

Traffic and Vehicular Incident Comparisons before and during the Pandemic (2019 vs 2020) in Metro Manila

Jinky Leilanie Lu, MOH, PhD¹ and Sophia Francesca L. Chua, MOS, PhD²

¹Road Safety Program, and Injury Prevention and Control Study Group, National Institutes of Health, University of the Philippines Manila, Manila, Philippines

²National College of Public Administration and Governance, University of the Philippines Diliman, Quezon City, Philippines

ABSTRACT

Background. The COVID-19 pandemic has not only been a public health concern but has also altered the transportation sector of the Philippines. Road decongestion has been apparent and has altered trends in road safety.

Objective. This study aims to explore the effect of pandemic-induced lockdowns on the severity profile of recorded road crashes. Specifically, this study aims to compare risky road user behaviors, collision types, classification of crashes, road user fatalities and injuries, and vehicle involvement before and during the pandemic.

Methods. Data collected from the Metro Manila Development Authority's (MMDA) Metro Manila Accident Recording and Analysis System (MMARAS) in the years 2019 and 2020 were used. A total of 186,802 cases were analyzed. Cross-tabulations on risky road user behaviors, collision type, and classification of crashes were conducted to compare the proportions of crashes that occurred before and during the pandemic. Mann-Whitney U test was done to compare road user injury/death and vehicle involvement in 2019 vs 2020. Then, an indicator variable for 2020 was used as a lone independent variable in logistic regression models to estimate the association of pandemic-period lockdowns with road user injury/fatality.

Results. The proportion of road crashes due to human error is significantly greater during the pandemic era, as well as road crashes due to the road. There is also a greater proportion of collisions due to angle impact, head-on collision, hit-and-run, hit object, multiple, and self-accident, while there are fewer "hit pedestrian" crashes, rear-end collisions, and side-swipe collisions. Results also show that despite the evident reduction of traffic congestion during the pandemic, there is an increase in fatal and non-fatal crashes. There are also significantly more drivers killed and injured during the pandemic period, while fewer passengers and pedestrians were injured. Public utility vehicles such as jeepneys, taxi/FX, and buses, as well as private cars, are less likely to be involved in crashes during the pandemic, while there is a significant increase in crashes involving cycles/pedicabs, motorcycles, vans, and trucks.

Conclusion. The findings of this study revealed that the COVID-19 pandemic has indeed influenced the trends in road safety in Metro Manila. It was revealed that the reduced traffic congestion during the pandemic, while resulting in an overall decrease in crashes, has led to an increase in the severity and fatality of crashes. Hence, road safety remains an important public concern in the midst of the pandemic.

Keywords: COVID-19 pandemic, MMARAS, road crashes, road user behavior, traffic decongestion



eISSN 2094-9278 (Online)
Published: September 30, 2026
<https://doi.org/10.47895/amp.v60i18.8302>
Copyright: The Author(s) 2026

Corresponding author: Jinky Leilanie Lu, MOH, PhD
National Telehealth Center
National Institutes of Health
University of the Philippines Manila
623 Pedro Gil St., Ermita, Manila 1000, Philippines
Email: jdlu@up.edu.ph
ORCID: <https://orcid.org/0009-0007-5717-1563>

INTRODUCTION

Road traffic crashes (RTCs) significantly contribute to a large fraction of deaths globally, more so than human diseases.¹ Approximately 1.3 million people die yearly due to road traffic crashes, costing 3% of the gross domestic product of most countries.² Traffic accidents can be influenced by a lot of factors. Environmental factors such as weather and light conditions, human elements such as driver characteristics and behaviors, vehicle factors, road design, and congestion all account for the occurrence of road crashes.³ Understanding that the occurrence of RTCs is an interplay between different internal and external factors, a major shift in road composition can be a cause of pattern change in RTC cases.

The COVID-19 pandemic has not only been a public health concern but has also altered the transportation sector of the Philippines. In March 2020, strict lockdown measures were imposed in the country. Metro Manila and the majority of provinces experienced enhanced community quarantine (ECQ) and modified enhanced community quarantine (MECQ), in which residents are only allowed to leave their homes for food and other essential goods, and only essential workers are allowed to work onsite. Public transportation has been limited to reduce virus transmission. This resulted in a major shift in traffic flow, as roads became decongested of the usual city traffic.^{4,5} This context may have fundamentally altered the nature and severity, as well as road user and vehicle involvement in road crashes, necessitating an updated analysis of road crashes in Metro Manila. Hence, there is a need to investigate the influence of the COVID-19 pandemic on road safety trends.

In the Philippines, RTCs are monitored by the Metro Manila Development Authority's (MMDA) Metro Manila Accident Recording and Analysis System (MMARAS), a reporting system for Metro Manila maintained by the MMDA. This system can identify vehicle types, collision types, and risky driving behaviors involved in road crashes. Using MMARAS, the effect of the COVID-19 pandemic can be analyzed to extract valuable findings needed for future policy-making measures.

This study aims to explore the effect of pandemic-induced lockdowns on the severity profile of recorded road crashes. Specifically, this study aims to compare risky road user behaviors, collision types, classification of crashes, road user fatalities and injuries, and vehicle involvement before and during the pandemic.

