Heart disease is the leading cause of death among Filipinos, accounting for 1 out of every 5 deaths in the past year. Each year, 170,000 Filipinos die from cardiovascular diseases, up from 85,000 more than 20 years ago. This paper aims to estimate the risk of developing Heart Attack using Survival Analysis. The data were obtained from the records of Quirino Memorial Medical Center with a total of 447 observations. The data includes the time (patient's age), gender of the patient, covariates such as lifestyle (smoking and drinking alcohol); health conditions (Hypertension, Diabetes, High-density Lipoprotein (HDL) and Low-density Lipoprotein (LDL) level); and family history of Cardiovascular Disease, and the event of interest which is the occurrence of heart attack. The researchers applied two main statistical treatments in examining the data: (1) Cox Regression in formulating a model to estimate the risk of heart attack based on the given covariates; (2) Kaplan-Meier Estimates in calculating the probability of each patient to survive in accordance to their gender depending on the covariates the patients have. Results showed that females have more risks of developing heart attack than males for patients with hypertension, with diabetes, with a family history of CVD, and those who are smoking. However, for patients who are alcoholic, men are more prone to the risk of heart attack than women. The results were obtained with the help of SPSS.

Heart attack is the death of a segment of heart muscle caused by the loss of blood supply [3]. It occurs when one or more of your coronary arteries become blocked. This is caused by a coronary artery narrowed from the build-up of various substances, including cholesterol known as coronary artery disease [4]. A heart attack can also be caused by a severe spasm of a coronary artery. The spasm cuts off blood flow through the artery. Spasms can occur in coronary arteries that aren’t affected by atherosclerosis. A spasm may be related to taking certain drugs, such as cocaine, emotional stress or pain, exposure to extreme cold and cigarette smoking [5].

Certain factors contribute to the unwanted build-up of fatty deposits that narrows arteries throughout the body [6]. There are modifiable risk factors (ones that can be changed) and non-modifiable risk factors (ones that can't be changed) that can contribute to having a heart attack. Modifiable risk factors include smoking, high total cholesterol, high blood pressure, diabetes, being physically inactive, being overweight or obese, depression, illegal use of drugs. Risk factors that can't be changed include increasing age, being male or female, and having a family history of heart disease [7].

Objective of the study

The main objective of this study is to formulate a mathematical model for the risk of developing a heart attack for patients with accordance to their age and gender, whether they are alcoholic or smoking, or if they have hypertension, diabetes, family history of Cardiovascular Disease (CVD), and based on the level of their high-density lipoprotein (HDL) and low-density lipoprotein (LDL). The researchers applied two main statistical treatments in examining the data which are Cox Regression Analysis and Kaplan-Meier Estimates. This paper will be helpful in aiding the health organizations in promoting awareness for the risk factors of a heart attack.
What are the survival curves of patients using Kaplan-Meier Estimates according to their gender?

What are the probability risks of developing heart attack of patients using Kaplan-Meier Estimates?

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study, the researchers used the Cox Regression to estimate the hazard rate of the event on patients. The formula is given by:

\[ H(t) = h_0(t) \times \exp(b_1x_1 + b_2x_2 + \cdots + b_kx_k) \]

Where \( h_0(t) \) is the cumulative baseline hazard function. This term depends on time but not the covariates, \( x_i \) is possibly time-independent covariates, and \( b \) is the regression coefficients.

RESULTS AND DISCUSSION

Risk profile of quirino memorial medical center patients

The table above exhibits the comparison of percentages of the risk profile of Quirino Memorial Medical Center patients that has and has not experienced a heart attack. The researchers used a total of 327 patients who have experienced a heart attack and 120 patients who do not, making a total of 447 observations. Males compose almost 60% of the population of patients with a heart attack while the females comprise the 60% of the patients without a heart attack. Also, with regards to age, the most frequency on the age of the patients is the range of 60 to 69 while the least is from the range of 90 to 99 with both having a single patient.

On alcohol consumption, almost 50% of the patients who have experienced a heart attack are alcoholic. On the contrary, approximately 50% of the patients who have not experienced a heart attack are non-alcoholic. For smoking, 55% of the patients that has experienced a heart attack are smoking while 70% of those who do not experience a heart attack are not smoking. Almost half of the patients with heart attack have a family history of CVD. On the other hand, 52% of the patients without heart attack reveal that they have no family history of CVD.

