Research Article

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Analyzing Heart Disease Mortality of Filipino: From Statistical Modeling to Health and Lifestyle Education Implications

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Abstract

This paper contributes an interdisciplinary cross-over in studying heart disease mortality of Filipino. First, it validates previous studies on heart diseases via ascertaining statistical models of analyses that estimate heart disease mortality predictability in the Philippines. It then proceeds to understand the implications of the issue through promoting health and lifestyle education. To do this, first, the report from the Epidemiology Bureau of the Department of Health (EBDOH) on mortality cases of diseases of the heart in the Philippines. Based on the statistical analyses, time series analysis suggested that the growth of heart disease mortality in the Philippines followed a quadratic trend. Moreover, symbolic regression (SR) analysis revealed that heredity has more significant influence over lifestyle between the identified factors. Based on the proposed models, this paper implies furthering community-oriented health and wellness programs as practical means to avoid untimely deaths brought by the said diseases.

Keywords: *heart diseases mortality, time series, symbolic regression, health and lifestyle guidance*

1. Introduction

The World Health Organization (WHO) (2017a) declared that heart diseases had taken millions of lives every year while causing thirty-one percent of deaths worldwide. Hajar (2016) claimed that heart disease mortality is expected to grow to more than 23.6 million by 2030. Heart diseases include coronary heart diseases, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis, and pulmonary embolism [2]. In the data of WHO (2017b), the Philippines has reached 122, 950 or 19.86% of total death caused by coronary heart disease. Consequently, the country ranked 28th in the survey of countries' death caused by the said disease. Simultaneously, the Department of Health (DOH) (2018) reported that heart diseases, among other illnesses, caused a fatality in the country. As written by Palaniappan et al. (2010), Filipino immigrants in the United States of America have a second highest heart disease threat after Indians. Consequently, heart diseases have become a recurrent health problem that every Filipino must be aware of regardless of age and gender.

The struggle to address the rise of deaths due to heart disease begins with addressing the very factors that may have caused it. As purported by Kannel et al. (2004), a risk factor is any condition or personal behavior that increases the chance to develop a particular disease, which may advance to fatality. The severity of a risk factor will be more likely to create one (Enas, 2001). As reported by CADI Research Foundation (2012a), hereditary and lifestyle choices actively promote heart diseases.

Being genetically predisposed or susceptible may cause individuals to be at high risk of acquiring heart diseases despite not being born with it. Reilly et al. (2011) purported that current scientific undertakings show heredity disposes of a patient with heart diseases to a probable heart attack. The Harvard Medical School (2017) cited that heart diseases can be passed down through families. It added that genetic risk scores were more accurate for predicting heart attacks than any other risk factors. Agarwal (2001) added that predisposition to heart diseases at an early age increases by heredity as standard behavioral modes are observed in members of the same family. Various contemporary studies found that heredity is an independent risk factor being considered in the family history of heart diseases (Higgins, 2000; Kraus, 2000; Pereira at al., 2000; Leander et al., 2001; Wood, 2001; de Giorgis, 2009). Hence, an individual's possibility to acquire heart diseases increases due to a family history of such conditions.

Moreover, such cannot discount the significance of lifestyle to affect a person to acquire heart diseases. The studies of Karvoven (1989), Rowe & Kahn (1998), Smedley & Syme (2000), and Ruston & Clayton (2002) found out that lifestyle also contributes to the growing number of heart disease mortality. Heart diseases is also a lifestyle-related non-communicable disease. An unhealthy lifestyle like smoking, eating unhealthy foods, and lack of exercise leads to acquiring heart diseases (DOH,2018). As purported by Idler & Benyamini (1997), Singer & Ryff (2001), and Niiranen & Vasan (2016), excess rates of chronic diseases, particularly the conditions of the heart, are affected by social and behavioral factors including lifestyle, diet, levels of physical activity, or gender and cultural stress responses. Filipino immigrants in the United States tend to cope with unhealthy eating and smoking to be relieved from work and family stress, thereby making them prone to acquiring heart diseases (U.S. Department of Health and Human Services, 2010).

