MAPPING DRUG OVERDOSE IN ADELAIDE

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Abstract
Effective data visualisation is an essential component of successful crime mapping. Crime data mapping synthesises many separate incidences to enable spatial patterns or concentrations of a particular crime to be more easily seen, however care must be taken to ensure that the mapping method, spatial and temporal unit, and scale chosen are appropriate to the data and the application. This paper uses the example of data for drug overdose cases, attended by SA Ambulance Service in the Adelaide metropolitan area, to compare alternative mapping and visualisation techniques to identify trends in the dataset. It is argued that geographical information systems, with their ability to visualise and synthesise data, make it relatively easy to identify trends and hot spots in the underlying data that may have otherwise been overlooked. Three dimensional hot spot mapping is shown to be a particularly useful technique for data visualisation and the spatial interrogation of the database.

1. Introduction

Criminal investigations are often hampered by the amount of information that is available; this is particularly true of illicit drug investigations. It is therefore important that any information is analysed using the most effective methods that are available. Crime mapping has long been an important analysis method employed in criminal investigations, although in recent years a shift in the use and usefulness of crime mapping has occurred. The advent of relatively low cost and computationally powerful personal computers coupled with the development of inexpensive and powerful desktop Geographical Information Systems (GIS) has made crime mapping a less time consuming process, which has the potential to yield even greater results, offering improved capabilities of complex data analysis and visualisation. Geography, more so than ever before, offers a means by which data can be explored, synthesised, queried, analysed and communicated. Interactive computer based maps are replacing the static paper maps of the past. The shift to digital maps and GIS based spatial analysis has led to improvements in our ability to synthesise and visualise crime data, thus enhancing our ability to understand the geographic and temporal dimension of crime.

Drug related crime is a growing problem in many countries throughout the world. There is an increasing number of Australians using illicit drugs (The Alcohol and Drug Council of Australia (ADCA), 2000). While the most common illicit drug used is cannabis, there has been a concerning increase in the use of heroin. ADCA states that Australia is "currently experiencing an epidemic of heroin-related fatal and non-fatal overdoses" (ADCA, 2000), with an estimated 112,000 heroin users in Australia (Australian Institute of Health and Welfare, 1999). The Australian Bureau of Statistics (ABS) has found that, while the number of drug related offences in Australia remained fairly stable from 1996/97 to 1997/98, there was a significant increase in the number of offences involving heroin, with an increase of 22 percent over the previous year (ABS, 2000). The National Drug Strategy Household Survey also found that amphetamines were the most widely used illicit drugs after cannabis, with 51% of injecting drug users surveyed saying that they had injected amphetamines (ADCA, 2000). With increased pressure on police budgets it is important that police investigators have access to the information that can help them focus on those areas that have the highest levels of illicit drug activity. The aim of this paper is to illustrate the application of some digital mapping and data visualisation techniques to explore and communicate spatial relationships in drug overdose data and South Australian Police (SAPOL) drug apprehension data in the Adelaide metropolitan area. The emphasis is on applying appropriate spatial visualisation techniques to the data and to demonstrate the advantages of moving towards interactive mapping and data analysis. The research considers five mapping techniques, unit record mapping, choropleth mapping, 2D and 3D density mapping and the use of animations for identifying changes in the patterns of drug overdose over time. Concluding comments consider the future of crime data visualisation.

2. The Data

The primary database for the analysis was the South Australian Ambulance Service (SAAS) drug overdose database for 1999. The database detailed all drug overdoses attended by SAAS in the Adelaide Statistical Division (ASD) by five relatively broad categories. The categories are based primarily on the physiological effects of the drug. These categories are detailed in Table 1.

Table 1. SAAS Overdose Categories

Overdose Category	Description
No Carry	The overdose patient was not transported to a medical facility.
Prescribed Drug	The overdose was the result of medically prescribed drugs
Non-Narcotic	The overdose was the result of a non-narcotic drug. These include: Amphetamines - speed ecstasy GBH Benzodiazepines- valium midazolam rohypnol (rollies)
Narcotic	Narcotic drug overdose, most commonly heroin, but also including methadone, morphine, codeine, pethidine and omnopon
Not Specified	Information about the type of drug was unknown or not adequately documented in the database.

Clearly, the categories are not mutually exclusive, as some of the narcotic and non-narcotic drugs were also prescribed drugs. From a clinical point of view, it is more relevant that they are identified by their action on the body. In the case of multiple drugs being used, the attending ambulance officer identified the drug type that presented the most urgent clinical need.

The database also detailed the gender of the patient, the date, time and location of the patient overdose. This information was geocoded at the street address level using MapInfo street address file. For the purposes of this study only Non-Narcotic and Narcotic categories were considered as these had the most obvious links to communities using illicit drugs. Anecdotal evidence from the ambulance crews also suggested that many of the no carry patients had overdosed on illicit drugs.

