have a label and a metric which corresponds to a cause of malnutrition. To model the problem tree in the system, a block can be considered a child of another block. For the construction of the causal model of the year, the system looks at previous causal models and identifies occurring root causes of malnutrition. Additional reports include reports that show the total number of children classified by nutritional status in the city, number of children given micronutrient supplementation, number of mothers given prenatal care, illness prevalence among children in the city, and impact of socioeconomic factors that affect the nutritional status in the city.

D. Causal Modeling Functionality

The causal modeling facility has garnered a UAT result of 4.8 out of 5. The nutritionists stressed on the importance of the generation of the causal models for this is their basis for their program interventions and city nutrition action plans. One of the problems that they are encountering with regards to the difficulty in conducting situational analysis is their inability to support their claims on the different causes of malnutrition. With this facility, the system is able to automatically generate the malnutrition causal model

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

for undernourished children. The different causes of malnutrition are supported by quantitative evidence having the metrics that have been identified to have reached their set thresholds as basis.

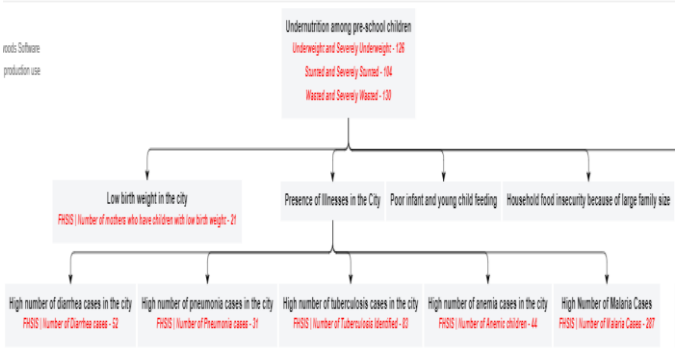

Figure. 2: Causal Modeling Facility

E. Pearson Correlation for Memo Generation

As added supplementation when generating a memo for a metric, the researchers implemented a feature wherein other metrics which have a strong Pearson correlation score (greater or equal to 0.8) with the selected metric are displayed when creating the memo. These strongly correlated metrics serve as additional insights for the user since the behavior of the selected metric may also affect its correlated metrics. Furthermore, the suggested interventions of these correlated metrics can also be included in the memo being created.

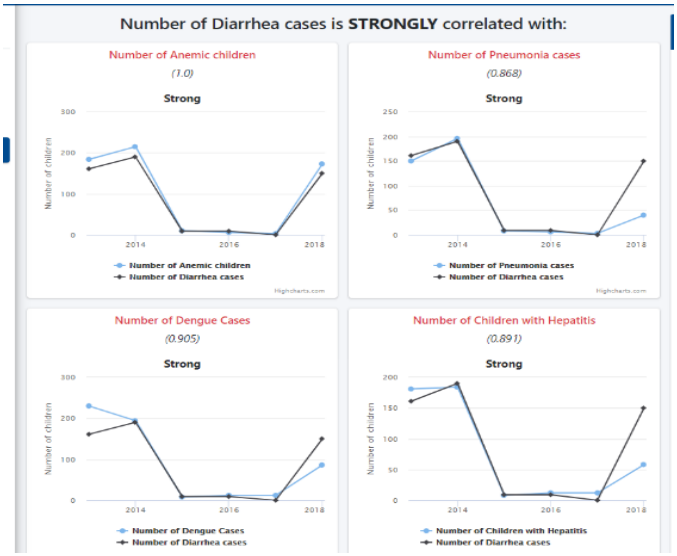

Figure. 3: Pearson Correlation Graphs

To further validate, the proponents administered a User Acceptance Testing (UAT) wherein the system was tested by six (6) Barangay Nutrition Scholars, three (3) Nutritionists, and one (1) Nutrition Program Coordinator before the actual implementation of the system in the working environment to assess if the system is aligned with the requirements of the Nutrition Committee. The UAT was conducted to get the feedback of the actual users of the system to know whether the system adheres to the requirements of the committee, if the newly developed system addresses the main problem of the committee in their difficulties in conducting situational analysis for the creation of the malnutrition causal models necessary for their City Nutrition Action Plans. The group modelled a UAT Questionnaire that allows the users to rate system component quality, user interface, security, and overall criteria (5 - Strongly Agree, 1 - Strongly Disagree). The table below outlines the UAT results gathered in terms of system component quality and user satisfaction.

