Factors Affecting Vulnerability of Barangays to COVID-19: A Study in Cebu City

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Abstract

The CoVid-19 virus caused a global crisis as it rapidly spread around the world. Cebu City in the Philippines reported the highest number of CoVid-19 cases in May 2020. This study has focused on the said city to identify the significant factors that contribute to the vulnerability of the city's barangays to CoVid-19 infection. Eleven factors were evaluated using multiple linear regression analysis and results showed that among the factors, only two were found to be significant on the barangay level, the residential housing type, and the barangay income. High building densities increase the probability of interaction among residents which heightens the risk of transmitting the virus. Moreover, poor communities or barangays are at a higher exposure due to the residents' lack of resources and need to seek labor. Further studies on reducing the vulnerability of communities to CoVid-19 and employing a similar study in other cities, adding various factors, and utilizing the latest data on infection rates are suggested. Vulnerability assessment may also be done on an aggregated level such as individual or household to generate more accurate results.

Keywords
CoVid-19, Cebu City, Vulnerability Assessment, and Regression Analysis

1. Introduction

The declaration of the CoVid-19 outbreak as a pandemic by the World Health Organization occurred on the 11th of March of 2020 (Vallejo Jr. and Ong 2020). The SARS-CoV-2, also known as the CoVid-19 pandemic, has increased the attention of the world since the start of the year 2020 (Sangiorgo and Parisi, 2020). Additionally, the contagion is said to have started its spread from China and after a few months, infections have started to be identified by other countries, forcing them to start a lockdown. During the SARS outbreak, there were only at least 8,000 confirmed cases (National Academies of Sciences, Engineering, Medicine, Board on Global Health, and Forum on Microbial Threats 2020) which is significantly lower than the recorded cases on CoVid-19, having surpassed 15.3 million worldwide and continuously rising. CoVid-19 is clear to be more infectious than the SARS virus although the mode of virus transmission is quite similar; being from the droplets emitted from coughing or sneezing and by physical contact (Shaylayka 2020, as cited in Yang et al. 2020).

With the risk of getting a virus, a 14-day quarantine is required to be faced by those who will come from other countries while observing their health status (Chiang and El Sony 2020, as cited in Vallejo Jr. and Ong 2020). In addition, there are also orders for citizens that require them to stay at home to reduce the risk of getting the virus. Quarantine was implemented in the Philippines on March 13, 2020, but it was only for the National Capital Region (NCR) (Vallejo

Jr. and Ong, 2020). Because of the quarantine, many businesses were suspended that affected the Philippine economy (Sangiorgo and Parisi 2020).

Health pandemic plans are needed to reduce the rate of spread of the virus and avoid deaths (Wrigley and Dawson, 2020). This made vulnerability assessments an important task because they indicate the ability of people to cope, resist, and heal from the aftermath of a dangerous phenomenon (Du et al. 2015), such as a virus outbreak. Furthermore, vulnerability assessments may also identify all the risks and factors that affect people's vulnerability while allowing other researchers to further investigate the results of previous vulnerability assessments as a guide or reference.

Cebu City is one of the key cities in the central Visayas region and the capital city of Cebu Province. It was titled "the Queen City of the Southern Philippines" because of its economic value to the Philippines (Consulate-General of the People's Republic of China 2006). The 2015 population in Cebu City was 922,611 (PSA, 2015), of which about 64% belonged to the working class, 4% are aged 65 years and older and 32% are below 15 years. Cebu City consists of 80 barangays with only 16 health facilities (DOH, 2020). The city, one of those that reported the highest number of CoVid-19 cases in the country during the early months of the outbreak (Erram, 2020), was the primary motivation why this study was conducted.

There have been numerous studies and assessments that have identified the vulnerability or risk factors of the recent CoVid-19 pandemic in their own respective countries. These studies covered a wide array of factors and utilized either existing pandemic tools or an adapted version of them to conduct tests such as the Influenza Risk Assessment Tool (IRAT) and the modified Index for Risk Management (INFORM) tool. However, none of the works found considered places in the Philippines, and no assessment tool was found that centered specifically on CoVid-19. This study determined the significant factors that contributed to the city's barangay level vulnerability to CoVid-19. As risk assessments provide important information about a person's vulnerability, the results of this study will provide specific information on the factors that could significantly affect a community's vulnerability to the CoVid-19 virus. This information could aid the local government, not only of Cebu City but of the whole country, in developing their strategies and action plans to reduce the number of confirmed cases.

