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Foreword | *Malicious hoax calls for service and suspicious fires are a significant burden to the community financially and in the potential danger they present, yet little is known about the dynamics associated with their prevalence. The present research is the first of its kind in Australia to comprehensively examine these offences using unit-level location data supplied by the Queensland Fire and Rescue Service. The aim of this research is to identify the temporal and spatial patterning of malicious hoax calls and suspicious fires. Analyses employed advanced methods of geographic visualisation and statistics to track the changing spatial patterns of these events over 13 years. Understanding the patterning of fire events provides an evidence base for initiatives designed to reduce the incidence of hoax calls for service and suspicious fires.*

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Malicious hoax calls and suspicious fires: An examination of their spatial and temporal dynamics

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Malicious hoax calls and suspicious fires are a significant burden to the community in terms of financial costs, as well as the potential danger caused by deliberate ignitions and a reduction in the availability of finite resources to respond to legitimate emergencies. In 2008, in the United Kingdom, malicious hoax calls to the fire brigade cost taxpayers more than \$73m per annum (Nugent & Sidders 2008) and in Queensland, malicious hoax calls comprise three percent of all call-outs. This includes a 1.4 percent increase over the period 2002 to 2007 (QFRS 2008). Suspicious fires also have a significant impact. The New South Wales Fire Service reported a \$38m annual cost associated with property loss (NSWFB 1994) and it is suggested that suspicious fires account for roughly half of all vegetation fires reported in Australia (Bryant 2008). However, very little is known about the dynamics of either malicious hoax calls or suspicious fires, even though they are prosecutable offences. While some studies find that malicious hoax calls and suspicious fires are more prevalent in economically disadvantaged areas (Corcoran, Higgs & Higginson 2010; Hirschfield & Bowers 2004), to date, international research has not explored the micro-geographical dynamics of these incidents or their evolution over time. Adopting a micro-geographic approach can identify persistent, transient and emergent dynamics of hotspots that can be used to inform optimal resource allocation in anticipation of likely load.

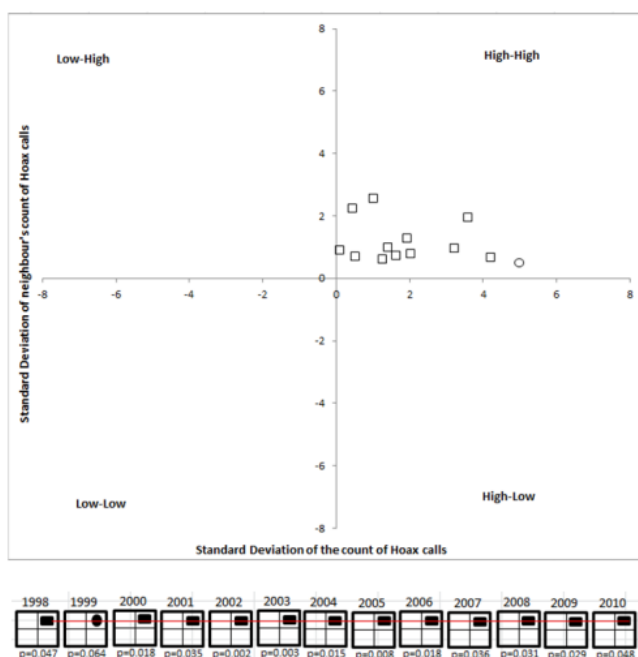
Recent studies in criminology demonstrate that crime has distinct and disguisable spatial dimensions (eg see Morenoff, Sampson & Raudenbush 2001). Neighbourhoods near or next to other criminogenic places are likely to experience more crime, whereas neighbourhoods further away experience less crime. Therefore, incidents of crime and disorder have spill-over effects. Put another way, contiguous areas influence each other in ways that either prevent or facilitate crime and disorder.

Until recently, the goal of criminological research has been to explain away or control these spatial dependencies. However, as Townsley (2009: 453) argues, through the theoretical



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Figure 1 An example local Moran temporal plot



advances of environmental criminology, the 'spatial structure of areas and their respective adjacency to other areas' are slowly becoming central points of interest in their own right.

Studies in criminology largely focus on the more traditionally investigated offences such as homicide or drug use to the exclusion of other types of offences that may also cause social harm to society. This paper redresses this gap in previous research by placing the location of the offences at the centre of empirical investigations. For the first time, the application of advanced geographic and temporal visualisation and statistical techniques are deployed to identify the spatial and temporal dynamics of malicious hoax calls and suspicious fires across Queensland.

