Assessment of the effects of COVID-19 on the travel behavior and mobility of residents in Metro Manila, Philippines: A case study for a megacity in a developing country

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Human mobility is affected by a combination of both internal (i.e., personal motivations) and external (i.e., disasters and other hazardous events) factors. The COVID-19 pandemic has significantly changed mobility and travel behavior on a global scale. However, there is still a huge gap in understanding the complex relationship between mobility patterns and sociodemographic characteristics in the context of a pandemic. The research aims to address this by using data from a household interview survey combined with social vulnerability indicators to examine the travel behavior changes of households due to COVID-19. To achieve this, an online questionnaire was distributed to households in Metro Manila, Philippines. Questions included: socio-economic characteristics, household access to vehicles, pre-COVID-19 and current travel activity of members and COVID-19 infection. The information was used to assess the overall vulnerability of each household to COVID-19. The approach was based on literature identifying specific socio-economic factors contributing to vulnerability to COVID-19, as well as the method of quantifying social vulnerability as proposed by Cutter et al. (2003). Findings offer a better understanding of the relationship between social vulnerability and mobility and serve as a basis in formulating sustainable transport policies during pandemics.

Key Words: *social vulnerability, travel behavior, mobility, COVID-19*

1. INTRODUCTION

Since the start of the COVID-19 pandemic, countries all around the globe have been experiencing overwhelming health and economic costs. Governments have implemented various levels of lockdown policies to contain the spread of contagion. Community quarantine regulations in the Philippines have not been lifted since early 2020 making the country hold the title for the longest lockdown in the world. Despite the prolonged duration of mobility restrictions, over 2 million cases have been recorded, as of September 2021. To date, new cases reach up to more than 20,000 per day making the country have the second-highest daily rate in Southeast Asia. The surge in cases may have been caused by the premature easing of travel restrictions as vaccine administration commenced. Furthermore, with a total of 35,307 deaths, the Philippines also has the third-highest mortality rate in Southeast Asia, following Malaysia and Indonesia.

With the worsening rate of infection and deaths due to COVID-19, Metro Manila was once again put under Modified Enhanced Community Quarantine or MECQ, the second strictest quarantine level, from August to September 2021. Under this restriction, movements are limited to accessing goods and health services, at-risk age groups are required to stay at home, social gatherings are prohibited, and establishments are allowed to operate only up to 50% of their working capacity.

The continuing lockdown policies have caused great economic impacts to the poorest of the society. Unemployment rates are increasing, low-income households are struggling financially, and hospitals are at over-capacity. These issues brought about by COVID-19 show that the world's most vulnerable countries lack the capacity to respond to a global pandemic because of the lack of financial resources, debt, and fragile health systems.

The social vulnerability pertains to the potential to harm people. It involves a group of factors that define the scale to which a person's life and livelihood are put at risk by a discrete and identifiable event in nature or in society [1)]. There is a diversity of methodological approaches and techniques for quantifying social vulnerability. One of the most well-acknowledged theoretical frameworks is based on the study by Cutter et al.[2)] on social vulnerability which proposes that social characteristics, or indicators such as income level, sex, access to basic services, etc. influence the susceptibility of various groups to harm and govern their ability to respond. Furthermore, the research formed an additive model to produce the social vulnerability index score (SoVI) which is regarded as the relative measure of the overall social vulnerability of the observed population. This concept of social vulnerability has recently been applied in the context of the COVID-19 pandemic and findings show a similar relationship between socially vulnerable groups and impacts of the pandemic. To cite, lower-income groups exhibit more work activity during the day making them more at-risk of COVID-19 infection[3)].

In addition to social inequalities, recent literature also draws attention to how transport played a critical role in the spread of COVID-19. In the Philippines, lockdowns and community quarantines resulted in drastic changes in travel behavior, as well as negative economic impacts to the transport sector and socially vulnerable groups. Even though public transport has been perceived as sustainable, efficient, and an affordable mode of travel, preliminary trends in re-opened cities have shown that public transport is considered relatively risky and is not recovering as quickly compared to the use of private vehicles, cycling, and walking [4)]. Furthermore, strict mobility restrictions and inaccessible public transport resulted in compounded negative economic shocks to poorer households who depend on using mass transport to continue working. This emphasizes how socially vulnerable groups are disproportionately affected by the impacts of the pandemic.

Founding on the literature and other early works, this research aims to understand the relationship between social vulnerability, travel behavior, and how they affect the increased risk of COVID-19 infection of residents in Metro Manila, Philippines. This study also provides a synopsis of the COVID-19 situation in a major city of a developing country, characterized by high economic activities and overpopulation.

