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Research article

COVID-19 Lockdown and Decline in Road Accidents in Bangkok, Thailand

Narong Pleerux* and Attawut Nardkulpat

Faculty of Geoinformatics, Burapha University, Chon Buri, Thailand

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Abstract

This study presents the distribution of road accidents in Bangkok, Thailand, during the COVID-19 outbreak (162 days) using spatial statistics. The findings show that the number of road accidents fell by 28.53% during the lockdown period (March 26 to June 14, 2020) compared to before the lockdown period (January 5 to March 25, 2020). There was also a considerable decrease in road accidents by approximately 4.96% compared to the same period in 2019 (January 4 to June 14, 2019). High accident incidence areas were located in central and southwestern Bangkok, and this pattern was also observed before and during the lockdown as well as in 2019. The findings revealed the numbers and patterns of road accidents that occurred during the COVID-19 outbreak. This information can be useful in minimizing and limiting the impact and damage caused by road accidents in Bangkok.

Keywords

COVID-19;
lockdown;
road accident;
Moran's I;
spatial autocorrelation

1. Introduction

According to a report from Wuhan, China, a patient with pneumonia that was caused by the 2019 novel coronavirus (2019-nCoV), commonly known as COVID-19. The infection spread to other cities in China and other nations [1]. The total number of infections worldwide reached 164.28 million, with 3.40 million deaths as of May 18, 2021 [2]. On January 13, 2020, Thailand revealed the number of people in its population who were infected with COVID-19 [3, 4]. After that, COVID-19 spread to several parts of the country and became more severe. Its spread has had serious and extensive economic and social consequences all over the world [5, 6]; tourism has been disrupted, expenditure has decreased, unemployment has increased, and revenue has been lost [7]. The economic impact in Thailand has been substantial. Thailand's state debt was expected to reach 58.7%-59.6% of GDP by the end of 2021, primarily due to borrowing to address problems and stimulate the economy [8].

*Corresponding author: Tel.: (+66) 822313386 Fax: (+66) 38102379
E-mail: narong_p@buu.ac.th

Controlling and reducing the movement of people is one strategy to minimize the transmission of COVID-19. The Thai government enforced a state of emergency to control the spread of COVID-19, which was in effect until March 26, 2020, and later extended. The important guidelines include prohibiting entry into areas where COVID-19 was a risk, closing venues where the disease was a concern, such as stadiums, pubs and bars, and prohibiting travel to Thailand [9]. With the situation of the COVID-19 pandemic still severe and spreading to different areas, the government announced a curfew. People were prohibited from leaving their houses between the hours of 10:00 p.m. and 4:00 a.m. [10]. When the situation improved, the government eased some enforcement measures, and allowed people to exercise outside, sit, and dine in restaurants. For instance, on June 15, 2020, the curfew ended [11, 12]. As a result, people were able to resume their normal activities outside the home.

In normal circumstances, road accidents are a major source of death, injury, and property damage in countries all over the world [13-15], especially in developing countries, where the rate of accidents is extremely high [16]. In response to the COVID-19 pandemic, several countries enacted measures to stop the disease from spreading. Lockdown measures are one strategy that has been used to restrict the back-and-forth movement of people [17]. The government and related businesses supported people working from home, communicating online, scheduling travel time, setting time constraints for opening and closing stores and restaurants, and reducing outdoor activities [18]. The lockdown not only helped to prevent the spread of COVID-19, but it also helped to reduce the number of accidents, injuries, and deaths, as well as the budget for managing accidents and treating the injured. Lockdowns were implemented in Spain [19], the United States [20], Turkey [21], and India [22]. Thailand, on the other hand, has yet to produce any studies on this subject. This study aimed to gain a better understanding of the impact of the COVID-19 outbreak on Thailand's road accidents. The results of this study, therefore, provide crucial information regarding the numbers and patterns of road accidents in Bangkok, and also confirm the accident patterns in each area (or sub-district) of Bangkok when compared to the pre-COVID-19 situation. Additionally, these results will serve as a guideline for solving road accident issues in various Bangkok areas accurately and appropriately.