Aims of the research

The aim of the research is to employ geographical statistical measures to identify hotspots and coldspots and map their evolution over time. Using the State Suburb as the spatial unit of analysis, the research is guided by three principal questions:

1. To what degree are malicious hoax calls and suspicious fires spatially concentrated in Queensland?
2. How has the spatial concentration of events varied over time?

3. To what extent are these spatial concentrations *persistent, transient or emergent*?

Data

Fire incident data

Queensland fire incident data for a period of 13 years (1 January 1998 to 31 December 2010) were provided by the Queensland Fire and Rescue Service. The data include all calls for service under the categories of malicious hoax calls and suspicious fires.

Malicious hoax calls are defined in the fire database as *malicious or mischievous calls including alarm activations and manual call points*. Suspicious fires are defined in the fire database as *fires of incendiary nature where physical evidence indicates that the fire was deliberately set and no accidental or natural ignition factor could be found*. Of the 19,119 malicious hoax calls reported in the fire database, a total of 19,051 (99.6%) possessed the necessary spatial reference (the map grid reference) and geographic precision (ie the map grid reference was complete and correct) for inclusion in this research. In relation to suspicious fires, there were 19,916 reported in the fire database, from which a total of 19,732 (99%) were geocoded. The subsequent analyses presented in this paper draw upon these geocoded data.

Measurement of spatial concentration

Spatial research allows for the examination of the geographic distribution of crime in a given area while also considering the impact of characteristics in neighbouring geographical areas. The extent of spatial dependency in State Suburbs can be measured both globally and locally. Global spatial correlation measures the degree to which fire incidents across the entire study region exhibit either positive spatial autocorrelation (ie areas with high counts/rates are surrounded by areas similarly high rate/counts) or negative spatial autocorrelation (ie where areas with low and high rates occur adjacent to one another). The standard measure for spatial autocorrelation at the *global* scale is Moran's I statistic (Moran 1950).

The *local* Moran's I statistic captures evidence of *local* spatial autocorrelation, recognising there is the possibility of spatial heterogeneity and that the degree of autocorrelation may vary within a study region. The importance of locally varying spatial patterns and in particular the identification of hotspot areas has been identified by Getis and Ord (1992) and more recently in relation to crime by Ratcliffe (2010). Ratcliffe (2010) also suggests that the local Moran's I statistical approach can help to identify subregions of greater spatial homogeneity and as a result, may be less vulnerable to the modifiable areal unit problem (Openshaw 1984; 1977), where the use of different administrative boundaries or different scales of aggregation can dramatically alter the outcome of an analysis.

The key output from the local Moran's I analysis for this research is the Moran scatter plot that is used to visualise how the local Moran statistic contributes to the overall global Moran (see Figure 1 for an example). The horizontal axis shows the normalised value of the attribute of each area, while the vertical axis shows the normalised spatially weighted value of the neighbouring areas. Each point in the scatter plot represents an annual count of fire calls for an individual suburb. There are four important areas to the scatter plot, formed by the vertical and horizontal axes, which describe an area to be either a spatial cluster or outlier. A spatial cluster

can comprise either an area with high values of a variable (such as malicious hoax calls), surrounded by areas with similarly high values or the opposite scenario—an area with low values surrounded by areas with similarly low values. Conversely, a spatial outlier is indicative of areas that have high values, surrounded by areas that have low values or vice versa.