METHODS

The COVID-19 pandemic has brought lockdowns across the country, which disrupted the normal life of Filipinos. Due to home quarantines and the abrupt shift to work-from-home setups, during the pandemic there were considerably fewer vehicles that roamed the streets. This analysis

aims to see whether this influences the severity of injuries due to road crashes.

Study Design

This study employed a retrospective secondary data analysis design using the Metro Manila Accident Recording and Analysis System (MMARAS) database, a road crash reporting system for Metro Manila maintained by the Metro Manila Development Authority (MMDA). It is created and operated by the Road Safety Unit (RSU) of the MMDA-Traffic Discipline Office-Traffic Engineering Center (MMDA-TDO-TEC), with the cooperation and assistance of the Traffic Enforcement Unit (TEU) of the Philippine National Police (PNP). The MMARAS records road crash incidents through two channels: (1) full field reports compiled by the MMDA Road Safety Unit researchers from Philippine National Police (PNP) blotter entries and Traffic Enforcement Unit (TEU) station reports, and (2) incidents logged remotely via calls or CCTV footage at the MMDA Metrobase.

Data Collection

MMARAS defines road users the following way: Driver is a person driving a mechanically propelled vehicle or a pedal cycle; Passenger is anyone carried in or on a mechanically propelled vehicle or pedal cycle; Pedestrian is anyone travelling on foot. MMARAS counts the number of Fatalities and injured persons for every road user for each road crash incident. Table 1 shows the number of road crash incidents for the years 2019 and 2020.

MMARAS also records vehicle types involved in road crash incidents. The vehicle types include: Cycle/Pedicab defined as a human-powered vehicle, Motorcycle defined as a two-wheeled mechanically propelled vehicle, Motor-Tricycle which is defined as a three-wheeled passenger carrying mechanically propelled vehicle, Car defined as a privately-owned mechanically propelled vehicle, including all forms of private-use small passenger-carrying vehicle, Jeepney/Taxi/FX/Bus which are defined as "public utility vehicles" which carries passengers for a payment of a fee, Van defined as a small vehicle for carrying goods, and Trucks which are defined as large vehicle for carrying goods.

MMARAS also records the collision type of road crash incidents. This includes Angle-Impact, Head-On Collision, Hit and Run, Hit Object, Hit Parked Vehicle, Hit Pedestrian, Multiple Collision, Rear-End Collision, Self-Accident, and Side Swipe. The Accident Causations or risky

Table 1. MMARAS Data Frequency per Year

Year	Frequency
2019	121,770
2020	65,032
Total	186,802

driving behaviors leading to road crashes were also noted. In MMARAS, they categorized accident causes as Human Error, Vehicle Defect, Others, and No Accident Factor.

Data Analysis

Three (3) statistical approaches were used to compare crash characteristics. First, chi-square tests with adjusted residual analysis were conducted for categorical variables including risky road user behavior, collision type, and classification of crash. Adjusted residuals were used to identify which specific categories contributed significantly to the overall chi-square statistic. An adjusted residual exceeding 1.96 in absolute value indicates that the observed frequency in that cell significantly deviates from what would be expected under the null hypothesis of no association, at a two-tailed significance level of $p < 0.05$. Positive values indicate higher-than-expected frequency and negative values indicate lower-than-expected frequency in that cell.

Second, Mann-Whitney U tests were conducted to compare road user fatality and injury counts, as well as vehicle involvement counts, between the two years. The Mann-Whitney U test was selected as the appropriate non-parametric alternative to the independent samples t-test, given that these variables are right-skewed count variables that do not satisfy the normality assumption required for parametric hypothesis testing. This test compares the mean ranks of the two groups, making it robust to the skewed distribution and zero-inflation characteristic of crash count data.

Third, logistic regression models were fitted for each dichotomized road user outcome (driver killed, driver injured, passenger killed, passenger injured, pedestrian killed, pedestrian injured) using a single dichotomous indicator variable coded 1 for 2020 and 0 for 2019 as the sole predictor. This approach was used to quantify the direction and magnitude of the association between pandemic year and each outcome, expressed as odds ratios (OR) with 95% confidence intervals (CI). These regression findings should be interpreted as unadjusted associations between pandemic year and road user outcomes, as the model does not account for potential confounding variables.

Ethical Considerations

In line with the Data Privacy Act, the study utilized de-identified administrative data in this study. Ethical approval was granted by the Department of Health Single Joint Research Ethics Board (DOH-SJREB). 186,802 cases were included in this analysis from 2019 to 2020. Cases logged in the database from January 1, 2005 to December 31, 2018 were excluded from the analysis.

RESULTS

For the chi-square analyses, adjusted residuals were used to identify which specific cells contributed significantly to the overall chi-square statistic. An adjusted residual

exceeding ± 1.96 in absolute value indicates that the observed frequency in that cell is significantly higher or lower than expected by chance alone, at a two-tailed significance level of $p < 0.05$. A positive adjusted residual indicates that a category was observed more frequently than expected in that year, while a negative adjusted residual indicates it was observed less frequently than expected. This approach allows for the identification of specific categories driving the overall association between crash characteristics and year, beyond what the chi-square statistic alone can reveal.

