

# A Relationship between Traffic Violation Types and Serious Traffic Accident Sites: Spatial Patterns of Serious Traffic Accident

Hyunhee Kim\*, JeongHyeon Chang \*\*

\*Big Data and Public Security Program, Kyonggi University

\*\* Contents Convergence Software Research Institution, Kyonggi University

andreakim@kyonggi.ac.kr, crime\_tiger564@kyonggi.ac.kr

**Abstract**— This study examines whether different types of traffic violations have distinct impacts on traffic accidents in Seoul and investigates the spatial patterns of these accidents to draw practical implications for traffic safety and prevention. Using data from the Korea Road Traffic Authority, two series of analyses were conducted. The results indicate that traffic hot spot sites in Seoul exhibit significant spatial clustering, with Gangnam-gu identified as the area most prone to accidents for both signal and centerline violations. The pronounced concentration of accidents in this district suggests that traffic incidents tend to cluster in specific locations. Regression analyses further reveal that traffic signal violations are associated with a higher number of accidents and greater casualties.

**Keywords**— Traffic accident, Traffic violation, Accident severity, Spatial pattern, Hot spots

## I. INTRODUCTION

The causes of traffic crashes vary across multiple circumstances, with driver negligence being one of the primary factors[1]. Drivers' failure to comply with traffic laws significantly increases the risk of serious accidents. Therefore, examining which types of traffic violations are most strongly associated with serious traffic crashes, as well as their spatial characteristics, may contribute to the development of effective prevention strategies. Furthermore, traffic accidents are not evenly distributed across the city. Similar to patterns observed in crime, certain areas experience a disproportionately higher number of accidents compared to others. In this context, analysing the spatial patterns of traffic accidents, while comparing distinct patterns by violation type, is expected to provide practical insights for the traffic safety and accident prevention literature.

This paper aims to examine the spatial relationship between different types of traffic violations and the locations of serious traffic accidents, using traffic accident hotspot data from Seoul covering the years 2017–2023.

## II. LITERATURE REVIEW

### A. Traffic Violation and Traffic Accidents

Driving behaviors such as speeding, drunk driving, and driving while fatigued are considered key factors contributing to traffic accidents [1]. Previous empirical studies generally conclude that drivers who commit more traffic violations are more likely to be involved in accidents, which often result in severe consequences. For example, Zhang and colleagues (2013) analysed traffic accident data in China and found that traffic violations play a major role in threatening road safety [2]. Similarly, Jiang and colleagues (2021) examined the relationship between traffic violations and accidents in two Chinese cities and reported that approximately 78% of traffic accidents could be explained by the total number of violations [3]. Ayuso et al. (2010) estimated the costs of traffic accidents by violation type, finding that speeding is associated with higher accident costs, indicating more victims and more severe injuries [4].

### B. Spatial Patterns of Traffic Accidents

Traffic accidents within a city do not proportionately distribute, rather they show the patterns of concentration [5]. These cluster of traffic accidents are commonly observed in the center of the city, in more commercial areas, business district, areas with more traffic volume, even more crime. For instance, Hwang and Ko (2024) also examined pedestrian and non-pedestrian traffic accidents in Seoul and found strong clusters for both types of traffic accidents [6]. Kim et al. (2017) analysed traffic accidents data from Ulsan in Korea. The results indicate that traffic accidents tend to show clusters in the center of the city [7]. More importantly, this cluster is more apparent for traffic accidents involving traffic signal violation.

## III. METHODS

### A. Data

For this study, data from the Korea Road Traffic Authority Department (KRTAD) were utilized. KRTAD collects detailed information on traffic accidents, including the presence of traffic violations, the number of casualties, and the location of each accident. In addition, KRTAD identifies traffic accident hot spot sites according to the type of traffic violation. This

study analyzes traffic accident hot spot data for the period 2017–2023. Over these seven years, KRTAD identified 1,380 serious car accident hot spot sites.

Furthermore, data is manipulated to examine the spatial patterns of serious traffic accidents. In particular, the Seoul metropolitan area was divided into 1,000-foot grids, and the total number of car accident hot spot sites within each grid was calculated. A total of 3,229 grids were created. To explore variations in spatial patterns by violation type, the data were further disaggregated according to specific traffic violations. Table 1 presents the structure of the data. Each row in the dataset represents a traffic accident hot spot site corresponding to a specific type of traffic violation. For example, the first site is located in Nonhyeon-dong, where three traffic accidents occurred, all of which involved traffic signal violations.

TABLE 1. STRUCTURE OF DATA

| Dong    | Accident | Death | Serious Injury | Location                 | Traffic Violation    |
|---------|----------|-------|----------------|--------------------------|----------------------|
| Nonhyun | 3        | 0     | 2              | (127.02442, 37.5047814)  | Signal Violation     |
| Nonhyun | 7        | 0     | 5              | (127.060498, 37.5139213) | Centerline Violation |
| Nonhyun | 2        | 0     | 4              | (127.042757, 37.5025734) | Signal Violation     |

Table 2 presents the descriptive statistics illustrating the characteristics of the data. Among the 1,380 traffic accident hot spot sites, 56% involved signal violations, while the remaining 44% involved centerline violations. On average, each site experienced 5.7 traffic incidents over the seven-year period. The average number of casualties per site was 9.18, ranging from a minimum of 2 to a maximum of 20.