Tracking spatial concentrations over time

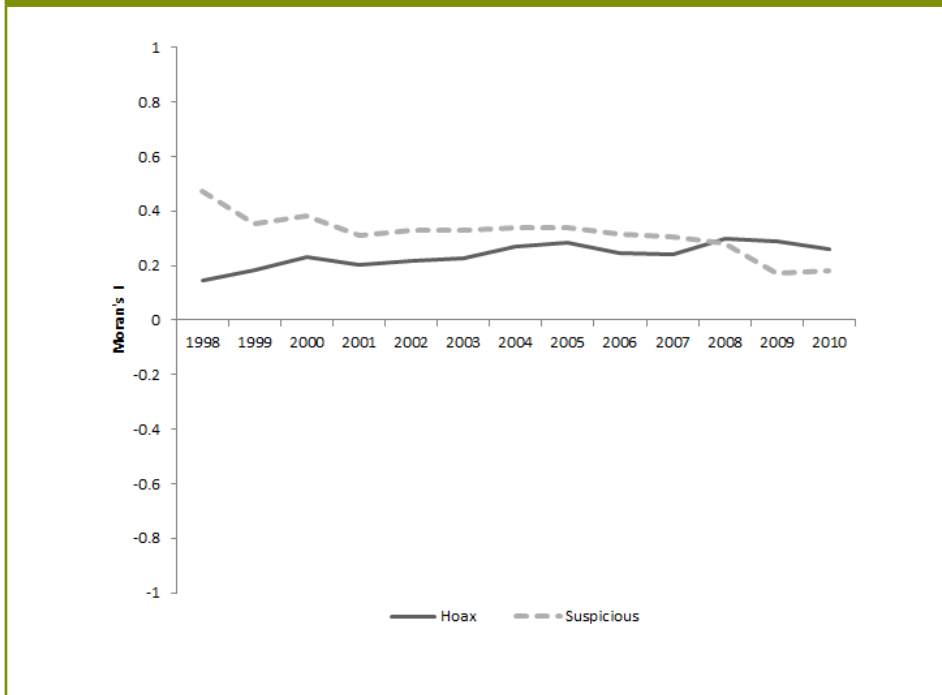
To track the evolution of spatial clusters and outliers over time, an augmentation of the original Moran scatterplot technique has been recently developed by Corcoran (see Vidyattama, Cassells & Corcoran 2010 for a detailed account of this technique).

The local Moran statistic is computed for each year (1998 to 2010) and then graphed for each State Suburb in a single Moran scatter plot, which has been termed a *Moran temporal plot*. Each year is represented as either a square (statistically significant) or a circle (not statistically significant) to depict whether or not the Moran's I score for that particular year was statistically significant. All years are plotted within a single graphic, using the square and circle representation in the Moran temporal plot. The Moran temporal plot is a simplified summary of temporal movement and appears at the base of Figure 1. This simplified summary depicts the change in cluster or outlier type (and associated statistical significance) over the 13 year period using the same square and circle symbology as previously described. By adopting this innovative technique and coupling each of the components of this figure together, the scatterplot and the summary of change permits a qualitative visual assessment of whether a State Suburb might be considered persistent, transient or emergent.

For the current study, a simple heuristic was defined to help distinguish between the three types (persistent, transient or emergent) based on the number and type of statistically significant transitions. A *transition* refers to the change in cluster/outlier type in adjacent years.

Using the simplified summary of temporal movement at the base of Figure 1, statistically significant transitions (ie 2 adjacent years that both are represented using a square indicative of a statistically significant result) can be summed and

Figure 2 Change in the global Moran statistic



described in terms of the number of years in which a particular State Suburb exhibited one of the four types of cluster/outlier (ie high-high, low-low, high-low and low-high).

Figure 1 shows a State Suburb with significant high-high clusters for 12 of the 13 years, indicating that this State Suburb had consistently high numbers of hoax calls during these time periods, as did adjacent State Suburbs. In this example, this pattern would be considered a *persistent* hot spot of malicious hoax calls in which the majority (83%) of significant transitions are located in the same cluster type (high-high).

Results

To assess change in spatial concentration over time, the *global* Moran statistic for malicious hoax calls and suspicious fires for each year over the 13 years was computed (see Figure 2). For malicious hoax calls (dark line), each year in the 13 year period was positively spatially autocorrelated, with some evidence to suggest that the strength of this has increased over time. For suspicious fires (dashed line), the relationship is broadly the same as malicious hoax calls in that each year is positively spatially autocorrelated but with some evidence to suggest that the strength of this has decreased over time—that is, the spatial association has tended towards a more random distribution with the index value (denoted as 'Moran's I' on the y-axis) approaching 0. Or in other

words, the level of incidents in neighbouring suburbs appears to be more strongly associated with malicious hoax calls.

Next, to unpack this global relationship and explore local (State Suburb level) patterns of spatial arrangement and their evolution over time, the local variant of the Moran statistic was employed. Here, the Moran temporal plot (described in detail previously) is used to explore changes in the spatial typology of a State Suburb and helps to perform a qualitative visual assessment of whether the trends in a State Suburb over time might be considered persistent, transient or emergent (see Figure 3).

For malicious hoax calls, there were 1,888 statistically significant transitions over the 13 years, which equated to eight percent of the total possible transitions ($n=23,580$). The relatively low proportion of significant transitions (in relation to all possible transitions) was a function of either the State Suburb not being part of a statistically significant cluster or outlier in either or one of the time periods; or, in other words, one or both of two consecutive years (eg 1998 and 1999) were not statistically significant and therefore could not be considered as part of a significant transition.

