Predicting alcohol-related harms from licensed outlet density: A feasibility study

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Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ASGC	Australian Standard Geographical Classification
BAC	Blood Alcohol Concentration
CD	Census Collector District
DAO	Western Australian Health Department Drug and Alcohol Office
EDIS	Emergency Department Information System
ERP	Estimated Resident Population
GIS	Geographic Information System
ICD	International Classification of Diseases
LGA	Local Government Area
MAPP	Measurement of Alcohol for Public Policy
MLR	Multiple linear regression
NAIP	National Alcohol Indicators Project
NCC	National Competition Council
NCP	National Competition Policy
RBT	Random Breath Testing
SEIFA	Socio-Economic Indexes for Areas (ABS)
SLA	Statistical Local Area
US	United States of America

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Executive Summary

Introduction

Regulatory control of the physical and economic availability of alcohol has long been used as means for limiting the undesirable consequences of alcohol consumption by responsible governments. Regulation of the sale and supply of alcohol in Australia is the responsibility of state/territory governments. Nonetheless, driven by Commonwealth policy, substantial change is currently occurring on a national scale. National Competition Policy in particular has direct ramifications for how state/territory governments regulate numbers and types of liquor licenses granted within their jurisdictions (outlet density) and has already resulted in considerable change to some liquor acts. Despite this, there is a dearth of knowledge in relation to the likely impact of changes to the regulation of numbers and types of licensed premises on levels of consumption and alcohol-related harms in local areas across Australia.

The overall aim of this feasibility study was to progress the development of an Australian model sensitive to local risk factors to help authorities determine appropriate liquor outlet densities for minimising alcohol-related harms within communities. The objectives pursued by the research team were a pointed response to the current information gap in relation to the regulatory practice of controlling outlet density for licensed premises. The project explored how best to apply the wealth of international and Australian research evidence, and systematically collected information on alcohol consumption and related harms to objectively evaluate (and ultimately predict) the impact of outlet density changes to the public health, safety and amenity of communities.
There were five specific project objectives:

(i) undertake a literature review of the national and international evidence in relation to the effect of outlet density for licensed premises on alcohol consumption and related harms and identify existing data sets (i.e. secondary data) on liquor outlet density and indicators of alcohol-related harms;

(ii) examine routinely collected secondary data on indicators of alcohol consumption and related harms for relationships with type and density of licensed premises;

(iii) determine the most appropriate means of identifying 'high' and 'low' risk regions in relation to outlet density, alcohol consumption and harms;

(iv) identify the most effective means of using this information to identify future high and low risk regions for alcohol consumption and related harms and to predict the likely impact of changes to outlet density; and

(v) create a framework to map the requirements for developing an outlet density model for minimising alcohol-related problems.

Methods

Literature review

A comprehensive review of peer-reviewed national and international literature included all available materials published up to January 2007. Studies were divided into four categories:

(i) studies pre-dating 1990, which tended to include less methodologically robust designs;

(ii) studies conducted during the 1990s, which typically used more sophisticated modelling techniques;

(iii) recent studies, which have been able to apply small area analysis (e.g. census tracts); and

(iv) Australian outlet density research.

Statistical analyses

All statistical analyses were based on Western Australian data, largely because this state currently has the most comprehensive alcohol consumption and alcohol-related harm data in the country, including fundamental wholesale alcohol purchase data.

The first stage in the analyses investigated whether associations existed between routinely collected secondary data on indicators of alcohol-related harms (police-reported assaults; drink-driving breath tests; alcohol-attributable hospitalisations; alcohol-attributable deaths) and three alternative measures of outlet density of licensed premises across local government areas (LGAs). The three alternative measures of outlet density tested were:

(i) simple raw count of the number of licensed outlets located within each LGA (count);

(ii) the number of licensed outlets divided by the total land area contained within the LGA (area); and

(iii) the volume of wholesale alcohol purchases made by retail outlets located within the LGA (volume of alcohol).

Associations were tested according to type of licensed outlet (e.g. hotel/tavern, restaurant/cafe) and for sub-categories of harm indicators including: location of offence (e.g. licensed or private); time of day of offence; type of offence/condition (e.g. serious offence, BAC >0.150, acute/chronic).

The second stage of analyses involved the use of multiple linear regression (MLR) to demonstrate how potential outlet density models could be constructed and applied to estimate the impact of changes to alcohol-related harms. Demonstration models predicted numbers of violent assaults and were adjusted for demographic/socio-economic factors and spatial autocorrelation. Using LGAs as the geographic unit of preference, two different analytical approaches were explored:

(i) state-wide analysis across 140 LGAs; and

(ii) aggregation and analysis by Heath Regions (Metropolitan, Goldfields, Great Southern, Kimberley, Midwest and Murchison, Pilbara, South West and Wheatbelt).

Summary of literature review findings

The brief summary of literature review findings provided here does not include specific references to evidentiary materials which underpin the conclusions. For a more complete discussion of the critical issues, readers are strongly encouraged to rely on the detailed discussion in Chapter 2.

- One of the greatest strengths of the outlet density research literature is the robust finding that assaults are highly correlated with outlet density; that is, as density increases so do levels of assault.
- Outcomes from outlet density studies in relation to violence are reassuringly predictable, despite problems with data quality and access, choice of geographical unit and outlet density measure, country or location of interest, methodological limitations, underlying assumptions and with reducing frequency and analytical error (i.e. failure to address spatial autocorrelation).

- In relation to studies which have investigated road crashes and drink-driving, the evidence for a positive linear relationship is less consistent. Recent studies have typically shown significant positive associations but some early studies found increased problems where densities were lowered. (Although some analysts suggest that these early findings were artefacts of inappropriate study design and choice of geographical unit.)
- Associations between outlet density and other harms such as homicide, child abuse and neglect, self-inflicted injury, alcohol-related morbidity and mortality tend to be less well established – largely due to a paucity of studies – but nonetheless appear to be both linear (at least in part) and positive.
- Only a small number of Australian research studies have investigated the relationship between licensed outlet density and alcohol consumption and/or related harm. Results from Australian studies typically demonstrate positive associations between levels of licensed outlet density, violence and other alcohol-related problems and thus concur with international findings.

Summary of analytical results

The following is only a brief summary of results from the statistical analyses described in the main report. For a more complete discussion of the critical findings, readers are strongly encouraged to rely on the detailed discussion in Chapters 6 and 7.

Descriptive analyses

- Of the three outlet density measures tested, overall consistently and strength of associations (correlations) with alcohol-related harm indicators were highest for wholesale purchases of regular strength beer. All three outlet density measures were strongly and positively associated with assault and drink-driving offences overall, but count of outlets and outlets per land area had only moderate/weak associations with alcohol-attributable hospitalisations and alcohol-attributable deaths.
- The strength of associations between wholesale purchases of regular strength beer and harm indicators varied by licence type: (i) hotels/taverns and liquor stores consistently indicated strong positive associations across all alcohol-related harm indicators; (ii) club licences and restaurants indicated moderate associations with offences (with the notable exception of restaurants and RBTs with a correlation of over 80%) and weaker associations with hospitalisations/deaths; and (iii) nightclub and other licences (i.e. special facility licences, wine distributors, canteens) indicated moderate to weak associations.

State-wide demonstration models

- Overall, the greatest proportion of variance in assaults was accounted for by models applying volume of regular strength beer as the density measure.
- In most cases, state-wide models which used volume of regular strength beer to predict assaults were able to account for most of the variance in reported assaults.
- The strength of association between assaults and measures of outlet density depends on both: (i) the type of licensed outlet being examined (e.g. hotel/tavern, liquor store) and (ii) location where assaults occurred (e.g. licensed outlets or private premises).
- Demographic and socio-economic factors in general were important to all models, although the specific predictive variables remaining in the final models varied.

- Despite the predictive power of demographic and socio-economic variables, volume of regular strength beer purchases predicted the greatest amount of variance in reported assaults and was the most influential of all predictor variables in five out of six final volume models.
- Overall, the presence and effect of serial autocorrelation in state-wide models was minimal.