2. Literature Review

Pandemic outbreaks give rise to different risks and dangers to global health, which is why a worldwide health crisis arises as to the novel coronavirus disease 2019 outbreak or CoVid-19 appeared. According to the World Health Organization (2020), the novel virus before the outbreak began in Wuhan was undetermined. It all started when several reports of pneumonia infected cases were said to be disclosed in Wuhan, China in December 2019 (Pourghasem et al. 2020). From there on, several cases of CoVid-19 were reported which directed the WHO to officially proclaim the CoVid-19 outbreak as a pandemic on March 11, 2020 (CDC, 2020). WHO also proclaimed the pandemic as a Public Health Emergency of International Concern (PHEIC) which implied that the outbreak includes more than one country as several positive cases were continuously reported, and therefore demands a coordinated international response (Chatterjee et al., 2020). Nearly 8.60 million positive cases and 455,575 deaths attributed to CoVid-19 were reported as of June 18, 2020 (Pourghasemi et al., 2020). Symptoms of coronaviruses extend from common colds to varying critical and fatal ones, including the Middle East Respiratory Syndrome (MERS-CoV) and the Severe Acute Respiratory Syndrome (SARS-CoV) and people with underlying medical problems and the elderly are more vulnerable to serious illnesses such as cardiac arrest, pneumonia, SARS-CoV, kidney failure, and death (Decaprio et al., 2020). The biggest problem is that there is still no specific cure discovered for the CoVid-19 disease while experts continue to explore the anatomy, symptoms, complications, and potential treatments for CoVid-19 disease (Decaprio et al. 2020). Currently, various CoVid-19 vaccines are made available to minimize the effect of the virus but efficacy to the current situation is still under study given that there are different kinds of variants of the virus. Social distancing and restricting gatherings are still recommended and practiced worldwide to reduce the CoVid-19 spread and protect everyone's health care system (CDC, 2021). Most countries also imposed travel restrictions and lockdowns to flatten the curve (Ekumah et al., 2020).

One of the concepts frequently utilized by public health ethics is vulnerability. Although its exact definition is vague, vulnerability, as defined by Wrigley and Dawson (2016), is a specific status of an individual or group which indicates how the aftermath of an event would affect their well-being. To add, as the individual or group will not be able to defend themselves, it suggests a responsibility to protect their well-being. The concept of vulnerability is important as

it is challenging to characterize the specific status and who to apply it to and because of an extending scope of multiple situations, it may become a problem knowing that any individual or group may be classified as vulnerable. Vulnerability has gone from research ethics and individual contexts into the area of healthcare, health technologies, and at present, families, populations, communities, groups, and whole countries may be classified as vulnerable (McMichael et al. 2003, van Lieshout et al. 2004, Haines et al. 2006, Few 2007, Costello et al. 2009, as cited by Clark and Preto 2018). Health vulnerability encompasses the physical, physiological, and psychological effects of extreme events; it is the combination of different risk and protective factors that dictate to what extent an individual or community may undergo the different consequences of such events (Cardona et al. 2012).

Multiple types of approaches can be used when conducting vulnerability assessments. According to Moret (2014), the basic assessment from most of the literature was "Risk + Response = Vulnerability." In the Household Economy approach, "Baseline + Hazard + Response = Outcome". Vulnerability assessments, as stated by Naudé et al. (2009) cited by Moret (2014), should be predictive activity. Furthermore, Moret (2014) suggests that the data from the Vulnerability assessment must be easily accumulated and subdivided on every approach. The susceptibility of people may also be measured economically, environmentally, physically, and socially, which are the main divisions of vulnerability (ODPM, 2013). Physical vulnerability requires the presence of structures such as the area's geography or location and the infrastructures' construction or stability. According to Rahmayanti and Nugraha (2020), infrastructures, such as communal washtubs, can be made to promote social distancing and lessen the spread of the virus. They added that disseminating information in different, clear, and simple languages, especially in secluded places will help educate people and put them in action. Moreover, healthcare facilities would help in the recovery of CoVid-19 patients. The rest of the types are often merged as they correlate to one another. Environmental vulnerability focuses on the access of an area to natural resources while social vulnerability considers the characteristics, culture, and knowledge of the individuals in an area's population. Lastly, economic vulnerability takes the economic status of individuals and the area where a poorer one has a greater susceptibility. When unified, the divisions are called the socio-economic environmental aspects which, regarding the pandemic, urban or rural settings, household dimensions, population density, educational degree, and lifestyle (Saadat et al. 2020).