TABLE 2. DESCRIPTIVE STATISTICS

|                        | Mean or Fre (%)                            | S.D  | Min | Max |
|------------------------|--------------------------------------------|------|-----|-----|
| Violation              | Signal: 768 (56%)<br>Centerline: 612 (44%) |      |     |     |
| # of Traffic Accidents | 5.7                                        | 2.49 | 2   | 20  |
| # of Casualty          | 9.18                                       | 5.48 | 2   | 48  |
| # of Death             | 0.06                                       | 0.24 | 0   | 2   |

## B. Analysis

For this study, two analytical approaches were employed. First, to examine the spatial patterns of serious traffic accidents, with a focus on clusters and concentrations, kernel density estimation was used. This method calculates the point density of the variable of interest within a defined area and effectively visualizes the distribution of serious traffic accident sites across the city. Second, Local Indicators of Spatial Association (LISA) were applied to identify statistically significant concentrations of events while accounting for spatial correlation between spatial units. Using the LISA maps, areas with concentrated serious traffic accident sites were identified in Seoul. Finally, a series of regression analyses were conducted to examine factors

influencing both the number of serious traffic accident sites and the severity of traffic accidents by traffic violation type.

## C. Spatial Patterns of Serious Traffic Accidents in Seoul

Figure 1 illustrates the spatial patterns of serious traffic accident sites involving centerline violations. The kernel density scores indicate areas with higher concentrations of traffic accident hot spots. According to the map, a greater number of hot spot sites are located in Gangnam-gu, while Dongdaemun and Yeongdeungpo-gu exhibit moderate concentrations of hot spots.

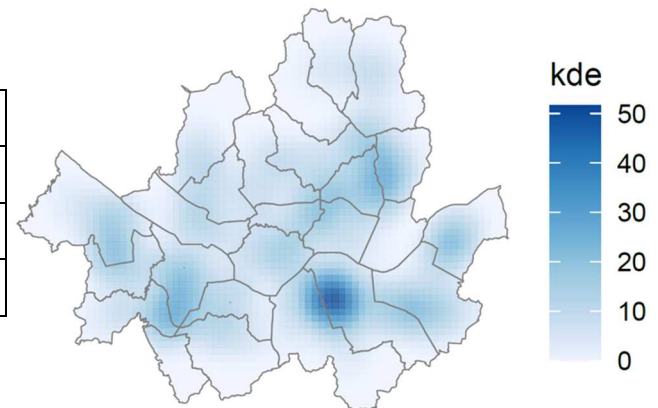


Figure 1. Spatial Patterns of Serious Traffic Accident Sites for Centerline Violation

Figure 2 illustrates the spatial patterns of serious traffic accident sites involving traffic signal violations. Similar to the map for centerline violations, Gangnam-gu emerges as a primary area with a high concentration of accident sites. Additionally, more pronounced hot spots are observed in Songpa-gu and Jongno-gu.

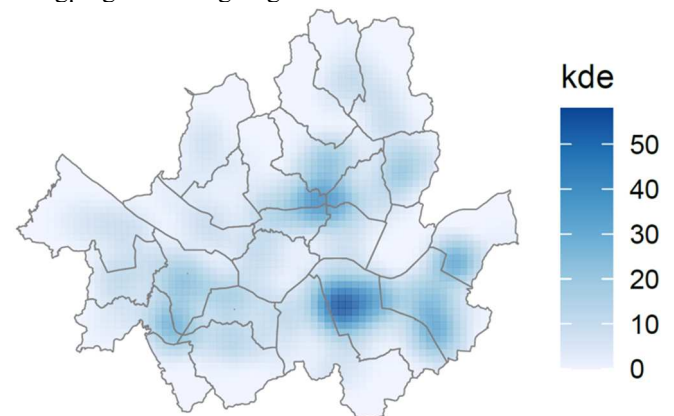


Figure 2. Spatial Patterns of Serious Traffic Accident Sites for Traffic Signal Violation

By comparing the two maps, it is evident that Gangnam-gu experiences a high concentration of serious traffic accident sites for both types of traffic violations. When examining each

violation type individually, hot spots for traffic signal violations appear more pronounced, whereas hot spots for centerline violations exhibit a more widespread spatial distribution.

Figure 3 visualizes the concentration of traffic accident hot spot sites in the city. The LISA map shows statistically significant clusters of high-high and low-low areas. Grid areas colored in red represent high-high concentrations, while blue areas indicate low-low concentrations. For centerline violations, several high-high clusters are observed across the city, with particularly significant concentrations in Gangnam-gu. Areas adjacent to these high-accident zones also tend to experience a high volume of accidents. Similar hot spot clusters are observed in Guro-gu, Dongdaemun-gu, and Yeongsan-gu.