| Factors                  | Classification | 447 patients | Percentage |
|--------------------------|----------------|--------------|------------|
|                          |                | Has experienced heart attack | Has not experienced heart attack |
|                          | Total          | 327          | 120        |
| Gender                   | Male           | 203 (62.08 %) | 41 (3.17 %) |
|                          | Female         | 124 (37.92 %) | 79 (6.58 %) |
| Age                      | 20–29          | 8 (2.45 %)    | 5 (1.7 %)   |
|                          | 30–39          | 19 (5.81 %)   | 12 (1.0 %)  |
|                          | 40–49          | 41 (12.54 %)  | 16 (1.33 %) |
|                          | 50–59          | 65 (19.80 %)  | 30 (2.5 %)  |
|                          | 60–69          | 98 (29.97 %)  | 35 (2.91 %) |
|                          | 70–79          | 73 (22.32 %)  | 17 (1.41 %) |
|                          | 80–89          | 22 (6.72 %)   | 4 (0.33 %)  |
|                          | 90–99          | 1 (0.31 %)    | 1 (0.03 %)  |
| Alcohol                  | Non-drinker    | 138 (42.20 %) | 63 (5.25 %) |
|                          | Drinker        | 189 (57.80 %) | 57 (4.75 %) |
| Smoking                  | Non-smoker     | 147 (44.95 %) | 87 (7.25 %) |
|                          | Smoker         | 180 (55.05 %) | 33 (2.75 %) |
| Family History of CVD    | Without Family History | 115 (35.16 %) | 62 (5.16 %) |
|                          | With Family History | 212 (64.83 %) | 58 (48.33 %) |
| Hypertension             | Normal         | 115 (35.22 %) | 92 (7.67 %) |
|                          | Hypertensive   | 212 (64.83 %) | 28 (2.33 %) |
| Diabetes                 | Non-Diabetic   | 171 (52.30 %) | 103 (85.83 %) |
|                          | Diabetic       | 156 (47.71 %) | 17 (1.41 %) |
| High-Density Lipoprotein (mmol/L) | Best (≥ 1.6) | 33 (10.09 %) | 6 (5 %) |
|                          | Better (≥ 1.5) | 50 (15.29 %) | 9 (7.5 %) |
|                          | Poor (≤ 1.1)   | 244 (74.52 %) | 104 (87.5 %) |
| Low-Density Lipoprotein (mmol/L) | Best (≥ 1.8) | 59 (18.04 %) | 14 (1.16 %) |
|                          | Better (≥ 2.6) | 70 (21.41 %) | 31 (2.58 %) |
|                          | Poor (≥ 2.6)   | 198 (60.55 %) | 75 (6.25 %) |

There are more non-diabetic patients for both groups compared with the diabetic patients. The table also presents that majority of patients on both groups have poor HDL levels and LDL levels.

Survival curves of patients using Kaplan-Meier estimates according to their gender

Fig. 2 shows the survival curves of heart attack patients with hypertension, with diabetes, with a family history of CVD, who are smoking, and who are alcoholic. The survival curve is the statistical representation of the survival experience of the patients displaying the percentage of surviving against time.

From the five figures, patients with hypertension, with diabetes, with a family history of CVD, who are smoking, and those who are alcoholic reveals an inversely proportional relationship between the age and survival rates of the patients. It can be seen that as the age of the patient elevates, the probability of him surviving a heart attack decreases. The survival curves of females and males are very close to each other indicating no difference between the survival chances of the two. However, for long-term observation, the curve for the males is lower than females because of some factors, indicating that as men ages, they survive lesser chance than women, but both end up in developing a heart attack.

Among the five figures, patients who are alcoholic exhibit a different result. Males has a greater chance of surviving than female which differs from the result of the other wherein women can survive more than men for patients with hypertension, with diabetes, with a family history of CVD and for those who are smoking.

Hazard function and hazard curves of patients using Cox regression

The researchers aimed to formulate a model that can actually estimate the risk of a patient to experience a heart attack. Through Cox Regression Analysis, the researchers are able to come up with the hazard function written as:

\[ h(t, x) = \frac{(0.00099444) e^{-0.207x_1 - 0.301x_2 - 0.062x_3 - 0.337x_4 - 0.164x_5 - 0.057x_6 - 0.197x_7 - 0.008x_8}}{} \]

Where \( t \) is the age of the patient, and \( x \) are the covariates: \( x_1 \) is gender, \( x_2 \) is hypertension, \( x_3 \) is smoking, \( x_4 \) is alcoholic, \( x_5 \) is diabetes, \( x_6 \) is a family history of CVD, \( x_7 \) is HDL and \( x_8 \) is LDL. This means that the cumulative hazard a patient can have depends on their age, gender, and the covariates they have.

Like the survival curves of the patients, the hazard curves of females and males are very close to each other showing no difference among
the survival chances of the two. Though for a long period of observation, the curve for the females is lesser than males because of some factors, meaning, as women ages, they become more prone to the risk of heart attack than men.

Based on the results, males with hypertension, with diabetes, with a family history of CVD, and those who are smoking shows a higher risk than females. Apparently, among the five covariates, patients who are alcoholic reveal an opposite result from the others. Hazard curves presented that females have a greater risk of developing a heart attack. Additionally, males experienced heart attack at an earlier age than women do.