The SAAS data was seen as a useful source of information regarding the drug using population, as there is a joint policy between SAAS and the SAPOL, that states; SAAS is not expected to routinely inform them of all drug overdose patients attended, but will seek police assistance should there be a known or possible risk of harm to the attending ambulance officers. This policy recognises the importance of encouraging drug users to seek medical attention without fearing criminal charges. Thus, the SAAS database represents a relatively unbiased representation of the locations of drug users. While there are still issues that could be raised about the reliability of this data source with regard to the movement of overdose victims prior to the call for assistance and the relationship of the location of the overdose to the users' home address and dealer locations, these issues are beyond the scope of this paper. The assumption was made that concentrations of overdoses would occur where there were large numbers of drug users. It was also assumed that in areas where there were concentrations of drug users there is likely to be drug dealers.

The SAPOL data set that was obtained for this study documented drug apprehension data for the month of December 1999 by suburb. The data noted the drug type, date and time of the offence and an indication if the drug was for personal use or was intended for supply. The suburb field of this database was matched to the CDATA96 suburbs coverage of the ASD. While this dataset was a relatively small sample dataset, containing only 80 records within the ASD, it was useful to illustrate how the GIS can be used to synthesis and layer multiple datasets of different types. The drug type classification was more detailed than the SAAS data with the particular type of drug or drugs being identified for each apprehension.

3. Advantages of Computer Based Mapping and Visualisation

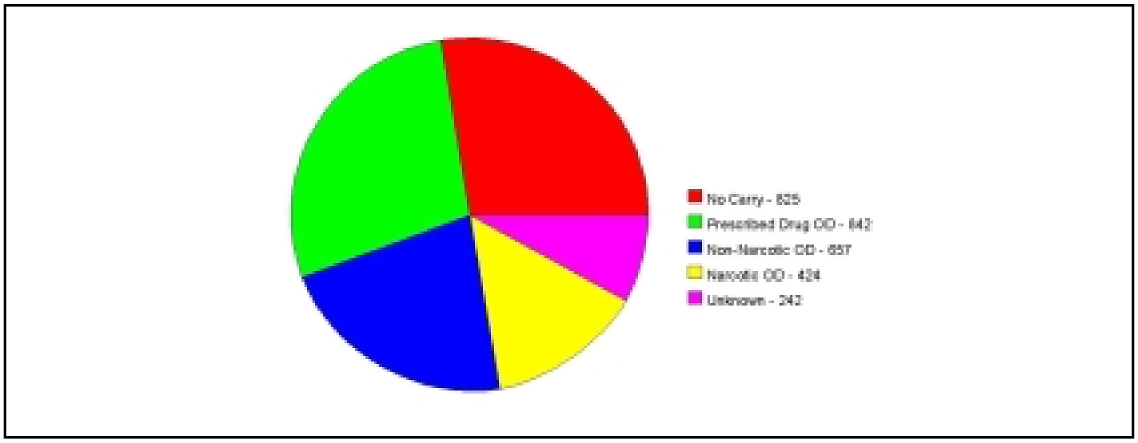
Maps are symbolic abstractions, generalisations or representations of reality (Foote and Crum, 2000). They enable vast and often complex information to be synthesised into a format that is easily visualised and interpreted. They are useful for their ability to: record and store geographic information; to analyse spatial relationships and identify spatial patterns; and to communicate findings. A good map is one that effectively conveys specific information to the reader. Maps can be produced in many mediums, although by far the most common is the traditional paper map. While the value of this type of map is not questioned, the added value of digital computer based maps should not be overlooked for some applications. Crime mapping is an application that can benefit greatly from the advantages of digital mapping and spatial analysis techniques. Some particular advantages to crime mapping are: the speed at which maps can be updated; the ease with which other information can be integrated or underlying data queried; and the ability to display the data at a range of scales and levels of abstraction, enabling both spatial and temporal patterns and relationships to be seen.

4. Preliminary Exploration of the Data

The initial stages of the analysis focused on exploring the data and identifying possible trends that have a spatial relationship, which may help to explain patterns of drug use in the ASD.

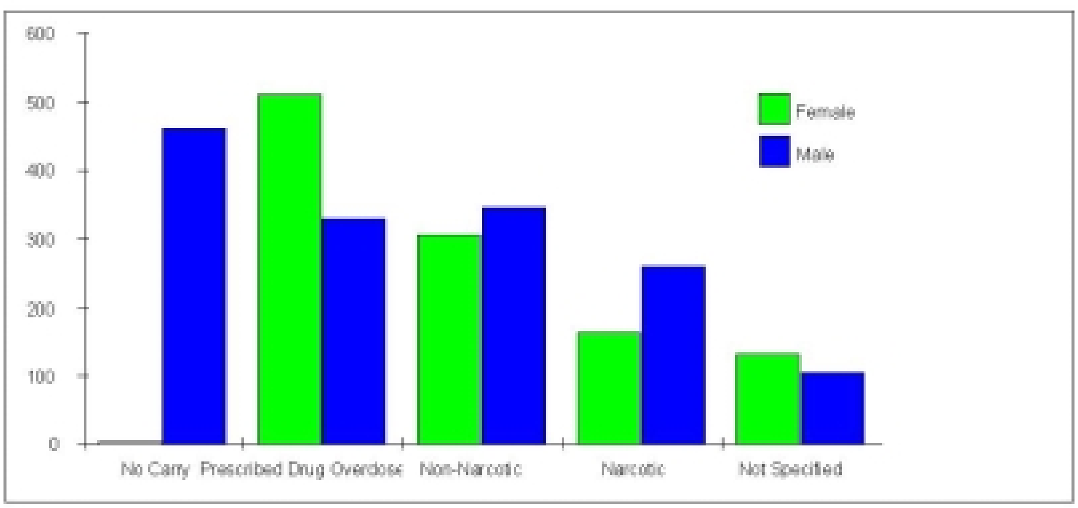
Preliminary analysis of the ambulance database showed that in 1999 SA Ambulance workers in the ASD responded to a total of 2990 overdoses. Figure 1 shows a chart indicating the number of overdoses in each of the drug type categories.