2. Objectives of the Study

Relative to the literature, we draw an assumption that heredity and lifestyle are two salient factors that could have contributed to the growing number of deaths due to the risk of getting heart diseases. In this context, this paper primarily intends to explore the trend of heart disease mortality in the Philippines. It validates previous studies on heart diseases via ascertaining statistical models of analyses that estimate heart disease mortality predictability in the Philippines. It also identifies which among the two identified risk factors, heredity and lifestyle, greatly influenced heart disease mortality in the Philippines by providing models to predict through symbolic regression analysis. It then proceeds to understand the implications of the issue through promoting health and lifestyle education.

3. Materials and Methods

This study retrieved essential data through data mining. Data mining is the process of taking out datasets to ascertain patterns and institute associations through data analysis (Rouse, 2008;

Witten, 2011; Deguma et al, 2018). Witten et al. (2011) furthered that data mining's benefit allows uncovering hidden patterns and relationships, which aids in making predictions. However, data mining must consider data privacy as an ethical consideration (Iles, 2013). According to Davis and Patterson (2012), data in itself is ethically neutral. In the Philippines, the responsible use of data for research purposes is a valid ground (National Privacy Commission, n.d.).

This study utilized the Epidemiology Bureau of the Department of Health (EBDOH) (2014) on mortality cases of diseases of the heart in the Philippines featured the demographics, natality, morbidity and notifiable diseases, and mortality statistics from 1964 to 2014. The report also included the mortality of diseases of the heart in the Philippines. Due to the difference in population volume for the past fifty years, this study used data from 1995 to 2014 to determine the trend of heart disease mortality, as shown in Table 1.

This study employed descriptive methods via time-series analyses using Minitab ® and Symbolic Regression using Eureqa Pro®. The data on the number of mortality cases of heart diseases in the Philippines is evaluated first through a trend analysis, which provides three models, namely linear, quadratic and exponential growth. Time series analysis is done to determine which model provides the least Mean Absolute Percentage Error (MAPE) and forecasts the trend of heart disease mortality in the Philippines for the past twenty years using Minitab ®. Moreover, the study also identified which among the two factors, hereditary or lifestyle, contributed significantly to heart disease mortality. Symbolic regression (SR) analysis using Eureqa Pro ® is done to look for formulas that provide the least Mean Absolute Error (MAE) for hereditary and lifestyle factors. SR is a method that predicts relationships and connects variables while providing a model that is not assumed beforehand. According to Barmpalexis et al. (2011), SR operates through genetic programming (GP). GP generates populations of equations patterned after the fittest principle's survival (Koza, 1994; Koza et al., 2003; Barmpalexis, 2011) GP searches for the fittest equation from a series of runs in every cycle called generation by setting a target expression. Through GP, SR structured patterns from a dataset of variables to find the "fittest" combination model prediction (Claveria, 2016). The current SR experiment used the same data of the Epidemiology Bureau of the Department of Health on heart disease mortality from 1995 to 2014. This experiment will find the fittest formula with the least Mean Absolute Error (MAE), which could provide a minimal error in arriving at model estimates (Loce & Dougherty, 1995; De Myttenaere et al., 2016).

Table 1: Reported Number of Mortality Cases of Diseases of the Heart in the Philippines from 1995 to 2014 by EBDOH (2014)

Year	Number of Mortality Cases of Diseases of the Heart	Year	Number of Mortality Cases of Diseases of the Heart
1995	50,252	2005	77,060
1996	53,865	2006	83,081
1997	54,787	2007	88,314
1998	55,830	2008	92,133
1999	58,574	2009	100,908
2000	60,417	2010	102,936
2001	62,950	2011	107,294
2002	70,861	2012	112,581
2003	67,696	2013	118,740
2004	70,861	2014	132,825

4. Results and Discussion

3.1 Structuring the Models for Analyses

The data from EBDOH (2014) on heart disease mortality from 1995 to 2014 provided a twenty-year time series analysis using linear, quadratic, and exponential growth as shown in Figures 1, 2, and 3. As indicated in the graphs, the number of heart disease mortality has significantly increased over the past twenty years. As shown in the figures, a remarkable difference among the provided by the three models. Results suggested that the Quadratic Trend Model has the least error to map the trend of Filipinos' heart disease mortality. The Quadratic Trend Model could provide the fittest trend analysis of the graph's behavior over the Linear Trend and Exponential Growth Models. With a quadratic trend, the time series values are constantly dependent on variables that could affect the trend's movement, thus changing over time (Wu & Zhao, 2007; Jebb & Tay, 2017). Hence, acknowledging that the mortality cases of heart diseases in the Philippines follow a quadratic trend furthered the importance of identifying the risk factors (e.g., lifestyle and heredity) as variables that could affect the rising and falling of the model trend.

