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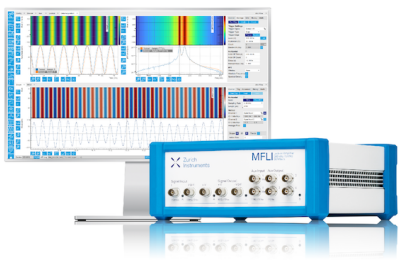

Effect of Covid-19 Lockdown on Mobility and Traffic Accidents in Malaysia

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Abstract. With the rapid spread of the coronavirus (COVID-19), the Malaysian government implemented a series of lockdown measures to break the chain of COVID-19 within the community. The lockdown measures were separated into three phases, namely movement control order (MCO), conditional movement control order (CMCO), and recovery movement control order (RMCO). Due to limited research conducted, this paper aims to investigate the effect of COVID-19 lockdown on mobility and traffic accidents in Malaysia. Quantitative data were collected from the internet and the government agency. They were analysed through descriptive and inferential statistics. Descriptive statistics were used to analyse the changes in mobility and the number of traffic accidents in different aspects. Meanwhile, inferential statistics such as simple regression analysis were applied to validate the relationship between mobility and the number of accidents. The results were presented using graphical and tabular methods. The findings show that the mobility dropped by 64% on average during MCO compared to a baseline value computed during the pre-lockdown period. The reduction in mobility during CMCO and RMCO was 40% and 15%, respectively. Next, the regression analysis reveals a strong positive relationship between mobility and the number of traffic accidents. Hence, the reduction in traffic accidents can be concluded as an impact of COVID-19 lockdown. The reduction in the number of accidents during the three lockdown periods was: MCO (73%), CMCO (46%), and RMCO (19%), compared to the average of 2015- 2019. Besides, it was found that the reduction in the number of traffic accidents was greater than the reduction in mobility during the lockdown periods. This suggests that traffic reduction has a multiplicative effect on road safety. Moreover, the findings reveal that the reduction in severe and fatal accidents was greater than the reduction in mobility. This suggests a positive effect of COVID-19 lockdown on the severity of traffic accidents. This study provides an insight into the effect of COVID-19 lockdown on traffic patterns in Malaysia. It also provides important implications for traffic management.

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INTRODUCTION

The novel Coronavirus (COVID-19) has spread rapidly over 60 countries in early 2020 after the first patient was diagnosed in Wuhan, China, in December 2019. Consequently, a global pandemic was declared by the World Health Organization (WHO) on March 11, 2020, with 118,000 confirmed cases and more than 4,000 deaths in 114 countries [1]. To break the chain of infection, many national governments responded by imposing lockdowns. The restrictions include personal mobility, closure of educational institutions, restaurants, and non-essential businesses. These restrictions have led to a significant change in the travel behaviour of individuals, which contributes to a direct impact on traffic volumes and traffic safety performance. For example, Figure 1 shows the mobility for workplace-based trips in different countries, including Malaysia, from February 15 to August 31, 2020, compared to a baseline value calculated from January 3 to February 6, 2020 [2] . As the outbreak of the COVID-19 diseases has significantly affected people's lifestyles, the effect on mobility and traffic accidents can be easily captured. Before COVID-19, the world has experienced several epidemics such as Influenza (H1N1), SARS, MERS, and Ebola. However, the impact of these epidemics was much smaller than the COVID-19 when looked into the geographical spread, the number of positive cases, and the severity of infection. Unfortunately, no study has been published to investigate the impacts of those epidemics on traffic [3].

In the current academic database, many studies have been conducted in different places to investigate the effect of implementing preventive measures during this pandemic on traffic volume and road safety. However, there is no prior evidence of the situation in Malaysia. Therefore, the authorities concerned could not comprehend the traffic situation during the pandemic in Malaysia due to limited information. In response to a sudden increase in COVID-19 cases, the first lockdown measure called Movement Control Order (MCO) came into effect on March 18, 2020. In essence, the restrictions including nationwide and international travel bans, closure of educational institutions, and closure of all private and government premises except those essential businesses [4]. Most companies implemented the work-from-home system to minimise travel, and the physical classes in school have switched to online.

Furthermore, gathering for any purposes was prohibited [5]. After 46 days of lockdown, the Malaysian government revoked the MCO and replaced it with new enforcement called Conditional Movement Control Order (CMCO), effective from May 4 to June 9, 2020. Under this enforcement, the interstate travel ban was still in effect. Most of the social activities were still prohibited. However, travel for working purposes was allowed, and the travel distance was no longer limited to 10 kilometres radius. Due to the success of frontliners and Malaysian who played their part to ensure the curb of the COVID- 19 infection, the government was further easing the restrictions by introducing the third lockdown measure named Recovery Movement Control Order (RMCO) [6]. During RMCO, more relaxed regulations were implemented compared to the previous enforcement. Schools and commercial businesses were allowed to reopen, and social activities were no longer prohibited. Besides, public transport was permitted to operate at full capacity [7].

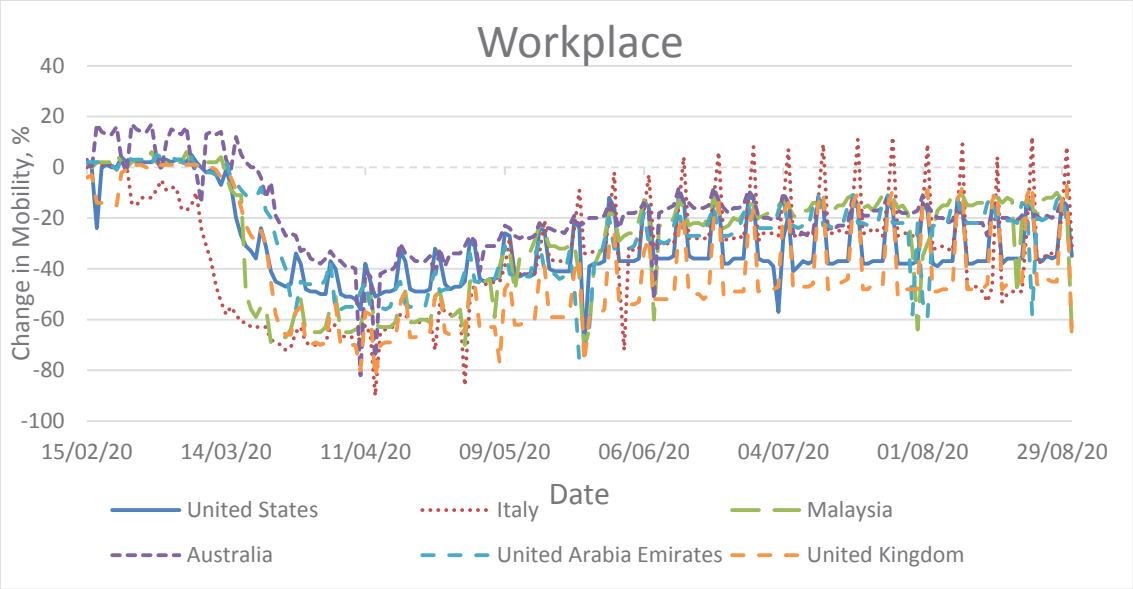

FIGURE 1. Mobility trends at workplaces in different countries (February 15 – August 31, 2020) [2]

A recent study conducted by Retallack and Ostendorf [8] aims to improve the understanding of the relationship between traffic volume and the accident rate at intersections in Adelaide, Australia. The findings showed a positive relationship between two variables at lower traffic volumes. However, at higher traffic volumes, the number of road accidents increases non-linearly. Hence, this study suggests that high congestion levels should be avoided as it has the greatest impact on the occurrence of accidents. Ayati and Abbasi [9] have investigated the role of traffic volume in the occurrence of accidents, taking into account several types of vehicles. The findings revealed that the volume of passenger cars plays a significant role in the occurrence of no injury accidents.

Moreover, the results showed a positive correlation between the volume of light non-passenger car vehicles and the likelihood of severe accidents. These conclusions have important implications for traffic management which might be helpful for future developments. Nevertheless, it is worth mentioning that the reduction in mobility has increased the severity of the accidents [10][11][12]. This might be due to the limitation of speed which higher traffic volumes are generally related to more traffic-congested areas, and hence the operating speeds are lower [10]. Golob and Recker [11] have concluded that the severity of accidents normally tracks the inverse of traffic flow.