2. Materials and Methods

2.1 Study area

The area of study is the capital city of Thailand, Bangkok. The city covers 1,568.7 square kilometers in central Thailand's Chao Phraya River delta and was home to 10.5 million people as of 2020, or 15.3% of the country's population. The 2010 census showed over 14 million people (22.2%) lived in the Bangkok Metropolitan Region, making it Thailand's most populous metropolis, dwarfing the country's other cities in both size and economic importance [23].

Bangkok's 50 districts and 160 sub-districts are administrative subdivisions under the Bangkok Metropolitan Administration's (BMA) control. Thirty-five of these districts are located east of the Chao Phraya, while 15 are located on the city's western bank, also known as the Thonburi side [24]. The 50 districts are shown in Figure 1.

The Road Accident Data Center [25] reported that there were 590,069 cumulative accidents and 9,058 fatalities from January to September 2021, with Bangkok having the most accidents, with 62,648 people injured and 536 people killed.

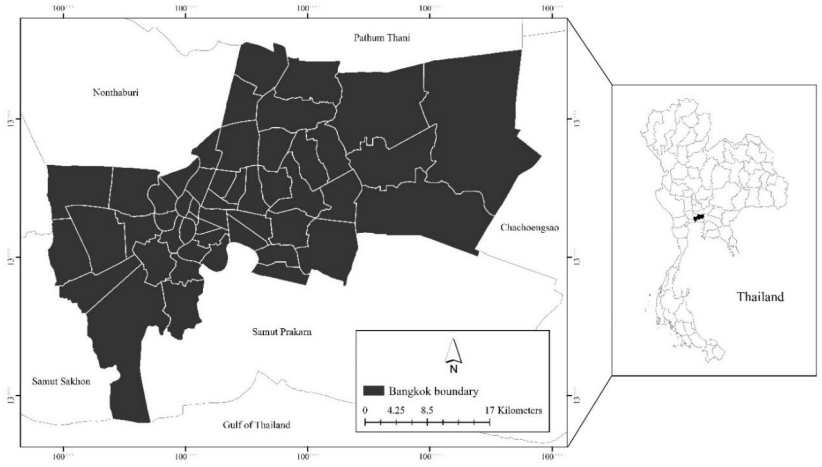

Figure 1. The study area: Bangkok, the capital city of Thailand

2.2 Road accident dataset

Road accident data for Bangkok were collected from the Road Accident Data Center [25] for a total of 162 days from January 5 to June 14, 2020. The first 81 days (January 5 to March 25) were the days before the lockdown, and the next 81 days (March 26 to June 14) were during the lockdown. Road accident data from the same period (162 days) in 2019 (January 4 to June 14), when was before the COVID-19 pandemic, were also used. The periods of the road accident datasets are shown in Figure 2.

Details of the road accident data include date (day, month, and year), time, coordinate system of the accident point, fatalities and injuries. Road accident data were stored in the GIS shapefile format. COVID-19 data were collected throughout the same period as road accident data, from January 5 to June 14, 2020, for a total of 182 days [26]. On January 13, 2019, Thailand's first COVID-19 case was reported.

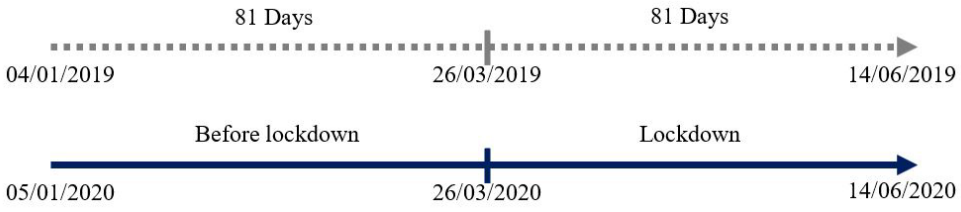

Figure 2. The period of road accident datasets used in this study

2.3 Methodology

2.3.1 Statistical test

The t-test (2-tailed) was employed to compare daily road accidents before and during the lockdown, and to compare them with the road accidents for the same period in 2019 [17, 20].