Regional demonstration models

- In some regions, demographic and socio-economic characteristics appeared to be more important for predicting reported assaults than did volume of beer purchases (e.g. assaults on licensed premises in the South West; assaults on licensed premises in the Metropolitan Health Region).
- For other regions, volume of beer purchases was the most important predictor for levels of reported assaults (e.g. liquor stores and private assault in the Goldfields).
- Across the six regions tested, the contribution of regular strength beer purchases by licensed outlets to levels of reported assault was highly variable and dependent on licence type (i.e. hotels/taverns, liquor stores) as well as location of the offence. For example, in the Metropolitan Health Region, regular strength beer purchases by hotels/taverns had no apparent association with assaults occurring on licensed premises; however, regular beer purchases by liquor stores in the Metropolitan Health Region predicted some 75% of the variance in assaults occurring on private premises.
- When compared to the expected increase in assaults estimated from LGAs across the whole state, some regions were excessively burdened while others were less so (see Table 35).

Summary of recommendations

This study has identified a range of key requirements which need to be met in order to achieve viable working models for estimating outlet density outcomes across Australia. The summary below is an excerpt from Chapter 8 of the main report where a range of recommendations for future work in this area have been provided. We strongly encourage interested readers to refer to the detailed discussions provided in the main report as it brings together what has been learnt from both the literature review and from the exploratory analyses.

(i) Establish a working group

An initial step toward further work on models for alcohol outlet density might include the identification of individuals with relevant expertise in this area and the establishment of a committed working group. The working group should ideally include: (i) individuals with a national perspective who also bring relevant national and international collaborative research links, and (ii) local practitioners who can inform on ground-level community issues.

(ii) Establish ongoing systematic data collection and facilitated data access across all states and territories

Ideally, specific models for predicting impacts of changes to licensed outlet density should be based on local data from functional regions within each state/territory (e.g. Health Regions). In order to achieve this, region-specific data measuring a range of harm, consumption and demographic/socio-economic variables must be systematically collected and accessible.

(iii) Utilise responsive and accurate measures of 'outlet density'

To date, most outlet density studies have been restricted to using inflexible outlet 'density' measures, that is, counts of licensed outlets in the numerator and some standardising measure as the denominator (e.g. number of outlets per geographic land area, number of outlets per estimated private population, number of outlets per kilometre of roadway). Alternatively, and based on our analyses, we propose that the most efficacious measure of alcohol 'outlet density' is not a measure of density per se but an approximation of alcoholic beverage sales – volumes of alcoholic beverage purchases made by retailers from wholesale traders.

A major advantage of wholesale beverage purchases as a measure of outlet density is that, unlike other density measures based on counts of liquor licences, it does not necessarily assume that all outlets (or types of outlets) are equivalent in terms of sale and supply of alcohol and levels of harm.

At present, only Western Australia routinely collects and allows that wholesale alcohol purchases by individual retailers be made available for research purposes. Although the Northern Territory and Queensland also collect wholesale purchase information, the data are typically aggregated by location, and in the past specific information on individual licensed premises has not been readily available to researchers. Without concerted effort to collect and provide comprehensive wholesale beverage purchase information across all states/territories, progress toward the development of outlet density models on a national scale will be limited.

(iv) Indicators of alcohol-related harm

This feasibility study examined the associations between outlet density and a range of alcohol-related harm indicators. The study purposely relied on information that was already available or which could readily be collected in a systematic manner by official agencies.

Among the range of harm indicators examined, police-reported assault offences emerged as having one of the strongest and most consistent relationships with outlet density. Moreover, the results highlighted the value and importance of distinguishing between incidents occurring on licensed versus private premises. Assault data should be considered an essential part of understanding the effect of changes to outlet density on communities but, on its own, it ought not to be considered sufficient. Volume of wholesale beverage purchases was strongly associated with a range of alcohol-related harms and the strength of that relationship is highly likely to vary by both geographic location and by licence type. Ideally, the best approach to forecasting the impact of changes to outlet density on the public health, safety and amenity of a community is one which allows as fulsome a view of the range of possible outcomes as is reasonably possible.

(v) Analytical considerations for future model design

There are many important analytical and study design issues to which future analysts will need to give due consideration when formulating predictive statistical models for outlet density. Not least of these is a need for Australian studies which examine the effect of changes to outlet density on consumption and harms over time and which are best placed (compared to cross-sectional studies) to demonstrate cause and effect. Other factors for consideration include: outlet density measure (i.e. volume of alcohol vs. density *per se*); functionality of geographic units and effect of atypical regions (i.e. outliers); licence type; demographic/socio-economic influences; interaction effects between variables; use of controls; potential for non-linear associations; lagged effects; and level of population mobility.

Conclusions

This feasibility study has demonstrated the utility of using systematically recorded data to model relationships between licensed outlet density and alcohol-related harm in Western Australia. This report describes in detail how volume of wholesale alcohol purchase data can be used effectively to: identify existing associations; identify the size and direction of associations; estimate the likely impact that changes to licensed outlet density will have on levels of alcohol-related harms; and demonstrate the variability of relationships among regions. The results also concur with the overall findings from the research literature; that is, greater physical availability of alcohol is associated with higher levels of alcohol-related harms.

Nonetheless, it must be recognised that any model which attempts to estimate the impact of one variable on another will only be as accurate, sensitive and reliable as the data and assumptions upon which it is based. One of the main reasons for selecting Western Australia as a test case for this project was relatively easy access to comprehensive alcohol consumption and alcohol-related harms data. Much of that which has been demonstrated in this report could not be achieved on a national scale given current gaps in data collection. This highlights a fundamental issue which needs to be addressed if work in this area is to move forward – access to data on alcohol purchases by licensed retail outlets.

Tangible progress toward the range of recommendations listed above will potentially benefit a wide range of key stakeholders: state and territory liquor licensing authorities to whom falls the responsibility of administering liquor legislation in a complex and changing environment; police and health services upon whom falls the responsibility to care for and protect those who are affected by their own or another's alcohol consumption; and the communities at large upon which the financial and social burden ultimately falls.

There is no doubt that some communities will be more susceptible to experiencing the negative effects of changes to licensed outlet density than others. Not all communities are the same and not all licensed premises are equal. It is highly likely that decisions about location and number of licensed premises can be guided to good effect by sensitive and reliable analytical models which bear out the variable nature of communities and licensed premises. (The final section of this report provides advice on how to proceed in the short, medium and long term.) Ultimately, however, it should be left to individual communities and their representatives to determine the 'optimal' balance between the apparent benefits brought by the physical availability of alcohol and the subsequent costs to public health, safety and amenity.

Chapter one: Introduction

In Australia, the enactment and enforcement of legislation regarding the sale and supply of alcohol is a state and territory government prerogative with each jurisdiction upholding its own liquor or licensing act. Originally, as well as being concerned with the licensing of suppliers and related controls on sale and supply, these acts were also concerned with promoting the sustainability of the liquor and hospitality industries. However, reviews of the various state and territory Liquor Acts in the 1980s and 1990s, and concerns about the costs of alcohol-related harm, ultimately led to most jurisdictions adopting 'harm minimisation' as a primary objective of such legislation.

Currently, liquor legislation and alcohol policy is again undergoing considerable change throughout Australian states and territories. In very recent years, much of the change has resulted from state and territory government response to National Competition Policy. Deriving from the Commonwealth Government, National Competition Policy (NCP) obliges state and territory governments to review and identify existing and new restrictions on trade which might unjustifiably reduce competition.

In relation to the sale and supply of alcohol, the National Competition Council (NCC) has taken issue with a range of regulatory practices which may potentially constrain retail competition by limiting numbers of licensees or restricting how and when retail liquor trade is conducted. The NCC has specifically identified concerns regarding restrictions, in various forms, on trading hours and numbers of licensed premises. The NCP does not preclude alcohol restrictions per se but requires that the approach taken be objectively demonstrated as efficacious, 'properly directed at harm reduction' and ultimately serving the 'public interest' (Marsden Jacob Associates 2005, foreword). In Marsden Jacob Associates (2005), both the National Competition Council's Acting President and Executive Director described the relation between NCP and liquor regulation as follows:

> *Clearly, regulation that restricts competition but has little, if any, impact on the public interest is inconsistent with NCP. However, regulation that successfully addresses the public interest but also restricts competition can be justified, so long as the impact on competition is minimised (foreword).*

There have been a range of responses to NCC reviews by state/territory governments. Victoria for instance moved relatively quickly to comply with the NCC instruction to remove a cap on the number of licences that could be held by a single person or entity in that state. The New South Wales Government eventually complied with the NCP and amended liquor legislation to require a social impact test in place of a needs test – although it was slow to do so and was initially fined for non-compliance in 2003/04. Western Australia also, following the recommendation of a review committee (Independent Review committee 2005), very recently amened its Liquor Act to require a public interest test on new licenses and has amended the Act to allow Sunday trading for liquor stores. Queensland however, continues to withstand NCC pressure to remove restrictions on liquor store ownership and the locations where they can be established (Marsden Jacob Associates 2005).