Moreover, it was found that the severity of accidents in urban areas is more affected by traffic volume rather than the operating speed. Besides that, previous research underlined that the severity of accidents at low traffic volume was 45% greater than at high traffic volume [12]. This was probably because the road user felt increased relaxation when the traffic volume is light, which resulted in overcompensation in speed. This study suggests that it was important to influence the driving behaviour of road users by introducing road safety campaigns. Research done by Saladié et al [13] concluded that the overall daily reduction in mobility was 62.9% in Tarragona, Spain, during the lockdown period compared to the average flows before the preventive measure was implemented. Muley et al [3] have documented the reduction in traffic volume at different stages of lockdown in the state of Qatar. From the study, the traffic demand declined by 6.2% when measure 1 was implemented. During the second phase of the lockdown period, the demand has further dropped by an additional 17.5%. Finally, the demand has decreased by an additional 10.1% after measure 3, and the strictest measure was implemented. This indicates an inverse correlation between traffic demand and the stringency of the preventive measures. Apart from that, up to a 55% reduction in traffic volumes has been recorded in California during the stay-at-home order [14]. The number of traffic accidents declined by 74% during the lockdown phase in Tarragona, Spain, compared to the average value that has been recorded in 2018-2019 [13]. At the same time, the findings have revealed that the number of accidents with injuries dropped by 78%. Oguzoglu [15] has analysed the decline of the number of traffic accidents, injuries, and fatalities in Turkey during the COVID-19 stay-at-home orders. It was found that the number of accidents declined by approximately 60%, the number of deaths declined by 43%, and the number of injuries dropped by 64% during the lockdown period. A rough estimate of 200 traffic-related deaths and 17600 injuries have been prevented during the months when the lockdown orders were in place. The results revealed that the reduction in traffic volumes would lead to a greater reduction in road accidents. Therefore, work from home policy was suggested to be introduced to

reduce traffic congestion in the cities. A further study was done by Katrakazas et al [16], who documented a 41% decline in Greece's total number of traffic accidents during the first month of COVID-19 lockdown. Meanwhile, a 41% decrease in the number of fatal accidents was observed, and severe accidents have fallen by 8%. However, they also found that the operating speed of vehicles had increased up to 11%, which led to more frequent harsh acceleration events. Finally, they suggest that the policymakers should establish new speed limits to enhance the level of road safety. Muley et al [3] has compared the monthly traffic crashes during COVID-19 lockdown to the values of 2019. The results revealed that the total traffic crashes dropped by 35% when partial restrictions were implemented. After that, the number of traffic crashes declined by 73% when all the restrictions were in place.

METHODOLOGY

Data Collection

The study period designated in this research was from January to August. This time frame was chosen as all states in Malaysia were controlled under the same lockdown measures. This helps to avoid the collection and inclusion of biased sample data. The whole study period was broken into four phases: (i) Before MCO; (ii) MCO; (iii) CMCO; (iv) RMCO. Mobility data were acquired from COVID-19 Community Mobility Reports issued by Google. The data before February 15, 2020, was not included in the dataset. Therefore, the data employed in this study was from February 15 to August 31, 2020. These mobility data contain information on the duration of visits or stay at specific places. The traffic accident data were issued by the Royal Police of Malaysia (PDRM), covering all the road accidents in every state across the country. These data contain information on the total number of traffic accidents, the severity of accidents, the mode of transport involved, and the classes of roads on which the accident occurred. The data regarding the severity of traffic accidents were divided into three categories, namely fatality, severe injury, and minor crashes. The mode of transport was split into four groups: motorcycles, car, bus, and lorry. Moreover, the data provided by the PDRM also split into these four classes. These detailed variables were used to study the effect of the COVID-19 lockdown on traffic accidents from different aspects. The data provided by the PDRM was presented on a monthly basis. Besides that, the traffic accident data from 2015 to 2019 was obtained. Hence, the comparison of the number of traffic accidents between 2015-2019 and 2020 was performed. The data was collected by the Traffic Investigation and Enforcement Department (JSPT), a government organisation responsible for traffic control and summons management. Nevertheless, the data was collected and recorded on a daily basis by the investigation and enforcement division at police headquarters in respective regions across the country.

Data Analysis

After the collection of the data, they were compiled and tabulated in Microsoft Excel. Descriptive and inferential statistics were used to analyse the data. Descriptive statistics were adopted to observe the mobility trend and the change in the number of traffic accidents before and during COVID-19 lockdown. Inferential statistics such as regression analysis was used to validate the correlation between mobility and the number of traffic accidents. Descriptive statistics summarise and organise the characteristics of a dataset to make the data more meaningful and understandable. Inferential statistics allows a researcher to make an inference from a sample about the population. It was used to make conclusions from sample data and generalise them for the population data. In this study, simple linear regression analysis was applied to determine the relationship between mobility and the number of traffic accidents. In the analysis, the independent variable was the mobility changes, while the dependent variable varies based on the available data. Lastly, the p-value for the independent variable tests the null hypothesis that the variable has no relationship with the dependent variable. The null hypothesis can be rejected, also meant by statistically significant, under the significance criterion of 0.05. After the regression analysis has been done, model validation was performed by evaluating the residual plots to ensure that the regression model is valid and trustworthy.

RESULTS AND DISCUSSION

Change in Mobility Due To Covid-19 Lockdown

It was observed, as shown in Figure 2, depicts the mobility changes during four phases of the study period through boxplot-and-whisker plots. To summarize, Figure 2 shows a wide difference in mobility changes between each phase of the study period. The change in mobility most concentrated during the pre-lockdown period, ranging from -6% to 3%. Inversely, it varied the most during CMCO, with a range of 20.8% excluding the outliers. The median percentage change in mobility before MCO was -2.3%, and the upper quartile was -1.3%. This indicates that mobility decreases for at least 75% of the time compared to the reference period. Besides that, the middle 50% of mobility changes before MCO only had a variability of 2.1%. This suggests that the mobility is remarkably consistent over the period. The distribution of the data was slightly skewed right, with an outlier at 3%. During MCO, the mobility changes ranged from -69.8% to -37.6%, with two outliers. The average reduction in mobility was 64%, which has the most significant drop over the entire study period. The interquartile range is 3.5%, suggesting that the percentage change in mobility spans between -66.2% to -62.7% for half of the period. The data was slightly skewed right, indicating that the data was mainly distributed between -69.8% and -64.2%. The percentage change in mobility during CMCO varied the most. The average reduction was 40%. The interquartile range was 11.5%, which is also marked as the greatest variability among all. This indicates that 50% of the days from May 4 to June 9, 2020, experienced a reduction in mobility from 33.8% to 45.3% compared to the reference period. There is no outlier in this dataset, and the distribution of the data was largely skewed left, which means the percentage change was more concentrated on the upper part (-38% to -31.2%). Lastly, the mobility changes during RMCO were spanning from -27% to 0%. The result shows that the reduction in mobility is less than 12% for at least 75% of the days over the period. This indicates that the mobility is moving towards the baseline value. The average reduction in mobility was 15%. The distribution of the data is symmetrical, with six outliers in total. The finding has confirmed the effect of COVID-19 lockdown on mobility. Moreover, it shows that the majority distribution of the data during the four phases of the study period did not overlap. This reveals that different stringency of lockdown measures affects mobility to different extents. Muley et al [3] have found that the traffic demand increases with the relaxation of the restrictions.

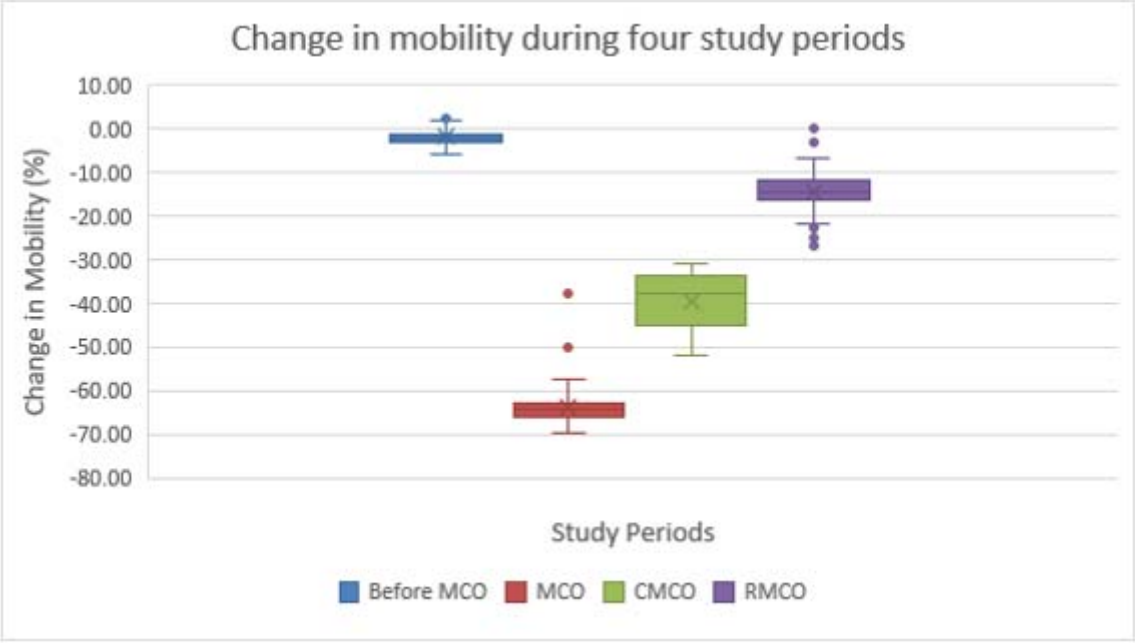

FIGURE 2. Change in mobility by study periods

Figure 3 shows the mobility trends at different locations. A total of six locations were considered in this study. In sum, the mobility trend in residential areas was completely opposed to other locations. It increased by almost

40% after the lockdown measure was implemented, then slowly decreased to the baseline as the restrictions gradually lifted. Several events are worth discussing from the graph. Firstly, a spike in mobility at grocery and pharmacy stores was noticed a few days before the lockdown came into force. The prime minister of Malaysia announced the implementation of MCO on March 16, 2020, which was two days before the enforcement took effect. After that, long queues can be seen at most grocery stores, people panic buying as fear grew after the announcement [17]. Secondly, differences in the reduction in mobility can be noticed between different locations during MCO. The reduction at grocery and pharmacy stores was least significant, at around 40%. During MCO, all government and private premises were closed, except for essential services such as healthcare centres, pharmacies, food supplies. People were only permitted to leave their houses to purchase daily necessities or seek healthcare services [18]. Therefore, the reduction in mobility was less significant compared to other locations.