2.3.2 Spatial autocorrelation and Moran's I statistics

The act of establishing consistent groups of objects based on the amounts of their attributes is known as spatial clustering [27]. There are two types of spatial clustering: global clustering, where a single index summarizes the zone's locational pattern; and local clustering, where sub-zones have a cluster of low values (cold spot) or a cluster of high values (hot spot) [28].

The Moran's I statistical tool, which converts a non-spatial correlation to a geographic context, is one of the most widely used statistics for evaluating spatial autocorrelation [29]. By combining attribute similarity and location adjacency into a single index of Moran's I, the spatial pattern of accident data accounts for both accident locations and their attribute values at the same time. In this study, Moran's global and local indices were used to determine the spatial concentration of road accidents [14, 30]. Moran's I index is drawn as equation 1 [30].

$$I = \frac{N\sum_{i=1}^{N}\sum_{j=1\, j\neq 1}^{N} w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{S_0\sum_{i=1}^{N}(x_i-\bar{x})^2} \forall_i = 1,\dots,n \Lambda \forall_i = 1,\dots,n \quad (1)$$

In equation 1, w_{ij} are the elements of a spatial binary contiguity matrix where weights represent the neighborhood relationships between location i and its neighboring location j, S_0 is the sum of all elements w_{ij}, x_i refers to the variable value (number of road accidents) at the exact location i, x_j is the variable value (number of road accidents) at another location (i/j), $\bar{x}$ represents the average of the variable, and N is the total number of locations. The distribution of road accidents in 2019 and 2020, covering the time before and after the lockdown announcement, was analyzed using Moran's I method. The road accidents were divided into the following groups: before and during the lockdown in 2020, and the road accidents for the same period in 2019.

The values of Moran's I index vary from -1 to 1. Greater negative values indicate spatial dispersion, strong positive values represent greater degrees of spatial clustering of similar values, and zero shows a randomly distributed feature pattern. The null hypothesis, which states that the attribute being investigated is randomly distributed across the features in the study area, is used to understand Moran's I statistics. Then, the Z-score method is used to calculate Moran's I index. A positive Z-score implies that adjacent features have comparable values, whereas a negative Z-score suggests that the adjacent feature has dissimilar values [31, 32]. The ArcGIS 10.0, Spatial Autocorrelation (Moran's I) and Cluster and Outlier Analysis (Anselin Local Moran's I) tools were used to analyze Spatial autocorrelation and Moran's I statistics, respectively.

3. Results and Discussion

3.1 Road accidents and COVID-19 cases

The study lasted 162 days, from January 5 to June 14, 2020, and included data from both before and during the lockdown during the COVID-19 pandemic. During this period, Bangkok had 22,018 road accidents, or 135.91 accidents per day. The average daily road accidents throughout the lockdown period (9,177 times, 113.30 times/day) were significantly lower than before the lockdown (12,841 times, 158.53 times/day, $p < 0.05$), with a decrease of 3,664 times or 28.53%. In addition, as shown in Table 1, in a comparison of the number of road accidents during the study period in 2020 and the same period in 2019, the number of average daily accidents was significantly lower (11,158, 137.75/day, $p < 0.05$). Because the lockdown's primary goal was to prevent the spread of COVID-19, the government imposed various measures such as prohibiting individuals from leaving their

homes between 10:00 p.m. and 4:00 a.m., closing places at risk of disease such as stadiums, pubs, and bars, and shutting down entrance to the country [10]. Furthermore, companies and agencies were also asked by the government to allow employees to work from home and communicate via online channels. Travel was minimized because of these initiatives. When travel is restricted, it has a direct impact on the number of road accidents.

Comparing the number of road accidents in 2019 and 2020 over the study period (162 days), it was found that the number of average daily road accidents in 2020 (22,018 times, 135.91 times/day) was significantly lower compared to the same period in 2019 (23,168 times, 143.01 times/day, $p < 0.05$). The number of road accidents decreased by 1,150 or 4.96%, as shown in Table 1. As can be shown, people were able to live and travel normally in 2019. When the outbreak of the COVID-19 began, they traveled less for work and outdoor activities. As a result, there was a decrease in the number of road accidents [17, 33]. Figure 3 shows that the number of road accidents before the lockdown in 2020 was higher than in the same period in 2019 even though there were no confirmed cases of COVID-19 in Thailand from January 5 to 12, 2020. People were not yet aware of this infectious disease. Therefore, they continued to travel and live normal lives. After the first case of COVID-19 was found on January 13, 2019, the epidemic became more severe. Road accidents began to decrease until the shutdown period when it became evident that there would be fewer road accidents in 2020 than in 2019.