Figure 1. SAAS Attended Overdoses by Drug Type - 1999



Gender profiles (Figure 2.) of the overdose patients show that females are more likely than males to overdose on prescription drugs, and males are more likely to have overdosed on narcotics or non-narcotic substances. Males may be over represented in the "no carry" class, because by default the database would record "male" if no gender was entered into the database. Overall, males represented 57% of all overdose patients.

Figure 2. Gender by Drug Type for SAAS Attended Overdoses in 1999



The SAPOL data contained 80 records of apprehensions in the ASD. Of these apprehensions 15 were female and 46 were male. Forty six of the apprehensions involved supply drug quantities. While the most common drug type was cannabis (61 apprehensions), for the purposes of this study only heroin apprehensions (17 records) were considered because these could be compared to the narcotic overdoses in the SAAS dataset.

5. Spatial Visualisation of the Data

Spatial data visualisation was done using ArcView Spatial Analyst and 3D Analyst software.

5.1 Unit Record Mapping

Preliminary spatial analysis of the SAAS data indicated that 15% of all overdoses occurred in the Adelaide Central Business District (CBD), although when only the categories of narcotic and non-narcotic overdoses are considered this figure increased to 22%. Figure 3 shows the distribution of the SAAS unit record data for all overdoses, and narcotic and non-narcotic overdoses across the ASD. The maps of all overdoses and non-narcotic overdoses appear to show a more even distribution of overdoses across the settled urban area, with a concentration of overdoses in the CBD and fewer overdoses occurring in the more sparsely settled areas, such as the foothills on the eastern side of the map. The Narcotic map however shows two distinct clusters of overdoses, one in the CBD, and the other in The Parks area, north west of the CBD.

The simple point maps shown in Figure 3 are useful for illustrating some of spatial variation in the data, however they are not the most effective means of communicating this information at the statistical division level, because many points overlap and thus may mask the significance of certain concentrations. While unit record mapping is a reliable method of mapping, as it does not suffer from problems associated with aggregating up to a larger spatial unit that does not correspond to the underlying spatial distribution of the data, it is more useful when applied to large scale mapping applications such as analysis at the suburb or neighbourhood level. Issues of privacy and data confidentiality may need to be addressed when maps are produced at this level of detail. Figure 4 shows an example of unit record mapping of narcotic overdoses in the Adelaide CBD area. This map shows a clear concentration of overdoses on the western side of the CBD.

Figure 3. Spatial Distribution of SAAS Attended Drug Overdoses in the Adelaide Statistical Division for 1999