On the other hand, the greatest reduction was recorded at transit stations and retail and recreation centres. Transit stations including subway, bus, and train stations, while the retail and recreation centres include places like restaurants, cafes, shopping centres [19]. These places were not allowed to open during MCO. Hence the reduction in mobility was more noticeable. Despite the restrictions being gradually lifted during CMCO and RMCO, the mobility was still lower than the other locations. This is because these places are typically confined spaces and crowded, which might increase the risk of infection. Finally, it was found that the gaps were slowly vanishing and moving towards the baseline as time went on. This is mainly due to the relaxation of enforcement and indicating the country is slowly getting back to normal like pre-pandemic days.

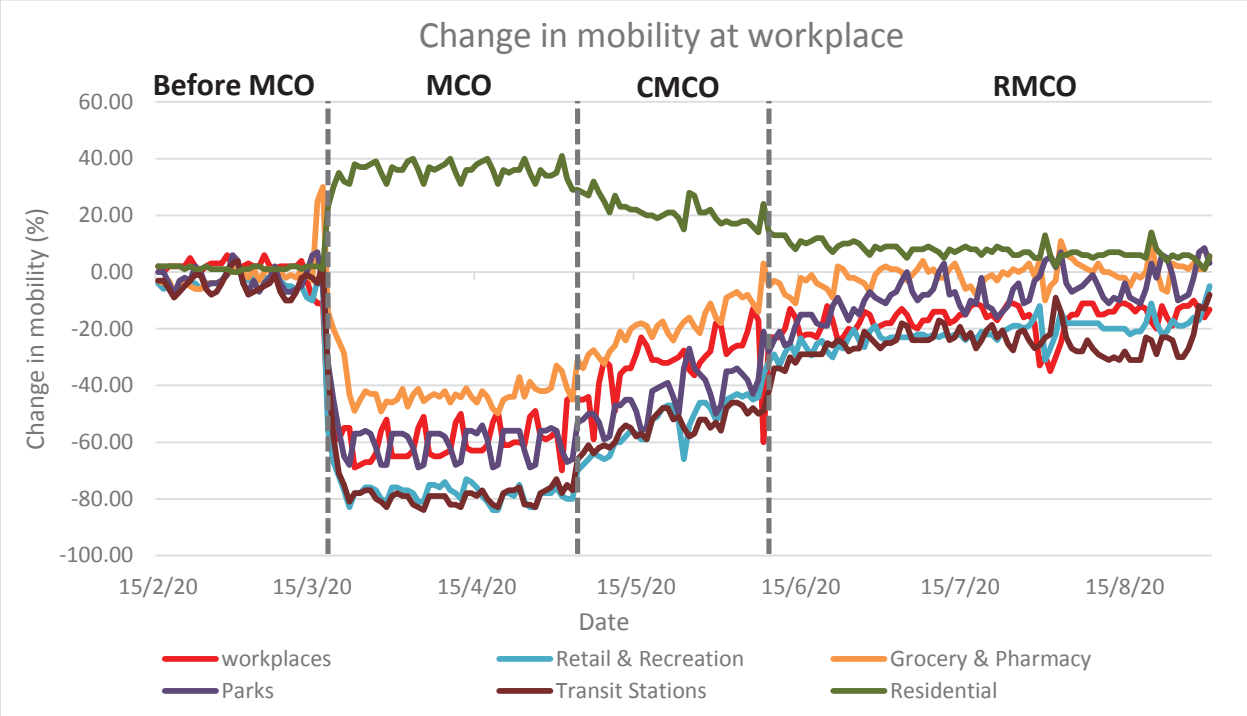

FIGURE 3. Mobility trends at different locations

Figure 4 illustrates the mobility trends in different states of Malaysia. Four states were taken into account: Selangor, Penang, Pahang, and Kelantan, to investigate the mobility changes in urban and rural areas. According to the population distribution and basic demographic characteristic report issued by the Department of Statistics Malaysia (DOSM), apart from the three federal territories, Selangor was noted as the state with the highest urbanisation level across the country. The proportion of the urban population in Selangor was 91.4%, followed by Penang (90.8%). Conversely, the states with lower urbanisation levels were Kelantan (42.4%) and Pahang (50.5%) [20]. Before MCO, the mobility trend of each state was very close, hovering around the baseline value. During the three phases of lockdown, it is evident that the reduction in mobility in urban areas was greater than in rural areas. A possible explanation is that the COVID-19 is spreading more rapidly in urban areas due to high population density levels. Hence, people living in urban areas will be more concerned about the disease, and they may refrain from

going out to reduce the risk of infection. A study conducted by Parr et al [21], who investigated the traffic impacts of the COVID-19 pandemic, also reached a similar conclusion.

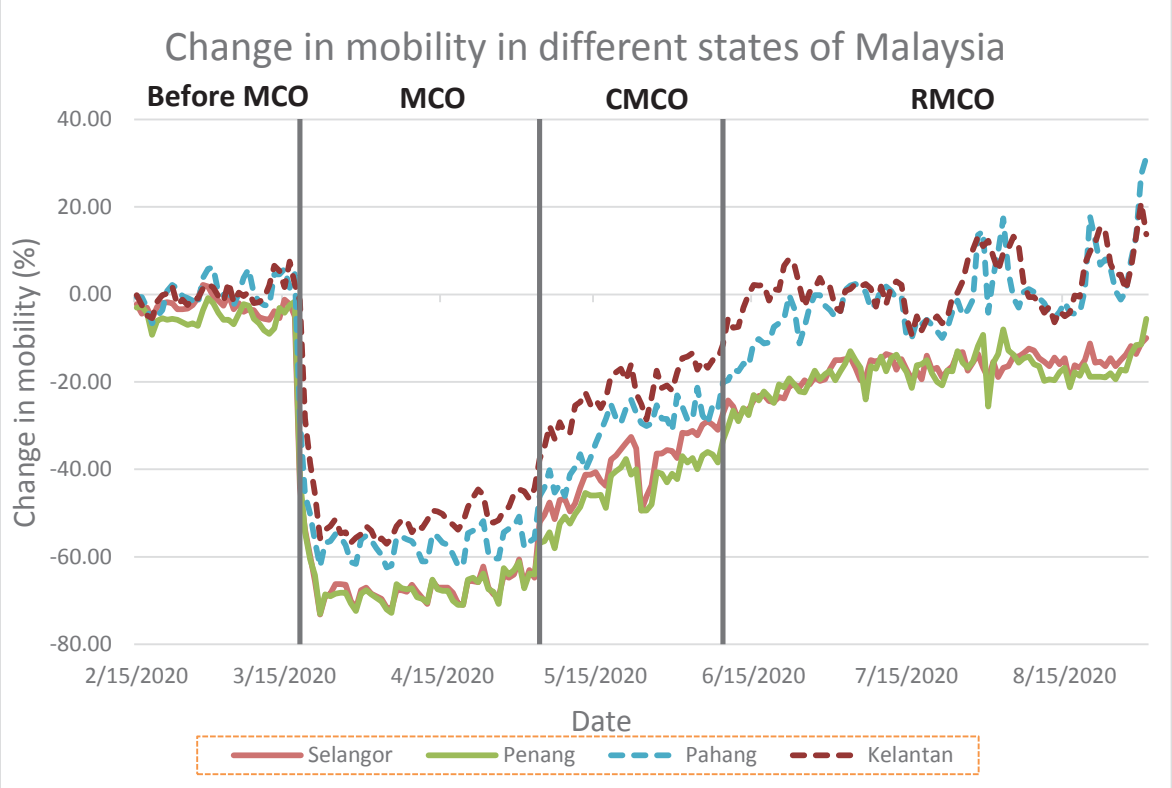

FIGURE 4. Mobility trends in different states of Malaysia

Relationship between Mobility and the Number of Accidents

Mobility versus the Total Number of Traffic Accidents

Figure 5 shows the relationship between the percentage change in mobility and the number of traffic accidents in 2020. The R-squared value (0.9905) indicates a very small difference between the observed data and fitted values. It also reveals that 99% of the variance found in the dependent variable (change in the number of traffic accidents) can be explained by the independent variable (change in mobility). Moreover, the coefficient of the regression equation is 1.188. This represents the mean reduction in the number of traffic accidents for every additional 1% reduction in mobility. If the mobility decreased by 1%, the total number of traffic accidents decreased by an average of 1.188%. Table 1 displays the results of simple regression analysis. It suggests that the average vertical distance from the data points to the fitted line is about 0.044%. This indicates that the sample mean is an accurate reflection of the actual population mean. Lastly, the p-value was very close to 0, which the null hypothesis can be rejected. Therefore, the outcomes from the analysis imply that there is a strong positive relationship between the two variables.