Table 1. Road accidents in Bangkok and the averages before and during the lockdown, and the whole period in 2019 and 2020

Time period	2020 (times)		2019 (times)	
	Total	Average	Total	Average
Before lockdown	12,841	158.53	12,010	148.27
Lockdown	9,177	113.30	11,158	137.75
Whole period	22,018	135.91	23,168	143.01

2019 equivalent period to 2020

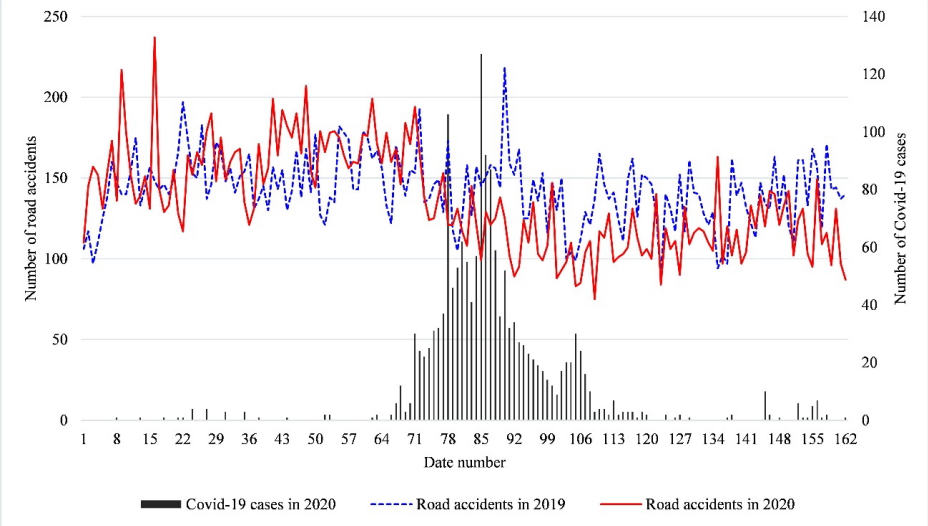

Figure 3. Number of daily road accidents and COVID-19 cases of Bangkok in the study period in 2019 and 2020

3.2 Spatial autocorrelation and Moran's I statistics

The road accident patterns in each Bangkok sub-district examined in this paper were divided into two periods: before and during the lockdown period since the COVID-19 outbreak in 2020 was compared to the same period in 2019. Spatial autocorrelation and Moran's I statistics were used to investigate the patterns of road accidents. Over the study period of 162 days, the number of road accidents in 2020 was significantly reduced compared to 2019. Therefore, a more detailed examination of road accident patterns using spatial autocorrelation or Global Moran's I statistics was done to determine whether the pattern was clustered, scattered, or random. The Global Moran's I results for road accidents is shown in Table 2. In 2020, before the lockdown period, Moran's I was 0.46 and the Z-score was 3.27 ($p < 0.01$). During the lockdown period, Moran's I was 0.45 and the Z-score was 3.20 ($p < 0.01$), while for the whole period of 2020, Moran's I was 0.45 and the Z-score was 3.22 ($p < 0.01$). Compared to the same period in 2019, Moran's I and the Z-scores did not substantially change. Thus, it is clear that traffic accidents in 2020 and 2019 exhibit a clustered pattern before and during the lockdown. Moran's I depend on the proximity of the location and the corresponding attribute of the accident location. Based on the normal distribution assumption, index values were determined using linear distance and the 95% confidence coefficient [32].