O'Sullivan and Bourgoin (2010) have found that the factors of vulnerabilities are gender, income, social environment, physical environment, education, employment, child development, racism, discrimination, age, disability, and access to health services. There is also a wide range of approaches to measure vulnerability and the best approaches for vulnerability assessment are categorized into three which are Comprehensive Livelihoods Frameworks: Macro to Micro Level Measures, Population-Level Measures, and Individual and Household Measures and Targeting (Moret 2014). Vulnerability assessments are conducted in a large variety of data collection and analysis (Moret 2014). One of these includes the regression analysis which allows researchers to study the relationship between different variables (Foley 2018). The study of the Washington State Department of Health (2019) utilized regression analysis and found five variables including population, unemployment rate, drug trafficking, patient quantity, and age range which affect the vulnerability of an area to a virus. The same tool was utilized to analyze the correlation between infected areas and essential aspects of a functional outbreak threat prediction (Pourghasemi et al. 2020); analyze the feedback and compliance of a population (Jose et. al. 2020); and predict assessment on a global scale (Arsalan et al. 2020).

The study of health vulnerability assessment aids in the identification of critical factors that affect susceptibility of the public to a pandemic. Although the CoVid-19 vaccines are being distributed gradually in the country, there is still a pressing need for the conduct of this type of assessment to different communities to raise awareness and help control and minimize the transmission of the virus.

3. Methods

Figure 1 presents the research design adopted in this study. A total of 36 literatures were reviewed, seven (7) of which were specifically utilized to identify the factors that affect the health vulnerability and vulnerability to CoVid-19. These literatures include books, published journal articles, and scholarly articles collected from online sources such as Google Scholar, Journal Storage (JSTOR), National Center for Biotechnology Information (NCBI), Research Gate, and ScienceDirect which were all published in 2010 to 2020. The study adopted the categorization of vulnerability factors used by various researchers (CDC, 2020; Chatterjee et al., 2020; Decaprio et al., 2020; Ekumah et al., 2020; O'Sullivan and Bourgoin, 2010; Pourghasemi et al., 2020) into economic, environmental, and social factors. The social factors include the barangays' population by age, gender, education, and literacy and the number of confirmed

CoVid-19 cases. Economic factors include barangay income, occupation, employment, working conditions, education, and access to health services. Environmental factors include population density, municipal category/type, and residential type.

