Exploring Road Safety Dynamics in the Metropolitan Manila

Hannah Marielle L. Anonuevo

iACADEMY

Advanced Big Data Analytics

Jay R. San Pedro

August 15, 2024

Abstract

Road traffic crashes have become an integral challenge that Filipino commuters face daily. This study examined the trends and factors influencing the number of road crashes in Metro Manila by utilizing statistical analysis and time series modeling. Analysis of the trends revealed the dynamics of traffic cases and their implications for road safety management in Metro Manila. Road traffic crash cases showed a consistent upward trend before 2020 which had a notable decline due to the worldwide pandemic. Partial recovery is observable in 2022 experiencing a slight increase as compared to the prior 2 years, however, the number of cases remained below pre-pandemic levels. The forecasted trends also predicted a gradual increase in cases, throughout the next 10 years. The distribution of cases per month also revealed that the latter months of the year, October to December, have a higher number of cases attributed to seasonal events and weather conditions. This paper serves as a step to highlighting the importance of monitoring and understanding road traffic dynamics in the roads of Metro Manila and improving the current road safety regulations.

Introduction

Every day, billions of people rely on various methods of transportation to get to their daily duties. The reliance on private vehicles in navigating daily transit has become a global phenomenon leading to a need for highways and roads to support the large number of commuters daily. However, with the increase in vehicle ownership and urbanization, road accidents have become an integral challenge that commuters face. It is estimated that more than 1.3 million people's deaths globally are from road traffic crashes. Road traffic crashes are the 8th leading cause of death worldwide with road traffic injuries being the leading cause of death among people aged 5 - 29 years old. 54% of the global deaths caused by road crashes are from vulnerable groups consisting of pedestrians, cyclists, and motorcyclists. 93% of fatalities occur in low to middle-income countries, a stark contrast to the percentage of global vehicle ownership as only 60% of vehicles are in low to middle-income countries.

In the Philippines, road traffic crash fatalities have become more prevalent throughout the years, seeing a 39% increase from 2011 to 2021. Road traffic injuries are also the leading cause of death among young Filipinos aged 15-29 years old. Factors contributing to the rise include high population density, inadequate road infrastructure, poor implementation of law enforcement, and human errors such as speeding and driving under the influence.

Metro Manila is notorious for its high incidence of road traffic crashes. Manila was built

following an automobile-dependent lifestyle that assumes that many of its citizens use cars and other automobiles to travel. However, it is still unable to support the sheer volume of commuters, leading to heavy traffic that further increases the likelihood of road collisions. The current road infrastructure also contributes to the number of crashes due to poorly designed intersections and road quality. It is also common for areas to lack proper walkways and biking lanes, posing a major safety risk for pedestrians and cyclists.

This research aims to explore the factors and patterns affecting the number of road traffic crashes occurring in the cities of Metro Manila based on the MMARAS Annual Report provided publicly by the Metropolitan Manila Development Authority (MMDA) for the year 2012 - 2022.

Research Objectives

The objective of the study is to unveil the patterns in road accidents in Metro Manila by evaluating the efficiency of existing road safety management regulations in Metro Manila. Utilizing time series, regression analysis, and heatmap visualization, the study aims to forecast future trends in road crashes based on historical data from the Metropolitan Manila Development Authority (MMDA).

Methods and Design

Data Preparation and Tools:

The data utilized in this study is sourced from the Metro Manila Accident Reporting and Analysis System (MMARAS) conducted by the Metropolitan Manila Development Authority (MMDA). This dataset contains relevant information on recorded accidents in Metro Manila, including details such as location, collision type, date, and time of occurrence. Specifically, data on road traffic crashes occurring in Metro Manila between the years 2016 - 2022 has been extracted. Before analysis, the dataset underwent preprocessing to ensure data quality and reliability through Google Sheets, a popular spreadsheet software that is efficient at data manipulation and handling of large datasets. The data was cleansed by identifying and removing any missing or outlying entries. Irrelevant data was removed to streamline the analysis and prioritize the examination of the chosen key factors known to significantly impact road traffic crashes in Metro Manila. Following data cleansing, analysis of the dataset was conducted through Google Colab, an online platform for data analysis that uses a Python programming environment with built-in support for popular data analysis libraries such as Pandas, NumPy, and Matplotlib that were used to facilitate the implementation of the data analysis techniques in the study.