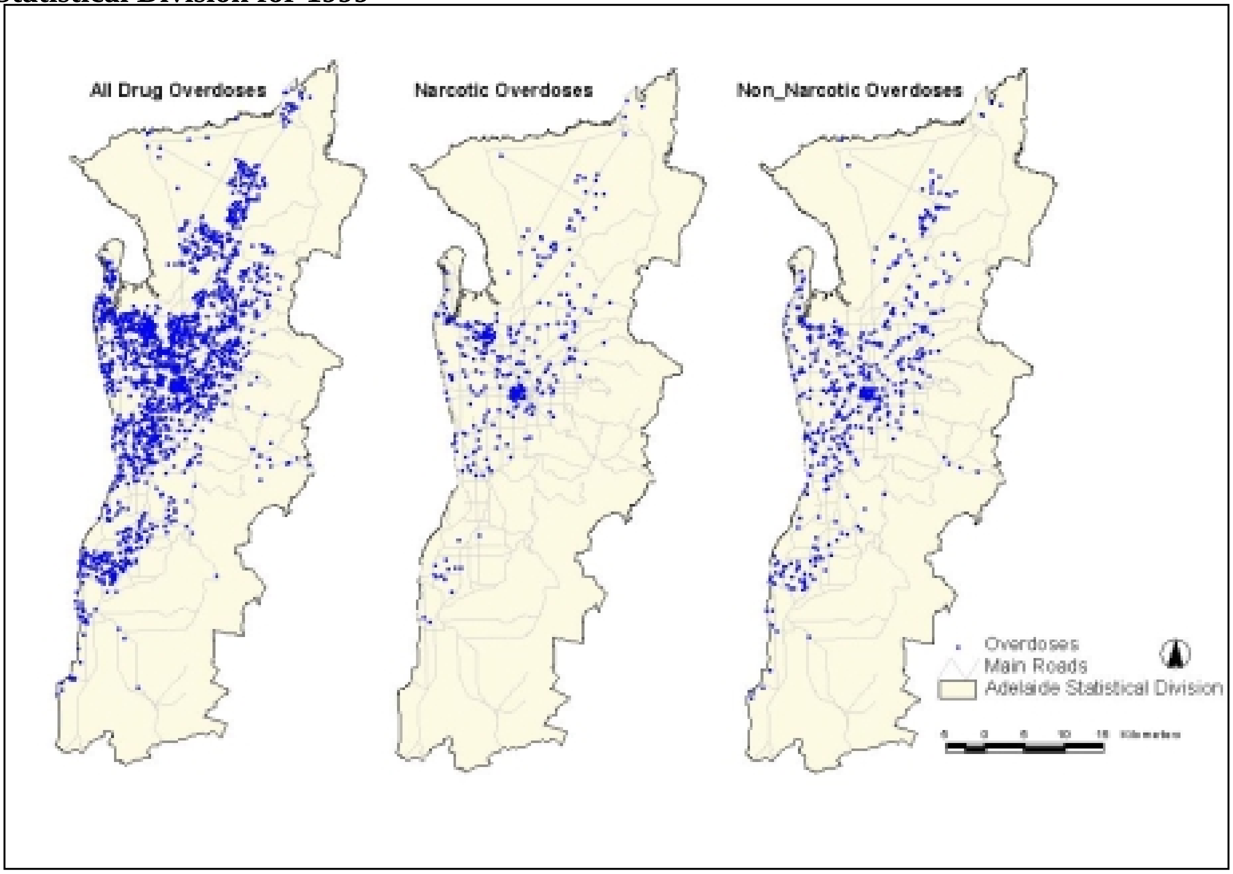
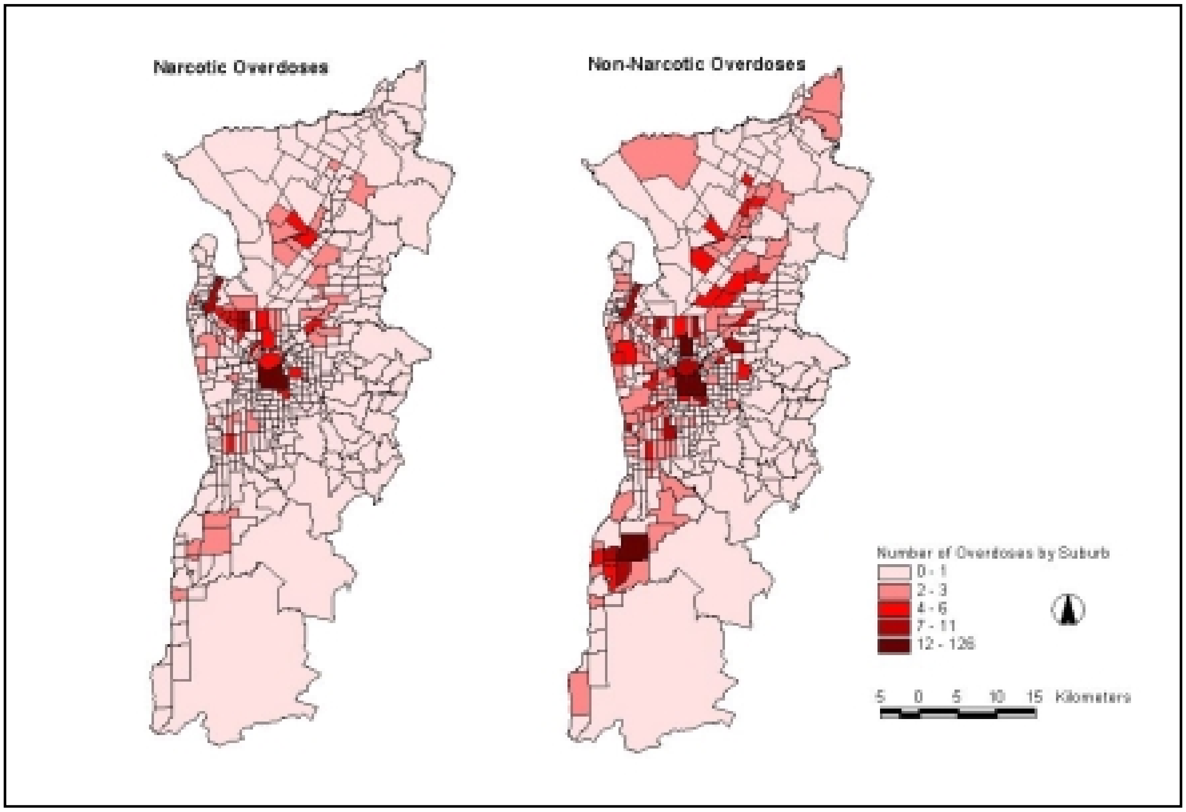