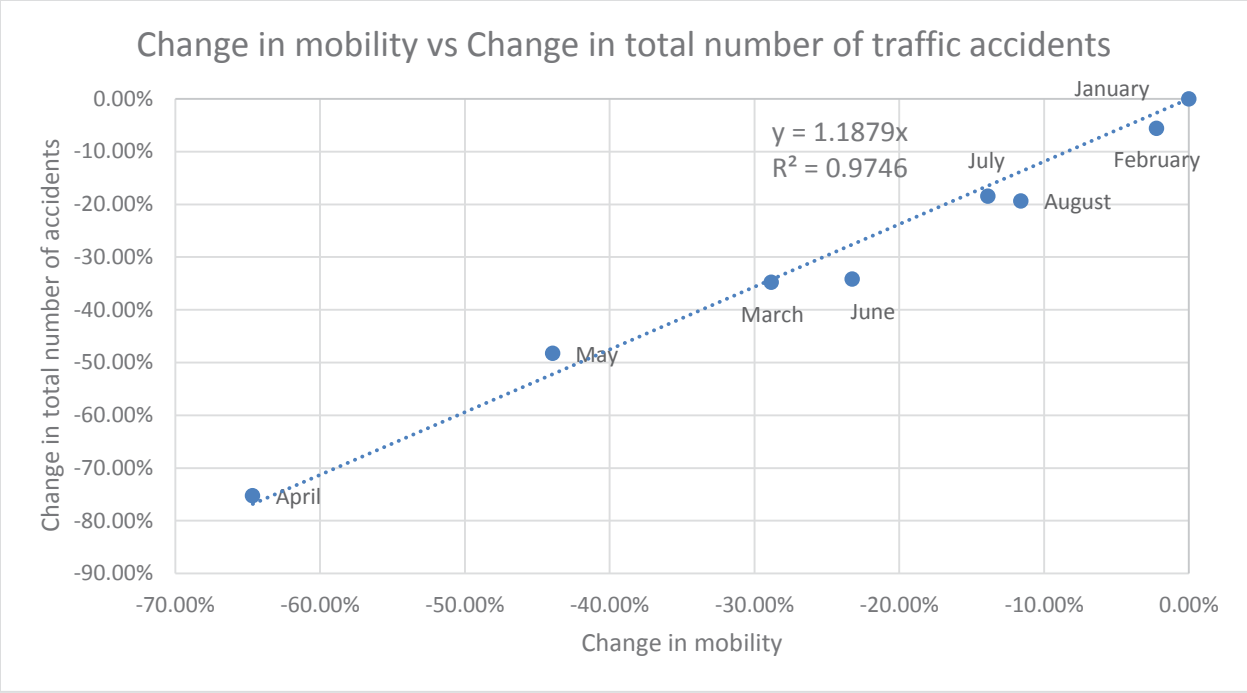

FIGURE 5. Change in mobility vs change in the total number of traffic accidents

TABLE 1. The summary output of simple regression analysis

	Coefficients	Standard Error	P-value
Intercept	0		
Change in mobility	1.188	0.044	2.440E-08

Mobility versus the number of traffic accidents by severity

The correlations between three degrees of severity were presented in Table 2. Each cell in Table 2 shows the correlation between two variables in terms of the percentage reduction in the number of traffic accidents. A strong positive relationship has been identified between each pair of variables, having a correlation coefficient of 0.70 and above. Hence, discussion of one of the variables is sufficient. Severe accident was chosen to be discussed in this section.

From Figure 6, the result showed a strong positive linear relationship between the two variables. The R-squared value (0.9514) suggests that mobility explains 95% of the sample variation in the number of severe accidents. In addition, the finding reveals that if the mobility decreased by 1%, the number of severe accidents decreased by an average of 1.1%. The sample data provide enough evidence to reject the null hypothesis for the entire population because the p-value for the independent variable is less than the significance level.

TABLE 2. Correlation matrix of the number of accidents by severity

	Minor	Severe	Death
Minor	1		
Severe	0.853	1	
Death	0.723	0.935	1

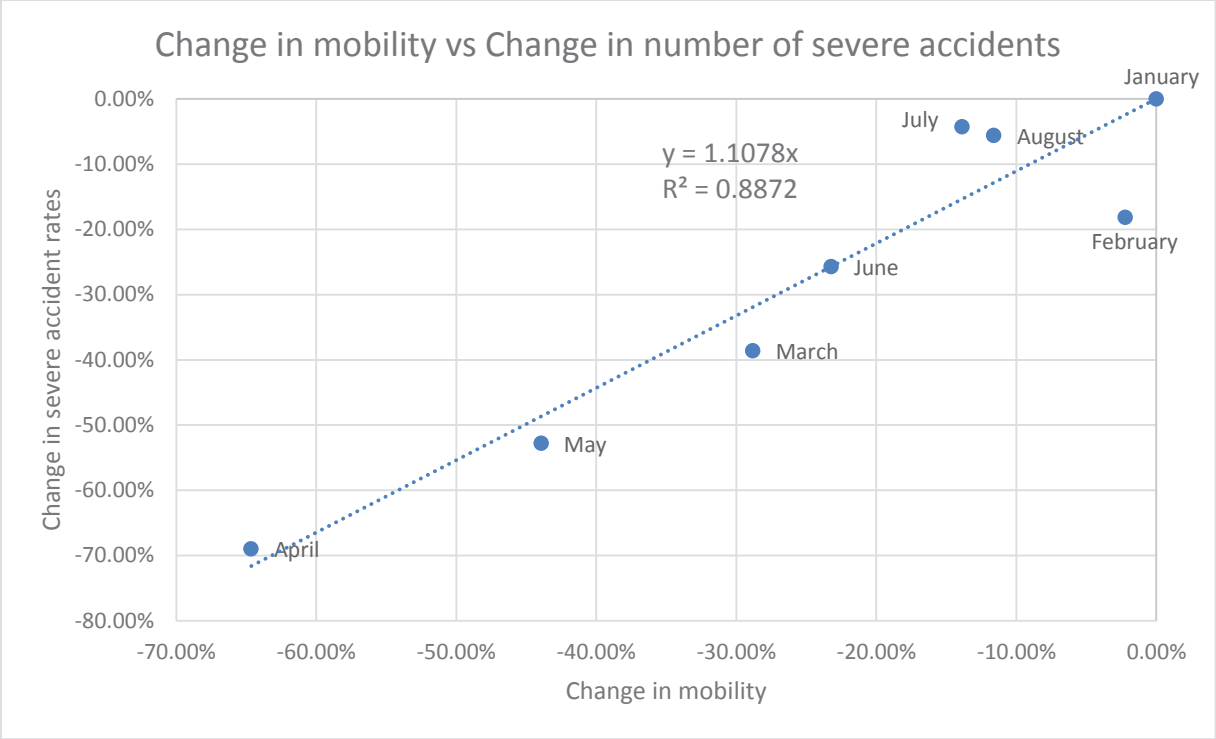

FIGURE 6. Change in mobility vs change in the number of severe accidents

TABLE 3. The summary output of simple regression analysis

	Coefficients	Standard Error	P-value
Intercept	0		
Change in mobility	1.108	0.095	7.510E-06

Mobility versus the number of traffic accidents by mode of transport

Table 4 presents the correlation matrix of four types of vehicles. Similarly, the result reveals a strong positive correlation between each pair of variables. Hence, this section will only discuss the correlation between mobility and the number of motorcycle accidents. The scatterplot shown in Figure 7 shows a strong positive association between mobility and the number of motorcycle accidents. There do not appear to be any outliers in the data. The R-squared value (0.9107) indicates that mobility accounted for 91% of the changes in motorcycle accidents while only 9% not being explained by mobility. Besides, the regression coefficient (1.2208) implies that for every 1% decrease in mobility, the number of motorcycle accidents fell by an average of 1.22%. The standard error shown in Table 5 suggests that approximately 95% of the observations should fall within ±0.14% of the fitted line. The significance level of the model was below the 0.05 significance criterion. Hence, it can be concluded that the analysis was statistically significant.

TABLE 4. Correlation matrix of the number of accidents by mode of transport

	Motorcycle	Car	Lorry	Bus
Motorcycle	1			
Car	0.947	1		
Lorry	0.842	0.965	1	
Bus	0.891	0.961	0.919	1