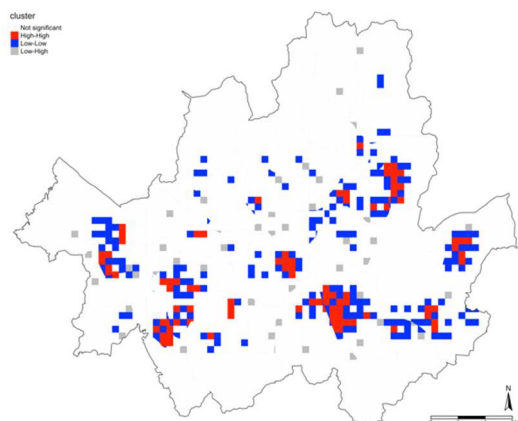


Figure 3. Serious Traffic Accident Concentration for Centerline Violation

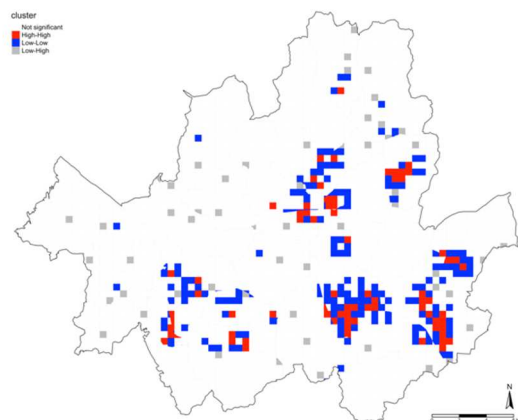


Figure 4. Serious Traffic Accident Concentration for Signal Violation

Figure 4 presents the LISA map for traffic accidents involving signal violations. Compared to the LISA map for centerline violations, fewer clusters are observed. High-high concentrations appear in Gangnam-gu and Songpa-gu, while grids in the western part of Seoul show relatively few traffic accident hot spots. This distinction suggests that the spatial patterns of traffic accidents differ between centerline and signal violations.

The regression analysis further highlights the effects of different types of traffic violations on accident frequency and

casualties. Compared to centerline violations, traffic hot spot sites with signal violations experience approximately 4 more accidents. The model fit indices indicate that around 59% of the variation in accident counts is explained by the type of violation. Regarding casualties, sites with signal violations experience roughly 7 more, although the model explains relatively less variation in this outcome, accounting for only 40%.

TABLE 3. REGRESSION ANALYSIS (N=1,380)

|                      | # of Traffic Accidents |          | # of Casualties |          |
|----------------------|------------------------|----------|-----------------|----------|
|                      | Coeff                  | t-value  | Coeff           | t-value  |
| Centerline Violation | -                      | -44.8*** | -7.02(0.22)     | -30.6*** |
| Constant             | 7.41(0.05)             | 129.2*** | 12.29(0.15)     | 80.67*** |
| F-value              | 2007***                |          | 942***          |          |
| R-squared            | 0.592                  |          | 0.406           |          |

Note. \*\*\* =  $p < .001$

#### IV. CONCLUSIONS

This study aims to examine the effects of traffic violations and identify spatial patterns of traffic accidents in Seoul. Two meaningful findings emerged. First, traffic signal violations are associated with more traffic accidents and casualties compared to centerline violations. Although both types of violations have serious consequences, the adverse outcomes are more pronounced for accidents caused by traffic signal violations. In this regard, traffic enforcement—whether by police presence or electronic devices such as surveillance cameras should prioritize traffic signal violations.

Second, the analysis indicates that traffic accidents are concentrated in specific areas, particularly in Gangnam-gu. Significant high-high clusters, where accidents are densely concentrated, were observed in this district. This finding suggests that efforts to reduce traffic accidents should focus on these hot spot areas. Given the concentration of accidents in certain locations, identifying common risk factors and allocating more resources to address traffic safety in these areas would be an essential first step in improving road safety.

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**Hyunhee Kim** is a first year graduate student of Big Data and Public Security program in Kyonggi University. Her research interest focuses on traffic accidents, crime prediction, and CCTV data analysis. She is also a student member of the Contents Convergence Software Research Institute in Kyonggi University.



**JeongHyeon Chang** received his Ph.D. degree in Police Administration from Kyonggi University, South Korea, in 2017. From 2019 to 2020, he served as an Assistant Professor in the Department of International Political Science at the University of Halla. In 2020, he joined the Contents Convergence Software Research Institute at Kyonggi University, where he is currently a Research Professor. His research interests span data-driven crime prevention, community-oriented policing strategies, and intelligent public safety systems that integrate AI and digital content technologies. He has extensively worked on computational crime analysis, video-based risk detection, and context-aware public safety models. He is also the Principal Investigator (PI) of a National Research Foundation of Korea (NRF) Young Scientist Program in the engineering field, where he leads a Creative Challenge Project focusing on AI-driven public safety analytics and intelligent crowd-risk prediction architectures.