Figure 4. Narcotic Overdoses Attened by SAAS in the Adelaide CBD in 1999

5.2 Choropleth Mapping

To improve the visualisation of the SAAS data at the ASD level generalisation of the data is necessary. Care must be taken when generalising the data that important information is not lost in the generalisation process. Most often generalisation involves displaying the data aggregated up to some type of spatial unit such as census districts, suburbs or postcodes. These spatial units are often used because they are areas that are easy to define and readily understood. Because these spatial units have little spatial relationship to the data, aggregation using such spatial units can easily mask the spatial relationships in the data that it was the aim to highlight. Generally the use of smaller spatial units reduces the impact of this problem, although a very small spatial unit may not greatly improve the visualisation of the data. Figure 5 shows a choropleth map of the number of narcotic and non-narcotic overdoses by suburb. The choice to map overdoses by numbers rather than overdose rates as a proportion of the population was made due to the inability to directly associate overdoses with the population at the suburb level. Overdose patients are not necessarily residents of the suburbs where the overdoses happen. This map is a more useful rendition of the data at the ASD level than the previous point maps. There are two main limitations to the chloropleth map; these are the spatial unit problem that has already been discussed and the visual impact of large suburbs in the final interpretation of the results. They are also difficult maps to construct well, as the choice of classes can greatly affect the appearance of the final map.

Figure 5. Number of Narcotic and Non-Narcotic SAAS Attended Overdoses by Suburb for 1999



5.3 Density Mapping

Density mapping of overdose locations helps to overcome the main limitations associated with chloropleth mapping. Density mapping produces a continuous surface over the study area that identifies areas where high concentrations of overdoses have occurred. A comparison between choropleth, density and unit record mapping can be seen in Figure 6. The Choropleth map in Figure 6 displays the suburb of Port Adelaide as having a relatively large number of drug overdoses, however, when the distribution of the unit record data is considered, it can be seen that the only overdoses have occurred in the southern part of the suburb. The density map in Figure 6 more accurately depicts the location and concentration of the overdoses in the area than the choropleth map.