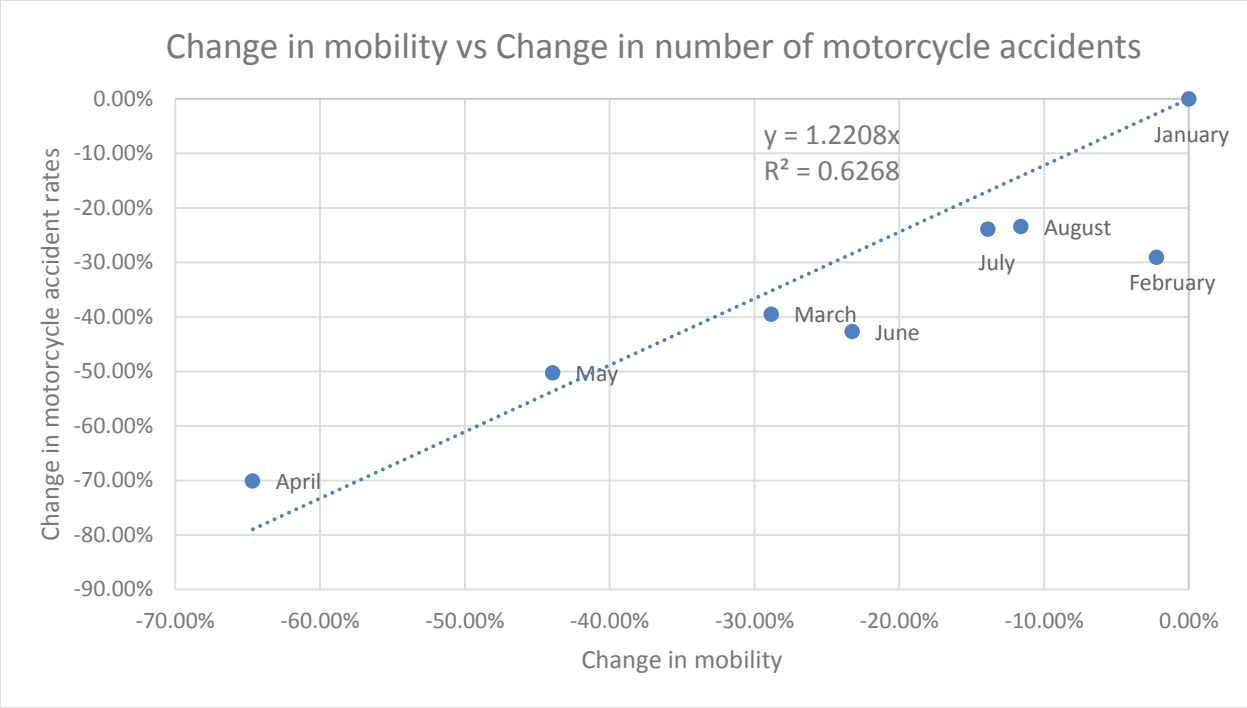

FIGURE 7. Change in mobility vs change in the number of motorcycle accidents

TABLE 5. The summary output of simple regression analysis

	Coefficients	Standard Error	P-value
Intercept	0		
Change in mobility	1.221	0.145	6.430E-05

Mobility versus the number of traffic accidents by road type

Table 6 indicates that the reduction in the number of traffic accidents was highly correlated between each type of road, with at least a 0.98 correlation coefficient. Hence, this section will focus on the association between mobility and the number of accidents on collectors. The actual observed points in Figure 8 fell very close to the fitted line, which indicates a strong positive relationship between the two variables. The finding reveals that more than 98% of the data fit the regression model. The coefficient of the equation indicates that for every 1% reduction in mobility, an average of 1.2% reduction in the number of accidents on collectors can be expected. In addition, the standard error shown in Table 7 indicates that the reduction in the number of accidents on collectors can vary by 0.054%. Last but not least, the result implies that the analysis was statistically significant. A p-value of very close to 0 provides strong evidence against the null hypothesis.

TABLE 6. Correlation matrix of the number of accidents by road type

	Expressways	Arterials	Collectors	Local Streets
Expressways	1			
Arterials	0.988	1		
Collectors	0.987	0.995	1	
Local Streets	0.984	0.988	0.985	1

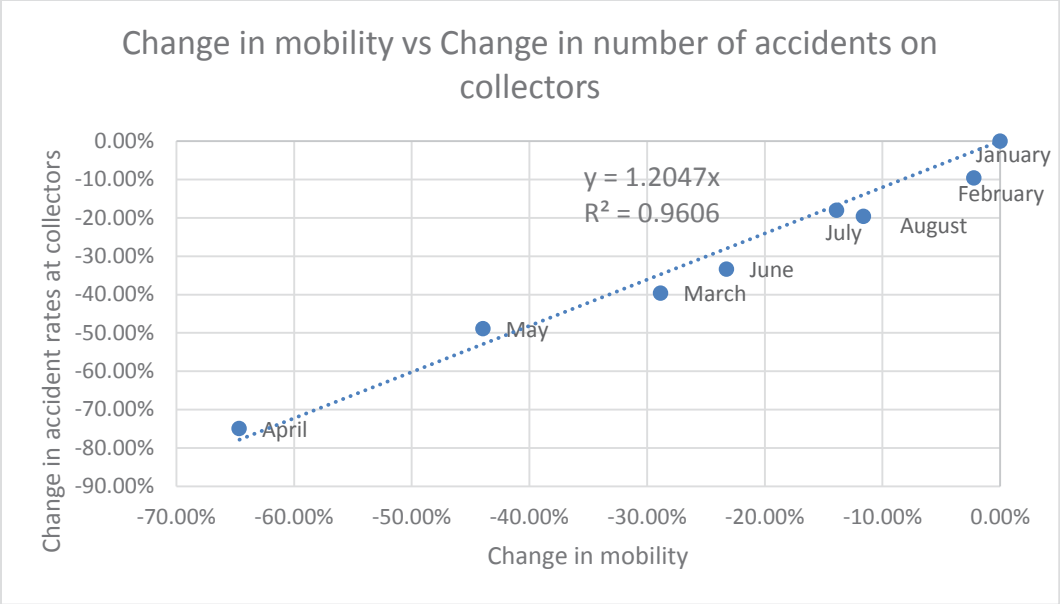

FIGURE 8. Change in mobility vs change in the number of accidents on collectors

TABLE 7. The summary output of simple regression analysis

	Coefficients	Standard Error	P-value
Intercept	0		
Change in mobility	1.205	0.054	9.200E-07

Model Validation

The regression model has been validated by looking at the residual plot to determine whether the residuals are consistent with random error. A residual value is a measure of the vertical distance between a data point and the regression line. The regression line is the best fit for a set of data. In this section, the residual plot of the regression model shown in section 3.2.1 was chosen as an example to validate the regression model. The residual plot shown in Figure 9 did not show any anomalies for the fitted regression model. Besides, it reveals that the residuals appear to be randomly scattered around zero. They would not be able to be predicted from the fitted values. It was seen that the negative residuals were gathered on the right, while the positive residuals were distributed on the left. However, the value of the residuals is very small, and they do not exhibit a certain trend. As a result, it can be concluded that the model's predictions are correct on average. The assumption of constant variance was satisfied.

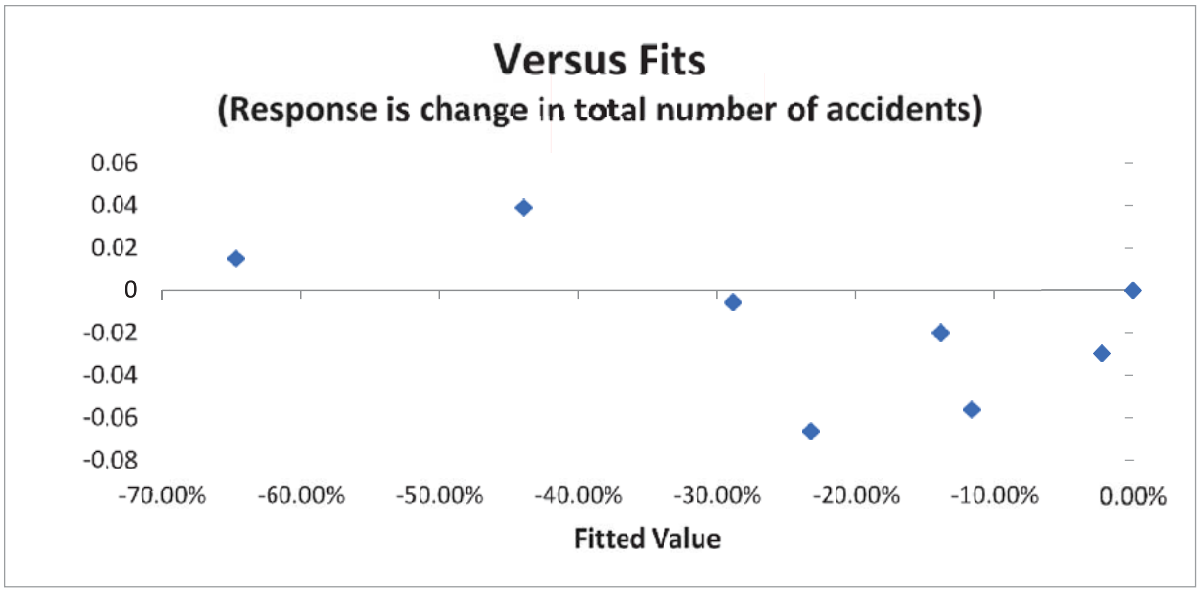

FIGURE 9. Residual plot of the regression model

Change in the Number of Accidents Due to COVID-19 Lockdown

Total Number of Traffic Accidents

Figure 10 illustrates the monthly distribution of traffic accidents in Malaysia in 2015-2019 and 2020. Overall, the average number of traffic accidents in 2015-2019 was higher than in 2020. The monthly traffic accidents in 2015-2019 were evenly distributed, ranging between 39,000 - 46,000 cases. The number of traffic accidents documented in the first two months of 2020 was slightly higher than in 2015-2019. Then, it dropped to approximately 31,000 in March 2020. Note that the first lockdown measure, MCO, formally came into force on March 18, 2020. Thus, a sudden decline in the number of traffic accidents after March 18 can be expected due to the reduction in mobility. The number of traffic accidents bottomed out in April, when the strictest measure was in place for the entire month, with only 12,000 cases recorded. The numbers doubled in May when the second phase of lockdown measure, CMCO, was imposed. Unfortunately, the number of traffic accidents grew constantly during CMCO and RMCO. The number of accidents stood at 40,000 in July and August. This coincides with travel restrictions being lifted and the increase in mobility.