Results show that there is a significant relationship found between risky road user behaviors and the year. Analysis of adjusted residuals reveals that the proportion of road crashes due to human error is significantly greater during the pandemic era (adj resid = 44.955 > 1.96). The proportion of road crashes due to road defects was also significantly greater during the pandemic than before the pandemic era (adj resid = 4.067 > 1.96) (Table 2).

As discussed in the Methods, the MMARAS database collects crash data through two channels: full field reports compiled by RSU researchers from PNP blotter entries and TEU station reports, and remote logging via calls or CCTV footage at the MMDA Metrobase. Remotely logged crashes often have a huge proportion of missing fields in the MMARAS dataset, while full field reports are likely to be more comprehensive and complete, but are more likely to be generated for more severe crashes. With this in mind, this jump becomes possible, especially if there is a significant increase in severe crashes, which will most likely be investigated and reported thoroughly.

Results show that there is a significant relationship found between collision types and the year. Analysis of adjusted residuals reveals that the proportion of road crashes due to angle impact (adj resid = 10.35 > 1.96), head on collision (adj resid = 7.19 > 1.96), hit and run (adj resid = 4.40 > 1.96), hit object (adj resid = 20.35 > 1.96), multiple collision (adj resid = 3.13 > 1.96), and self-accident (adj resid = 12.20 > 1.96) are significantly greater during the pandemic era than the pre-pandemic year. The proportion of "hit pedestrian" crashes was significantly lower during the pandemic, along with rear-end collision and side-swipe collision (Table 3).

Chi-square Analysis of Classification of Crashes during Pre-pandemic and Pandemic-era

Results show that there is a significant relationship found between the classification of crashes and the year.

Analysis of adjusted residuals reveals that the proportion of fatal crashes is significantly greater during the pandemic year (adj resid = 7.12 > 1.96). The proportion of non-fatal crashes is also significantly greater during the pandemic year (adj resid = 28.7 > 1.96) (Table 4).

Mann-Whitney U test is the non-parametric counterpart of the T-test used to compare two groups. The number of road users killed and injured in road crashes does not follow a normal distribution since these variables are right-skewed.

Table 2. Chi-square Analysis of Risk Factors between 2019 and 2020

		Year		Total	Chi-square	p-value
		2019	2020			
Alcohol suspected	Count (Column %)	54 (0.04%)	31 (0.05%)	85	2045.968	<0.0001
	Adjusted Residual	-0.321	0.321			
Drug Suspected	Count (Column %)	0 (0.00%)	1 (0.00%)	1		
	Adjusted Residual	-1.368	1.368			
Human error	Count (Column %)	40 (0.03%)	1152 (1.77%)	1192		
	Adjusted Residual	-44.955	44.955			
Lost control	Count (Column %)	89 (0.07%)	50 (0.08%)	139		
	Adjusted Residual	-0.287	0.287			
No accident factor	Count (Column %)	121538 (99.81%)	63741 (97.86%)	185279		
	Adjusted Residual	41.091	-41.091			
Others	Count (Column %)	5 (0.00%)	5 (0.01%)	10		
	Adjusted Residual	-1.008	1.008			
Road defect	Count (Column %)	8 (0.01%)	20 (0.03%)	28		
	Adjusted Residual	-4.067	4.067			
Vehicle defect	Count (Column %)	36 (0.03%)	32 (0.05%)	68		
	Adjusted Residual	-2.120	2.120			
Total	Count (Column %)	121770 (100%)	65032 (100%)	186802		

Table 3. Chi-square Analysis of Collision Types during Pre-pandemic and Pandemic

		Year		Total	Chi-square	p-value
		2019	2020			
Angle impact	Count	7953 (6.53%)	5081 (7.81%)	13034	1140.326	<0.0001
	Adjusted Residual	-10.36	10.35			
Head-on	Count (Column %)	873 (0.72%)	672 (1.03%)	1545		
	Adjusted Residual	-7.19	7.19			
Hit and run	Count (Column %)	4530 (3.72%)	2687 (4.13%)	7217		
	Adjusted Residual	-4.40	4.40			
Hit object	Count (Column %)	2500 (2.05%)	2358 (3.62%)	4858		
	Adjusted Residual	-20.35	20.35			
Hit parked vehicle	Count (Column %)	2710 (2.23%)	1535 (2.36%)	4245		
	Adjusted Residual	-1.86	1.86			
Hit pedestrian	Count (Column %)	4605 (3.78%)	2128 (3.27%)	6733		
	Adjusted Residual	5.63	-5.63			
Multiple collision	Count (Column %)	3662 (3.01%)	2127 (3.27%)	5789		
	Adjusted Residual	-3.13	3.13			
No collision stated	Count (Column %)	25750 (21.15%)	14753 (22.69%)	40503		
	Adjusted Residual	-7.69	7.69			
Rear-end	Count (Column %)	27076 (22.24%)	12149 (18.68%)	39225		
	Adjusted Residual	17.96	-17.96			
Self-accident	Count (Column %)	2775 (2.28%)	2096 (3.22%)	4871		
	Adjusted Residual	-12.20	12.20			
Side swipe	Count (Column %)	39336 (32.30%)	19446 (29.90%)	58782		
	Adjusted Residual	10.65	-10.65			
Total	Count (Column %)	121770 (100%)	65032 (100%)	186802		

Results show that there are significant differences between drivers killed, drivers injured, passengers injured, and pedestrians injured.