Considerable costs, both economic and social, can be directly attributed to alcohol use. It is often said that 'alcohol is no ordinary commodity' (Babor et al. 2003) and there is no doubt that along with the considerable economic returns to be made on the sale and supply of alcohol come considerable burdens. The most recent estimate of the total social costs of alcohol misuse (1989/99) for Australia is about $7.6 billion, some $1.7 billion of which is due to alcohol-attributable crime and $225 million to illness and injury (Collins and Lapsley 2002).

Responsible governments throughout the world have long viewed the regulatory control of the physical and economic availability of alcohol as a fundamental mechanism for limiting the undesirable consequences of alcohol consumption. Yet alcohol policy is rarely based on objective evidence (Stockwell 1995), being typically ad hoc or a continuation of historical precedent. This may well be due, in part, to the considerable gap which exists between the focus of scientific research and practical policy outcomes.

Aims and objectives

The overall aim of this feasibility study was to progress the development of an Australian model sensitive to local risk factors to help authorities determine appropriate liquor outlet densities for minimising alcohol-related harms within communities.

The objectives pursued by the research team were a pointed response to the current information gap in relation to the regulatory practice of controlling outlet density for licensed premises. The project explored how best to apply the wealth of international and Australian research evidence, and systematically collected information on alcohol consumption and related harms to objectively evaluate (and ultimately predict) the impact of outlet density changes to the public health, safety and amenity of communities. There were five specific project objectives:

(i) undertake a literature review of the national and international evidence in relation to the effect of outlet density for licensed premises on alcohol consumption and related harms and identify existing data sets (i.e. secondary data) on liquor outlet density and indicators of alcohol related harms;

(ii) examine routinely collected secondary data on indicators of alcohol consumption and related harms for relationships with type and density of licensed premises;

(iii) determine the most appropriate means of identifying 'high' and 'low' risk regions in relation to outlet density, alcohol consumption and harms;

(iv) identify the most effective means of using this information to identify future high and low risk regions for alcohol consumption and related harms and to predict the likely impact of changes to outlet density; and

(v) create a framework to map the requirements for developing an outlet density model for minimising alcohol-related problems.

Report overview

This report is structured so as to address each of the project objectives sequentially.

- **Chapter 2** presents the formal literature review of international and Australian outlet density studies. This chapter also discusses the strengths, limitations and salient issues borne out in the review.
- **Chapter 3** identifies current and possible sources of alcohol indicator data across Australia which may be useful for evaluating the impact of outlet density on public health and safety.
- **Chapter 4** describes the analytical methods which underlie the statistical modelling component of the project.
- **Chapter 5** provides detailed descriptions of the data sets used in the analyses.
- **Chapter 6** presents the results of correlational analyses between a suite of outlet density measures and alcohol-related harm indicators.

- **Chapter 7** contains the results from multivariate demonstration models for estimating the impact of changes to outlet density.
- **Chapter 8** synthesises the overall findings of the study, makes recommendations and identifies the necessary requirements for future progress in this area.

Chapter two: Literature review

This chapter contains the results of the formal literature review component of the project, and to assist comprehension has been divided into four sub-sections:

(i) studies pre-dating 1990, which tended to include less methodologically robust designs;

(ii) studies conducted during the 1990s, which typically used more sophisticated modelling techniques;

(iii) recent studies, which have been able to apply small area analysis (e.g. census tracts); and

(iv) Australian outlet density research.

The first three sub-sections generally reflect study design and methodological trends typical of the period. Although only a few Australian studies have been conducted to date, the high level of geographical, social and cultural relevance of these studies warrants detailed consideration in chapter four.

Overview

There is a growing body of research evidence to suggest significant positive relations between the retail availability of alcohol, alcohol consumption and alcohol-related harms. The majority of these studies have applied cross-sectional designs that have compared cities, local government areas or other large geographic regions at a single point in time. Some studies have been able to use longitudinal data and employ time- series designs. A few have managed to combine both approaches. In recent years there has also been a trend toward evaluating the relation between outlet density, alcohol consumption and related harms at the smaller neighbourhood area rather than across large cities. New statistical approaches and computer-assisted analyses have further improved the quality of outlet density research over time. Nonetheless, the ecological nature of most of these studies limits the degree to which they can be used to draw conclusions about causal relationships.

Search strategy

A comprehensive search and review of the peer-reviewed national and international literature was carried out. All available materials published up to January 2007 were considered. Using key word searches, electronic databases (e.g. Pubmed, ProQuest 5000, AGIS, APA) and on-line journals were accessed to locate published material. Internet search engines (Google and Google Scholar) and the National Drug Research Institute (NDRI) library were extensively searched to locate unpublished government reports and other information relevant to outlet density.

Early international studies pre-dating 1990

Several older cross-sectional studies of state-level data have provided some evidence of an association between levels of alcohol-related harms and outlet density (Smart 1977a; Parker et al. 1978; Harford et al. 1979; Colon et al. 1982; Colon and Cutter 1983; Rabow and Watts 1982). These studies have been criticised on a range of methodological grounds including: failure to adequately control for confounding factors such as socio-economic variables; a reliance on multiple tests thereby increasing the likelihood of false positives; and failure to incorporate simultaneous effects into their models (Gruenewald et al. 1993; Gruenewald 1991).

According to Gruenewald (1993), many of these earlier studies were intrinsically flawed because they:

> *… neglect the possibility that consumption and availability may be simultaneously determined. That is, availability may drive consumption and consumption may drive availability (p. 38).*

Two cross-sectional studies published in the mid-1980s (Gliksman and Rush 1986; Rush et al. 1986) and another by Watts and Rabow (1983) conducted more stringent tests of the association between outlet density, levels of alcohol consumption and alcohol-related problems. Each of these studies found significant associations between outlet density, consumption and alcohol-related problems including: cirrhosis morbidity and mortality, alcohol dependence, alcohol-related traffic fatalities and drunk-driving. Unfortunately, they each failed to address the possible confounding influences of economic factors such as income and changes in the real price of alcohol.

During the 1980s, however, several other studies which used time series (Godfrey 1988; McGuinness 1983), cross-sectional (Schweitzer et al. 1983) and cross-sectional time-series approaches (Ornstein and Hanssens 1985; McCornac and Filante 1984; Wilkinson 1987) did adjust for income and price. The time-series studies found associations between per-capita outlet densities and levels of consumption but were limited in their reliability due to the small numbers of observations available. Interestingly, however, Godfrey (1988) concluded that there were suggestive (but non-significant) indications of a simultaneous association between the density of beer outlets and beer sales; such that as the availability of beer drives consumption, beer consumption may also drive availability. According to Gruenewald (1993) the Ornstein and Hanssens (1985) and McCornac and Filante (1984) studies applied inappropriate statistical analyses and were likely to have produced biased estimates of effect sizes while the cross-sectional study by Schweitzer et al. (1983) applied too many variables to too few observations, thereby reducing the statistical power of the analyses. The cross-sectional time series study by Wilkinson (1987) was more statistically robust than previous studies and indicated a significant (although small) association between alcohol consumption and per-capita outlet density. Unlike the tentative findings by Godfrey (1988), this study found that that while outlet density predicted consumption, alcohol sales did not predict outlet density.