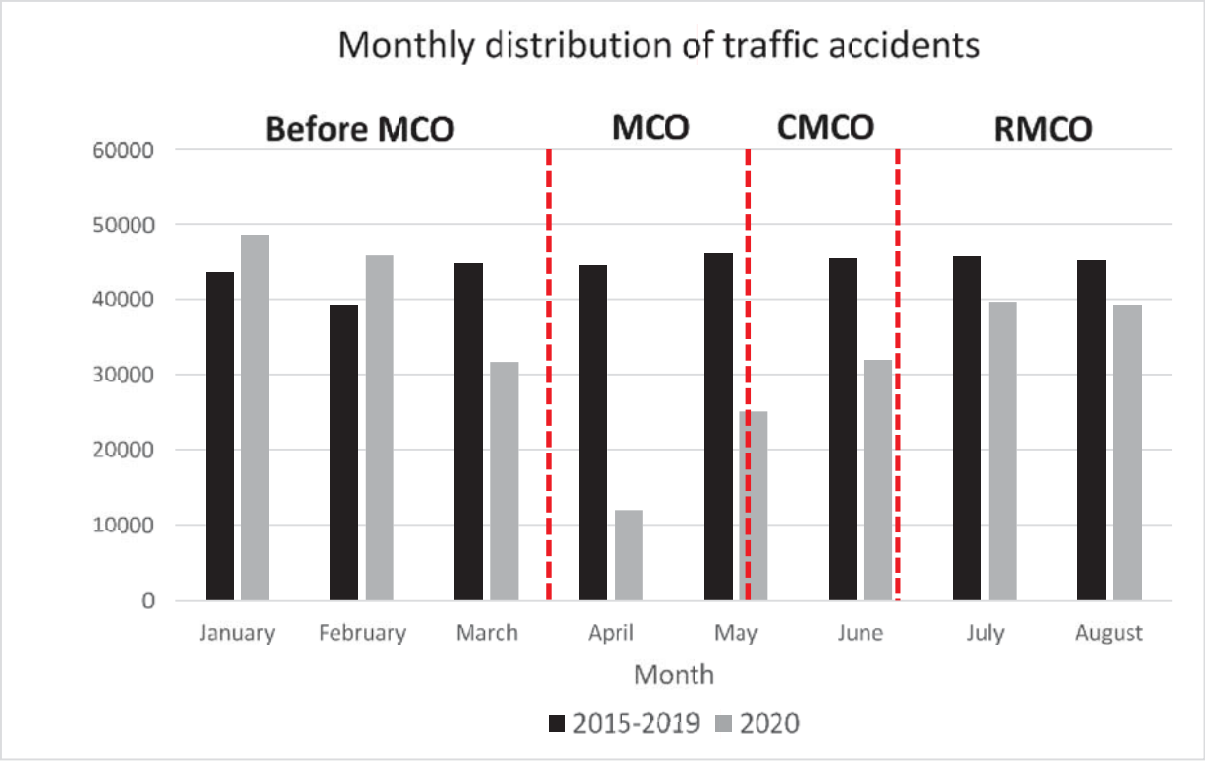

FIGURE 10. Monthly distribution of traffic accidents: 2015-2019 and 2020

Table 8 depicts the total number of traffic accidents and daily mean registered over the study period. In 2020, a total of 274,198 accidents were recorded. The daily average was 1128 cases. Overall, the number of traffic accidents recorded decreased by 23% compared to the average for the same period in 2015-2019. Before MCO was implemented, the number of traffic accidents (126,214) was close to the same period in 2015-2019 (127,734). It was associated with 46% of the total number of accidents in 2020. During MCO, the number of traffic accidents dropped by 73% compared to 2015-2019, and the daily mean fell to 400 cases. This result was consistent with the outcomes reported by Bernama [22]. The traffic accidents that took place in April only accounted for 5% over the study period. During CMCO, the numbers increased twofold, with an average of 811 cases per day. However, it still declined by 46% compared to the same period in 2015-2019. During RMCO, the number of traffic accidents slowly approached the number of accidents in 2015-2019, with only 19% lesser. The daily average was 1,205 cases.

TABLE 8. Traffic accidents and daily mean (DM): 2015-2019 and 2020

	Before MCO		**MCO**		**CMCO**		**RMCO**		**Whole Period**	
Year	Total	DM	Total	DM	Total	DM	Total	DM	Total	DM
2015-2019	127734	1435	44569	1486	46211	1491	136473	1483	354987	1467
2020	126214	1402	12010	400	25147	811	110827	1205	274198	1128

The finding has confirmed the effect of lockdown measures had on traffic accidents. Moreover, it shows that the stringency of different lockdown measures completely affects the frequency of traffic accidents. The stricter the lockdown measure, the lesser the mobility, the fewer traffic accidents occurred. Figure 11 shows the change in mobility and the number of traffic accidents from January to August 2020. January was set as the reference period. The result indicates that the change in the number of traffic accidents followed the same pattern as the change in mobility. In addition, it reveals that the reduction in the number of traffic accidents was greater than the reduction in mobility over the study period. This suggests that the reduction in mobility has a multiplicative effect on reducing the number of traffic accidents. A recent study conducted by Saladié et al [13] also reached the same conclusion.

They found that the reduction in the number of accidents (76%) has been greater than the reduction in mobility (63%) during COVID-19 lockdown.

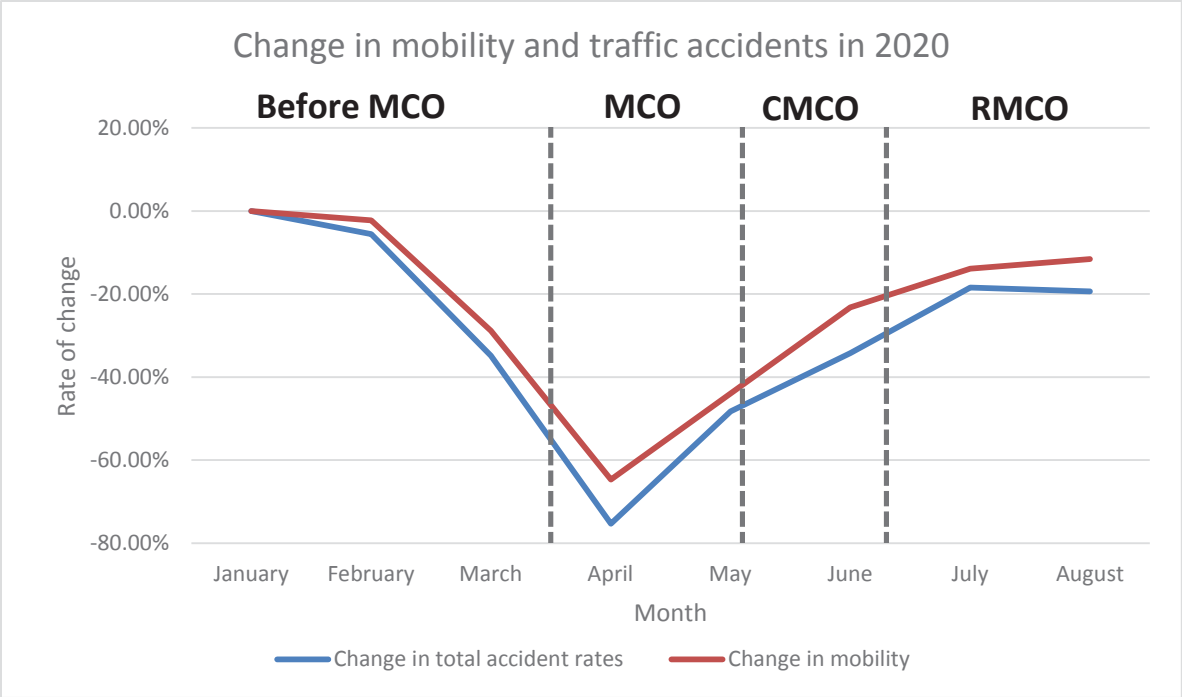

FIGURE 11. Change in mobility and change in the number of traffic accidents in 2020 regarding the reference period (January 2020)

Traffic Accidents by Severity

Table 9 shows the daily mean of the number of traffic accidents by severity over the study period in 2015-2019 and 2020. The percentage distribution was also included in the table. Overall, the number of minor crashes registered in 2020 increased by 26% compared to the average in 2015-2019. Inversely, the number of severe and fatal accidents decreased by 30% and 32%, respectively. In 2015-2019, the distribution remained remarkably consistent over the study period. The proportions of minor and fatal accidents were almost the same, at 39% respectively, and severe accidents made up 22% for the whole period. The daily minor crashes ranged from 17 to 19 cases, the severe crashes were around 10 to 11 cases, and the fatal accidents were approximately 19 cases per day.

On the other hand, the distribution in 2020 was somewhat different. The distribution of minor crashes surged to 54%, while the distribution of severe and fatal accidents fell to 17% and 29%, respectively, for the whole period. It is worth mentioning that the distribution of severe accidents before MCO was higher than the distribution during the phases of lockdown. This result agreed with the findings from Saladié et al [13], who suggests that the frequency of severe accidents decreased while the proportion of minor accidents increased during the lockdown period. Besides that, the distribution of fatal accidents was fluctuating over the four phases of the study period.