Research Approach:

This research followed a quantitative approach to explore the patterns and factors influencing the occurrence of road crashes in Metro Manila. The quantitative research

method provided a rigorous approach to the exploration and numerical analysis of the data and provided valuable tools for understanding and addressing road traffic safety issues in Metro Manila.

Line Chart Visualization:

A trend line chart was constructed to visually illustrate the pattern of road traffic crashes in Metro Manila. This chart displays the total number of crashes recorded for each year depicting the trend in road traffic crash occurrences over time and providing insights into any significant changes or fluctuations in the data.

Time Series Analysis:

The Autoregressive Integrated Moving Average (ARIMA) model is used to make predictions on future traffic crashes based on the dataset. Augmented Dickey-Fuller test and Autocorrelation function are used to determine the values of the Differencing parameter (d), Moving Average parameter (q), and Autoregressive parameter (p) in the created Arima model.

Heatmap Visualization:

Heatmap analysis was conducted to visualize the distribution of road traffic crashes over time in Commonwealth, Quezon Avenue, and the Metro Manila main roads. The resulting dataset was formatted with months represented as the index, years as

columns, and the number of crashes as values.

Results and Discussion

This section presents the findings of the analysis conducted to explore the patterns and factors influencing road traffic crashes in Metro Manila. The results are presented together with a discussion of their significance and role in road safety management in the region.

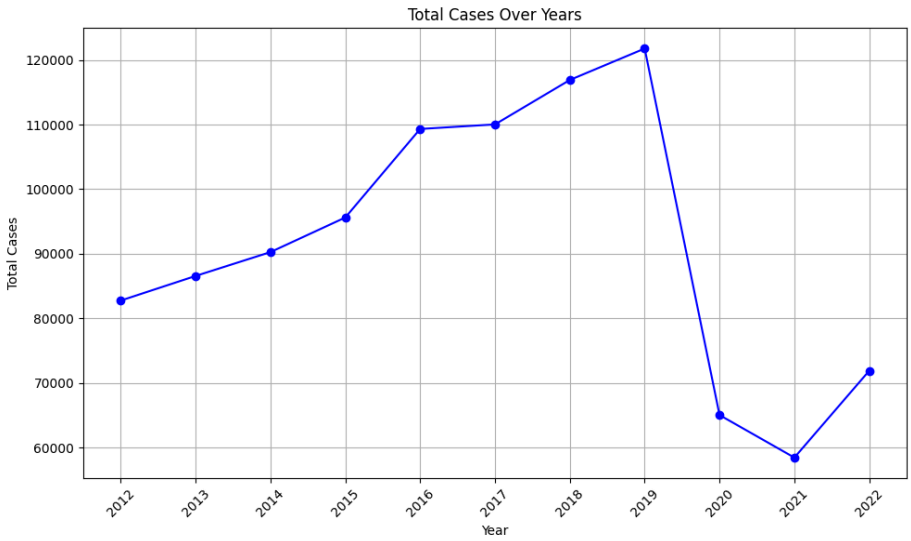

Figure 1. Statistical Trend of the Total Recorded Traffic Cases among the main roads in Metro Manila from 2012 - 2022

The figure above shows the statistical trend of recorded traffic cases in Metro Manila from the years 2012 - 2022. From 2012 to 2019, there was a consistent upward

trend in road traffic crashes. The number of reported incidents increased steadily over the years, indicating an overall rise in road accidents particularly in the year 2016 which had a growth rate of 14.34% compared to the prior year. There is a significant drop in cases in the year 2020 likely due to the effect of the worldwide pandemic which led to widespread lockdowns, travel restrictions, and reduced mobility across Metro Manila. In 2021, road traffic crashes continued to drop lower than pre-pandemic levels, indicating the lingering impact of COVID-19 on traffic patterns and road safety. There is a slight increase in cases in 2022, indicating a partial recovery from the impact of the pandemic. The observed trend highlights the importance of monitoring road traffic patterns and adapting road safety measures in response to external factors such as the worldwide pandemic. Continued surveillance and proactive interventions are essential for ensuring the safety of commuters on Metro Manila's roads as the number of cases is expected to rise as recovery from the pandemic continues.

