*Featured graphics*

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# A network-constrained spatial identification of high-risk roads for hit-parked-vehicle collisions in Brisbane, Australia

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## Abstract

The severe loss of human life and material damage caused by traffic accidents is a growing concern faced by many countries across the world. In Australia, despite a decline in the total number of traffic collisions since 2001, the number of hit-parked-vehicle (HPV) collisions as a special type of road accident has increased over time. Utilizing the road collisions and roadway network data in Brisbane, Australia over a 10-year period from 2001 to 2010, we generated graphics illustrating the spatial patterning of high-risk road segments for HPV crashes identified using the local indicator of network-constrained clusters (LINCS) approach. These spatial patterns vary by days of the week and times of the day. Roads with high risk for HPV collision tend to occur in high-density road networks and cluster around road intersections. The methodology applied in this work is applicable to other network-constrained point-pattern analysis.

## Keywords

Hit-parked-vehicle collision, network-constrained spatial statistics, local indicator of network-constrained clusters, Brisbane

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The severe loss of human life and material damage caused by traffic accidents is a growing concern faced by many countries. In Australia, despite a decline in the total number of traffic collisions since 2001, the number of hit-parked-vehicle (HPV) collisions as a special type of road accident has increased over time. HPV collision occurs when a mobile vehicle hits an unattended or stationary vehicle parked by the roadside, which accounted for 5% of all traffic accidents in Brisbane between 2001 and 2010 (DTMR, 2012), increasing in frequency over this timespan due to the growing number of vehicles and limited roadside parking space. The graphics herein illustrate high-risk road segments for HPV in Brisbane by a novel spatial statistical approach that depicts the spatiotemporal patterns of HPV collision clustering over different times of the day and days of the week.

Two datasets were utilized in generating the graphics: road collisions data and roadway network data within the Brisbane City jurisdiction, sourced from the Department of Transport and Main Roads. A total of 2869 records of HPV collisions from 2001 to 2010 in Brisbane was extracted and geocoded in GIS. The local indicator of network-constrained clusters (LINCS) method (Yamada and Thill, 2010) was used to extract high-risk road segments for HPV collisions, where clusters were identified by comparing the similarity of each road segment with its neighbouring segments. Through the data analysis suite of GeoDaNet, the road network data were split at road intersections, and the HPV data points were snapped to the nearest road segment. By aggregating the number of HPV collisions by road segment, a new attribute for each snapped road segment was created. The network-constrained spatial weight matrix was calculated with node-based neighbouring relationships, a direct way to define two road segments as neighbours if they share the same junction (Hoef et al., 2014). This was achieved using the Spatial Modelling Tool of Stream Networks package in R studio (version 3.2.5) and the LINCS for each road segment were calculated (Yamada and Thill, 2010).[1] 3D graphics illustrating roads at high risk of HPV collisions were generated using ESRI's ArcScene. The height of the vertical bars represents the degree of risk for HPV collisions according to the value of the LINCS statistics. Figure 1 illustrates the spatiotemporal pattern of road segments exposed to HPV collision over four time periods of the day, differentiated by colour. Figure 2 illustrates its spatial variation from Monday to Thursday (a), and Friday to Sunday (b). Friday was grouped together with Saturday and Sunday given the relatively higher number of HPV collisions on Fridays, and the spatial pattern closely resembles the pattern on weekends. Three circular rings were added as distance references from the city centre at 5, 10 and 15 kilometres.

The graphics show that high-risk road segments are primarily concentrated in the Brisbane central business district, and in areas near the inner-city ring. Suburbs north and east of the Brisbane River were exposed to a higher risk of HPV during the 1:00–6:00 period and lower risk in the 13:00–18:00 period. In the south-west areas within the inner-city ring and the eastern suburbs towards the coastline, the risk is lower in the 1:00–6:00 period but higher in the 19:00–0:00 period. The distribution of high-risk roads is dispersed during the day but concentrated within the 10 km circular ring in the morning (7:00–12:00) and within the 5 km ring in the afternoon (13:00–18:00). Spatial patterns differ between Monday–Thursday and Friday–Sunday, with high-risk roads dispersed throughout Brisbane for the Monday–Thursday period but concentrated within the 5 m ring. For the Friday–Sunday period, high-risk roads are primarily constrained within the 10 km ring. Further investigation reveals that roads at high risk of HPV collisions are more likely to be intersecting road corridors between main roads and side streets, or those in close proximity to T-junctions, intersections and roundabouts; they also tend to occur along the ramps to highways and motorways, which may be caused by malfunctioning vehicles temporarily parked at road shoulders that are