TABLE 9. The daily mean of traffic accidents by severity: 2015-2019 and 2020

Year	Severity	Before MCO	MCO	CMCO	RMCO	Whole Period
2015-2019	Minor	18 (39%)	17 (38%)	18 (39%)	19 (39%)	19 (39%)
	Severe	10 (22%)	10 (22%)	10 (22%)	11 (22%)	10 (22%)
	Death	18 (39%)	18 (40%)	18 (39%)	19 (39%)	19 (39%)
2020	Minor	24 (50%)	10 (53%)	15 (50%)	32 (58%)	24 (54%)
	Severe	8 (18%)	3 (17%)	5 (15%)	9 (16%)	7 (17%)
	Death	15 (32%)	6 (30%)	10 (35%)	14 (26%)	13 (29%)

Figure 12 illustrates the percentage change in mobility and severity of traffic accidents in 2020. Similarly, January was set as the reference period. In general, all variables had similar trends over the study period. They dipped dramatically once the lockdown measure was imposed. Then, they bounced back when the restrictive measures were gradually lifted. It was important to note that the number of minor crashes rose sharply during RMCO. It increased by over 40% compared to the reference period. This was an unusual event as the overall mobility was still lower than the baseline value. This remained unexplained why the mobility was not growing with the number of minor accidents. This phenomenon required attention from relevant government agencies. Appropriate precautions should be taken to avoid the same problem happening again in the future.

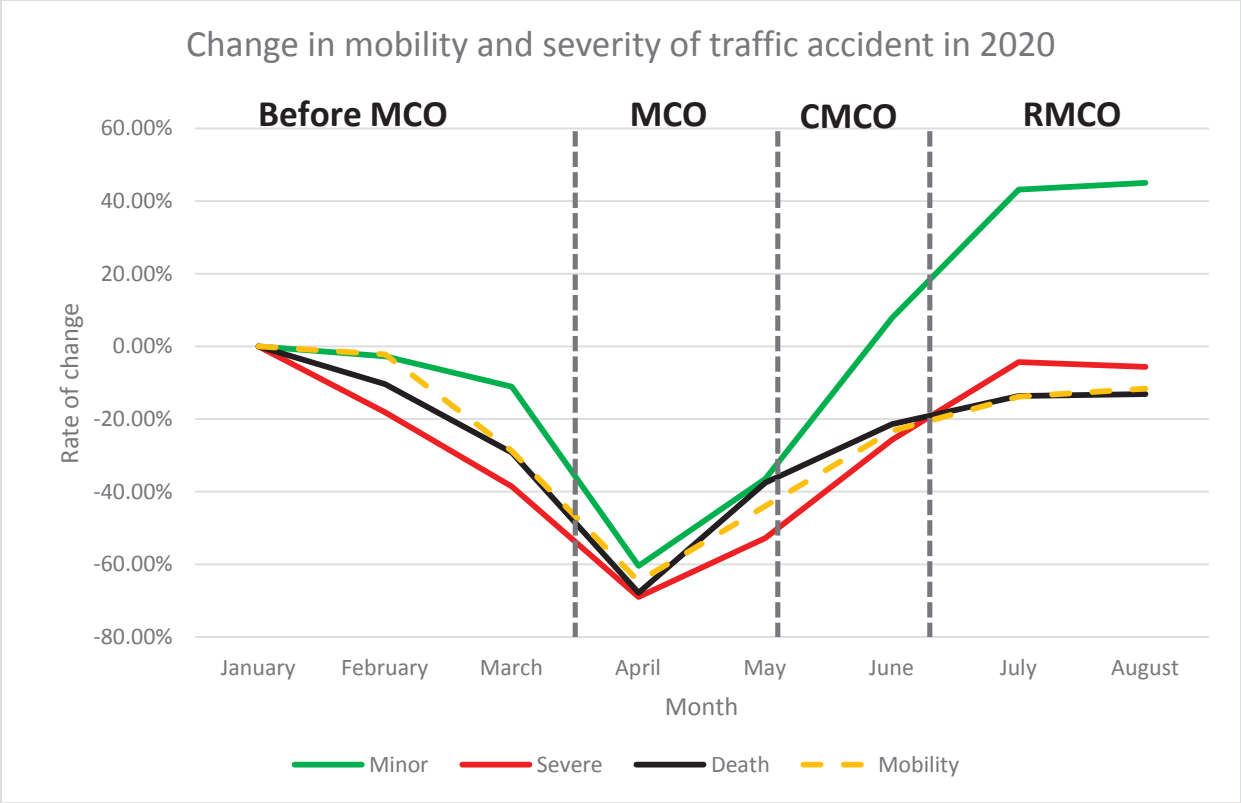

FIGURE 12. Change in mobility and change in the number of traffic accidents by severity in 2020 regarding the reference period (January 2020)

Figure 13 shows the percentage reduction in traffic accidents by severity during three lockdown periods compared to the reference period (2015-2019). The declination of severe and fatal accidents was greater than minor accidents over the three lockdown periods. During MCO, the reduction in severe and fatal accidents was 69%, while the number of minor crashes dropped by 44%. During CMCO, the percentage reduction in minor and fatal accidents declined by 26% and 27%, respectively, while severe accidents decreased by 14%. Finally, an anomalously increase in minor accidents was documented during RMCO, with 68% growth compared to the reference period. The reduction in severe and fatal accidents was 17% and 25%, respectively. To date, many studies have been conducted to investigate the relationship between mobility and the severity of traffic accidents. Most of them concluded that the reduction in traffic volumes had increased the severity of traffic accidents [10][11][12]. The main reason is that the vehicle's travel speed was not restricted by the road congestion under low traffic volumes. Free-flow conditions tend to encourage drivers to violate the designated speed limits [3]. However, the findings reveal that the reduction in severe and deadly accidents has been greater than reducing minor accidents during lockdown periods when the traffic volumes are lower. Therefore, the assumption that low traffic volume increased the severity of traffic accidents is not supported by the analysis results. Nevertheless, the finding suggests a positive effect that COVID-19 lockdown has had on the severity of accidents as more severe injuries and deaths have been avoided.

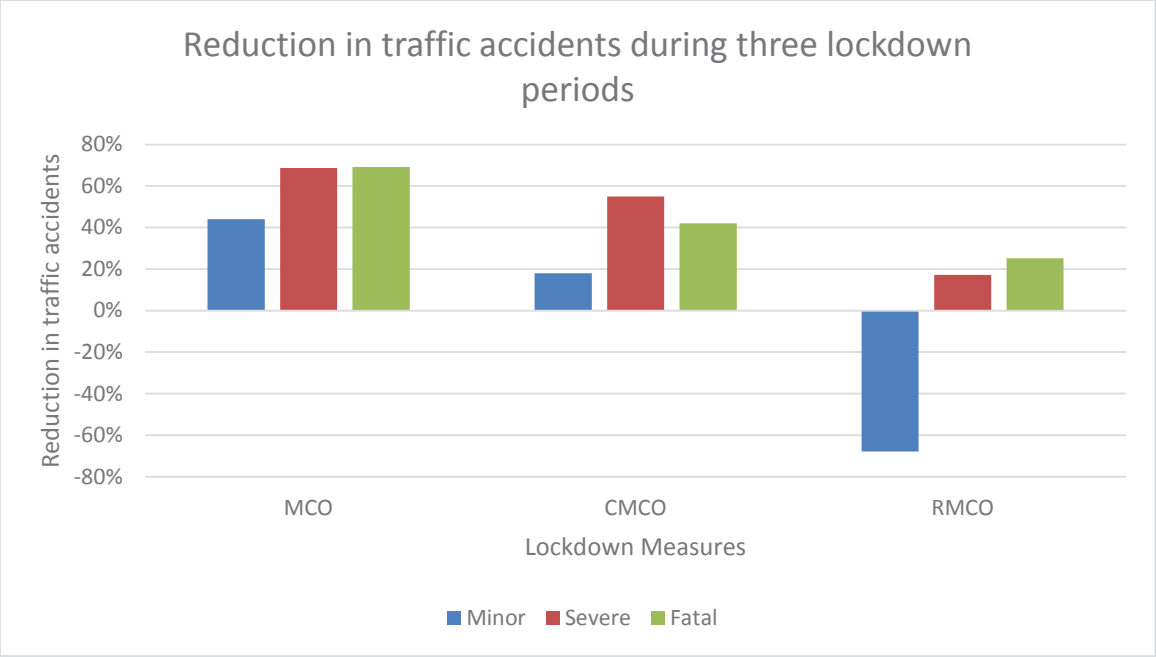

FIGURE 13. The reduction in traffic accidents by severity during three lockdown periods regarding to the reference period (2015-2019)

Traffic Accidents by Mode of Transport

Table 10 illustrates the daily average and percentage distribution of traffic accidents, taking into account the various types of vehicles involved. For the whole period, the reduction in traffic accidents of the four types of vehicles in 2020 was motorcycle (26.5%), car (34.3%), lorry (15.8%), and bus (59.1%) compared to 2015-2019. In 2015-2019, the distribution of traffic accidents by each mode of transport was relatively consistent. Overall, car accidents corresponded to nearly four of every five accidents registered, followed by motorcycles, at 16%. Lorry and bus accidents were made up of 5% and 1%, respectively. Surprisingly, the number of car accidents was much more than other modes of transport. Based on the data obtained from the Department of Statistics Malaysia (DOSM), the number of registered motorcycles (13.2 million) was higher than cars (12.5 million) as of 2019 (Department of Statistics Malaysia, 2020). Therefore, the finding indicates no correlation between the number of registered vehicles and the number of traffic accidents. The distribution was slightly different in 2020. For the whole period, the proportion of bus accidents remained unchanged compared to 2015-2019. The distribution of motorcycle and lorry accidents was slightly increased by 1% while the proportion of car accidents dropped by 2%. Note that the distribution of car accidents before MCO was higher than the distribution during the three lockdown periods.