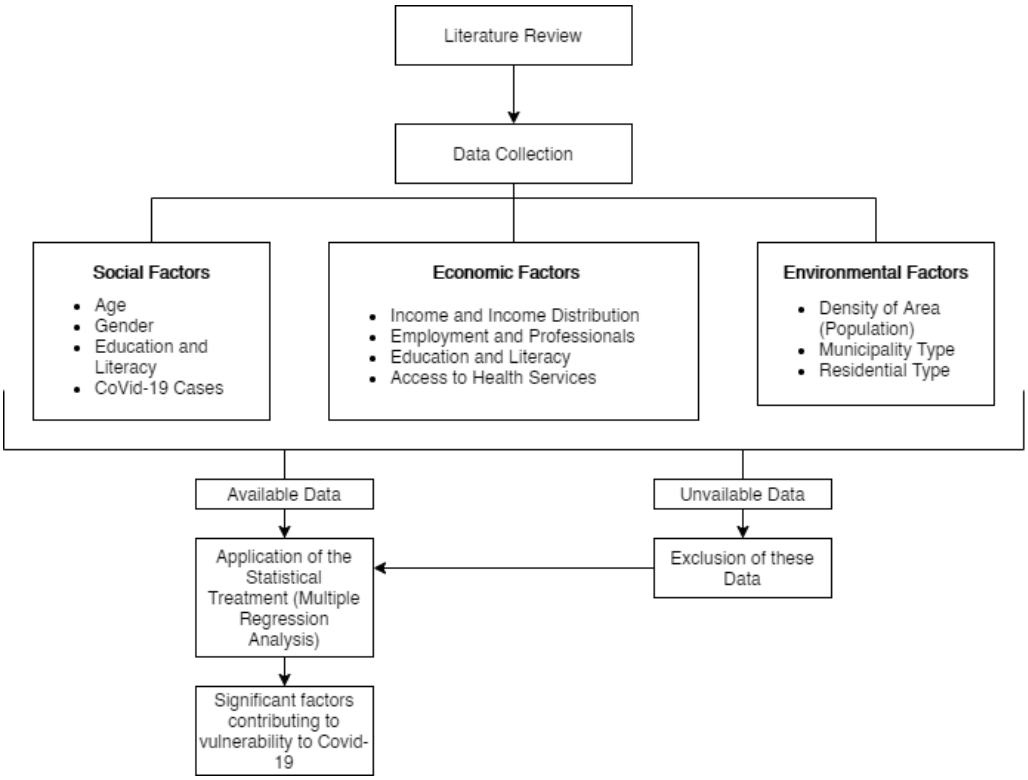

Figure 1. Research Design

The study utilized a quantitative method of examining the data, which entails the use and analysis of numerical data using a set of different statistical techniques and portrays the methods of analyzing an occurrence or problem through gathering data in numerical form (Apuke, 2020). Multiple regression analysis was applied to analyze the connection between a single dependent variable and multiple independent variables (Salkind, 2010). This statistical tool was found to be an effective model in vulnerability assessments (Arsalan et al. 2020; Jose et al. 2020; Pourghasemi et al. 2020) and can be utilized for projection and relationship models (Adesoji and Babatunde, 2018).

The multiple regression lines were computed using the formula in Equation 1, where y is the dependent variable, x_1 through x_p are the independent variables, β_o is the y value when independent variables are equal to zero, β_1 through β_p are the coefficients, and ε is the error (La Morte, 2016). For this study, the independent variables are the factors that affect the vulnerability of a barangay to CoVid-19 while the dependent variables are the number of confirmed cases of Covid19 in each barangay.

$$\hat{y} = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \varepsilon \quad (1)$$

Additionally, assumptions of multiple regression analysis include normally distributed variables, independent and dependent variables with linear relationships, no multicollinearity between the different independent variables, and homoscedasticity, where independent variables' variance of errors are equal (Williams et al. 2013). This was done to evaluate whether the factor is significant or not with regards to the increase of infection rate of CoVid-19 in Cebu City. Public data of Cebu City related to CoVid-19 were collected through online sources such as population data from the 2015 Census of the Philippine Statistics Authority (PSA), the number of confirmed cases from the Department of Health (DOH), and other data from the local government of Cebu. Data for the period of April to July 2020 were considered since these were the only available data of the city during the period of study.

4. Results and Discussion

Table 1 shows the social factors affecting the barangay's vulnerability to CoVid-19 namely S1, S2, S3, S4, and S5. From the table, S1 - Population of Children, S2 - population of senior citizens, and S3 - population of males have a positive or upward functional relationship to vulnerability. According to O'Sullivan and Bourgoin (2010), the number of CoVid-19 cases may rise as the population of children arises because children are considered at high risk due to their weak and underdeveloped immune systems. Risk also increases as age increases which is why senior citizens are also considered at high risk (Chatterjee et al. 2020; CDC 2020). In terms of susceptibility, men are more susceptible to COVID-19 compared to women (Chatterjee et al., 2020). On the other hand, S4 - number of literates and S5 - number of educated citizens has a negative relationship to the community's vulnerability. It is identified that literate people have a low risk of acquiring the virus for communication is necessary during a pandemic as people need to follow what the authority suggests for safety while knowledge about basic hygiene and knowing the precautionary measures, which are typically taught in school, reduces the risk of exposure to the virus during a pandemic outbreak (O'Sullivan and Bourgoin 2010).