Table 1. UAT Results based on System Component Quality

Rank	System Component Criteria	Score (AVG= 4.5 of 5)
1	Data Collection allows uploading of excel sheets, which captures nutritional status data used for automatic computations on monthly reweighing. In parallel, Data Validation follows data type and completeness in field checks ensuring completeness of data	4.8
2	Causal Modeling makes use of Pearson Correlation to establish quantitative relationships between data points. Additionally, chi-square method was utilized for qualitative data needed in building the causal model that highlight and quantify underlying root cause of the health situation in various barangays.	4.8
3	Data Visualization displays charts, graphs, and reports with respect to the data collected and consolidated.	4.7

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

4	Memo Generation allows sending of notice to barangays concerned, needing more urgent health care interventions to address malnutrition.	4.5
5	Threshold Setting allows setting of targets, which triggers alerts for barangays reaching target set by the barangay nutritionists based from historical data.	4.0

Table 2. UAT Results based on User Satisfaction

Rank	System Component Criteria	Score (AVG= 4.5 of 5)
1	Security allows authorized users to log in the system and to access information specific to their level.	4.7
2	Function follows consistent navigation with links routed to the correct page.	4.7
3	User Interface uses appropriate color scheming, with consistent text and icons.	4.6

V. CONCLUSION

In developing countries such as the Philippines, despite ICT being one of the rapidly growing industries, ICT solutions for the local government are still not widely used and prioritized, due to the cost and significance. In this work that we present, the Malnutrition Causal Modeling Analytics for Mandaluyong City's Nutrition Committee is a low-cost analytics system that will be able to address the city of Mandaluyong's problem of difficulty in conducting situational analyses on the city's nutritional landscape. The system provided insights and information to the users regarding the possible causes of malnutrition in the city and the different factors that affect nutrition in general such as illnesses and supplementations given. With the use of an analytics system, the city can provide a more accurate supporting information for their planning, backed by expert judgement.

Although the development showed evidences that the system is successful in identifying the different root causes of malnutrition. The system still has some drawbacks, one example, is that the result can be inaccurate because it uses a correlation formula, for the reason that correlation does not equate causation. This will lead to one of the team's recommendations to explore on different statistical techniques to come up with a predictive model to further strengthen the quantitative evidence support for the different root causes of malnutrition in the city. In which, a time series analysis and causality formula could be one of the many statistical methods that can be utilized.

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VI. REFERENCES

[1] E. I. Cabral, "The Philippine Health Agenda for 2016-2022," Philipp. J. Intern. Med., vol. 2, p. 54, 2016.

[2] R. Endevelt, J. Kachall, P. Singer, R. Doyev, and I. Grotto, "Optimal Nutrition Care for all, from Policy to Action - A National Nutrition Program in Israel," Proc. 50th Hawaii Int. Conf. Syst. Sci., pp. 5084–5091, 2017.

[3] A. T. K. Kumar, D. Asamoah, and R. Sharda, "Can social media support public health? Demonstrating disease surveillance using big data analytics," 2015 Am. Conf. Inf. Syst. AMCIS 2015, 2015.

[4] C. Zhang, "Using Open Healthcare Datasets to Teach Health Data Analytics," 2018.

[5] V. Repa, "Application of Modelling Methods from Informatics in Evidence Based Health Care," in 27th International Conference on Information Systems Development, 2018.

[6] H. Hao and H. Hao, "Digital Divide in Online Health Utilization in China : A Case Study of Geographical Difference in Online Health Analytics," p. 2017.

[7] W. Raghupathi and S. J. Wu, "The relationship between information and communication technologies and the delivery of public health: A

January - February 2020
ISSN: 0193 - 4120 Page No. 11941 - 11947

country-level study," Commun. Assoc. Inf. Syst., vol. 28, no. 1, pp. 99–116, 2015.

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