On the contrary, the distributions of motorcycle and lorry accidents were lower before MCO. This reveals that the reduction in car accidents was more remarkable than the reduction in motorcycle and lorry accidents. The bus accidents remain a tiny fraction over the study period.

TABLE 10. The daily mean of traffic accidents by mode of transport: 2015-2019 and 2020

Year	Mode of transport	Before MCO	MCO	CMCO	RMCO	Whole Period
2015-2019	Motorcycle	332 (16%)	321 (15%)	327 (15%)	337 (16%)	332 (16%)
	Car	1,666 (79%)	1,687 (79%)	1,719 (79%)	1,692 (78%)	1,685 (79%)
	Lorry	96 (5%)	99 (5%)	105 (5%)	104 (5%)	101 (5%)
	Bus	22 (1%)	23 (1%)	24 (1%)	22 (1%)	22 (1%)
2020	Motorcycle	293 (16%)	114 (18%)	183 (19%)	260 (17%)	244 (17%)
	Car	1,395 (78%)	463 (75%)	712 (74%)	1,168 (76%)	1,107 (77%)
	Lorry	98 (5%)	40 (6%)	62 (6%)	94 (6%)	85 (6%)
	Bus	14 (1%)	2 (0%)	5 (0%)	8 (1%)	9 (1%)

Figure 14 illustrates the percentage change in the number of traffic accidents by mode of transport regarding the reference period from 2015 to 2019. Besides, the total number of accidents also presented in the diagram to compare the trends between each variable. To summarize, all variables had a similar trend over the study period. They started to dip when the movement control order was imposed. Then, they bounced back from the bottom and grew steadily during CMCO and RMCO. From the graph, it was important to note that the reduction in the number of motorcycle accidents became less significant compared to the reduction in the total number of traffic accidents after MCO was implemented. In other words, the proportion of motorcycle accidents was increased during MCO. This could be explained by the immediate growth of the number of motorcyclists on the road. After the movement control order was decreed, people were forced to stay at home, and they became dependent on food delivery services [23]. According to Foodpanda Malaysia's head of logistics, to cope with a spike in demand, the number of riders rose by 7.5%, and a 37% increase in applications for the job since the MCO started [24]. Therefore, the rising number of riders might increase the occurrence of motorcycle accidents.

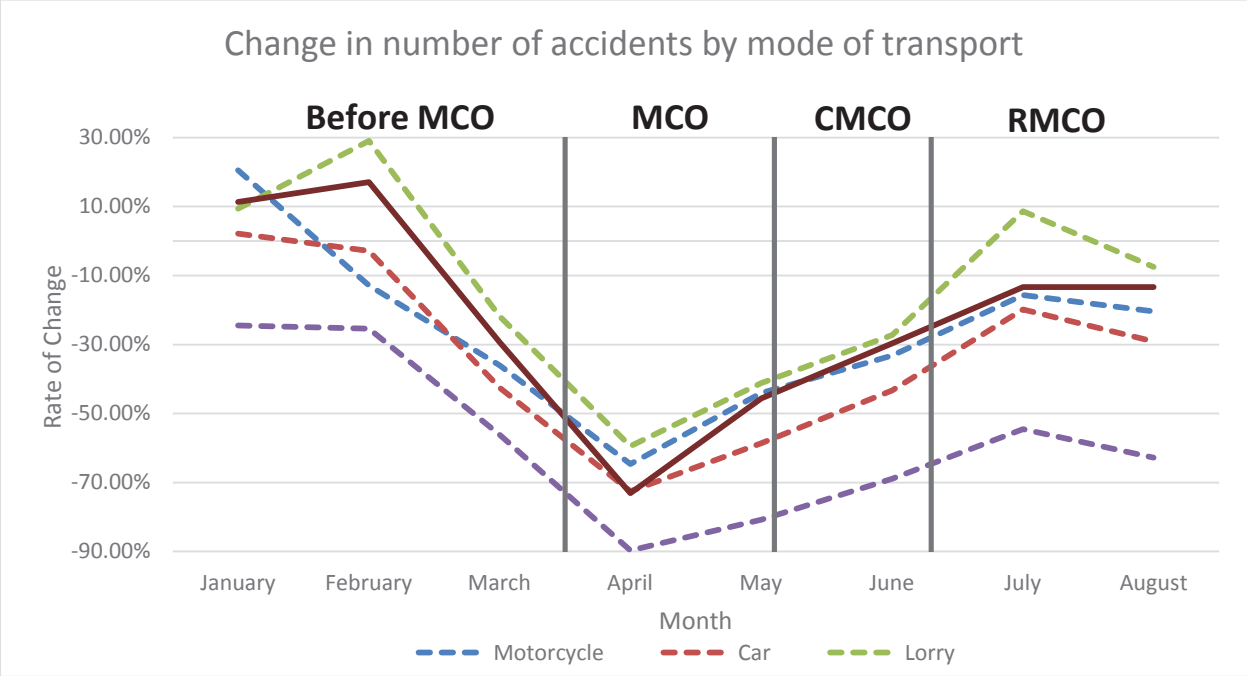

FIGURE 14. Change in the total number of traffic accidents and by mode of transport in 2020 regarding to the reference period (2015-2019)

Figure 15 depicts the percentage reduction during three lockdown periods. Noticeable differences of declination were observed between each mode of transport. The finding shows that the declination of each variable followed the same sequence over the three phases of lockdown. The reduction in bus accidents was most significant, followed by car, lorry accidents. The reduction in bus accidents was the least significant during the lockdown periods. The differences in the declination were mainly due to the regulations imposed. During MCO, interdistrict and interstate travel was not allowed. This results in the temporary suspension for nearly all the long-distance bus services; only regional buses were allowed to operate with a certain time limit [25]. Therefore, fewer traffic volumes of buses resulted in a drastic decline in the frequency of bus accidents. Apart from that, the pandemic has changed travel behaviours. Abdullah et al [26] aims to investigate the changes in travel behaviour and mode choice of transport due to the COVID-19 pandemic in many countries around the world. They found a remarkable shift from public transport to private transport during the COVID-19 pandemic. Hence, the ridership of public transport has significantly influenced. Recent research conducted by Aloi et al [27] also found that bus travel during the lockdown period fell by 93% compared to private car travel (68%).

In contrast, the effect of COVID-19 lockdown on lorry accidents was least significant over the lockdown periods. This was probably because the essential services were allowed to operate during the lockdown period, including postal, e-commerce, food supply [28]. Furthermore, transportation and logistics activities were allowed to operate as part of the essential services during MCO, CMCO, and RMCO [29]. It was known that most of the

essential goods were mainly transported by lorries and trucks. Hence the reduction in the number of lorries and trucks on the road was not as remarkable as the other types of vehicles.

FIGURE 15. The reduction in traffic accidents by mode of transport during three lockdown periods regarding the reference period (2015-2019)

CONCLUSION

The difference in the change in mobility was evident during the four phases of the study period. The result shows that the mobility remained very stable during the pre-lockdown period compared to the reference period (January 3 - February 6, 2020). The most noticeable reduction was observed during MCO, when the strictest lockdown measure was implemented, at an average of 64%. Then, the mobility gradually increased during CMCO as part of the regulations was lifted. It dropped by an average of 40% compared to the reference period. The mobility continues to grow during RMCO. The average percentage reduction was 15%. Besides, the findings indicate that the reduction in mobility at retail and recreation centres and transit stations was more remarkable during lockdown periods. Inversely, the reduction in mobility at grocery and pharmacy stores was less significant. Lastly, it was found that the reduction in mobility was more notable in urban areas than rural areas.

A possible explanation is that people living in urban areas, where the population density level is higher, refrain from going out as it might increase the risk of infection. The regression analysis reveals that there is a strong, positive correlation between each pair of variables. However, it was found that mobility did not explain much in the variation of the number of minor accidents. The analysis was not statistically significant as the p-value exceeded the significance criterion of 0.05. Besides, all regression models have been validated, and the assumption of constant variance was satisfied. The total number of traffic accidents over the study period in 2020 has declined by 23% compared to the reference period (2015-2019). The average reduction in the total number of accidents for the four phases of the study period was: before MCO (2%), MCO (73%), CMCO (46%), and RMCO (19%).

Interestingly, the findings suggest that the reduction in mobility has a multiplicative effect on traffic accidents as the reduction in the number of accidents was greater than the reduction in mobility. In terms of the severity of accidents, the number of minor crashes increased by 26%, while the number of severe and fatal accidents decreased by 30% and 32%. Besides, it is worth mentioning that the number of minor accidents surged anomalously during RMCO. It was inconsistent with the growth in mobility. Hence, precautions must be taken by the relevant authorities to prevent this from happening again. The findings also reveal that the reduction in severe and fatal accidents was much higher than the minor accidents during the lockdown period. This suggests a positive effect of COVID-19 lockdown on the severity of traffic accidents. Apart from that, a sudden increase in the proportion of motorcycle accidents during MCO was pointed out due to a spike in the number of food delivery riders. The findings also suggest that bus accidents have reduced most significantly over the lockdown periods. This was mainly due to the

suspension of the long-distance bus services, and people resist using public transit, which might increase the risk of infection. In contrast, the reduction in lorry accidents was the least significant. This indicates that the lorry traffic volumes were not much affected by the lockdown measures. It was known that most of the essential goods were transported by lorries and trucks.

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