Figure 6. A comparison between Choropleth, Density and Unit Record Mapping

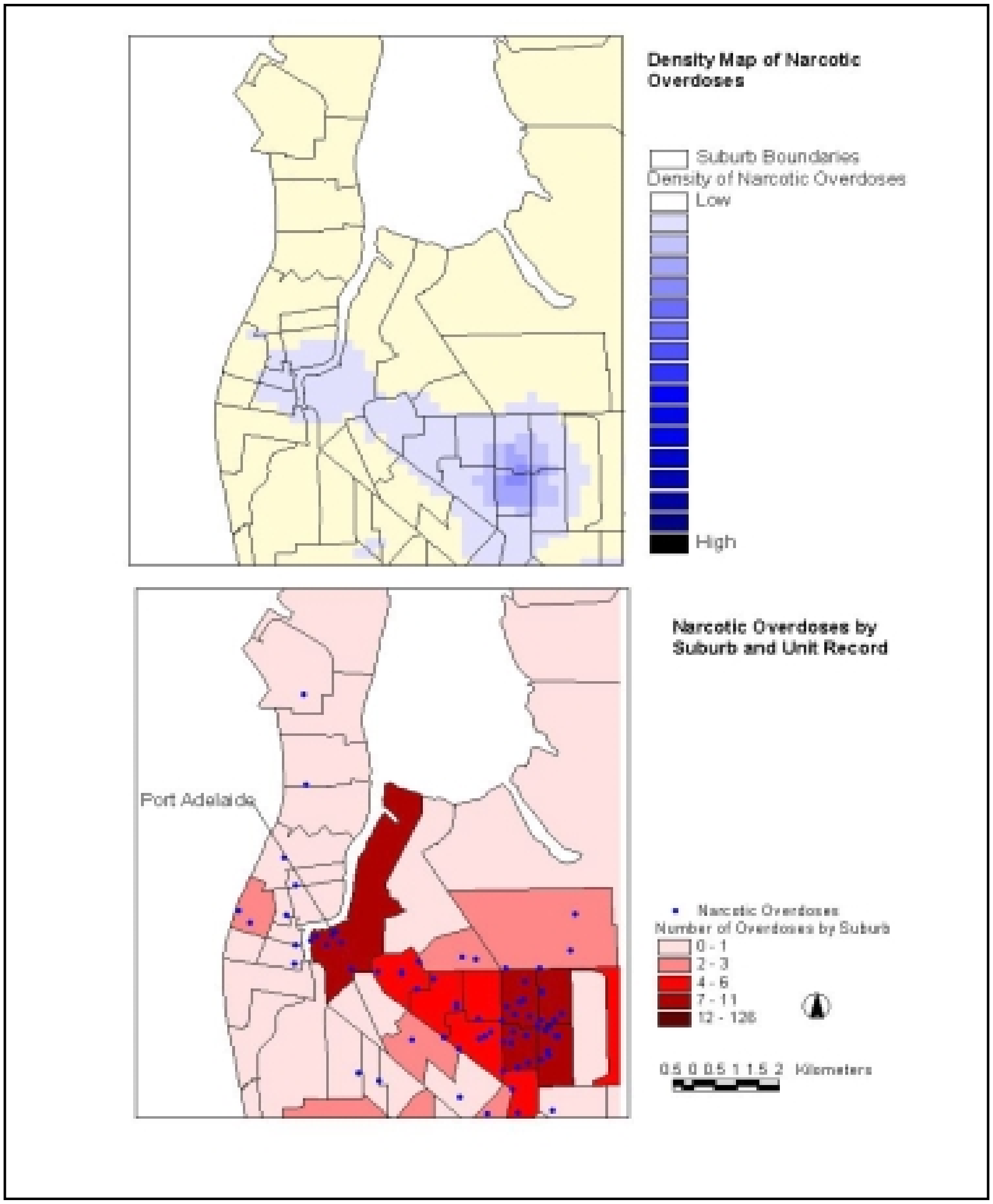
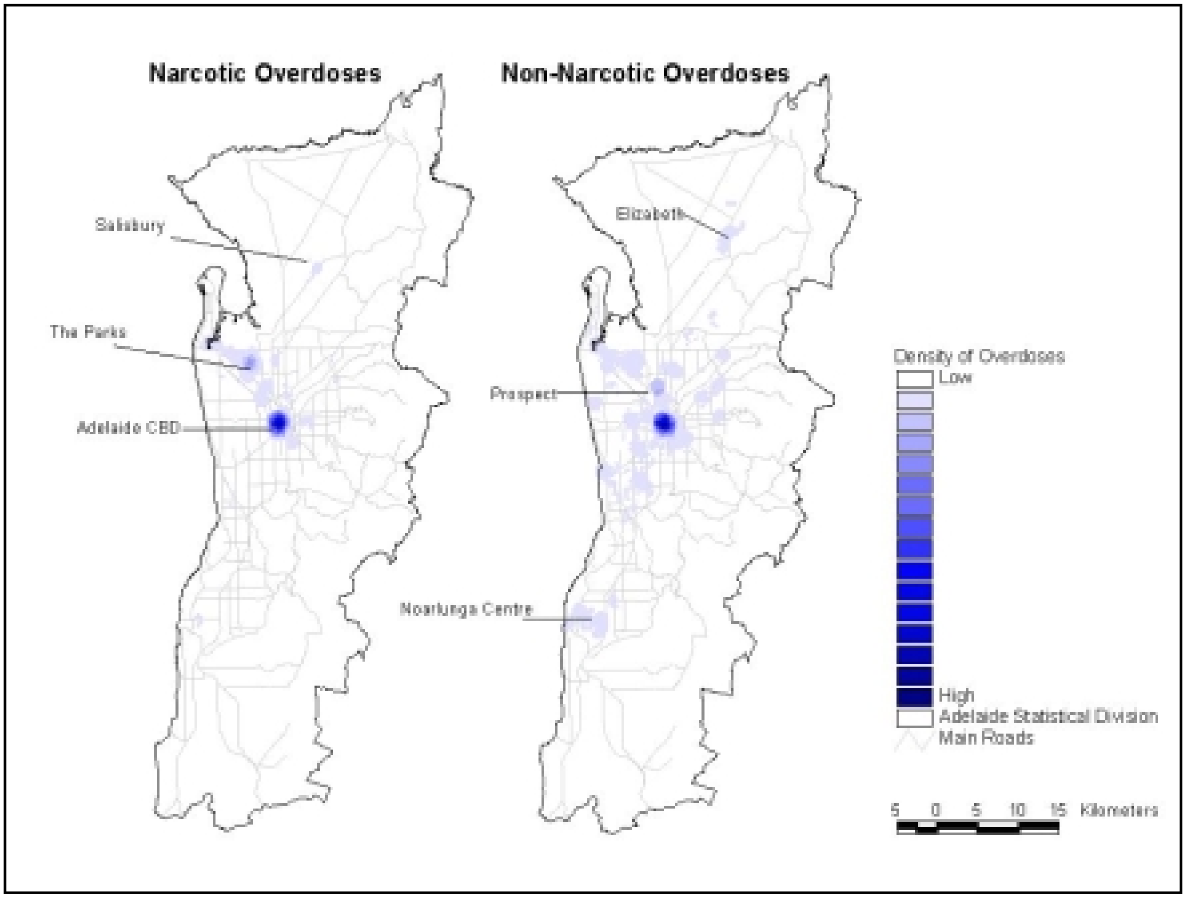


Figure 7 shows a density map of narcotic and non-narcotic overdoses in the ASD. Clearly significant differences in the spatial distributions of overdoses for each of the drug types are apparent, although both display the highest density of overdoses in the Adelaide CBD. The narcotics overdose map also shows a clear concentration of overdoses in The Parks area and extending northwest towards Port Adelaide. In comparison the non-narcotics map shows a broader distribution of overdoses across the ASD.

