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*Original Article*

# An Analysis on High Temperature and Hospitalizations for Cardiovascular Cases in the City of Cabanatuan, Philippines

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***Abstract*** *- Extreme heat is now a tremendous concern worldwide, especially in urban settings, which may risk the health of every individual. People in the Philippines continuously experience soaring heat events yearly in many large urban areas. Cabanatuan was recorded as one of the hottest urban areas in the Philippines. This issue is very alarming, especially in the prevalent cases of cardiovascular diseases. Hence, the application of data analysis is needed to identify if the high temperature can be associated with the number of hospital admissions for cardiovascular causes. This study aims to identify the relationship between the high temperature and the number of hospital admissions for cardiovascular cases. Using the dataset from 2011-2016 obtained from PAGASA for temperature and the City Hospital for the admissions of cardiovascular causes, we further clustered the data separately. We compare the highest recorded temperature and the number of hospital admission to see if a positive correlation exists. We used linear regression to determine the association of hospitalization for cardiovascular cases triggered by high temperature. This study also aims to predict the possible rate of hospital admissions for cardiovascular cases with high temperatures. The results of this study can potentially improve decision-making in the health sector. Other responsible agencies and policymakers can use them to develop a mechanism for how this information can be disseminated to the public.*

***Keywords*** *- Regression Analysis, Cardiovascular Cases, Extreme Heat, Hospitalization.*

## 1. Introduction

Extreme heat caused by high temperatures has been a big issue all over the world [1][2]. The adverse effects of these extreme temperatures will manifest mostly in cities of low and middle-income countries, regardless of climatological orientation, whether in temperate, sub-tropical, or tropical contexts [3][4]. Currently, many communities are unprepared to deal with this extreme heat. Many people most vulnerable to heat-health risks do not take protective actions during extreme heat [5][6]. They may not believe their health is at risk or not know about the measures that should be taken. The public must understand the message being issued when excessive heat is forecast [7]. As such, these risks depend on several factors that should consider and analysed. These given factors should serve as the basis for formulating an analysis that will give insight into how to adapt the community to extreme heat [8]. In addition, what will be the mechanism developed or planned by responsible agencies regarding this matter.

By better understanding extreme heat effects on morbidity [9], local communities can develop appropriate public health interventions and increase their adaptive capacity to cope with heat waves today and in a globally warming future [10].

The Philippines is listed as one of the most vulnerable nations with a high climate change impact, especially in urban areas [11][12]. The city of Cabanatuan is one of the cities in the country which continuously experiences extreme heat, as recorded by PAG-ASA [13]. This climate change mostly affects vulnerable populations such as senior citizens, children, low-income, low education, and people with heat-related diseases [14].

This study aims to determine the relationship between the high temperature and the number of hospital admissions for cardiovascular cases and to predict the possible rate of hospital admissions for cardiovascular cases at high temperatures. It will give a valuable fact in improving the decision-making in the health sector and can be used by other responsible agencies and policymakers to develop a mechanism on how this information can be disseminated to the public. It can also serve as a revelation to educate people about health risks related to high temperatures in reducing or preventing people from heat-related diseases.

## 2. Materials and Methods

This part of the paper discusses the materials and methods used in the study and is organized as follows:

Study Site, Meteorological and Morbidity Data, and Statistical Analysis.

### *2.1. Study Site*

Cabanatuan City is a first-class city in the province of Nueva Ecija, Philippines [15]. It has a population of 303,032 people, making it aster most populous city in Nueva Ecija and the 5th populous in Central Luzon. The geographic coordinates of the city are 15° 29' 22 N, 120° 58' 14 E. It has a tropical wet and dry climate, with year-round warm weather and distinct dry seasons. It administratively subdivided into 89 barangays.


**Fig. 1 Study Site (Cabanatuan City)**

### *2.2. Meteorological and Morbidity Data*

The authors collected data regarding meteorological variables, such as the temperature and others, during 2011– 2016 from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) in Cabanatuan City. The authors also collected data regarding the monthly hospital admissions for cardiovascular-related cases and total monthly admission during the same period from the M.V. Gallego Cabanatuan City General Hospital. These data were coded using the International Classification of Diseases (ICD) 10 system. The authors also computed the percentage of hospital admission due to cardiovascular cases.