The majority of these early studies suggest a positive association between outlet density, alcohol consumption and related harms; however, there were also some which indicated increased levels of road crashes where reductions in alcohol outlets occurred (e.g. Smart and Docherty 1976; Colon and Cutter 1983). Smith (1989a) also found that following increases in the numbers of hotels trading throughout Western Australia, there was a corresponding significant decline in male road fatalities, but not female fatalities. However, this study was complicated by the fact that there were simultaneous changes in both outlet density and the types of outlets (i.e. more hotels and fewer restaurants) which could not be disentangled. More recent studies (e.g. Scribner et al. 1994; Gruenewald et al. 1996) have not confirmed the conclusions of the early outlet density and road crash studies and have suggested that these unexpected results were due to problematic study design and use of inappropriate geographic scale.

International studies from the 1990s

In the 1990s, researchers generally became more sophisticated in their approach to investigating impacts of licensed outlet density.

Oers and Garretsen (1993) examined systematically-reported health information system data pertaining to neighbourhoods of Rotterdam, The Netherlands, and found significant correlations between the: i) proportion of drinkers and traffic injuries, ii) number of bars and traffic injuries and iii) the proportion of drinkers and number of liquor stores. The authors prophetically concluded that:

> … *knowledge of the geographic relation between alcohol use, traffic injuries and number of bars can be useful for further development of multi-sectoral health policies (p.739).*

Two correlation studies by Lester (1993; 1995) demonstrated that the more 'liberal' the availability of alcohol across the states of America, the higher the rate of death from suicide and cirrhosis, but not homicide.

Scribner and colleagues (1995) used cross-sectional design to examine outlet density and violence at a large-scale aggregate level. Their results indicated that after controlling for a range of likely confounders (i.e. economics, age, race, urbanity and social structures), significant geographic association existed between the rate of violent assault and total per-capita licensed outlets (off-premise and on-premise licenses) across 74 Los Angeles county cities. A similar design was used to investigate the geographic association between outlet density and alcohol-related road crashes resulting in injury and those resulting in property damage, for different types of outlets. The results indicated that while there was no significant relation between outlet density and crashes resulting in injury, property damage crashes were positively associated with restaurant and bar densities (Scribner et al. 1994). Controlling for socio-demographic confounders, Scribner and colleagues (1999) also investigated the geographic relation between homicide rates and outlet density using small-scale private aggregations (census tracts) designed to more closely reflect the social structures of neighbourhoods in New Orleans. The density of off-premise outlets yielded a strong geographic association with homicide but no relation was found for on-premise licenses or total licenses. It was suggested that the failure to find a significant result for on-premise sales may have been due to uncontrolled-for confounding by high levels of tourism among the large numbers of licensed restaurants (on-premise sales).

For studies which measure differences across geographical regions, one possible source of error is that observations from adjacent regions may be correlated – a phenomenon otherwise known as 'spatial serial autocorrelation'. Gruenewald and colleagues (1996a; b), in particular, have described how spatial autocorrelation may both inflate and deflate estimated standard errors. Many older studies, including the Scribner et al. (1999) study described above, failed to test for spatial autocorrelation. In defence of their methods, Scribner and colleagues have argued that spatial autocorrelation was – at that time – only an emerging issue, the seriousness of which was 'yet to be determined' (p.315).

Another study of small community areas by Scribner and colleagues (2000) suggested that the effect of outlet density on alcohol-related harms operates at the neighbourhood level rather than at the individual level and that high-risk drinkers tend to be grouped into neighbourhoods. Conversely, in a study of larger city regions within New Jersey, Gorman and colleagues (1998) reported that while 70% of the variance in assault rates was explained by socio-economic factors, the geographic distribution of assaults was unrelated to outlet density. Speer et al. (1998) re-analysed this data at smaller census areas and found that outlet density added significantly to models relating serious violent crime (homicide, rape, aggravated assault and robbery) such that a 1% decrease in violent crime could be obtained by a 1% decrease in outlet density (measured as a density per 100 persons) compared to a required 5% decrease in single parent households or a 4.5% increase in median income.

Jewel and Brown (1995) conducted an analysis of the association between motor vehicle accidents across Texas counties and outlet density measured as outlets per mile of road. Their results estimated that, for the average county, an additional licensed outlet per roadway mile would result in 0.012 fatal accidents and 0.272 non-fatal accidents per year.

Providing what is arguably the most authoritative group of studies in this area to date, Gruenewald and colleagues have published results from several studies which examined the association between per-capita outlet density and consumption, again using ecological cross-sectional and time series cross-sectional designs. In an investigation of the association between per-capita consumption of various beverage types (wine, beer, spirits) and outlet density across 44 United States jurisdictions, Gruenewald and colleagues (1992) found that each of these measures was capable of 'driving' the other and that 'availability may be responsive to sales and sales responsive to availability' (p.596). However, the sample size was small (44 observations) and therefore may have produced unreliable results. Moreover, as Gruenewald and colleagues (e.g. 1996a; 1996b) have noted in later publications, spatial autocorrelation among geographic regions may significantly affect the outcomes of cross-sectional studies – a factor which was overlooked in their earlier paper.

Gruenewald and colleagues have also used time series cross-sectional data to relate outlet densities and alcohol-related traffic crashes (Gruenewald et al. 1993; Gruenewald and Ponicki 1995). This type of study design is ideally suited to determining differences between cross-sectional observations while simultaneously adjusting for possible confounders such as changes to socio-economic factors over time. Assuming a simultaneous relation between outlet density and sales, and controlling for various confounders, Gruenewald and colleagues (1993) found that physical availability of alcohol was positively related to wine and spirits sales – although due to a lack of sales data, beer sales were not tested. Further evidence in support of a relationship between the physical availability of alcohol and consumption was provided by the finding that as land area per adult increased (an index of physical distance to alcohol outlets), wine and spirit sales decreased.

Gruenewald and Ponicki (1995) investigated the association between outlet density and single-vehicle night-time crash fatalities (usually highly alcohol-related crashes). Contrary to findings from earlier studies which employed limited cross-sectional designs, they did not find significant negative associations between consumption of wine and spirits, outlet density and crashes. However, data allowing the calculation of densities for beer outlets was again unavailable and hence its association with crash rates could not be tested. This is a major shortcoming, particularly since beer was initially identified within the study as having the strongest association with crash fatalities and has been identified elsewhere as the beverage of choice among drink drivers (Berger and Snortum 1985).

More recently, a growing number of researchers have investigated the association between the physical availability of alcohol and alcohol-related harm across adjacent geographical regions using spatial analyses (lagged effects). After adjusting for a wide range of socio-economic and geographic confounders, Gruenewald and colleagues (1996a) examined the geographic patterning of alcohol-related crashes across four Californian communities. They found that the physical availability of alcohol within a target location was significantly and positively related to rates of single-vehicle night-time crashes both within the target region and adjacent areas.

Recent international studies

Studies conducted within the current decade have tended to feature analyses of smaller geographical regions than had previously been the case and are dominated by US-based research (the state of California in particular). For example, rather than examining aggregated data across states, Gruenewald and colleagues have begun to explore associations between outlet density and alcohol-related harms at the census tract level within US jurisdictions. Studies which rely on self-report survey data also appear to be applied by analysts with increasing frequency.

Using a survey-based study of Californian residents, Gruenewald and colleagues (2002a) found that when measured as the number of outlets per roadway mile, outlet densities surrounding respondents' place of residence were not related to self-reported driving while under the influence of alcohol. Conversely, they found an association between outlet density and alcohol-related crashes such that a 10% increase in density led to a 3% increase in drink-driving.

Treno et al. (2001) found a relationship between self-reported injury and outlet density when measured as the number of outlets within a two mile radius of the respondent's home across 102 geographical units in California and South Carolina. Spatial autocorrelation significantly affected the data and was controlled for in analyses. In another self-report study of drink-driving in the state of California, Treno and colleagues (2003) found that higher outlet density (measured as outlets per square mile) was related to higher levels of driving after drinking among youth – particularly for females and the very youngest drivers. There was no indication that the effect differed by type of licence.

In an analysis of self-reported levels of assault across Californian zip codes which included population socio-demographic control measures, Lipton and Gruenewald (2002) found that outlet density per road mile marginally predicted rates of hospitalisation records per road mile. They estimated that for every additional bar per roadway mile there was a corresponding increase of between 0.068 and 0.095 self-reported hospitalisations for assault-related injury per 100 persons. Although their model explained some 88% of all assaults, they concluded that the size of zip codes, particularly rural zip codes, were too large to detect the effect imparted by variations in outlet density when measured per road mile.