The highest numbers of State Suburb transitions (849 or 45% of the total significant transitions) were high-high to high-high transitions equating to an 83 percent retainment; or 83 percent of

high-high State Suburbs in the first time period remained high-high in the second time period. The smallest number of State Suburb transitions were low-low (16 or 0.8%), with an 89 percent retention. The low-high outlier type was the second largest transition type with 709 (38% of all transitions), which was associated with an 81 percent retention rate. Finally, the high-low type captured 144 or eight percent of transitions, with a 98 percent retention rate. Overall, this shows that over time, the rate of malicious hoax calls in an area is relatively stable and also that neighbouring areas tend to remain stable. As such, these local Moran

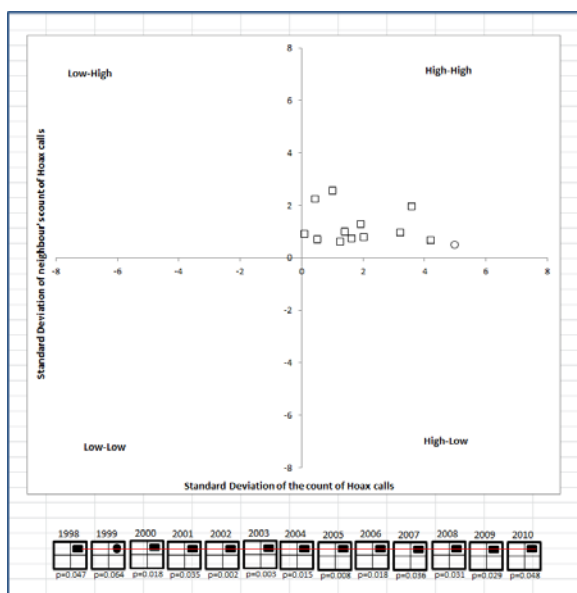
plots demonstrate malicious hoax calls to be a fairly persistent phenomenon, potentially making it easier to target resources to tackle the issue.

Next, investigating the movement between cluster and outlier types, the largest change was observed between high-high (cluster) and low-high (outlier). Here, there were 165 moves (or 9% of transitions) between low-high to high-high and 144 (8%) transitions between low-high and high-high. In summary, there is evidence of predominant local clustering (in particular high-high clusters), with a small strengthening of such spatial arrangement over the 13 years.

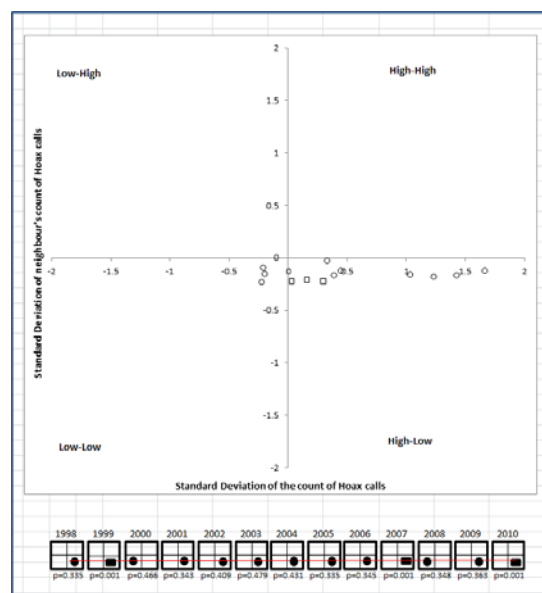
For suspicious fires, there were 1,773 statistically significant transitions over the 13 years, which equated to 7.5 percent of the total possible transitions ($n=23,580$). The highest number of State Suburb transitions (966 or 54% of the total significant transitions) were high-high to high-high transitions, equating to an 84 percent retainment rate. The smallest numbers of State Suburb transitions were high-low (99 or 5.6%), with an 85 percent retention rate. The low-high outlier type was the second largest transition type with 198 (11% of all transitions), which was associated with only a 54 percent retention