In an article entitled 'How does Heart Disease affect Women,' it is also stated that women are more likely than men to have Coronary Microvascular Disease. Many researchers think that a drop in estrogen levels during menopause combined with other heart disease risk factors causes coronary MVD in females [18].

Probability risk of patients to develop heart attack

The probability risk of developing heart attack is identified by the model \( R(t, \text{Heart Attack}) = 1 - e^{-H(t,X)} \) where \( e^{-H(t,X)} \) is the survival probability in terms of a cumulative hazard rate function \( H(t,X) \) which is derived from Cox Proportional Hazard Model and can be confirmed in the appendices.

Substituting the Cox proportional hazard rate function to the model, the probability risk function is written as:

\[
R(t, \text{Heart Attack}) = 1 - e^{-0.00094944 e^{0.00099 x_6} - 0.207 x_1 + 0.313 x_2 + 0.042 x_3 - 0.337 x_4 + 0.045 x_5 - 0.337 x_6 - 0.137 x_7 + 0.836 x_3}
\]

Where \( t \) = age of the individual

\[
x_1 = \begin{cases} 
1, & \text{if female} \\
0, & \text{if male} 
\end{cases}
\]

\[
x_2 = \begin{cases} 
1, & \text{if he has hypertension} \\
0, & \text{if he has no hypertension} 
\end{cases}
\]

\[
x_3 = \begin{cases} 
1, & \text{if smoker} \\
0, & \text{if non-smoker} 
\end{cases}
\]

\[
x_4 = \begin{cases} 
1, & \text{if he is alcoholic} \\
0, & \text{if he is not alcoholic} 
\end{cases}
\]

\[
x_5 = \begin{cases} 
1, & \text{if he is diabetic} \\
0, & \text{if he is not diabetic} 
\end{cases}
\]

\[
x_6 = \begin{cases} 
1, & \text{if he has family history of CVD} \\
0, & \text{if he has no family history of CVD} 
\end{cases}
\]

Using the formulated model, the probability risks of Heart Attack patients were computed. Some of the patients with tremendous results are shown below together with their age. The table indicates that elderly are really prone to the development of Heart Attack.

| Age | Probability risks percentage |
|-----|-------------------------------|
| 61  | 54.216                        |
| 62  | 51.033                        |
| 63  | 64.538                        |
| 64  | 51.499                        |
| 65  | 69.105                        |
| 66  | 73.695                        |
| 67  | 75.712                        |
| 68  | 80.172                        |
| 69  | 83.804                        |
| 70  | 82.574                        |
| 71  | 82.875                        |
| 72  | 91.352                        |
| 73  | 89.143                        |
| 74  | 87.775                        |
| 75  | 88.443                        |
| 76  | 92.243                        |
| 77  | 93.809                        |
| 78  | 95.877                        |
| 79  | 97.309                        |
| 80  | 96.906                        |
| 81  | 99.716                        |
| 82  | 99.625                        |
| 83  | 99.821                        |
| 84  | 99.925                        |
| 85  | 99.140                        |
| 86  | 99.840                        |
| 87  | 99.936                        |
| 88  | 99.639                        |
| 89  | 99.982                        |

Table 2: Probability risk

CONCLUSION

Heart attack kills many lives without any notice. It is important to monitor this disease that exterminates people silently. Founded by the results, the researchers concluded that there is a 99 % possibility of developing a heart attack when a patient is positive of the given covariates: (hypertension, diabetes, family history of CVD, smoking and alcoholic) and when the patients are within the range of 60 to 90 y old.

Furthermore, in comparing the probability risks of patients according to their gender, men showed a higher record than women. In addition, Kaplan-Meier Estimates showed that females could survive more, than males.

Among the five covariates, patients who are alcoholic reveal an opposite result from the others. Survival curves of alcoholic patient's display that males have more possibility of surviving and their hazard curves presented that females have a greater risk of developing a heart attack. For patients with the other covariates, they showed the opposite result both in their survival and hazard rates. Also, males experienced heart attack at an earlier age than women do.

Additionally, patients must have a high level of HDL and low level of LDL to avoid having a heart attack. An HDL greater than 1.6 mmol/l is considered as poor. For LDL level, it is good to have a total of less than 1.00 mmol/l. A total cholesterol level of less than 2.00 mmol/l is considered as the best level of HDL while an HDL of less than one is considered as poor. For LDL level, it is good to have a total of less.
than 1.8 mmol/l. If the patient exceeds to 2.6 mmol/l, it is measured as dangerous for the heart.

The researchers recommend that governments and heart associations must introduce new plans and policies in order to tackle about the awareness of heart attack and reduce the frequency of patients having a heart attack. This requires the understanding of the conventional risk factors and also the less known and new risk factors and ways which they may be prevented.

CONFLICT OF INTERESTS
Declared none

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