### *2.3. Statistical Analysis*

The data collected from these sources were classified and analyzed to validate and identify if there is a significant relationship between the high temperature and the number of hospital admissions for cardiovascular cases. The authors compare this to see if a positive correlation exists.

The authors used linear regression to determine the association between hospitalization for cardiovascular cases triggered by high temperature [16]. This study also aims to predict the possible rate of hospital admissions for cardiovascular cases with high temperatures.

The authors classified the two heterogeneous data and clustered them accordingly. The authors selected and included the monthly highest temperature and average for the temperature. For the cardiovascular disease (CVD) occurrence, the author picked the number of CVD hospital admissions, month and year, CVD admissions, and the percentage of CVD hospitalization admission.

The authors use correlation analysis to measure the strength of the association (linear relationship) between two variables [17]. The high temperature is represented by variable x, and the percentage of hospital admission due to CVD is represented by variable y.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n(\sum x^2) - (\sum x)^2]\,[n(\sum y^2) - (\sum y)^2]}}$$

Where:
r = Sample correlation coefficient
n = Sample size
x = highest recorded temperature
y = percentage of hospital admission due to CVD

The correlation coefficient, r, tells us about the strength and direction of the linear relationship between x and y [18].

However, the reliability of the linear model also depends on how many observed data points are in the sample [19].

The authors need to look at the value of the correlation coefficient, r, and the sample size, n, together.

To do this, we perform a hypothesis test of the "significance of the correlation coefficient" to decide whether the linear relationship in the sample data is strong enough to use to model the relationship in the sample data.

The hypothesis test allows us to decide whether the value of the sample data correlation coefficient ρ is "close to zero" or "significantly different from zero" [29]. The authors decide this based on the sample correlation coefficient r and the sample size n.

$H_0$: There is a significant relationship between the highest temperature and the percentage of hospital admission due to cardiovascular disease.

$H_a$: There is no significant relationship between the highest temperature and the percentage of hospital admission due to cardiovascular disease.

$$r = t = \frac{r}{\sqrt{\frac{1-r^2}{n-2}}}$$

The null hypothesis is rejected if the p-value is less than a predetermined level, α. The α is, called the significance level, is the probability of rejecting the null hypothesis given that it is true. It is usually set at or below 5% [21].

### 2.4. Regression Analysis

In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships among variables [22]. Simple linear regression involves a single independent variable [23]. The purpose of regression analysis is to analyze relationships among variables. The analysis is carried out through the estimation of a relationship, and the results serve the following two purposes:

Answer the question of how much y changes with changes in each of the x's (x1, x2,...,xk). Y *is the* dependent variable.

Forecast or predict the value of y based on the values of the X's; x *is the independent variable*

$$Yi = \beta\_0 + \beta\_1Xi + \varepsilon$$

Where:

Yi = Dependent Variable
β_0 =Y intercept
β_1=Slope coefficient
Xi = Independent Variable
ε = Random Error term

## 3. Results and Discussion

### 3.1. Results

The following are the results of the statistical analysis and graphical representations of the authors' findings in analyzing the relationship between the highest recorded temperature and hospital admission due to cardiovascular disease.

Figure 2 contains the histogram of the highest recorded temperature. The histogram generated by the data of the highest recorded temperature reflected that it is not normally distributed. There are values far higher than what the normal curve requires. Figure 2 shows the Mean, which is 35.43, the standard deviation of 1.61, and the number of samples equal to 72.

The histogram generated by the data of the percentage of Hospital Admission Due to CVD reflected that it is not normally distributed. There are values far higher than what the normal curve requires. Also, we can see a bar that seems to be an outlier. Figure 3 shows the Mean hospital admission percentage due to CVD, equal to 2.01, with a standard deviation of .792 and 72 as the total number of samples.

Table 1 is the variables processing summary. The table shows the independent and dependent variables and their corresponding values. The dependent variable is the percentage of hospital admission due to CVD, and the independent variable is the Highest Recorded Temperature.