Analysis of mean ranks shows that there are significantly more drivers killed in crashes during the pandemic period. There are also significantly more drivers injured during the pandemic. On the other hand, there are significantly fewer passengers and pedestrians injured during the pandemic period (Table 5).

Mann-Whitney U was also used in the analysis of Vehicle Type since this variable is also right-skewed. Results show that there are significant differences between the number of cycle/pedicabs, motorcycles, motor tricycles, cars, jeepneys, taxi/FX, buses, vans, and trucks involved in crashes before and during the pandemic.

Analysis of mean ranks shows that there are significantly more cycle/pedicabs, motorcycles, vans, and trucks involved in crashes during the pandemic than before the pandemic. On the other hand, there are significantly fewer motor tricycles, cars, jeepneys, taxi/FX, and buses involved in crashes during the pandemic (Table 6).

Regression Analysis with the Pandemic Year as the Lone Independent Variable

A logistic regression using a dummy variable that gives 1 if the year is 2020 and 0 if it's 2019 was done to see if

road user injury and fatality are positively or negatively influenced by the pandemic year.

Results show that the odds ratios of driver death, driver injury, passenger injury, and pedestrian injury are significantly associated with the pandemic year. In particular, the pandemic increased the odds of driver fatality and injury by 113.0% and 74.8%, respectively. Meanwhile, the pandemic decreased the odds ratio of passenger and pedestrian injury by a factor of 0.834 and 0.852, respectively (Table 7).

DISCUSSION

Coronavirus disease 2019 (COVID-19) is a highly transmissible viral infection caused by the SARS-CoV-2 virus that started an outbreak in Wuhan, China in 2019. It can be transmitted mostly through direct contact and by respiratory droplets from coughing and sneezing.⁵ Because of its high transmission, a global outbreak began in 2020, resulting in governments from different countries imposing stay-at-home orders for individuals to prevent virus transmission. This has caused a significant reduction in traffic congestion in most countries and lower economic activity, bringing substantial changes in road safety trends during the COVID-19 pandemic. Because of fewer vehicles on the road, it can be assumed that individuals had lower exposure to road-related accidents.⁶

Table 4. Chi-Square Analysis of Classification of Crashes during Pre-pandemic and Pandemic

		Year		Total	Chi-square	p-value
		2019	2020			
Fatal	Count	372	337	709	887.541	<0.0001
	Adjusted Residual	-7.12	7.12			
Non-fatal (Injurious)	Count	20466	14465	34931		
	Adjusted Residual	-28.70	28.70			
Damage to property	Count	100932	50230	151162		
	Adjusted Residual	29.60	-29.60			
Total	Count	121770	65032	186802		

Table 5. Mann-Whitney U Test for Comparison of Road User Fatality and Injury before and during Pandemic

Variables	Groups	N	Mean Rank	Mann-Whitney U	p-value
Drivers killed	Before 2020	121770	93337.144	3951636689	<0.0001
	During 2020	65032	93522.004		
Drivers injured	Before 2020	121770	91243.563	3696701272	<0.0001
	During 2020	65032	97442.158		
Passengers killed	Before 2020	121770	93402.119	3959397987	0.847
	During 2020	65032	93400.342		
Passengers injured	Before 2020	121770	93599.806	3935325582	<0.0001
	During 2020	65032	93030.179		
Pedestrians killed	Before 2020	121770	93396.242	3958833007	0.296
	During 2020	65032	93411.346		
Pedestrians injured	Before 2020	121770	93577.605	3938028977	<0.0001
	During 2020	65032	93071.749		

Table 6. Mann-Whitney U Test for Comparison of Vehicle Involvement before and during Pandemic

Variables	Groups	N	Mean Rank	Mann-Whitney U	p-value
<i>Cycle/Pedicab</i>	Before 2020	121770	92389.52	3836245067	<0.0001
	During 2020	65032	95296.39		
<i>Motorcycle</i>	Before 2020	121770	90654.77	3625004480	<0.0001
	During 2020	65032	98544.64		
<i>Motor Tricycle</i>	Before 2020	121770	93478.97	3950039643	0.004
	During 2020	65032	93256.44		
<i>Car</i>	Before 2020	121770	95058.10	3757748806	<0.0001
	During 2020	65032	90299.57		
<i>Jeepney</i>	Before 2020	121770	94836.31	3784756798	<0.0001
	During 2020	65032	90714.88		
<i>Taxi/FX</i>	Before 2020	121770	93562.09	3939918321	<0.0001
	During 2020	65032	93100.80		
<i>Bus</i>	Before 2020	121770	94472.45	3829063410	<0.0001
	During 2020	65032	91396.18		
<i>Van</i>	Before 2020	121770	93167.52	3930982176	<0.0001
	During 2020	65032	93839.61		
<i>Truck</i>	Before 2020	121770	93137.23	3927293415	<0.0001
	During 2020	65032	93896.33		
<i>Train</i>	Before 2020	121770	93399.54	3959234587	0.327
	During 2020	65032	93405.17		