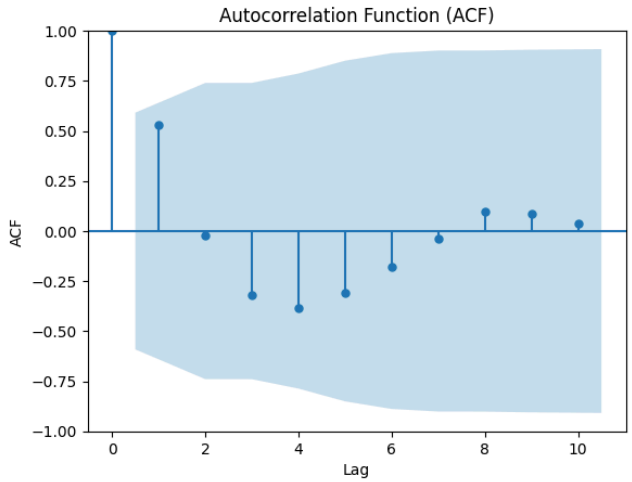

Figure 2. Autocorrelation Function Plot

The figure above displays the Autocorrelation Function Plot used to determine the order of the Autoregressive component (p) and Moving Average component (q) in the ARIMA model. Based on the output plot, there is a significant autocorrelation at lag 1 that suggests an autoregressive component, influencing the selection of p. Although there is a significant negative spike at lag 4, the chosen q value for the created Arima model is 0 due to the size of the dataset and tested model performance.

ADF Statistic	-5.03043620702068
p-value:	1.9312311658470818e-05
1%:	-4.9386902332361515
5%:	-3.477582857142857
10%:	-2.8438679591836733

Table 2. Augmented Dickey-Fuller (ADF) Test

The table above shows the results of the ADF Test. The ADF statistic is more negative than the critical values at the 1%, 5%, and 10% significance levels signifying that the null hypothesis is likely to be rejected. The resulting p-value is small which further indicates strong evidence against the null hypothesis. This indicates that the time series is stationary without the presence of a unit root, and no differencing is required influencing the value of d as 0.

Year	Predicted Cases	
2023	81055	12.73%
2024	85978	6.08%
2025	88622	3.07%
2026	90042	1.61%
2027	90805	0.90%
2028	91214	0.47%
2029	91435	0.24%
2030	91553	0.09%
2031	91616	0.07%
2032	91650	0.02%
2033	91669	0.01%

Table 1. Predicted Number of Total Cases

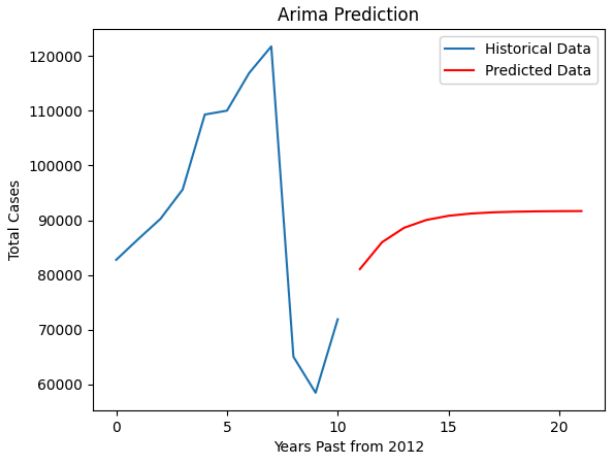

Figure 3. Forecasted Number of Cases Trend for 2023 - 2033

The table and figure above show the output of the Arima model based on the historical number of total crash cases recorded from 2012 - 2022. The ARIMA model is specified as ARIMA(1, 0, 0), indicating one autoregressive (AR) term and no moving average (MA) terms. 11 observations were used as the historical data of the model covering the years 2012 - 2022. The model predicts that there will be a significant increase in 2023 at a 12.73% growth rate then gradually declining for the following years with the increase in cases reducing over time. The year 2032 shows the smallest increase in growth rate at 0.02%. The average growth rate for the predicted number of cases for the next 11 years was calculated to be approximately 2.92%, which suggests a relatively stable trend in the predicted number of total cases over time.