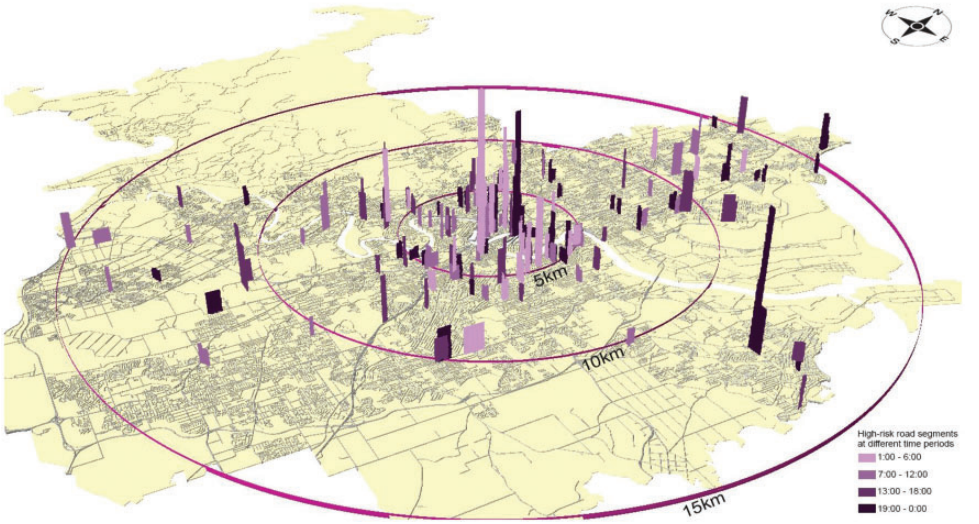


**Figure 1.** 3D visualization of high-risk roads for HPV collisions over four time periods during the day.

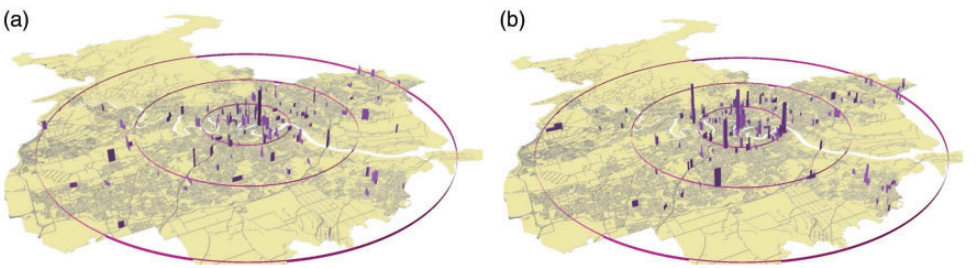


**Figure 2.** High-risk roads for HPV collisions in Brisbane by days of the week: (a) Monday to Thursday; (b) Friday to Sunday.

exposed to high speed and greater volume of traffic flow. The methodology used in this study is applicable for other network-constrained point-pattern analysis.

## Software

GeoDaNet; ArcGIS 10.6; ArcScene; R Studio (version 3.2.5).

## Declaration of conflicting interests

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## Note

1. Similar to the Global Moran's I, the LINCS statistic is calculated as follow:

$$I_i = \frac{(n-1)(x_i - \bar{X})\sum_{j=1,j\neq i}^{n} w_{i,j}(x_j - \bar{X})}{\sum_{j=1,j\neq i}^{n}(x_j - \bar{X})^2}$$

where $I_i$ is the LINCS statistic at road segment $i$; $x_i$ and $x_j$ are the number of HPV collisions for road segment $i$ and $j$, respectively; $\bar{X}$ is the average number of HPV collisions of all road segments; $n$ is the total number of road segments with HPV collisions; $w_{i,j}$ is the network-constrained spatial weight matrix representing the connectivity between road segments $i$ and $j$ (i.e., it designates whether $i$ and $j$ share any common node).

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