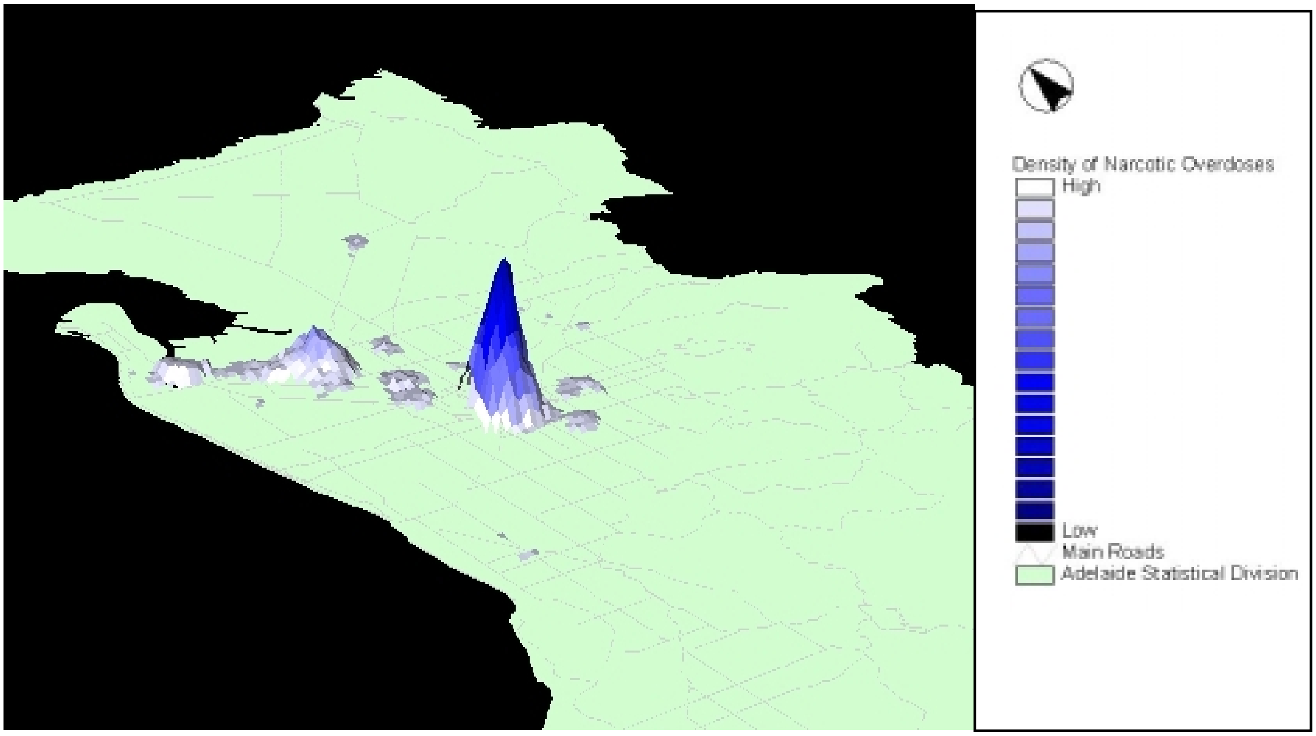
Figure 7. Density Maps of SAAS Attended Narcotic and Non Narcotic Drug Overdoses in the Adelaide Statistical Division for 1999



5.4 3D Visualisation

Another visualisation technique that can aid the interpretation of spatial relationships is the use of 3D mapping to extrude the areas with high values so that hot spots are more easily seen. This type of mapping is particularly easy to interpret thus making it a valuable method of visualisation. Figure 8 shows the narcotic density grid displayed as a 3D map. This type of mapping is most useful when displayed on the computer screen enabling the user to move around the image, viewing it from a range of angles. In hard copy representations areas of the map are masked by the peaks of higher values, this has been identified as a limitation of this method (Harries, 2000). This problem aside, Figure 8 clearly shows those areas with the highest concentration narcotic overdoses.

Figure 8. Density of SAAS Attended Narcotic Overdoses Displayed as a 3D Visualisation