A number of studies, also from California, have used secondary data to explore the association between outlet density and alcohol-related harms. Tatlow et al. (2000) found a significant association between alcohol-related hospitalisations (based on a rough fractional approach using ICD 9 codes) and total licences across San Diego zip codes. For each unit increase in outlet density per 10,000 persons, there was a 0.48 increase in morbidity per 10,000 persons. In San Francisco, outlet density measured as the number of licenses per kilometre of roadway was found to be positively related to pedestrian injuries (LaScala et al. 2000). Friesthler et al. (2004) demonstrated that child abuse and neglect in census tracts of California were positively related to per-capita density of bars, restaurants and off-licenses, such that a one unit increase in density resulted in 2.2 additional cases of abuse. In a follow-up study of census tracts in Sacramento and Santa Clara counties, Friesthler et al.(2004) concluded that after controlling for spatial autocorrelation, off-premise outlet density was related to substantiated cases of abuse, whereas bar density was related to neglect. However, results from a study by Pollack and colleagues (2005) using self-reported alcohol consumption refuted the notion that the density of licensed premises was significantly and positively associated with levels of alcohol consumption. Interestingly, they found that neighbourhood outlet density was related to all measures of deprivation but was not significantly related to greater levels of alcohol consumption. Moreover, they found that although alcohol availability was concentrated in deprived neighbourhoods, the less deprived neighbourhoods were most likely to have the heavy drinkers (Pollack et al. 2005).

A recently published cross-sectional study of licensed premises in California conducted by Gruenewald and colleagues (2006) deserves special attention as it is among the first to have expanded on the theoretical underpinnings of the relationship between outlet density and violence in order to explain how it relates to other environmental and situational factors. They proposed that there is fundamental support for the basic application of 'crime potential theory' to the relation between the physical availability of alcohol and harm; that is, that 'violence rates are a function of population characteristics, place characteristics and their interactions across spatial areas' (p.673). They argued that studies of alcohol sales and violence have consistently shown that violence among at-risk populations is greater where alcohol is more readily available. However, as yet, other factors which undoubtedly influence these relationships (e.g. illegal drug activity, prostitution) have not been successfully identified and integrated into explanatory models. In addition, the locations where licensed premises tend to be situated may be highly associated with the presence of other retail activities, which may also be related to violence.

Gruenewald and colleagues' (2006) results support the notion that levels of violence are associated with characteristics of the environment and that, in turn, these associations are related to the availability of alcohol. In particular, for off-premise licenses (e.g. bottleshops), the positive relationship between alcohol availability and violence remained strong and was evidently independent of 'a wide array of population and place characteristics for which alcohol outlets act as markers' (p.674). This was not found to be the case for on-premise licenses (e.g. hotels and nightclubs), but rather, the impact of outlet density for such premises on violence was found to be context specific. That is, only where greater densities of 'bars' occurred in unstable, poor and rural areas was there a significant relationship to increased levels of violence. The authors interpreted this as evidence for crime potential theory which suggests that the:

> *… combination of these potentials for violence are far more than the sum of their parts, and offers additional support for the conclusion that bars provide additional opportunities for violence in poor minority areas of US communities (Gruenewald 2006, p.674).*

Results from a number of other US studies have generally concurred with the results derived from Californian data described above. Costanza and colleagues (2001) examined outlet densities at census tract levels in Baton Rouge, Louisiana, and found that both taverns and off-licenses per 100 households correlated significantly with robbery and assault. When measured as rates per 100 persons, areas with high outlet density in New Jersey had more violent crime after controlling for social factors and spatial autocorrelation. However, they found no evidence of lagged effects between adjacent neighbourhoods (Gorman et al. 2001). Conversely, Zhu et al. (2004) found that spatial autocorrelation significantly influenced the relationship between outlet density (as number of outlets per 100 persons) and violence in neighbouring census tracts of Austin and San Antonio, Texas.

Gyimah-Brempong (2001) found that violence and property crime in census tracts of Detroit were related to licensed outlets per 1,000 persons. However, the author noted that as no control variables were applied in analyses, either to control for differences between census tract demographics or to take into account any deterrence effects, the final model needed to be applied with caution. In a follow-up study, Gyimah-Bremprong and Racine (2003) used non-parametric models to link outlet density with violent crime. They found that once outlet density exceeded 10–25 outlets per census tract, crime increased in a non-linear fashion. Unlike the Gorman et al. (2001) study, they concluded that outlet density was a predictor of violence in neighbouring census tracts. They proposed that typically applied standard models described in the literature are likely to underestimate the effect of outlet density on crime rates. Gyimah-Bremprong and colleagues proposed that the development of models should take into account the possibility that two or more variables may interact, that relationships may not always be entirely linear and that density of outlets in one area may affect levels of harms in adjacent and proximal areas.

From a survey of college students in Boston, Weitzman et al. (2003) found that outlet density was correlated with heavy drinking (0.82), frequent drinking (0.77) and drinking-related problems (0.79). Outlet density was measured as the number of outlets within a two mile radius of the residence of each survey participant. For Miami, Nielsen et al. (2005) found that outlet density measured as outlets per 1,000 persons aggregated by census tracts was not related to violence for blacks, but was related to robbery (but not assault) for Latin Americans. Escobedo and Utiz (2002) examined the relation between outlet density, injuries caused by violence, drink-driving and other forms of morbidity across counties of New Mexico. For each unit increase in outlet density, average suicide rates per 1,000 person increased by 0.23, alcohol-related crashes increased by 2.4 and alcohol-related crash deaths by 0.22.

There are a small number of studies which have examined data collected from other countries in recent years. These studies typically concur with the more numerous US-based studies. Using Norwegian time-series data from 1965 to 1995, Norstrom (2000) found a significant relation between violent crimes and outlet density measured per 10,000 residents aged over 15 years. In Brazil, Larajera and Hinkley (2002) found only a small association between outlet density (measured per kilometre of roadway and as a ratio of all buildings) and violence in Sao Paulo, a particularly violent area. However, the authors acknowledged significant problems with data quality in what was essentially a survey-based analysis.

Australian outlet density studies

Only a handful of outlet density studies have used data from Australian populations. These studies are of particular relevance to the current project and have been discussed in detail below.

In Western Australia (WA), the Measurement of Alcohol for Public Policy (MAPP) consortium produced several publications which examined the relationship between wholesale alcohol purchases by retail outlets (a proxy measure for outlet density) across geographic regions and various harm indicators. The first of these was a detailed 1995 report of work in progress (National Centre for Research into the Prevention of Drug Abuse 1995). The study brought together a range of alcohol-related harm indicators collected for the whole of WA in 1991/92 including; police-reported assault charges (aggregated by time of day); breath-testing data (positive result); road crash data; and hospital morbidity data. Data were aggregated into 130 local areas, with 105 falling outside of the Perth metropolitan area. Multivariate analyses controlling for variations in economic and demographic factors were applied to gauge the degree of correlation between per-capita wholesale alcohol purchases and alcohol-related harm indicators. Attempts were also made to adjust population data to reflect the relative impact of tourism across regions.

Total assault rates across the 130 regions were not significantly associated with per-capita alcohol consumption; however, assaults that occurred during night-time hours (i.e. 10pm to 6am) were significantly and positively correlated (0.33) with alcohol consumption. Much of the positive association between per-capita consumption and night-time assaults was due to full strength beer purchases, and to a lesser degree, wine purchases. Regions with the highest levels of low strength beer consumption tended to have the lowest rates of night-time assaults. Total numbers of positive breath tests and rates of road crashes were significantly and positively associated with per-capita consumption, particularly among offences occurring between 10pm and 6am. Alcohol-related hospitalisations were strongly and positively associated with per-capita alcohol consumption; male admissions for acute conditions were most strongly related to consumption. There was also a weak positive relation between non-alcohol-related hospitalisations and consumption. Per-capita consumption of full strength beer, wine and spirits each significantly predicted alcohol-related hospitalisation rates.