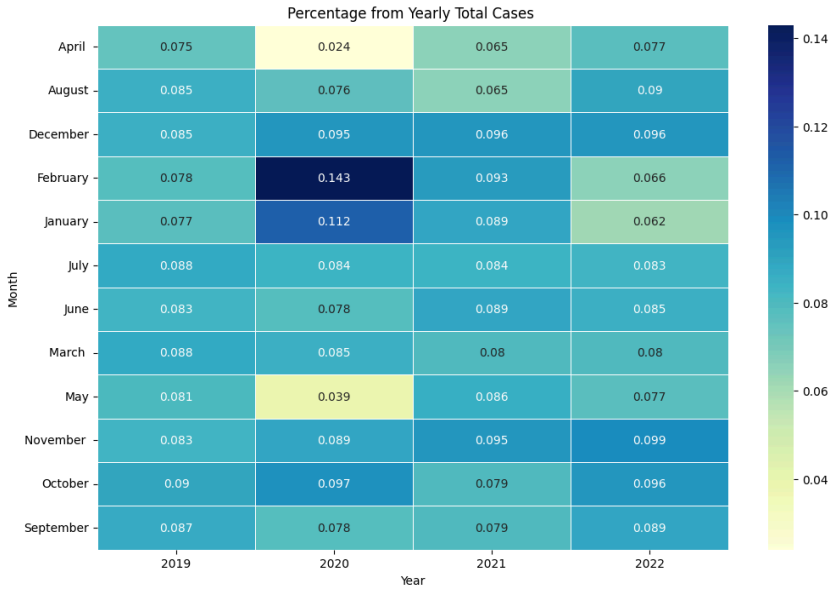

Figure 4.1 Time Series Heatmap of the 7 Main Roads for 2019 - 2022

The figure above displays the distribution of cases in the 7 main roads of metro Manila for the years 2019 to 2022. There is an observable trend in the distribution of cases where the latter months of the year, September - December have a higher ratio of cases likely due to seasonal events or holidays where it is common to travel to meet with family and friends. The early to middle months of the year have distributions that are similar to each other, however, April is observed to have the smallest distribution among all of the months with it experiencing an extreme drop to 2.4% in 2020.

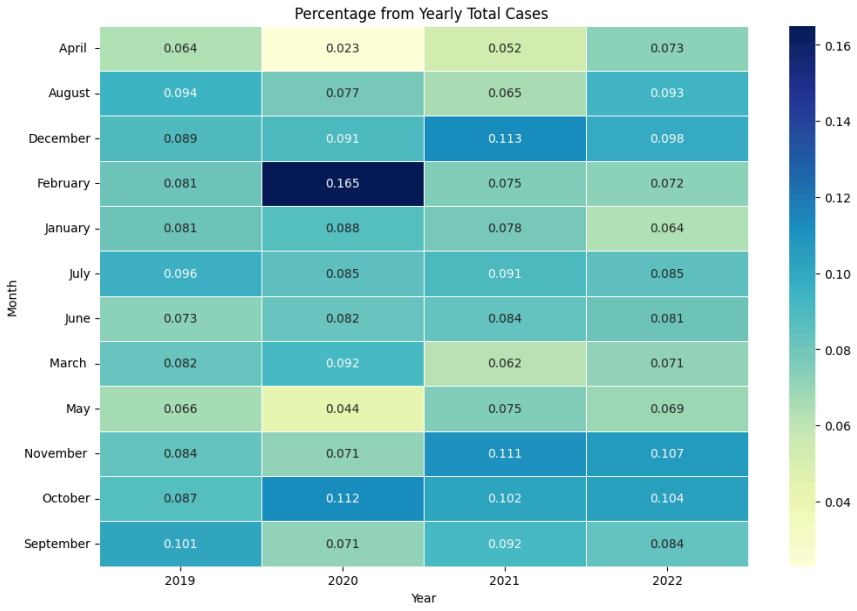

Figure 4.2 Commonwealth Time Series Heatmap for 2019 - 2022

The figure above shows the distribution of traffic cases in Commonwealth for each month of the years 2019 - 2022. It is observable that the earlier months of the year experience relatively fewer cases from January to May. The heatmap revealed a consistent trend in the number of cases in the earlier months of the year. The months of January to May had relatively fewer cases. However, there was a fluctuation in cases in February 2020, with cases rising unexpectedly high. This may be due to external factors that occurred in this period, such as the worldwide pandemic that had citizens on lockdown and restricted traveling for the months following it. The months of June to September showed similar results with cases ranging from both the higher and lower ratios depending on the year. This variability could have been influenced by external factors such as weather conditions and events or holidays. The latter months of the year

October - December overall had higher ratios from the past months with October being identified as displaying the highest distribution of cases among all months.