The research structure will be as follows:

Section 2 describes details of the methodology. The section includes data source, and the selection and evaluation of social vulnerability and transport behavior indicators.

Section 3 provides details on the results and discussion. The section includes results on population distribution, correlation of indicators, characteristics of the socially vulnerable population, and changes in their travel behavior. It also discusses the application of ordered logistic regression analysis and its corresponding results which attempts to understand the relationship between the social vulnerability indicators and exposure to COVID-19.

Section 4 summarizes the main findings of this study.

2. METHODOLOGY

(1) Data source

The data used for this study is based on an online household survey conducted from June 1 to July 31, 2021. The survey questions were organized into three sections, namely: socio-economic characteristics, travel activity, and COVID-19 status. The data used in the analyses were based on a total of 140 individual records from 39 households living in Metro Manila. After eliminating responses with insufficient and/or incorrect

Table 1 Social vulnerability indicators

Factor	Indicator	Vulnerability criteria	Rationale (source)
Socio-economic characteristics	Income	Income below the poverty line	Low-income groups do not significantly reduce work-related trips making them more exposed to higher health risk[5)]
	Gender	Female	Women have experienced greater mobility and used public transportation more often than men during the pandemic and are thus more likely to be exposed to the virus[6)]
	Occupation	Essential and health workers	Main occupation is the key factor affecting travel time change[7)]
	Age	Over 60 years old	COVID-19 is often more severe in people who are older than 60 years[8)]
	Crowding	Person per bedroom > 2	A larger share of individuals in crowded housing contributes to disparities in disease risk[9)]
Travel behavior	Vehicle access	No access to private vehicle	There is a high risk of exposure for people who use public transit[10)]

data, a subsample of 140 individuals from 39 households living in Metro Manila was considered for this research.

(2) Selection and evaluation of indicators

Adapting social vulnerability as defined in the research of Cutter et al. (2003), six (6) social vulnerability indicators were identified from the survey each presumed to exacerbate the risk of contracting COVID-19 (Table 1). Indicators were selected based on previous literatures identifying socio-economic qualities, travel behavior, and access to private vehicles as some of the factors influencing the risk of virus infection. These were then defined and ascertained a binarized criterion to determine how it contributes to vulnerability to COVID-19.

3. RESULTS & DISCUSSION

(1) Population distribution

Based on the survey responses, The most common social characteristics among the population are women, middle age group; working, and upper-middle-income. 58% of the population are women and 74% belong to the middle age group. 64% are employed while 20% are students. Finally, 49% of the individuals belong to upper-middle-income families.

(2) Correlation matrix

Using Pearson's correlation analysis, it was found that the linear relationship among indicators is generally weak (Figure 1). The strongest correlations appear between age and occupation (0.36), indicating that the senior age group also most likely belong to vulnerable jobs, such as essential or health workers. None of the variables are multicollinear and, therefore, may be used in the regression analyses.

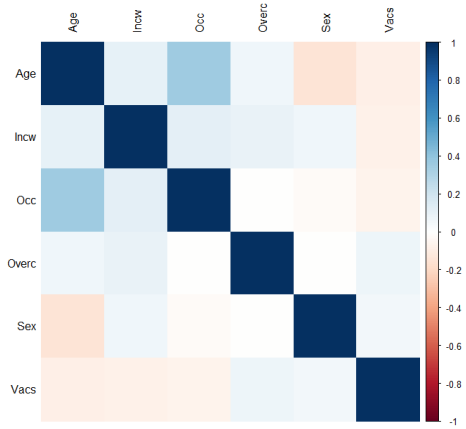

Figure 1 Correlation Matrix

(3) Socially vulnerable population

First, the survey data were analyzed to identify the prevailing characteristics which make the population vulnerable. It was found that: gender (58%), crowding (34%), and age (29%), were the topmost vulnerable traits that are common among most of the population.

Founding on the approach by Cutter et al., we used the Social Vulnerability Index or SoVI to evaluate the overall social vulnerability for every individual. Each indicator is defined and set a criterion to indicate how they contribute to vulnerability. Each score is then tallied to show the overall social vulnerability (1).

$$\text{SoVI} = \sum_{i=1}^{n=6} x_i \qquad (1)$$

Results show that 95% of the population has a low to moderate level of overall social vulnerability (SoVI = 0 to 3), indicating that while they are not immediately at risk, they are still prone to negative impacts of the pandemic.

We found that while 22% of employed individuals experienced income loss, there is no change in the composition of income status indicating that the losses are not big enough to affect or change their income level status.