Table 2. Global Moran's I for road accidents in Bangkok during the COVID-19 outbreak compared to the same period in 2019

Time period	2020			2019		
	Moran's I	Z	P-value	Moran's I	Z	P-value
Before lockdown	0.46	3.27	0.01	0.48	3.45	0.01
Lockdown	0.45	3.20	0.01	0.50	3.55	0.01
Whole period	0.45	3.22	0.01	0.49	3.52	0.01

Local Moran's I values were examined at the sub-district level in 160 Bangkok sub-districts and displayed as clusters and outliers on a map. Spatial clusters can be seen in the dark blue and dark red areas. They are divided into two types: high accident areas surrounding high accident areas (High-High: HH; dark blue) and low accident areas surrounding low accident areas (Low-Low: LL; dark red). On the other hand, the light blue and light red areas display spatial outliers with high accident areas surrounding low accident areas (High-Low: HL; light blue) and low accident areas surrounding high accident areas (Low-High: LH; light red).

In 2020, high accident sub-districts (HH) were clustered in central and southwestern Bangkok (Nos. 3 and 1). They were extremely similar before and during the lockdown period. Similar accident patterns were observed when compared to the same period in 2019. Low accident aggregation sub-districts (LL) were concentrated in two main areas: the eastern and central regions west of Bangkok (Nos. 4 and 2). These locations showed significant differences between 2020 and 2019. Before the lockdown in 2020, there were 76 LL sub-districts, compared to 82 LL sub-districts during the same period in 2019. During the lockdown period in 2020, there were 75 LL sub-districts compared to 80 LL sub-districts in 2019 (Table 3 and Figure 4). This demonstrates that there were fewer accidents during the COVID-19 outbreak because the government required people to work at home and refrain from engaging in outdoor activities. Because of fewer people traveling, there were fewer accidents. This corresponds to a drop in the number of accidents in several nations affected by the COVID-19 outbreak, such as Spain [19], the United States [20], and Turkey [21].

Table 3. Number of Bangkok sub-districts with a high-high, low-low, high-low, and low-high patterns of road accidents during the COVID-19 lockdown period in 2020 compared to the same period in 2019

Time period	Number of sub-districts in 2020						Number of sub-districts in 2019					
	HH	LL	HL	LH	Not sig	Total	HH	LL	HL	LH	Not sig	Total
Before lockdown	23	76	7	2	52	160	24	82	7	2	45	160
Lockdown	23	75	5	3	54	160	20	80	7	4	49	160
Whole period	20	71	7	2	60	160	20	76	5	2	57	160