The study also examined variations in the association between consumption and alcohol-related harms by type of liquor outlet (e.g. hotel, liquor store, restaurant). The positive association between night-time assaults and consumption was highest when alcohol was purchased from either a hotel or liquor store. Positive breath tests were most strongly predicted by any type of alcohol purchased from liquor stores. For minor night-time crashes, levels of purchases from hotels, nightclubs and liquor stores indicated the strongest associations. The association between alcohol-related hospital admissions and alcohol purchases was greatest when alcohol was purchased by hotels and liquor stores. Assault rates demonstrated some evidence of spatial auto-correlation. However, when controlled for in multivariate analyses, spatial-autocorrelation covariate had only a marginal impact on the association between per-capita consumption and assault rate.

In a subsequent MAPP paper, Stockwell and colleagues (1996) compared the relative power of ‘hazardous’ versus total per-capita alcohol consumption to predict acute and chronic alcohol-related harm indicators across 130 geographical regions in WA. Overall, they found that when estimated from wholesale alcohol purchase data, the predictive power of hazardous alcohol consumption was only marginally different from that of total consumption.

The variable relationships between specific types of alcoholic beverages and levels of harms were further explored by the MAPP consortium in 1998 (Stockwell et al. 1998). Per-capita full strength beer consumption was more strongly associated with both night-time assaults and hospital admissions than was low strength beer consumption. Moreover, low strength beer consumption was found to be negatively related (i.e. protective) to assault and morbidity. When compared to bottled wine, cask wine consumption (typically cheaper per standard drink than bottled wine) was much more strongly associated with assaults and acute hospitalisations.

Finally, Midford and colleagues (1998) aggregated the MAPP data sets into five major functional regions across WA: northern, central, western, southern and Perth metropolitan. The aim of the study was to describe, in geographic terms, the variability in levels of alcohol consumption and related harms across the five regions and to determine whether differences existed for males and females.

The study found that although the general level and type of association between per-capita consumption and alcohol-related harm indicators were similar for both sexes, there was considerable variation in the overall nature and strength of the associations among the regions. Minor night-time crashes were the least associated with per-capita consumption across the regions. For instance, although it had the highest level of per-capita consumption in WA, the northern region had only low rates of minor night-time crashes. The authors explained this as an artefact of unique characteristics including: a high proportion of Indigenous residents, among whom, socio-economic disadvantage restricts car ownership; a general tendency not to report minor accidents; and an increase likelihood that crashes would be of a more serious nature due to high speeds and poor quality roads. In contrast to the weak association between minor night-time crashes and drinking levels, night-time assaults and alcohol-related hospitalisations were strongly correlated with per-capita consumption estimates across the five regions.

The remaining Australian studies have arisen from research conducted on New South Wales data. Stevenson and colleagues (1999a) examined the association between rates of assault, per-capita outlet density and per-capita wholesale alcohol purchases separately for metropolitan (Sydney) and non-metropolitan Local Government Areas (LGAs) of New South Wales using a cross-sectional design. Across the 44 metropolitan LGAs, per-capita consumption was highly correlated with per-capita outlet density. To avoid collinearity, the authors elected to apply per-capita alcohol consumption instead of per-capita outlet density throughout their analyses. After controlling for spatial autocorrelation and a range of demographic and social factors, about 25% of the variance in assault rates across Sydney LGAs could be explained by level of alcohol consumption. The type of liquor licence had little bearing on levels of assault. Moreover, no significant lagged effects were evident, leading to the conclusion that drinking and subsequently offences were most likely to occur within the same LGA.

The correlation between per-capita alcohol consumption and outlet density across the 131 non-metropolitan LGAs of New South Wales was much weaker than was evident for Sydney. About 8% of the variance in assault rates could be explained by wholesale alcohol purchases – the vast majority of which were directly attributable to purchases made by hotels and off-premise licenses. There was no statistically significant relationship between per-capita outlet density and assault rates throughout country New South Wales.

Stevenson and colleagues explored the alternative explanation that rather than being due to alcohol consumption per se, the apparent relationship between alcohol sales and assault might in fact be due to alcohol sales acting as a proxy for levels of social contact and varying opportunities for violent crime to occur. They further posited that if this was indeed the case, then the apparent association would be strongest at the most social of outlets, namely hotels and nightclubs, as opposed to the relatively weak opportunity for social interaction afforded by restaurants and liquor stores. As they pointed out, the results did not support this alternative explanation since licence type had no bearing on the results among metropolitan LGAs. For country New South Wales, purchases from hotels and liquor stores were both associated with assault rates.

The authors also offer some explanation for the apparent differences between metropolitan and country New South Wales. They propose that the contrasting results may arise from 'differences in the homogeneity of an LGA's characteristics than from some unique property of either region' (p. 408). In a large city such as Sydney, the variability in socio-economic and demographic characteristics of individuals across LGAs can be reasonably accounted for by statistical controls. However, within small country towns and regional LGAs there may be wide variability in socio-economic and demographic characteristics. Because socio-economic and demographic measures typically relate to an aggregate across an entire LGA, they are unable to bear-out the true level of heterogeneity which underlies the average.

Finally, the results raised concerns about the use of outlet density measures in place of wholesale alcohol purchase data – as is often the case for US studies. In the case of metropolitan Sydney, outlet density and alcohol purchases were highly correlated and similar results would have been obtained using either measure. Clearly, however, for country New South Wales, outlet density was not correlated with alcohol purchases and did not successfully predict assault rates. This raises the serious question as to whether outlet density per se is sensitive enough a measure to uncover the full extent of relationships between the physical availability of alcohol and alcohol-related harm.

In a second study, Stevenson and colleagues (1999b) examined the association between per-capita wholesale alcohol purchases, malicious damage to property and offensive behaviour rates in New South Wales using a cross-sectional design. As with their earlier study (Stevenson et al. 1999a), in order to accommodate variability in spatial autocorrelation, separate analyses were conducted for metropolitan and country New South Wales and included controls for a number of possible confounders (proportion of young males, resident Indigenous population, educational level, poverty and unemployment). Outlet density and wholesale alcohol purchases were highly correlated across the Sydney LGAs but not across the country regions. For both Sydney and country LGAs, wholesale alcohol purchases were significantly associated with levels of malicious damage and offensive behaviour and remained significant after controlling for possible confounders and spatial autocorrelation (country LGAs). No spatially lagged effects were detected. Nonetheless, the size of the correlation appeared to be greater for Sydney, possibly reflecting greater social and demographic homogeneity at the LGA level across Sydney compared to country LGAs. Noteworthy was the observation that despite only making up small proportions of country

LGA populations, there was a significant interaction between indigenous status and wholesale alcohol purchases which predicted offensive behaviour in country areas.

Donnelly and colleagues (2006) recently reported their findings from another New South Wales-based study into the impact of outlet density of licensed premises on neighbourhood amenity. The study used an innovative method, whereby responses to a nation-wide survey on crime and safety were linked to locations of licensed premises in New South Wales. The study used two measures of alcohol outlet concentration: outlet accessibility and outlet density, and examined the impact of each on reported levels of neighbourhood drunkenness, property damage and assault victimisation in the home.

Using geo-coded locations of licensed premises linked to respondent residence, statistical modelling demonstrated that people who lived closest to licensed premises (relative accessibility) reported the highest levels of drunkenness and property damage in their neighbourhoods. The relationship remained significant after statistical adjustment for possible confounding factors. The study also demonstrated that outlet density was significantly associated with residents' reported levels of drunkenness and related problems in their neighbourhoods. Although the authors identified a number of limitations in the design of their study including – an inability to assess the impact of outlet density on levels of domestic violence; an inability to compare relationships among different licence types (e.g. hotel versus liquor store); and some inaccuracy in geo-coding locations for licensed premises – they do not seriously detract from the overall veracity of the findings (Donnelley et al. 2006).