Results also revealed that poor to low-income families are hardest hit by economic impacts of the pandemic with all employed members experiencing income loss, while the majority of upper-middle to rich families only had at least one member experienced income loss (Figure 2).

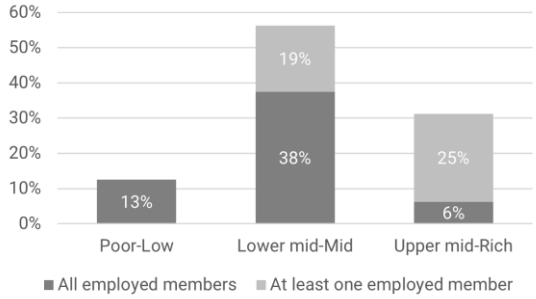

Figure 2 Percentage of individuals affected by income loss

(4) Changes in travel behavior

Due to mobility restrictions as a response to the pandemic, travel behavior has changed drastically. Survey data showed that work, education, and grocery shopping are the most reduced travel activities since the implementation of community quarantine. Education at 100% decline shows that online learning is still strongly enforced in the country, as face-to-face classes are still suspended. Work trips also decreased to 56% reflecting opposite spectrums of the impacts of the pandemic: that some people can work from home and that there are also people who lost their jobs. The decrease in grocery trips by 63% is a probable result of strict lockdown regulations and fear of contracting the virus in enclosed public areas (Table 2).

Table 2 Pre-COVID-19 and current trip frequency

Travel purpose	**Total frequency of trips** (total weekly trip frequency of all respondents)		**Decline**
	Pre-COVID-19	**Current**	
Work	383	215	56%
Education	112	0	100%
Grocery	136	85	63%
Recreational	145	60	41%
Religious	68	16	24%

There was also a significant change in the mode of transport used after the pandemic started. Private cars became the most common choice of transportation. Mass transport is also avoided as more private and individual modes like bicycle, motorcycle, taxis, and walking became more preferred (Figure 3).

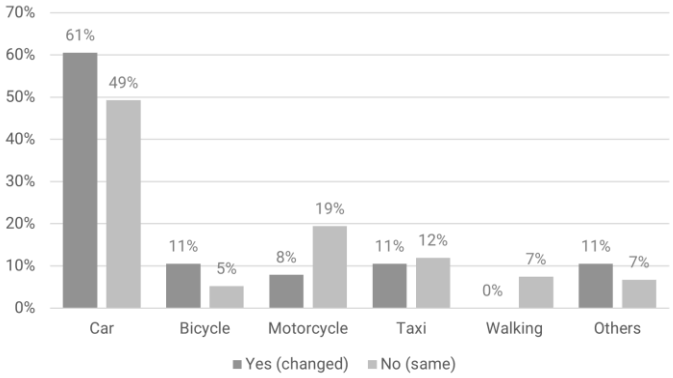

Figure 3 Change in mode of transport

For grocery trips, it was also observed that 67% of those individuals belong to the 20's to 30's age group. This may be due to information that older adults should avoid making trips to stores and other retail locations which are high-risk for exposure.

(5) Ordered logistic regression

To understand how the different vulnerability factors affect COVID-19 exposure, we applied the method ordinal logistic regression for our analysis (2).

$$ln\left(\frac{P(Y \leq j)}{1 - P(Y \leq j)}\right) = a_j + a_{Sex} + \sum_i \beta_i \cdot x_i \qquad (2)$$

where,

Random variable: Y
Response variable: j
j = 1 (not exposed); 2 (home quarantined); 3 (infected)
Categorical explanatory variable: a_{sex}
a_{sex}= 1 (female); 0 (male)
Categorical vulnerability variable in terms of *i of* x_i
x_i = 1 (vulnerable); 0 (not vulnerable)

Ordinal logistic analysis is a statistical analysis method used to model the relationship between an ordinal response variable and one or more explanatory variables. As previously stated, none of the indicators were multicollinear and were therefore used for this analysis. The results of the ordinal logistic regression analysis are shown on Table 3.