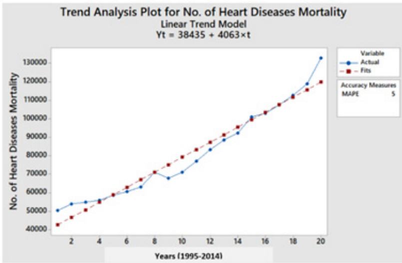

Figure 1: Linear Trend Model for Heart Diseases Mortality in the Philippines from 1995-2014 with a MAPE of 5

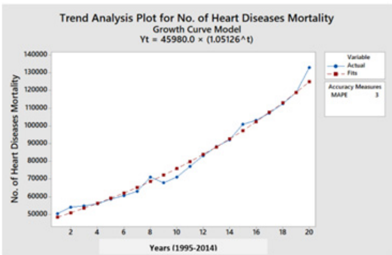

Figure 2: Exponential Trend Model for Heart Diseases Mortality in the Philippines from 1995-2014 with a MAPE of 3

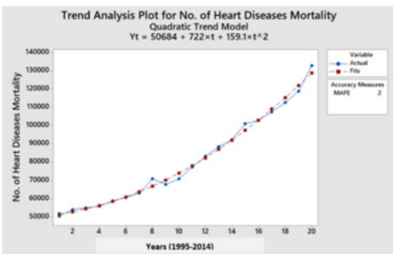

Figure 3: Quadratic Trend Model for Heart Diseases Mortality in the Philippines from 1995-2014 with a MAPE of 2

The study advanced at generating the fittest equations for estimating the predictability of heart disease mortality through symbolic regression (SR) using another software, Eureqa Pro ®. The first target expression used to predict lifestyle is as follows: y=f(t), where the number of cases of heart disease mortality (y) is affected by the function of time, which is represented by lifestyle (t). The lifestyle of individuals is generally associated with the function of time wherein one unit of time (t) is equivalent to a one-unit change in lifestyle of the people (Monk et al., 2002; Sakano et al., 2009; Feldman et al., 2017; Brinkman et al., 2018). The target expression presumed that lifestyle is a factor that contributes to heart disease mortality. The result of symbolic regression analysis for the target expression provides a fit formula that follows:

$$y = 5.13e4 + 416t + 177t^2 + 203t^2\sin(t) - 1.36e3\,t\sin(t) - 2.42e3\cos(158t) - 6.27t^3\sin(t)$$

The generated equation result showed a quadratic trend manifested by the presence of t^2. The *sine* and *cos*ine functions indicated correction factors and seasonal variations, which contributed to the formula's accuracy to predict the number of heart disease mortality in the Philippines. The model generates a Mean Absolute Error (MAE) of 819.0044.

Moreover, the next target expression used to predict heredity as a cause of heart diseases mortality is as follows: y=f(delay(y,1), delay (y,2), delay (y,3)), where the number of cases of heart diseases mortality (y) is affected by the function of the previous number of those who die due to heart diseases (y). The number of heart diseases death (y) is affected up to the third-degree consanguinity, thereby looking at heredity as a factor that causes heart disease mortality (Bailleul et al.,1995; Singh et al., 1999; Wienke et al., 2001; Glowinska at al., 2002; Zdravkovic et al., 2002; Daniels, 2011). The result of symbolic regression analysis for the target expression provides a formula that follows:

$$y = 970 + 0.919\,\mathrm{delay}(y,1) + 0.136\,\mathrm{delay}(y,3) + 2.66e3\sin(2\,\mathrm{delay}(y,2)) + \frac{-332}{\sin(1.09 + \mathrm{delay}(y,2))} + \frac{-846}{\sin(\sin(5.17 + \mathrm{delay}(y,3)))}$$

The presence of *sin*e function indicated fluctuations within the cycle, which contributed to the accuracy of predicting the number of heart disease mortality in the Philippines, resulting in a Mean Absolute Error (MAE) of 544.07409.