Synthesis of issues from the licensed outlet density research literature

For the most part, research within this domain remains exploratory and descriptive. In methodological terms, one of the main weaknesses applicable to all ecological studies is the possibility that associations which are evident at aggregate levels are not in fact related to causal mechanisms at the individual level (i.e. ecological fallacy). Despite the observance of multiple socio-economic and demographic factors and the statistical ingenuity of more recent studies, in many respects they remain largely correlational in nature and cannot discount confounding by some unknown and unmeasured factor. The conclusion drawn by some researchers that poverty and deprivation 'drive' the apparent associations between outlet density and levels of alcohol consumption (e.g. Pollack et al. 2005) is a case in point, and one which is clearly at odds with availability theory.

(i) Outlet density measures

The ability to draw firm conclusions from the literature has been hampered by a lack of clear consensus as to the preferred method for measuring outlet density. For instance, early research conducted on road crash rates by Gruenewald and Polnicki (1995) used numbers of licensed outlets per area or outlets per head of population to measure density, whereas more recent US studies have moved toward use of outlets per roadway mile (e.g. Lipton and Gruenewald 2002; LaScala et al. 2000, 2001). Australian studies have not used roadway miles in their analyses, but have typically applied measures of per-capita alcohol consumption as a 'proxy' measure of outlet density – although it could be argued that outlet density is in fact a proxy measure for alcohol consumption data which is more often than not unavailable (e.g. Stevenson et al.1999a, 1999b; Stockwell et al. 1998; Midford et al. 1998; MAPP 1995). Stevenson and colleagues (1999a) argued that in the case of New South Wales, use of a per-capita measure of density was far preferable to an area-based measure because many of the areas under investigation were (i) either uninhabited or had very low population density and (ii) the majority of the population within New South Wales

LGAs lived in regional centres or small towns. Moreover, they warned that despite the widespread use of outlet density measures in US studies, relative to per-capita alcohol consumption measures, they may be less effective at detecting associations within regional and non-densely populated areas. At least in the case of New South Wales, while outlet density and per-capita alcohol consumption were highly correlated in metropolitan Sydney, there was no similar association across country New South Wales (Stevenson et al. 1999a; 1999b). Donnelley and colleagues (2006) used a novel approach, comparing the utility of outlet density measured as (i) a population rate and (ii) distance to nearest five licensed outlets (accessibility) and concluded that both measures significantly predicted reported levels of neighbourhood drunkenness and property damage for residents.

In part, the degree of variability in how outlet density is measured arises from practical considerations such as the degree of difficulty and cost involved in obtaining the necessary information. In the US it is relatively easy and inexpensive for researchers to obtain routinely collected data on roadway miles, whereas this information is not typically made available by Australian collection agencies. In the reverse, many US researchers simply do not have the option of using per-capita alcohol consumption estimates because there is only limited access (state level) or no access to wholesale or retail alcohol sales data at local levels. In the past, wholesale alcohol purchase data was available for all Australian states and territories but collection was discontinued by most jurisdictions in 1997 (see Chikritzhs et al. 2004). Western Australia, Queensland and the Northern Territory (eight NT defined regions) currently collect wholesale alcohol purchases data in enough detail as to allow aggregation at sub-jurisdictional levels.

(ii) Geographic scale

After many years of trial and error there appears to be a general consensus in the research literature that measurement of the association between outlet density and violence/crime/disorder is best achieved using smaller (e.g. postcode, census tracts) rather than larger units of analysis (e.g. counties, states, nations) (Gorman et al. 2001; Zhu et al. 2004; Stockwell and Gruenewald 2004). Early studies of violence and outlet density which examined data aggregated at city and state levels tended overall to demonstrate conflicting results (especially for non-urban areas), whereas smaller unit analyses almost uniformly demonstrate strong positive associations (Gorman et al. 2001). Speer and colleagues (1998) highlighted this point when they showed that alcohol outlet densities predict violence with greater power when they focus on problems occurring within immediate neighbourhoods rather than aggregated effects at municipal levels. In part, studies which use smaller geographical units to examine density and violence tend to fair better because aggregated larger units neglect local differences, effectively averaging out substantial variation and 'watering down' otherwise strong relationships. In a similar vein, smaller units of analysis are better able to apply more sensitive socio-economic and demographic data, whereas when measured at larger aggregates these factors fail to adequately specify the true variability within complex regions which are, in essence, amalgams of smaller, distinguishable neighbourhoods and communities.

Of particular interest, a recent Australian study by Donnelley and colleagues (2006) found it necessary to apply both census districts and Statistical Local Areas (SLAs). They used two distinct measures to indicate physical availability of alcohol across the state of New South Wales: outlet accessibility and outlet density. For the outlet accessibility measure, their geographical unit of choice was the census collection district (CD), which is the smallest geographical area used by the Australian Bureau of Statistics. For each CD they calculated the average distance from the geographic centre of the CD to the five closest licensed premises. When taken as a measure across all licensed premises, this appeared to provide a robust indicator of physical access, but skewed geographical distribution precluded further breakdowns by licence type. Interestingly, at the outset of the study, Donnelley and colleagues (2006) anticipated using postcodes as the unit of analysis for their outlet density measure. However, the authors found that they were unable to match their harm indicator data (CD units) to postal areas (post codes do not map to Australian standard geographic classifications), and that a number of postal areas 'were not spatially contiguous' (p.3). Ultimately, larger SLAs (especially for country areas) formed the basic unit of analysis for the per-capita outlet density measure – a necessary trade-off between practicality and precision.

It may be that a better understanding of the relationships between outlet density and road crashes or impaired driving may be best served by examining geographical units beyond the neighbourhood level. As Scribner and colleagues (1994) have noted in relation to alcohol-related motor vehicle crashes:

Local analyses assume alcohol-related problems associated with a particular outlet are unit specific, which they need not be. Clearly, an individual could purchase alcohol in one locality and be involved in an alcohol-related outcome in another. This problem is exacerbated as the unit of analysis gets smaller (i.e. census-tract, zip code) (p.452).

The MAPP consortium identified a similar issue related to mobile populations who resided in one area but whom in all likelihood purchased alcohol in an adjacent area (MAPP 1995). Among about 150 standard SLAs across WA, they identified a number which were bereft of any type of licensed liquor outlet but which were adjacent to another SLA which contained several licensed premises 'just over the border'. When this was found to be the case, all data for the suspected SLAs were merged, thereby reducing the number of units of analysis (130), but arguably providing a more meaningful set of data.

(iii) Data availability and data quality

Conclusions drawn from any scientific study are only as good as the quality, reliability and validity of the data upon which they are based. The ability to explore and reveal relationships which exist in the real world is ultimately determined by the existence of and access to the necessary data. The rarity of accurate and complete data such as retail sales or wholesale alcohol purchases made by licensed outlets, required for estimating per-capita alcohol consumption is a case in point. Some US outlet density studies, for example, have used only spirit sales or a combination of spirit and wine sales to provide a measure of per-capita consumption, because access to sales information for other types of beverages (e.g. beer) is difficult, if not impossible, to access.

This is problematic on several fronts. Firstly, spirits only account for a limited proportion of all beverage sales (Catalano et al. 2001). Secondly, several studies have shown that beer is strongly associated with alcohol-related harm (Gruenewald 1999) and high alcohol content beer in particular (Stockwell et al. 1998). Thirdly, beverage preferences may vary widely between regions; for example, the proportion of all beverages consumed as spirits in one region may be considerably more or less than the amount consumed in another region – which may in turn relate to levels of alcohol-related harm. Fourthly, not only may beverage preference vary from region to region but also over time. In Western Australia for instance, with the influx of pre-mixed spirit beverages (i.e., ready-to-drink beverages) the proportion of all spirit-based beverages sold as straight-spirits declined markedly between 1990/91 and 1997/98 (Catalano et al. 2001). All of these factors may relate not only to levels of alcohol-related harm but also to outlet densities.

A more subtle but potentially more insidious problem than the complete absence of data is poor quality or unrepresentative data. Scribner and colleagues (1994) report on their explanation for the apparent variability in the reporting of property damage traffic crashes in Los Angeles County which had been previously attributed to variable police reporting practices. They proposed that a motorist's willingness to remain at the scene of a crash varied across cities as a direct result of legislation introduced in 1990 which required drivers to demonstrate proof of car insurance.

Drivers without car insurance were therefore less likely to remain at the scene of a crash than those who did possess insurance and at a city level, possession of insurance was associated with the proportion of high-school graduates and non-blacks.