Table 1. Indicators of Social Factors

Social Factors		
Code	**Indicator**	**Functional Relationship**
S1	Children	↑
S2	Senior Citizen	↑
S3	Male	↑
S4	Literate	↓
S5	Educated	↓

The indicators of economic factors, which are EC1 - barangay income, EC2 - no. of professionals, and EC3 - access to health services, are shown in Table 2. These indicators demonstrated a negative or downward functional relationship to vulnerability. The level of risk decreases as individuals from a certain community have adequate access to financial resources and good income and people in the middle class who are living in safe and clean places often have good sanitation because of their sufficient income which then decreases their risk of getting a virus (O'Sullivan and Bourgoin, 2010). The same author mentioned that people who have access to health services were part of the low-risk group because they have the advantage of obtaining treatment compared to those who are far from health service facilities. The number of professionals (EC2), on the other hand, is directly proportional to the vulnerability of the community. Despite the implementation of quarantine and social distancing, professional workers are considered at high risk because they are widely exposed not only to the virus but also to exhaustion and stress (O'Sullivan and Bourgoin 2010). However, in an economical aspect, the lower the number of professionals, the higher the vulnerability of people to the virus (Grooms, et al. 2020).

Table 2. Indicators of Economic Factors

Economic Factors		
Code	**Indicator**	**Functional Relationship**
EC1	Barangay Income	↓
EC2	No. of Professionals	↓
EC3	Access to Health Services	↓

In Table 3, the indicators of environmental factors which are E1 - Population, E2 - Municipal Type, and E3 - Residential Type show a positive or upward functional relationship to vulnerability. According to the Washington State Department of Health (2019), the vulnerability of a community is increased as the population rises because the risk of exposure heightens in social contacts. People living in urban areas also have a high risk of virus transmission for the distance from public places, such as ATMs, attraction sites, fuel stations, mosques, the road, temperature, and density is highly significant to the vulnerability of a community (Pourghasemi et al. 2020). Moreover, people's risk of being widely exposed to a virus and obtaining it depends on the environment they are living in and those who are living in crowded places and adjoining houses have a high risk of virus transmission (O'Sullivan and Bourgoin 2010).

Table 3. Indicators of Environmental Factors

Environmental Factors		
Code	**Indicator**	**Functional Relationship**
E1	Population	↑
E2	Municipal Type	↑
E3	Residential Type	↑

Using Minitab 17 software, the regression model was generated as shown in Equation 2, where the number of confirmed CoVid-19 cases in Cebu City is the dependent variable and the factors of vulnerability are the independent variables while the p-values, coefficients, and functional relationships are presented in Table 4.

$$No.\ of\ confirmed\ Cases = -59.1 + 0.000028\ \boldsymbol{EC1} + 21.53\ \boldsymbol{E3} \quad (2)$$

Table 4. Ranking of Factors of Barangay Vulnerability to CoVid-19

Code	Factor	Regression Coefficient	P-value	Functional Relationship to Vulnerability
E3	Residential Type	21.53	0.004	↑ (positive)
EC1	Barangay Income	0.000028	0.033	↓ (negative)
S3	Population of Males	-0.1261	0.104	↓ (negative)
S5	Number of College Graduates	0.00776	0.123	↓ (negative)
S1	Population of Children	0.0605	0.199	↑ (positive)
E1	Population	0.0419	0.375	↑ (positive)
S2	Population of Seniors	-0.0206	0.534	↓ (negative)
EC3	Access to Health Services	0.64	0.597	↓ (negative)
S4	Population of Literate	-0.0085	0.667	↓ (negative)
EC2	Total Number of Professionals	0.0105	0.777	↑ (positive)
E2	Municipal Type	3.0	0.883	↑ (positive)

The social factors S1, S2, S3, S4, and S5, economic factors EC2 and EC3, and environmental factors E1 and E2 have p-values of > 0.05, which indicate that they are not significant. On the other hand, the variables that have a significant contribution to the vulnerability of the barangays are those that have p-values of ≤ 0.05 which include the factors E3 - Residential Type and EC1 - Barangay Income.

