Use of Spatial Analysis Techniques to Identify Statistically Significant Crash Hots Spots in Metropolitan Melbourne

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Abstract

Traditional statistical techniques have limitations in analysing crashes as these techniques assume spatial independence and stationarity. Crashes break these assumptions as they tend to cluster at specific locations (spatial dependency) and vary from one location to another (non-stationarity). Several spatial statistical methods were used to examine crash clustering in metropolitan Melbourne, including the Getis-Ord Gi* method which identified statistically significant crash clusters. Using this method, the degree, location and extent of clustering were found to vary for different crash categories, with fatal crashes exhibiting the lowest level of clustering and bicycle crashes exhibiting the highest level of clustering.

Background

Understanding where, when, what type and why crashes are occurring can help in determining the most appropriate initiatives to reduce road trauma. As crashes are influenced by spatial factors (Loo & Yao, 2012), spatial statistical analysis techniques are better suited to analysing crashes than traditional statistical techniques (Gudes, Varhol, Sun & Meuleners, 2017). Traditional statistical techniques assume spatial independence and stationarity, however crashes exhibit spatial autocorrelation (spatial dependence) clustering at specific locations such as on vertical and horizontal curves (Mohaymany, Shahri & Mirbagheri, 2013) and they exhibit non-stationarity, varying from one location to another. Failure to account for spatial autocorrelation can lead to interpretation errors (Getis & Ord, 1992).

Method

Several spatial statistical tools from the Esri ArcGIS 10.3.1 for Desktop software package were used to examine crash clustering in metropolitan Melbourne, including the Spatial Autocorrelation (Morans I) tool to explore clustering of crashes globally (for the entire study area), Kernel Density Estimation (KDE) to identify areas with a high density of crashes and the Getis-Ord Gi* hot spot analysis method to identify statistically significant casualty crash hot spots. Police-reported casualty crash data for the 2012 to 2016 period were used in the analysis. The crash data was segmented by year, time-period, crash severity, crash type and vehicle type and the Global Moran's I method was used to investigate global clustering and the Getis-Ord Gi* method was used to identify statistically significant casualty crash hot spots for the different categories. The output from the Getis-Ord Gi* analysis was overlaid with land use and road classification data.

Results

The Global Moran's I statistic identified statistically significant global clustering for 2012-2016 metropolitan Melbourne casualty crashes and for each of the crash categories with the exception of fatal crashes and crashes involving certain vehicle type (light commercial vehicles, buses and trams), indicating a random global pattern for each of these four crash categories. This method, however, was unable to identify if there was clustering at a local level, nor where the clustering occurred.

Although the Kernel Density Estimation method identified areas with a higher density of crashes, it was unable to identify whether the clusters were statistically significant. This method was therefore not used for the analysis of the individual crash categories.

The Getis-Ord Gi* method was able to identify local crash clustering and indicate whether the clustering was statistically significant or not. This method identified that only 15.7 per cent of casualty crash locations in metropolitan Melbourne had statistically significant hot spots at the 95% confidence level. It also found that the degree of clustering, as well as the location and extent, varied for the different crash categories, with fatal crashes exhibiting the lowest level of clustering (1.8%) and bicycle crashes exhibiting the highest level of clustering (22.5%). For example, locations with hot spots clusters include the Melbourne Central Business District (CBD) and its surrounds, and high activity areas such as Dandenong and Footscray. Bicycle crash hot spot clusters were mainly located along popular bicycle routes, including the CBD. Heavy vehicle crash hot spot clusters, on the other hand, were mainly located around industrial areas. Investigation of temporal factors has shown that some crash clusters are persistent from year to year, some only occur in one year and not in other years, others decline over time whilst others emerge over time.

Overlaying the results with other spatial data such as land use and road classification found that hot spot clusters were located in areas with a higher proportion of commercial land use and a higher proportion of arterial and sub-arterial roads compared to the total metropolitan Melbourne area.

Conclusion

Spatial analysis techniques can help with understanding where, when, what and why crashes are occurring. This understanding is important for developing initiatives to target road trauma and ensuring that the right interventions are applied in the right locations. The use of spatial statistical analysis techniques can lead to more effective remedial treatments as they enable statistically significant crash clusters to be distinguished from random crash locations. An understanding of how hot spot locations have changed over time is important for efficient allocation of resources by ensuring effort is put into persistent and emerging clusters rather than declining clusters. Knowing which clusters are emerging can allow early intervention and prevent further injuries and fatalities.

References

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