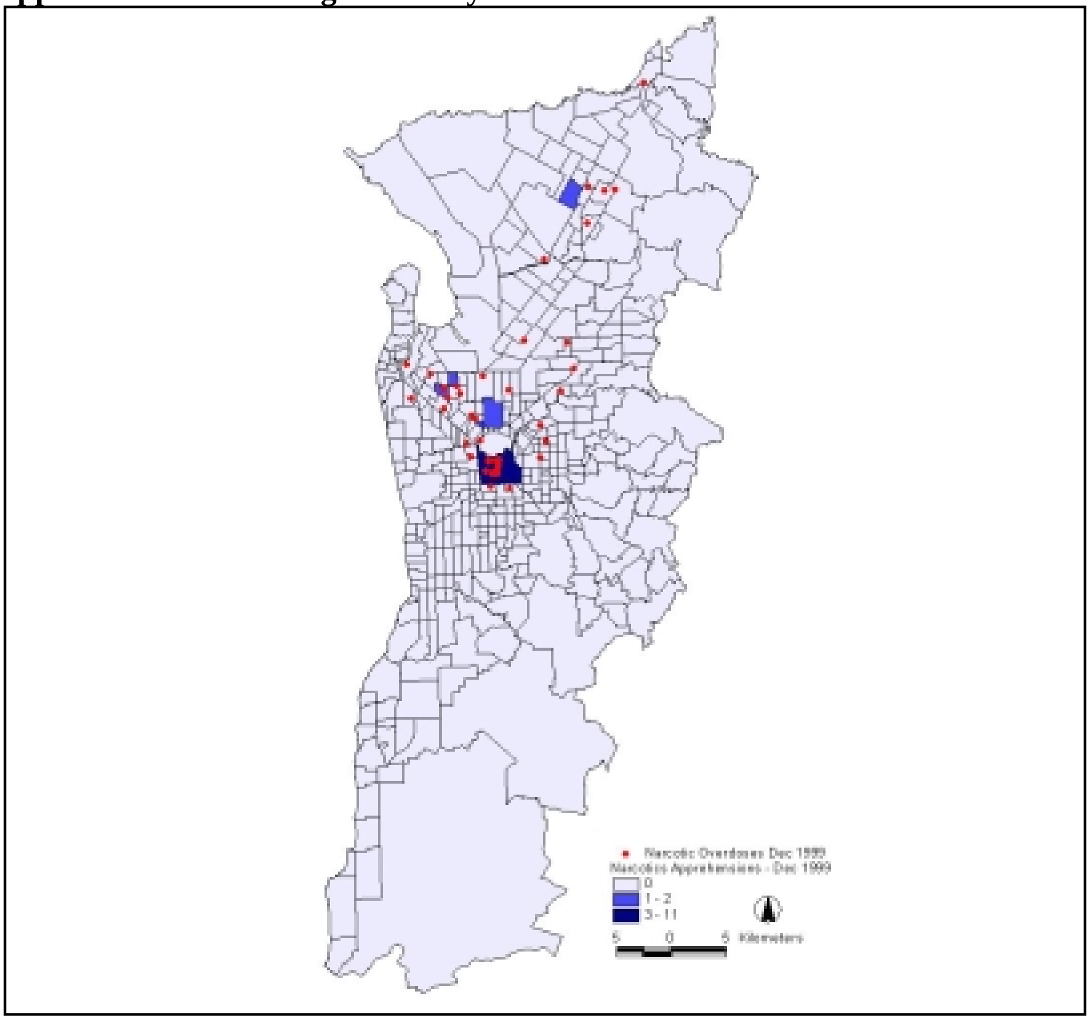
5.5 Animation

Animation has also emerged as a useful technique in computer mapping. By animating a time series of data it is possible to gain an understanding of the temporal variation in the data spatially across the study area. This may be a useful technique to monitor the effectiveness of policy initiatives aimed at reducing drug activity or identifying temporal patterns of drug overdose in the data. An animation of the days of the week non-narcotic overdoses occurred identified Friday, Saturday and Sunday in the CBD as having the highest rates of non-narcotic overdoses, while Wednesday showed the lowest concentrations of overdoses in any particular area. Animations of time of day or months of the year may also identify additional clusters of overdoses that may assist police and the ambulance service respond to these concentrations.

5.6 Data integration

Through the use of GIS it is easy to overlay or analyse multiple datasets to look for relationships, even if the datasets are at different spatial resolutions. An example of data overlay can be seen in Figure 9. Heroin apprehensions extracted from the SAPOL database are displayed at suburb level and the unit record information of drug overdoses for December is overlaid. While both datasets, particularly the SAPOL data only contain a small number of records and thus no conclusive relationship can be established, there does appear to be some coincidence between the two datasets.

Figure 9. Spatial Distribution of SAAS Attended Narcotic Overdoses and SAPOL Apprehensions Involving Heroin by Suburbs in the ASD in December 1999.



6. Future Directions

The development of integrated and flexible databases that can that can take full advantage of the modern analysis techniques are the key to modern crime mapping. GIS mapping enables a holistic approach to understanding the distribution of crime in our community. With the use of GIS systems the crime researcher has the ability to move easily between different scales of analysis, from the neighbourhood to the suburb to region to state and take the maximum advantage of GIS visualisation techniques and the ability of these systems to layer and integrate many different types of data which can assist crime researchers visualise the dynamics of crime.

The inclusion of a spatial reference in administrative datasets would assist the move to more efficient crime mapping. The technology is available to enable the automated capture of the geographic dimension of both the SAPOL and SAAS data. Global

Positioning System's (GPS's) can record the location of the response and automatically feed this information back to the larger database, so it can be used immediately. If appropriate security was in place there is no reason why this information could not be supplied directly to other organisations that could benefit from more timely information. This type of capability has the potential to decrease police work loads by identifying trends early and enabling the police to focus resources on areas that are known to have high drug usage. A hypothetical example could be the use of this type of system to quickly identify a problem such as a cluster of overdoses due to a contaminated mix of heroin. Police could use the overdose information to assist them in locating suppliers. Health warnings could also be targeted to these communities in an attempt to minimise the heath risks.

In addition to more timely information, increased cooperation between agencies can also result in more useful information being collected. Currently the SAAS database has been designed to meet the needs of the ambulance service, which it does adequately, however this database could be more valuable for a range of research applications including, police research, if the database contained more detailed information about specific drugs. It is recognised that this type of information may not always be available to the ambulance officer, but where it is, it could be advantageous to include it. A direct comparison could then be made between specific drug overdoses and police apprehensions for the same drug.

Acknowledgements
The authors would like to gratefully acknowledge the assistance of several key contributors. The South Australian Police force for providing some of the data that was used in this study. MapInfo for providing the street network database, which enabled the precise geocoding of each of the SA Ambulance overdose records. Deb Snoad for her work in geocoding the overdose database.

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