Table 7. Regression Analysis on Road User Fatality during the Pandemic

Dependent Variables	Parameter Estimates	Standard Error	p-value	Odds Ratio	95% CI for OR	
					Lower	Upper
<i>A driver is killed</i>	0.756	0.094	<0.0001	2.130	1.772	2.561
<i>A driver is injured</i>	0.558	0.014	<0.0001	1.748	1.701	1.796
<i>A passenger is killed</i>	-0.046	0.241	0.847	0.955	0.595	1.531
<i>A passenger is injured</i>	-0.182	0.027	<0.0001	0.834	0.791	0.879
<i>A pedestrian is killed</i>	0.156	0.149	0.297	1.168	0.872	1.565
<i>A pedestrian is injured</i>	-0.160	0.027	<0.0001	0.852	0.809	0.898

Road traffic crashes (RTCs) significantly contribute to a large fraction of deaths and are responsible for more years of life lost than most human diseases.¹ Road traffic injuries (RTIs) are one of the most persistent public health challenges globally and are the eighth leading cause of death worldwide.⁷ The majority of these deaths occur in undeveloped countries and developing countries, suggesting that it is not only a public health challenge, but also a socio-economic development issue.⁸

Road traffic injuries can be influenced by human factors, road environments, and vehicle conditions. Human factors, or human errors, specifically contribute predominantly to traffic-related injuries.⁷ In Metro Manila, the most commonly reported human errors from 2005 to 2010 were speeding, inattentive driving, and bad turning. Fatigue, traffic violations, and suspected alcohol use were also reported.⁹ Petridou & Moustaki previously classified alcohol consumption, use of psychotropic drugs, motor vehicle crime, suicidal behavior,

and other compulsive acts as risk-taking behaviors associated with short-term impact.¹ Aside from this, risky driving behaviors also include speeding, following closely, and unbelted seating.¹⁰ Risky driving behaviors have been linked to many factors such as age, gender, socioeconomic status, personality, type of vehicle being driven, as well as regional culture and systems.¹¹

In this study, such risky user behaviors were taken into consideration, comparing the recorded road crashes between the pre-COVID-19 pandemic (2019) and during the COVID-19 pandemic (2020). To control the spread of the COVID-19 disease, reduced social interactions along with travel restrictions were implemented. Within this period, road traffic congestion reduced immensely.¹² It reduced the overall absolute numbers of RTCs and related deaths and injuries.¹³ A previous study by Lu et al. also associated a direct correlation between traffic congestion and risk for road-related accidents.¹⁴

Despite the reduction of RTCs during the pandemic, analysis of adjusted residuals ($\text{adj resid} = 44.955 > 1.96$) revealed that road accidents involving human errors are significantly greater in this period compared to the pre-pandemic. This agrees with a study in which they found that risky driving behaviors such as speeding and failing to signal are more frequent during the COVID-19 pandemic.¹⁰ Exceeding speed limits were also observed to a greater extent in several countries during the pandemic.¹² In their study, it was revealed that at the peak of COVID-19 in Greece and the Kingdom of Saudi Arabia, reduced traffic volumes brought about by lockdowns resulted in an increase in speeds by 6-11% and harsh acceleration and braking events by 12%. The researchers also noted a 42% increase in mobile phone use. Aggressive driving, which is associated with speeding, harsh acceleration and deceleration, close distance to other vehicles, and sharp steering, also increased during the lockdown period in Malaysia, in comparison to before and after the lockdown period.¹⁵

Restrictions on mobility were found to affect driving behaviors, altering driving indicators like average speed, the exceedance of speed limits, and harsh acceleration or braking per distance.¹² This can be due to the lower traffic volume on the streets as an opportunity for drivers for speed driving.^{16,17} There are also accounts of an increase in alcohol consumption in response to travel and social restrictions, psychological stress, anxiety, and fear of exposure to the virus.¹³

In addition to increased human errors in the pandemic era contributing to road crashes, our study also found that the proportion of road crashes due to road defects was significantly greater during the pandemic than before the pandemic era ($\text{adj resid} = 4.067 > 1.96$). According to Zainuddin et al., poor road structures and environmental factors can all contribute to crashes.¹⁸ This includes detours, steep grades, non-signalized intersections, insufficient road signs, deteriorating road conditions, insufficient night lights, wet roads, and weather conditions. In the context of the COVID-19 pandemic, however, there are limited studies regarding road crashes relating to road defects. The increase in road crashes due to road defects during the pandemic era can be attributed to the lack of road regulations brought about by strict restrictions on mobility.