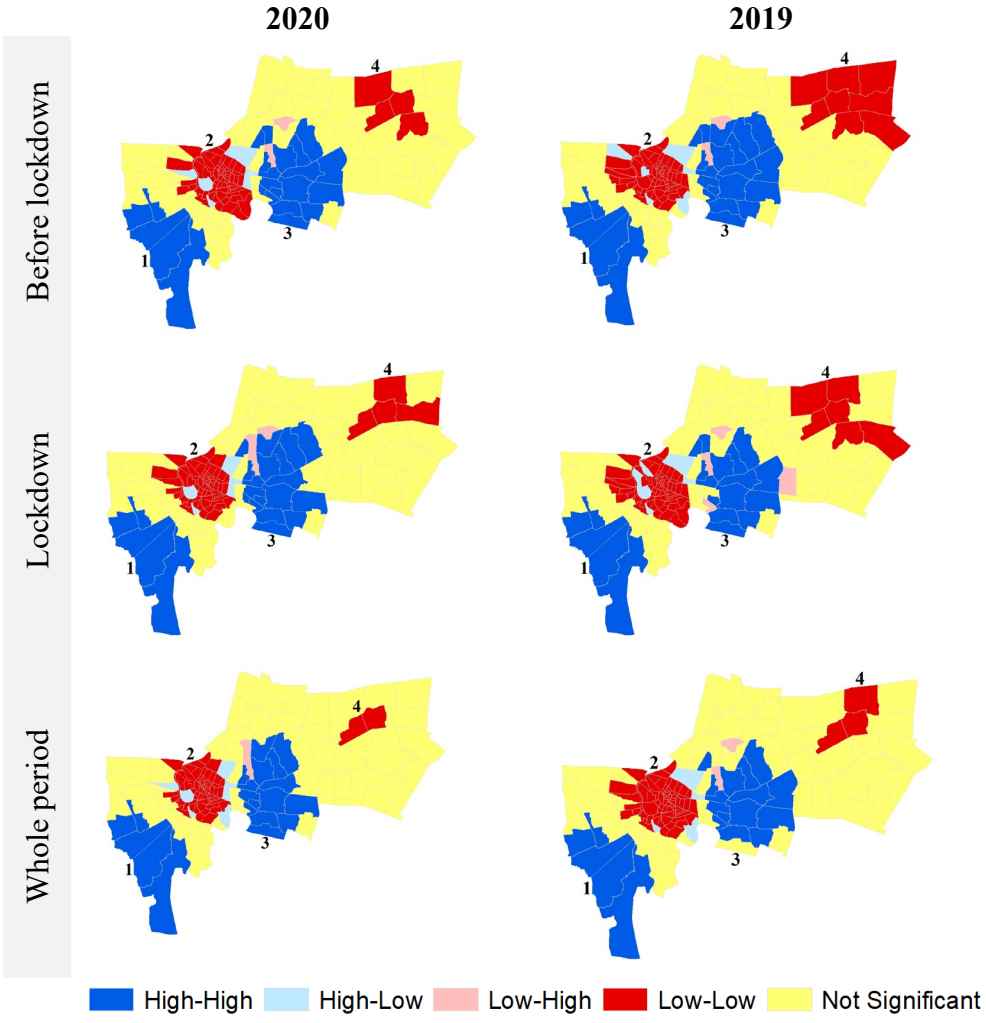

Figure 4. Clusters-outliers map of Bangkok before and during the lockdown since the spread of COVID-19 in 2020 compared to the same period in 2019

Sub-districts with diffuse accident patterns (HL and LH) were found in central Bangkok (Nos. 2 and 3). When the period before the lockdown in 2020 was compared to the same period in 2019, the number of sub-districts with HL and LH patterns was the same. However, there were fewer sub-districts in 2020 than in 2019, even when simply considering the lockdown period, as shown in Table 3 and Figure 4.

The map shows the high accident sub-districts clustered around central and southwestern Bangkok (Nos. 3 and 1) (Figure 4). The pattern was similar for before and during the lockdown period in 2020 and during the same period in 2019, even though fewer accidents occurred during the COVID-19 pandemic as a response to the government's various measures [9-12]. In actuality, the sub-districts with high accidents before the COVID-19 pandemic remained to have high numbers of accidents, although the number of accidents decreased during the COVID-19 pandemic. Similar to this, the sub-districts with lower accidents before the COVID-19 pandemic also had lower accidents during COVID-19. Therefore, the high (HH) and low (LL) accident patterns among these sub-districts remained the same during the COVID-19 pandemic. The accident patterns during the COVID-19 pandemic did not change, regardless of the fact that there were fewer accidents according to the result of this research. A comparison of the number of accidents per sub-district showed that Samae Dam, Suan Luang, Bang Bon, Wang Thong Lang, and Hua Mak had the highest number of accidents in both 2020 and 2019, according to a report from Bangkok's Traffic and Transport Department on accident risk areas [34]. These sub-districts are higher risk areas, and this is essential information that can be used to minimize accidents in Bangkok.

4. Conclusions

The COVID-19 outbreak has had a significant impact on people's health and lifestyles in addition to causing worldwide economic distress. To prevent COVID-19 from spreading, people had to limit their travel and refrain from engaging in outdoor activities. Lockdown restrictions were used in many countries around the world, including Thailand. Lockdowns restrict travel, which reduces the number of road accidents significantly.

The findings of this study reveal that the number of road accidents during the study period of 2020 was much lower than it was for the same time in 2019. The spatial statistics method is a powerful tool for identifying road accident hotspots, and the results of the analysis showed that road accident patterns in Bangkok were similar before and during the lockdown. That is, the pattern of road accidents was not significantly different from the same period in 2019, despite the fact that the number of accidents in 2020 was lower. High (HH) and low (LL) accident areas were still clustered in the same areas. This information can be used by the appropriate agencies to plan for and mitigate the severity of road accidents in these areas.

Only the location of road accidents was employed to analyze spatial patterns in this study. Other factors such as driver behavior, weather conditions, road characteristics, and land use should be included for research that is more comprehensive.

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