Referring to the p-values, findings show that occupation, a_1, a2_, and a_sex are the indicators which

Table 3 Ordinal logistic analysis summary results

	Coef	*Std error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*
x_1 (Crowding)	-0.0002	0.0001	-1.5072	0.1343	-0.0004	0.0000	-0.0004
x_2 (Vehicle access)	-0.0001	0.0001	-0.5859	0.5590	-0.0003	0.0002	-0.0003
x_3 (Age)	0.0000	0.0001	0.3158	0.7527	-0.0002	0.0003	-0.0002
x_4 (Income level)	-0.0002	0.0002	-1.0736	0.2851	-0.0006	0.0002	-0.0006
x_5 (Occupation)	-0.0003	0.0001	-2.8351	0.0053	-0.0005	-0.0001	-0.0005
a_1	1.7152	0.0001	18205.3238	0.0000	1.7150	1.7154	1.7150
a_2	2.9251	0.0002	17532.8992	0.0000	2.9248	2.9254	2.9248
a_sex	0.0340	0.0001	355.2998	0.0000	0.0338	0.0342	0.0338

affect the level of exposure to COVID-19. These results concur with earlier literature stating that time travel reductions are differentiated among various occupations, especially blue-collar workers,[7] increasing their risk of exposure to the virus. In addition, women tend to use public transportation more often than men, contributing to the possibility of contagion[6].

The sign of the coefficients also indicates that the results are in line with previous studies used as the foundation for defining social vulnerability as indicated in Table 1. Household crowding because of stay at home working conditions and mobility restrictions have contributed to the ease of virus transmission[9]. Despite travel regulations, lower-income groups are less likely to (be able to) follow such rules[5] and could possibly be due to the nature of their employment which do not have the option to work from home[7]. The use of public transport has also been associated with high risk exposure to the virus, and households who do not have access to private modes of transportation are more susceptible[10]. Finally, while senior age groups or those who are 60 years old and above belong to high-risk groups of virus infection[8], results show that younger or middle age groups are more susceptible to exposure. This may be attributed to stricter mobility regulations imposed on older age groups. These vulnerability indicators all contribute to increasing the potential risk of exposure to COVID-19.

4. CONCLUSION

This research aimed to examine the social vulnerability and travel behavior characteristics of residents in Metro Manila. Using data from an online household survey, a set of indicators was obtained and evaluated to identify the vulnerability characteristics of the population.

Results from this study support early and current COVID-19 impacts in Metro Manila. Lower-income groups have much harder time to cover hospitalization expenses or recover lost income due to suspension of work or unemployment. Despite increasing their exposure, households without access to private vehicles are left without any alternative options but to use public transport for distant travels, prioritizing their need to continue having income over their safety. More recent lockdown regulations have also allowed more people to travel for work, especially those in the middle age group, but remain restrictive to the mobility of senior age group.

These observations underscore that socially vulnerable populations are affected disproportionately during pandemics. Furthermore, travel behavior also significantly shifts based on mobility restrictions and perceived safety of using public transit. Findings from this study can be used as an evidentiary basis for developing initiatives to mitigate the impacts of a pandemic.

For future studies, further analyses can be conducted by applying other methodological approach, such as utility maximization formulation. This can be applied to understand the benefit loss experienced pre-COVID-19 up to the present. Comparative temporal analysis may also be conducted by performing the interview again to the same respondents years later from the initial interview. Results can provide a basis on how travel behavior changed adapting to the “new normal”.

REFERENCES

1) United Nations Development Program (UNDP), “Introduction to social vulnerability,” Understanding Risk Forum, Italy, May 2016.
2) Cutter, S., Boruff, B., Shirley, W., “Social Vulnerability to Environmental Hazards,” Social Science Quarterly, No. 84(2), pp. 242-261, 2003.
3) Dave, R., et al., “A Quantitative Framework for Establishing Low-risk Inter-district Travel Corridors during COVID-19,” Physics and Society, 2020.
4) Asian Development Bank (ADB), “COVID-19 and Transport in Asia and the Pacific: Guidance Note,” Institutional document, December 2020.
5) Lou, J., Shen, X., Niemeier, D., "Are stay-at-home orders more difficult to follow for low-income groups?," Journal of Transport Geography, Volume 89, December 2020.

6) Assoumou Ella, G., "Gender, Mobility, and Covid-19: The Case of Belgium," Feminist Economics, 27:1-2, 66-80, 2021.
7) Borkowski, P., Jażdżewska-Gutta, M., Szmelter-Jarosz, A., "Lockdowned: Everyday mobility changes in response to COVID-19," Journal of Transport Geography, Volume 90, January 2021.
8) World Health Organization, “COVID-19: vulnerable and high-risk groups,” https://www.who.int/westernpacific/emergencies/covid-19/information/high-risk-groups, Accessed September 22, 2021.
9) Almagro, M., Coven, J., Gupta, A., Orane-Hutchinson, A., "Racial Disparities in Frontline Workers and Housing Crowding during COVID-19: Evidence from Geolocation Data," Institute Working Paper 37, 2021.
10) Shamshiripour, A., Rahimi, e., Shabanpour, R., Mohammadian, A., “How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago,” Transportation Research Interdisciplinary Perspectives Volume 7, September 2020.