The risky behaviors of drivers, as well as the increased traffic flow during the pandemic, both play roles in why, despite the reduced traffic congestion, there is an increase in the severity of road crashes during the pandemic.^{13,19} As congestion also plays a vital role in traffic accidents, traffic accidents are found to be inversely correlated with the number of vehicles on the road, especially when fatal accidents are considered. Lower levels of congestion denote an increase in fatal accidents.³ This agrees with our result, showing that the proportion of fatal crashes ($\text{adj resid} = 7.12 > 1.96$) and non-fatal crashes ($\text{adj resid} = 7.12 > 1.96$) are significantly greater during the pandemic era compared to before the pandemic. In the study by Shaik & Ahmed, fatal accidents

also increased during the pandemic, despite the drop in total accidents.²⁰ Similarly, in the study by Alhajyaseen et al., road crashes in Qatar significantly reduced during the pandemic, in comparison to the past 5 years, but serious and fatal injuries have increased.²¹ However, trends may vary per country. Wegman & Katrakazas reported a general reduction of 17.3% in the number of fatalities in road-related crashes among 24 IRTAD member countries (Argentina, Australia, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Iceland, Israel, Italy, Japan, Luxembourg, Mexico, The Netherlands, New Zealand, Poland, Slovenia, Sweden and Switzerland) during the pandemic period compared with the baseline period from 2017 to 2019.²²

For collision types involved in road crashes, analysis of adjusted residuals reveals that the proportion of road crashes due to angle impact ($\text{adj resid} = 10.35 > 1.96$), head on collision ($\text{adj resid} = 7.19 > 1.96$), hit and run ($\text{adj resid} = 4.40 > 1.96$), hit object ($\text{adj resid} = 20.35 > 1.96$), multiple collision ($\text{adj resid} = 3.13 > 1.96$), and self-accident ($\text{adj resid} = 12.20 > 1.96$) are significantly greater during the pandemic era compared to the pre-pandemic year, and less proportion of "hit pedestrian" crashes, along with rear-end collision and side-swept collision. This agrees with the results of Liao & Lowry, in which they also compared road crashes in 2019 and 2020, revealing that angle and head-on collisions both significantly increased during the pandemic, as these collision types are more correlated with severe impact and fatalities.¹⁹ The authors also concluded fewer pedestrian and bicycle-related collisions during the pandemic, as well as rear-end and side-swept collisions. This supports the previous observation that the pandemic has increased the likelihood of fatal crashes.

For road user fatality and injury, a Mann-Whitney U test was conducted. Results show that there is a significant difference between road user fatality and injury, specifically among drivers killed, drivers injured, passengers injured, and pedestrians injured. This agrees with the regression analysis done with the pandemic year as the lone independent factor, revealing that the pandemic year increased the odds ratio of driver fatality and driver injury by 113% and 74.8%, respectively. Similarly, it also reflects the decreased odds ratio of passenger and pedestrian injury by factors of 0.834 and 0.852, respectively. Driver injury and fatality due to road crashes during the pandemic are significantly greater, while there are significantly fewer injuries among passengers and pedestrians during this period. This can be attributed to the abrupt decrease in pedestrian activity during the pandemic. The decrease in pedestrian-related injuries can be explained by the decreased population movement due to strict stay-at-home orders and the emergence of both remote work and learning.²³ This also agrees with the study by Redelmeier & Zipursky: the 50-60% decline in pedestrian activity during the initial COVID lockdown in New York City was associated with the 84% relative reduction in total pedestrian

deaths.²⁴ Similarly, the decrease in passenger injuries can be associated with the reduction of public transportation.

The reduction of public transportation during the pandemic can also be accounted for by the type of vehicle involved in road crashes. Results show that vehicular crashes involving cycles/*pedicabs*, motorcycles, vans, and trucks were significantly greater during the pandemic, and fewer crashes involved tricycles, cars, jeepneys, taxi/FX, and buses. This is validated by previous data on road crashes in Metro Manila, revealing that the most common vehicles involved in road crashes were cars before the pandemic (2005 to 2015).⁹ The reduction in cars involved in crashes during the pandemic can be attributed to the increase in remote work and remote learning adjustments for car owners. Moreover, since there is restriction in mass transportation during the pandemic, public utility vehicles (tricycles, jeepneys, taxi/FX, and buses) were also less susceptible to crashes. In addition to the imposed restrictions, people are also inclined to voluntarily avoid using public transportation, as social interaction and close distance with other people can promote virus transmission. In the study by Garcia et al., 65% of their respondents were concerned about possible COVID-19 infection when using public transportation in the Philippines.⁴ This caused people to resort to alternative and cheaper modes of transportation such as using bicycles.²⁰ As total travel and the majority of transportation diminished during the pandemic, cycling increased significantly in most cities of Europe, North America, and Australia.²⁵ In the Philippines, cycling also gained recognition as a primary mode of transportation during the pandemic, as commuters sought a safer option to travel, and most Filipino workers do not have access to private vehicles.⁴ The popularity of such alternative transportation during the pandemic can explain the increase in crashes involving such vehicles. In addition to alternative transportation (cycling and *pedicabs*), as mentioned, there is also an increase in crashes among motorized vehicles like motorcycles, vans, and trucks during the pandemic. This can be associated with the increased demand in the delivery sector due to the rapid growth of e-commerce during the pandemic. Many riders and drivers worked longer hours during the pandemic.²⁶ In the study by Crizzle et al., the pandemic has brought an increase in demand for truck drivers since long-haul trucks are the main transportation for essential goods as well as vaccine materials.²⁷ Similarly, it also brought high demand for two-wheeled delivery vehicles, specifically due to the rise of app-based food delivery ordering systems.²⁸

The variations in the pre- and post-pandemic years can also offer other possible explanations. This presents as a limitation and may warrant further investigation, such as, but not limited to, changes in police reporting, differential reporting of minor crashes during lockdown, changes in enforcement priorities, fewer minor property-damage reports, seasonality, changes in work and delivery patterns, altered pedestrian exposure, and differences between early 2020 and the strict lockdown period.