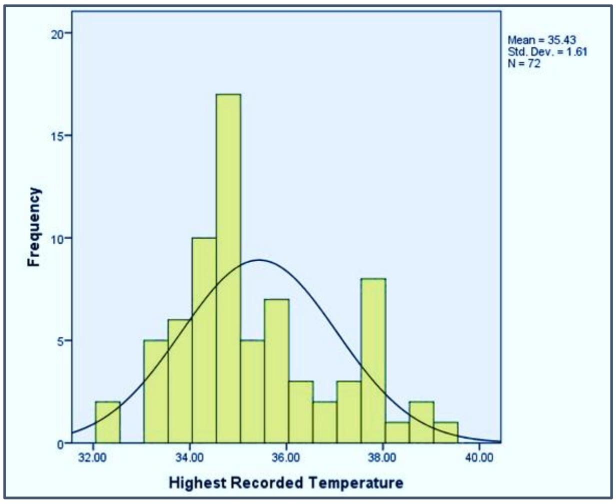


**Fig. 2 Histogram of highest recorded temperature**

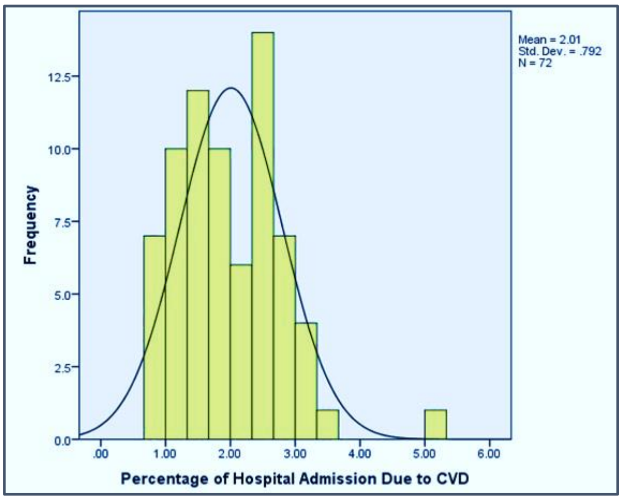


**Fig. 3Histogram of the percentage of hospital admission due to CVD.**

**Table 1. Variable Processing Summary**

| | Variables | |
|---|---|---|
| | **Dependent** | **Independent** |
| | Percentage of Hospital Admission due to CVD | Highest Recorded Temperature |
| Number of Positive Values | 72 | 72 |
| Number of Zeroes | 0 | 0 |
| Number of Negative Values | 0 | 0 |
| Number of Missing Values (User Missing) | 0 | 0 |
| Number of Missing Values (System Missing) | 0 | 0 |

In the model summary table, R denotes the correlation between the predicted and observed Percentage of Hospital Admission due to CVD. In our case, R = .099. Since this is a very low correlation, the model imperceptibly predicts job performance.

R square is the square of R. It indicates the proportion of variance in the Percentage of Hospital Admissions due to CVD that can be "explained" by the highest recorded temperature (the predictor). Our R square = .010, which tells that the highest recorded temperature can only explain .010 of the percentage of hospital admission due to CVD, which is rather small.

Because regression maximizes R square [24], it will be somewhat lower for the entire population, a phenomenon known as shrinkage. The adjusted R square estimates the population R square for the used model and thus gives a more realistic indication of its predictive power. The adjusted R square = -.004, which means that the model's predictive power is less than zero. Thus, the highest recorded temperature cannot predict the percentage of hospital admission due to CVD.

**Table 2. Model Summary**

| R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|
| **.099** | .010 | -.004 | .794 |

Table 3 displays the Analysis of Variance (ANOVA) [25]. The p-value is equal to .406, which will interpret as not significant.