The study progressed at evaluating the MAE of both heredity and lifestyle factors by getting the sum of the total MAE, which is 1,363.07849. The MAE of the heredity affected lifestyle and vice versa. Hence, by dividing the MAE of either of the factors over the total MAE, the result shows the computed value of the factors contributing to heart disease mortality. The study revealed that the influence of lifestyle as a factor has a computed value of 39.92%, whereas heredity has 60.08%. Thus, SR revealed that heredity has more significant influence over lifestyle on heart disease mortality in the Philippines for the past twenty years.

4. Furthering the Implication Based on the Proposed Models

The Sustainable Development Goals (SDG) of the United Nations Development Programme (2015) aimed to increase life expectancy and to reduce mortality from chronic diseases and mental illnesses by promoting good health and well-being for all people. Good health promotes a sound economy while being beneficial to individual lives (National Academy on an Aging Society 1999a, 1999b). As validated in this paper, a quadratic trend model provided the fittest equation with the least MAPE for the mortality cases of diseases of the heart in the Philippines from 1995 to 2014. It supports the claim of Tuomilehto et al. (1984) that starting from 1963 to 1976, there an increase in the cardiovascular disease death rate among Filipinos. This increasing trend is prevalent in many low-income and middle-income countries like the Philippines (Epping-Jordan et al., 2005). Epping-Jordan et al. (2005) added that the reason behind such a phenomenon is the rapid social and environmental changes that cause the increase of risk factors of heart disease mortality. According to the study of WHO (2002), such phenomenon can be prevented through a healthy lifestyle, which becomes uncommon to people living in third world countries. Therefore, it is recommended that supportive policies for a healthy lifestyle could be enacted to reduce the increasing number (WHO, 2005).

Although this study provided that lifestyle is a lesser risk factor that leads to heart disease mortality, adopting a positive lifestyle change can effectively prevent the 39.92% risk factor of heart disease mortality and improve one's life quality. According to CADI Research Foundation (2012b), a critical choice of lifestyle is needed to sharpen the chances of developing heart diseases. Through DOH, the Philippines government must adopt health promotion programs like lifestyle modification, including proper diet, avoidance of vices such as smoking, heavy drinking, etc., and regular exercises that reduce the chance by 39.92% of getting heart diseases. As suggested by Barbara et al. (2003), lifestyle guidance is encouraged through training to help the individual make and maintain the right choices of a healthier lifestyle. It is thereby reducing the risk through the individual's ability to manage the self through correct lifestyle choices. However, lifestyle intervention must be culturally tailored to be effectively implemented (Leake et al., 2011). Wallace et al. (2008) maintained that a culturally tailored cardiovascular disease prevention curriculum was effective in reducing the mortality rate. Also, Hinohara et al. (1982) recommended strengthening community-oriented health and wellness programs by government and private sectors. These programs must be focusing on reducing lifestyle factors through education, which is tailored specifically to address the most prevalent needs of a particular community. Hence, education must also focus on health promotion and protection and disease prevention (Fitch & Blue, 1982).

5. Conclusion and Recommendation

In conclusion, heart disease mortality among Filipinos is increasing for the past twenty years, from 1995 to 2014, if nothing is positively and effectively done to change the trend. The rise of such health phenomenon is greatly affected by two identified factors like heredity and lifestyle. The former is seen to be of more significant influence than the latter. However, modern technology advances at determining an individual's genetic predisposition to heart diseases, the rising trend of heart disease mortality is affected by Filipinos' unhealthy lifestyle. Hence, the change of lifestyle is significantly recommended to lessen the increasing trend of heart disease mortality. Overall, it is imperative to invest in health and wellness, which will eventually lead to better monetary, social, and environmental returns, good health and well-being for all people, and the Sustainable Development Goals' attainment.

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