CONCLUSION

The COVID-19 pandemic has undoubtedly changed the landscape of road traffic, brought about by stringent travel restrictions in its earlier phase in 2020. With the changes in road safety trends, road traffic crashes are also affected. In this study, the severity of injuries from road traffic crashes was analyzed in the context of the pandemic-induced lockdowns.

The main findings of this study revealed that despite the evident reduction of traffic congestion during the pandemic due to travel restrictions and limitations on public transportation, there is an increase in the severity and fatality of crashes. This is also supported by the increased angle impact and head-on collisions reported, which are associated with more fatal crashes. Increased hit-and-run, hit-object, multiple-collision, and self-accident were also reported during the pandemic, while rear-end, side-swiped, and hit-pedestrian collisions were reported less. Moreover, due to the decrease in vehicles on the road, human errors due to risky driving behaviors also escalated since a wider road is an opportunity for speeding and sharp steering. Increased crashes due to road defects have also increased during the pandemic.

The COVID-19 pandemic also highlighted the changes in vehicle types often involved in crashes. As public transportation became limited, public utility vehicles (jeepneys, taxi/FX, buses) were less likely to be involved in crashes during the pandemic. Crashes involving private cars were also reported to decline during the pandemic, which can be attributed to the abrupt shift to remote work and remote learning. A greater proportion of crashes were recorded for alternative modes of transportation such as cycling and *pedicabs*, as well as vehicles often used for delivery such as motorcycles, vans, and trucks, which can be associated with the increased use of e-commerce platforms during the pandemic. This finding was further validated by the findings on road user injuries and fatalities during the pandemic. As there were fewer passengers and pedestrians on the road, injuries recorded for such a population were reduced. Drivers injured and killed, on the other hand, significantly increased during the pandemic.

MMARAS-recorded crashes decreased in 2020, while the severity profile among recorded crashes shifted toward a higher proportion of fatal and injurious outcomes and different vehicle/collision patterns. Road safety is an important public concern, before and even in the midst of a global pandemic. Improvements in road regulations, road infrastructure, and public transportation must be considered for future policymaking; hence, further research is recommended.

Statement of Authorship

Both authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

Both authors declared no conflicts of interest.

Funding Source

This study was funded by the AHEAD-HPSR of the Department of Health.