**Table 3. Analysis of Variance (ANOVA)**

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | .440 | 1 | .440 | .698 | **.406** |
| Residual | 44.076 | 70 | .630 | | |
| Total | 44.515 | 71 | | | |

In table 4, the B coefficients tell how many units of hospital admission due to CVD increases for a single unit increase in the predictor (highest recorded temperature). Like so, a 1-point increase in the highest recorded temperature corresponds to a .049-point increase in hospital admission due to CVD. Given only the scores on the predictors, it can predict job performance by computing hospital admission due to CVD = 0.277 + (0.049 x Highest recorded temperature) + (other predictors)

Importantly, note that our B coefficient is a positive number; B coefficients having the "wrong direction" often indicate a multicollinear problem with the analysis. But in this case, it is not in the "wrong direction," but rather, it is too small, indicating that other factor/s that might be considered in the future might be stronger predictors of hospital admission due to CVD.

As a rule of thumb, the result can say that a B coefficient is statistically significant if its p-value is smaller than 0.05. The B coefficient is not statistically significant because the p-value equals .406, and the p-value is greater than .05.

**Table 4. Coefficients**

| | Unstandardized Coefficients | | Standardized Coefficients | t | | Sig. |
|---|---|---|---|---|---|---|
| B | Std. Error | | | Beta | | |
| Highest | .049 | .058 | | .099 | .836 | .406 |
| Recorded Temperature | | | | | | |
| (Constant) | .227 | 2.074 | | | .134 | .894 |

Lastly, the beta coefficient allows us to compare the relative strength of the predictor [30]. Predictors are at .099, which is rather small. Hence, the strength of the highest recorded temperature to predict hospital admission due to CVD is rather weak.

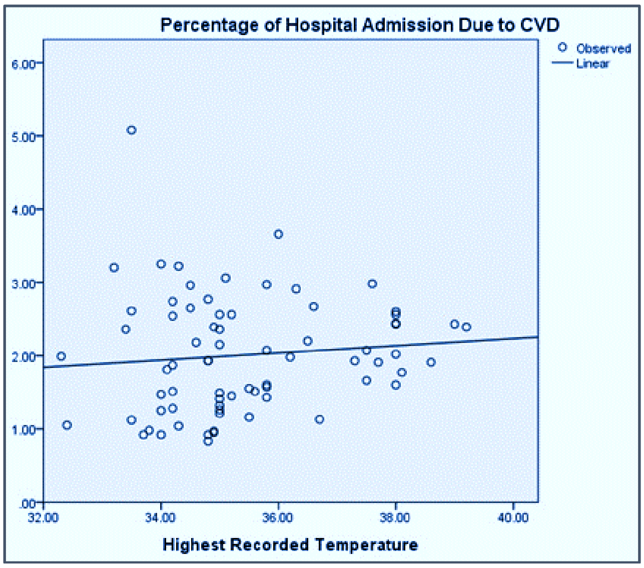


**Fig. 4 Scatter Plot of highest recorded temperature and percentage of Hospital admission due to CVD.**

Figure 4 shows the scatter plot of the highest recorded temperature and percentage of Hospital admission due to CVD.Magnetic Normal Modes of Bi-Component Perm alloy Structures.

The trend line indicates that there is a positive correlation but very small.

### *3.2 Discussion*

Based on the data gathered in the research study site, the following are the significant findings of this study.

1. There is a weak relationship between the highest recorded temperature and hospital admission due to Cardio Vascular Disease (CVD).

2. There is a very low correlation between the two variables (highest recorded temperature and percentage of hospital admissions), and the model could predict quite imperceptibly.

3. High temperature alone cannot be used to predict accurate hospital admission due to cardiovascular disease because other factor/s might be considered to gain stronger predicting power for hospital admission due to CVD.

4. The null hypothesis, "There is a significant relationship between the highest temperature and the percentage of hospital admission due to cardiovascular disease," is rejected.

For future works, the authors would be looking for other predictors/factors that may contribute to the number of hospital admission in order to develop a platform that will help and aid the decision-maker in the health sector, other responsible agencies, and policymakers to develop a mechanism on how the information can be disseminated to the public will serve as a tool to educate people about health risk related to high temperature in order reduce or prevent people from heat related diseases.

The authors will also consider other factors such as age, gender, medical history, and others to improve the model's predicting power [27]. The researcher may also use or include other heat-related diseases (such as respiratory disease) to expand the scope of the study.

Other researchers may also conduct a similar study in different research study sites to validate the study's result.

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