Figure 3 Local Moran temporal plots for malicious hoax calls

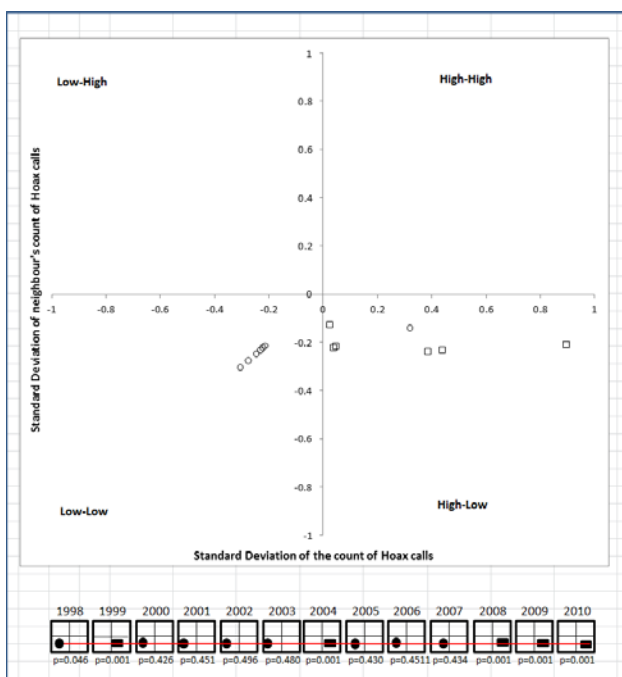
Persistent



Transient



Emergent



Persistent—meaning maintaining the status quo or no change, but characterised by a predominance of significant transitions. In the example, there is a predominance of significant transitions (91%) over the 13 year period, all of which are in the high-high cluster. This means that both this State Suburb and surrounding State Suburbs are high in the number of malicious hoax calls occurring.

Transient—meaning that over time, transitions are neither in the same category and largely not statistically significant. The example patterning shows that there were no significant transitions, however, there were three individual periods (1999, 2007 and 2010) that were high-low, indicating that this State Suburb was high and the surrounding State Suburbs remained low. For those addressing the problem of malicious hoax calls, this identifies an area that occasionally has peaks in incidences relative to its surrounding areas.

Emergent—Across the 13 years, 83 percent of transitions were not significant, however, the final three years were significant, highlighting this State Suburb to be part of a high-low outlier. In terms of practical implications, this highlights an area where there appears to be an emerging trend that could indicate the formation of a local hotspot.

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rate. Finally, the high–low type captured 123 or seven percent of transitions with an 89 percent retention rate.

Next, investigating the movement between cluster and outlier types, the largest change was observed between high–high (cluster) and low–high (outlier). Here, there were 184 moves (or 10.4% of all transitions) between high–high to low–high and 166 (9.4%) transitions between high–high and low–high. In summary, there is evidence of local clustering (in particular high–high clusters), with a small weakening of such spatial arrangement (greater movement to outliers) over the 13 years. Therefore, the importance of incident levels in neighbouring suburbs appears to be less important in the more recent years covered by the data. The likelihood that suburbs are surrounded by ‘like’ suburbs (with similarly high or low levels of incidents—spatial clusters) is lower. Rather, in more recent years, suburbs are surrounded by neighbourhoods with very different levels of fire incidents (forming spatial outliers).

Policy implications

The results from this research have the potential to provide critical information regarding the *persistent*, *transient* and *emergent* nature of hotspots of malicious hoax calls and suspicious fires, which can be used to guide optimal resource allocation in anticipation of likely load. More broadly, the research has identified the location and timing of such fires in a manner that has the capacity to inform the implementation of preventive strategies at specific times in specific areas that are identified as having *persistent* or *emerging* problems. Through improved response and prevention strategies, lives can be saved and the economic burden of these types of offences can be reduced. Finally, the

findings and the development of these methodological techniques have broader application to a range of other offence types.

Conclusion

This research is the first of its kind in Australia as well as internationally to examine malicious hoax calls and suspicious fire offences using geographical clustering techniques that both statistically and graphically explore the spatial dynamics of fires and hoax calls and how these patterns have changed over a 13 year time period.

Both malicious hoax calls and suspicious fires are a significant burden to the community financially and in the potential danger they cause. The findings discussed herein have implications for targeting hotspot areas where malicious hoax call and suspicious fire incidents occur in Queensland. In particular, this research proposes a new technique (the local Moran temporal plot) that offers the capacity to develop and implement evidence-based prevention strategies designed to target finite resources in areas of concern across Australia. Deployment of such tools within similar operational and strategic settings (eg the police service) has the potential to save public money, safeguard property and save lives.

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All URLs are correct at May 2013

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