REFERENCES

1. Petridou E, Moustaki M. Human factors in the causation of road traffic crashes. *Eur J Epidemiol*. 2000;16:819–26. doi: 10.1023/A:1007649804201. PMID: 11297224.
2. World Health Organization. Road traffic injuries [Internet]. Geneva: WHO; 2023 [updated 2022 Jun 20; cited 2022 Dec 29]. Available from: <https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries>.
3. Retallack AE, Ostendorf B. Current understanding of the effects of congestion on traffic accidents. *Int J Environ Res Public Health*. 2019;16(18):3400. PMID: 31540246; PMCID: PMC6766193.
4. Garcia M, Nakamura F, Tanaka S, Matsuyuki M, Ariyoshi R. Public transport trends and environmentally sustainable transport acceptance during the COVID-19 pandemic in the Philippines. *J East Asia Doc Transp Studies*. 2022;14:90–107. doi: 10.11175/easts.14.90.
5. Rauf A, Abu-Izneid T, Olatunde A, Ahmed Khalil A, Alhumaydhi FA, Tufail T, et al. COVID-19 Pandemic: Epidemiology, etiology, conventional and non-conventional therapies. *Int J Environ Res Public Health*. 2020;17(21):8155. doi: 10.3390/ijerph17218155. PMID: 33158234; PMCID: PMC7662254.
6. Miyar JRBdl, Hoehn-Velasco L, Silverio-Murillo A, Tennyson SL. No Traffic Expected: The Impact of the COVID-19 Pandemic on Road Safety in Mexico [Internet]. 2022 Jul [cited 2022 Dec]. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4168530.
7. Mekonnen TH, Tesfaye YA, Moges HG, Gebremedin RB. Factors associated with risky driving behaviors for road traffic crashes among professional car drivers in Bahirdar City, Northwest Ethiopia, 2016: a cross-sectional study. *Environ Health Prev Med*. 2019;24(1):17. doi: 10.1186/s12199-019-0772-1. PMID: 30851730; PMCID: PMC6408773.
8. Gutierrez-Osorio C, Pedraza C. Modern data sources and techniques for analysis and forecast of road accidents: A review. *J Traffic Transp Eng*. 2020;7(4):432–46. doi.org/10.1016/j.jtte.2020.05.002.
9. Lu SF, Lu JL. Analysis of human error as a factor in road crash in Metro Manila (2005–2015). *Acta Med Philipp*. 2021;55(6):666–74. doi: 10.47895/amp.v55i6.3325.
10. Dong X, Xie K, Yang H. How did COVID-19 impact driving behaviors and crash severity? A multigroup structural equation modeling. *Accid Anal Prev*. 2022;172:106687. PMID: 35500416.
11. Adanu EK, Brown D, Jones S, Parrish A. How did the COVID-19 pandemic affect road crashes and crash outcomes in Alabama? *Accid Anal Prev*. 2021;163:106428. doi: 10.1016/j.aap.2021.106428. PMID: 34649013; PMCID: PMC8504103.
12. Sekadakis M, Katrakazas C, Michelaraki E, Kehagia F, Yannis G. Analysis of the impact of COVID-19 on collisions, fatalities and injuries using time series forecasting: The case of Greece. *Accid Anal Prev*. 2021;162:106391. doi: 10.1016/j.aap.2021.106391. PMID: 34525414; PMCID: PMC8426576.
13. Yasin YJ, Grivna M, Abu-Zidan FM. Global impact of COVID-19 pandemic on road traffic collisions. *World J Emerg Surg*. 2021;16(1):51. doi: 10.1186/s13017-021-00395-8. PMID: 34583713; PMCID: PMC8478263.
14. Lu JL, Herbosa TJ, Lu SF. Analysis of transport and vehicular crash cases using the Online National Electronic Injury Surveillance System (ONEISS) from 2010 to 2019. *Acta Med Philipp*. 2022;56(1):118–31. doi: 10.47895/amp.v56i1.3874.
15. Al-Hussein WA, Li W, Por LY, Ku CS, Alredany WHD, Leesri T, et al. Investigating the effect of COVID-19 on driver behavior and road safety: a naturalistic driving study in Malaysia. *Int J Environ Res Public Health*. 2022;19(18):11224. doi: 10.3390/ijerph191811224. PMID: 36141497; PMCID: PMC9517654.
16. Vadoros S. COVID-19, lockdowns and motor vehicle collisions: empirical evidence from Greece. *Inj Prev*. 2022;28(1):81–5.
17. Li G, Lai W, Sui X, Li X, Qu X, Zhang T, et al. Influence of traffic congestion on driver behavior in post-congestion driving. *Accid Anal Prev*. 2020;141:105508. doi: 10.1016/j.aap.2020.105508. PMID: 32334153.
18. Zainuddin NI, Arshad AK, Hamidun R, Haron S, Hashim W. Influence of road and environmental factors towards heavy-goods vehicle fatal crashes. *Phys Chem Earth, Parts A/B/C*. 2022;129:103342. doi: 10.1016/j.pce.2022.103342.
19. Liao HF, Lowry M. Urban Road Safety and Crash Severity during the 2020 COVID-19 Pandemic: The Case of Seattle [Internet]. 2021 Dec 10 [cited 2022 Dec]. Available from: <https://rosap.ntl.bts.gov/view/dot/67368>.
20. Ebrahim Shaik M, Ahmed S. An overview of the impact of COVID-19 on road traffic safety and travel behavior. *Transportation Engineering*. 2022;9:100119. doi: 10.1016/j.treng.2022.100119.
21. Alhajyaseen WK, Almukdad A, Hussain Q, Almallah M, Al Malki MA, Singaravelu J, et al. Road safety status during COVID-19 pandemic: exploring public and road safety expert's opinions. *Int J Inj Contr Saf Promot*. 2022;29(2):135–51. doi: 10.1080/17457300.2021.1962915. PMID: 34392810.
22. Wegman F, Katrakazas C. Did the COVID-19 pandemic influence traffic fatalities in 2020? A presentation of first findings. *IATSS Res*. 2021;45(4):469–84. doi.org/10.1016/j.iatssr.2021.11.005.
23. Yeates EO, Grigorian A, Barrios C, Schellenberg M, Owattanapanich N, Barmparas G, et al. Changes in traumatic mechanisms of injury in Southern California related to COVID-19: Penetrating trauma as a second pandemic. *J Trauma Acute Care Surg*. 2021;90(4):714–21. doi: 10.1097/TA.0000000000003068.
24. Redelmeier DA, Zipursky JS. Pedestrian deaths during the COVID-19 Pandemic. *Am J Lifestyle Med*. 2021;17(2):276–9. doi: 10.1177/15598276211058378. PMID: 36896038; PMCID: PMC9988591.
25. Buehler R, Pucher J. COVID-19 impacts on cycling, 2019–2020. *Transp Rev*. 2021; 41(4):393–400. doi: 10.1080/01441647.2021.1914900.
26. Tran NAT, Nguyen HLA, Nguyen TBH, Nguyen QH, Huynh TNL, Pojani D, et al. Health and safety risks faced by delivery riders during the COVID-19 pandemic. *J Transp Health*. 2022;25:101343. PMID: 35194551; PMCID: PMC8853807.
27. Crizzle AM, Malik SS, Toxopeus R. The impact of COVID-19 on the work environment in long-haul truck drivers. *J Occup Environ Med*. 2021;63(12):1073–7. PMID: 34860203; PMCID: PMC8630933.
28. McKinlay A, Mitchell G, Bertenshaw C. DINED (Delivery-related Injuries in the Emergency Department) part 1: A scoping review of risk factors and injuries affecting food delivery riders. *Emerg Med Australas*. 2022;34(2):150–6. doi: 10.1111/1742-6723.13927. PMID: 35037394.