With a coefficient of 21.53 and a p-value of 0.004, variable E3 yielded the lowest p-value which means that the vulnerability of barangays in the city heightens the most in areas that have denser buildings. The compactness of buildings in Cebu City's barangays ranges from 2,000 to 20,000 buildings per square meter. Barangays such as Calamba, Duljo, Labangon, Lorega-San Miguel, Luz, Mambaling, Pasil, Sambag, Sinsin, T. Padilla, Tejero, and Tinago have the highest building densities, ranging from 16,000 to 20,000 buildings per square meters, and had a noticeably larger number of CoVid-19 cases. This trend was also shown in the study of Pourghasemi et al. (2020), describing the density of areas as a moderate influencer for vulnerability as it considered other geographical factors that have a higher significance than area density. Moreover, even though there were implementations such as lockdown, the distance between buildings still contributed to the virus transmission. This explains the growing concern in urban-poor communities in other countries and is supported by the statement, "Dense cities are Petri dishes that spread the coronavirus" (Miller, 2020).

Results showed that the barangay's income is significant and contributory to health vulnerability which means that low-income barangays are at higher risk of infection than high-income ones, as evident in EC1 factor which has a coefficient of 0.0419 and a p-value of 0.033. Exposure rises when there is a lack of sufficient financial resources and those in poverty and who are living in unsafe, crowded, and poorly sanitated areas due to lack of income are more likely to be infected (O'Sullivan and Bourgoin, 2010). Barangays with lower incomes will have more difficulty

providing resources to address the needs of their citizens, such as equipment for prevention, health-related assistance, and necessities which could lead to a rise in exposure as the citizens would find ways to fend and obtain these for themselves. Additionally, most urban-poor communities have high population densities, which also contributes to exposure levels and increased risk. The barangays with the highest barangay income are Guadalupe, Lahug, and Basak San Nicolas while those with the lowest barangay income are Paril, Pung-ol Sibungay, and Kalubihan. The CoVid-19 cases of each high-income barangay reach about 0.50% of their respective population while that of the low-income barangays vary. Kalubihan has 0.80% of its population infected with the virus whereas Paril and Pung-ol Sibungay have none. The variation may be related to the area type. Although their residential types are both less than 6000 buildings per square meter, Paril and Pung-ol Sibungay are secluded rural areas while Kalubihan is an urban area. Kalubihan is a good example of an urban-poor community. As such, the percentage of its population that has CoVid-19 virus became higher than those of urban barangays with high barangay income such as Guadalupe. Moreover, despite having a greater population, the high-income barangays still have more professionals and have the access and capability of quality health service.

The results of this study identified that the residential type and income of barangay in Cebu City are the two most significant factors of vulnerability to CoVid-19. However, the results could not be concluded with other cities in the country with high numbers of CoVid-19 cases since the data on each indicator or factor of vulnerability varies.

5. Conclusion

The 2020 CoVid-19 outbreak has contributed to the death of millions worldwide and in the Philippines, it continues to pose a great threat to the health and safety of the citizens. It is therefore essential that vulnerability assessments be conducted as they help determine the people's ability to withstand dangerous events and play a key role in mitigation strategies. This study determined the significant factors that contribute to vulnerability to CoVid-19 of barangays in Cebu City by utilizing various literature and public data. To examine how the factors take part in the community's vulnerability to the virus, regression analysis was applied. Results showed that of the eleven (11) factors, only two (2) were found to be significant to the no. of confirmed cases, which are residential type (E3) and barangay income (EC1). Lower barangay income results in urban-poor communities which then increases an area's population and building density, and further increases their exposure levels. High population density increases the likelihood of contact between people and broadens the virus' reach as there would be more persons to infect which contributes to a greater rate of infection. Moreover, low-income barangays are considered as high risk for they cannot provide the resources needed by the citizens. The risk of exposure increases as people in poor communities would be required to go outside and work to earn a living. Future researchers may conduct similar studies utilizing additional factors and the most recent data available. Vulnerability assessment may also be done on an aggregated level such as individual or household to generate more accurate results.

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Biography

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Princess Dy R. Padagdag is a Science, Technology, Engineering, and Mathematics (STEM) student at Mapúa University who is a consistent Honor roll and strives to graduate with High Honors. As an aspiring architect, she has always been curious of the application of fine arts and design into her surroundings and plans to follow in her father's footsteps in the Design and Construction Industry.

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