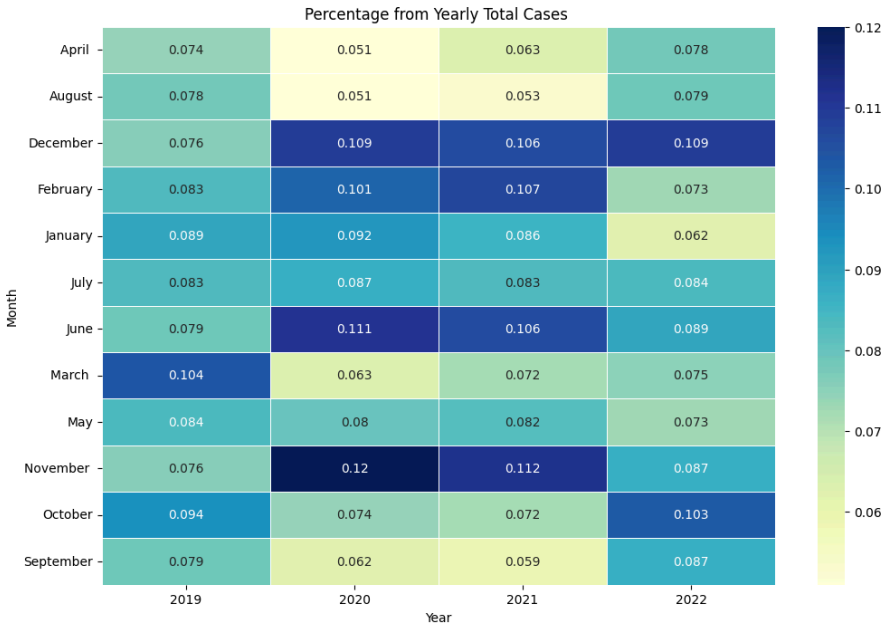

Figure 4.3 Quezon Avenue Time Series Heatmap for 2019 - 2022

The figure above depicts the distribution of traffic crash cases for the months of 2019 - 2022 in Quezon Avenue. There is an observable trend for the months of April, August, May, September, and March having a lower distribution of total cases for the 4 years with an exemption of March 2019 experiencing a large fluctuation at almost twice the percentage of cases that occurred in 2020 in the same month and September that had a sudden fluctuation in 2021 to 2022. The months of January, July, and May followed a consistent trend in cases. December is observed to have the highest overall distribution of cases followed by November, June, and February.

Conclusion

Analysis of the MMARAS dataset revealed several significant trends and factors influencing road safety in Metro Manila. The results show that there was a consistent increase in traffic cases over the years, but experienced a significant drop in cases in 2020 due to the worldwide pandemic. However, the number of cases is predicted to rise significantly in 2023 followed by a steady decline in its growth rate in the following years. The average growth rate for the predicted number of cases for the next 11 years is 2.92%, which suggests a stable trend. Further analysis focused on the distribution of traffic cases in the 7 main roads of Metro Manila and specific roads such as Commonwealth and Quezon Avenue. The heatmaps revealed distinct trends in the distribution of cases across different months, with higher ratios observed during the latter months of the year, particularly from October to December. There were also observable fluctuations in certain months likely due to external factors such as the weather, holidays, or events. These findings highlight the importance of monitoring the incidents in the area. By understanding the trends and factors influencing the number of traffic cases, the development of road safety management practices that suit the specifications of the area will be easier and will therefore reduce the risk and total cases of road traffic.

References

Department of Transportation, World Health Organization. (2023, May 31). Department of Transportation, World Health Organization launch Philippine Road Safety Action Plan 2023-2028. Joint News Release. Retrieved from https://www.who.int/philippines/news/detail/31-05-2023-department-of-transportation--world-health-organization-launch-philippine-road-safety-action-plan-2023-2028

Kim, G., Ng, M., & Ferrer, P. (n.d.). An Introduction to Manila's Traffic Congestion Issue. UBC Governance 352 Blog. https://blogs.ubc.ca/governance352/traffic/

Camello, J. M. (2023, March 21). Metro Manila Traffic. FuturArc. https://www.futurarc.com/commentary/metro-manila-traffic/

Pangalangan, R. A. (2023, June 29). How Manila's traffic steals more than minutes. Philippine Daily Inquirer. https://newsinfo.inquirer.net/123456/how-manilas-traffic-steals-more-than-minutes

Metropolitan Manila Development Authority. (2020). MMARAS Annual Report 2019. Metropolitan Manila Development Authority.

Metropolitan Manila Development Authority. (2021). MMARAS Annual Report 2020. Metropolitan Manila Development Authority.

Metropolitan Manila Development Authority. (2022). MMARAS Annual Report 2021. Metropolitan Manila Development Authority.

Metropolitan Manila Development Authority. (2023). MMARAS Annual Report 2022. Metropolitan Manila Development Authority.