Similar issues have been shown to affect the quality of Australian alcohol indicator data. Catalano and colleagues (2002) described the declining completion rate of 'last place of drinking' information collected by Western Australian Police. When collection began in 1991/92, almost all cases of drink-driving where the apprehended driver last drank at a licensed premise received an entry identifying the actual name of the venue. Eight years later, last place of drinking information had not been reported in about 20% of all drink-driving cases. Indiscriminate use of such data could result in misleading and spurious outcomes.

Potential indicators must also occur with high enough frequency so as to allow reliable estimates. This is especially important where small local areas or sparsely populated areas are examined. For instance, the low frequency of alcohol-attributable deaths over sparsely populated remote regions of Western Australia means, that for analytical purposes, such a measure is less practical than an alternative indicator which occurs with much greater frequency, such as violent assault.

(iv) Licence type and beverage type

Across the range of currently available licence types, levels of alcohol consumption and ensuing harms are not necessarily equivalent (Stockwell et al. 1992). Yet only a minority of studies have differentiated between alcohol consumption levels associated with specific types of outlets such as hotel, restaurant, nightclub, liquor store (e.g. MAPP 1995; Stevenson et al. 1999a, 1999b; Gruenewald et al. 1999). Due to data limitations, most studies have necessarily assumed that both alcohol consumption and related harms are spread equally across all types of licensed outlets. The problems that many researchers face in relation to information access and licence type also diminish the ability to study different beverage types, known to vary widely in their relation to levels of consumption and related harms (e.g. MAPP 1995).

An inability to quantify the amount of alcohol directly associated with individual licensed premises or aggregates of types of outlets is a major shortcoming for the outlet density literature in general. Unfortunately, most studies in this domain are information driven – that is, they are only as comprehensive and as precise as the available data allows. Some Australian researchers have been able to access systematically recorded wholesale alcohol purchases made by individual licensed premises for some jurisdictions – a major advantage.

A range of international studies and reviews suggest that it is important to draw distinctions between on- and off-premise outlet density (e.g. Stockwell and Gruenewald 2004). It is critical to understand however, that such a distinction is not equivalent to the investigative power afforded by the ability to identify the actual amount and type of alcohol purchases made by individual premises or aggregates by premise type. More often than not, densities of on- versus off-premise licensed outlets tend to be associated with different types of problems. As exemplified by Stockwell and Gruenewald (2004):

> *… rates of youth violence in minority neighbourhoods are related to greater off-premise outlet densities…rates of pedestrian injuries are greater in neighbourhoods near on-premise outlets…and rates of violent assaults are greater in high-density outlet areas selling greater proportions of specific beverage types (i.e. high-alcohol beer and spirits)… (p.223)*

(v) Spatial autocorrelation and control variables in statistical analysis

Early research which examined relationships between concentrations of alcohol outlets and alcohol-related harms was, often limited, not only because it applied geographical units which were often too large, but because it generally failed to account for relationships between adjacent regions – that is, lack of independence among the regions of interest. Application of parametric regression techniques requires that observations are independent of each other. When spatial autocorrelation is present but not taken into account in statistical analyses, it may bias results, leading to either Type I error (positive spatial autocorrelation) or Type II error (negative spatial autocorrelation) (Gruenewald et al. 2000).

Despite detailed enunciation of the problems associated with least squares regression models based on geographic units (Gruenewald et al. 2000), there is not necessarily a current consensus as to the extent to which studies may have been unduly affected by spatial autocorrelation (Scribner et al. 1999). Moreover, it is becoming increasingly clear in the research literature that the presence, absence, size and direction of spatial autocorrelation will, in all likelihood, vary from location to location and may even vary between different units of measurement within the same general region (Chou 1991; Zhu et al. 2004).

Whatever the choice of geographic unit (e.g. census tracts, local government areas) to avoid excessive spatial autocorrelation, regions should as far as possible, resemble functional areas. In some cases, administrative boundaries actually 'split functional regions' and thereby use of such units fails to reflect the spatial structure of local economic and social activities (Keilbach 2000).

Most outlet density studies, especially those conducted in the 1990s and the current decade, have included socio-economic (e.g. unemployment rate, single parent households, poverty and wealth) and demographic (e.g. proportion of males, age distribution, race and ethnicity) controls as standard in their analyses. Many studies find that these factors alone can explain much of the variability in levels of alcohol-related harms across geographic areas. However, although often ignored by outlet density studies, it has been suggested that other physical neighbourhood characteristics such as the presence of convenience stores and major street intersections may attract criminal activity (Zhu et al. 2004). Some recent studies have controlled for densities of non-alcohol related retail outlets such as department stores, butchers, motels, and snack food distributors in their analyses which may be indicative of community characteristics that influence harms typically associated with licensed outlets but which are not directly significantly associated with violence (e.g. Gruenewald et al. 2006).

(vi) Theoretical underpinnings

The outlet density research literature has been criticised for its lack of attention to underlying theoretical principles. A review of outlet density studies by Stockwell and Gruenewald (2004) concluded that while more research in this area is needed, future research will need to be better supported by theoretical models that may independently relate to different types of alcohol-related harms. For instance, models of the relation between alcohol-related crashes and outlet density at the community level should not necessarily be extended to studies on outlet density and violence – independently derived models may be necessary. Moreover, the inter-relations between situational factors typical to certain alcohol environments and aggressive behaviour, as well as locations of violent acts in relation to residences of victims and offenders should, be critical to any model seeking to explain alcohol and violence at the aggregate level.

It is important to recognise that the relationship between harm and alcohol availability for licensed premises is highly context-specific and therefore, by the same token, the relationship is likely to vary between countries, cultures and communities where social norms, town planning policies and licensing systems may also vary considerably. Thus, a relationship observed among a US population may not hold true in an Australian context.

(vii) Statistical methods

In addition to the basic requirements for addressing fundamental statistical assumptions in geographic modelling (e.g. serial spatial autocorrelation), there are a number of emerging issues in relation to statistical methods in outlet density modelling. These issues have been highlighted by Gyimah-Bremprong and colleagues (2003). They suggest that previous models may have underestimated the size of apparent associations because they have relied solely on parametric models which assume linear relationships. More wide-spread use of non-parametric tests in the future may address some of this concern. They also note that most past outlet density models have not considered the potential for interaction effects between two or more predictor variables. Models which take significant interaction effects into account are also more likely to account for a greater level of variance in the dependent variable. Finally, Gyimah-Bremprong and colleagues also bring attention to the potential for lagged effects, especially where neighbourhood units (i.e. small local areas) are analysed and mobility between geographic units is high.

(viii) Summary of findings

- One of the greatest strengths of the outlet density research literature is the robust finding that assaults are highly correlated with outlet density – that is, as density increases so do levels of assault.
- Outcomes from outlet density studies in relation to violence are reassuringly predictable, despite problems with data quality and access, choice of geographical unit and outlet density measure, country or location of interest, methodological limitations, underlying assumptions and less frequently in current times, analytical error (i.e. failure to address spatial autocorrelation).
- In relation to studies which have investigated road crashes and drink-driving the evidence for a positive linear relationship is less consistent. Recent studies have typically shown significant positive associations but some early studies found increased problems where densities were lowered, although some analysts suggest that these early findings were artefacts of inappropriate study design and choice of geographical unit.
- Associations between outlet density and other harms such as homicide, child abuse and neglect, self-inflicted injury and alcohol-related morbidity and mortality tend to be less well established – largely due to a paucity of studies – but nonetheless appear to be both linear (at least in part) and positive.
- Only a small number of Australian research studies have investigated the relationship between licensed outlet density and alcohol consumption and/or related harm. Results from Australian studies typically demonstrate positive associations between levels of licensed outlet density, violence and other alcohol-related problems and thus concur with international findings.

Chapter three: Alcohol indicator data for Australian states and territories

Routinely collected secondary data on indicators of alcohol-related harms were examined for relationships with alternative measures of outlet density of licensed premises. This aspect of the project relied heavily on work undertaken by the National Alcohol Indicators Project (NAIP). The NAIP is a national monitoring system for tracking levels of alcohol consumption and harms throughout Australian states and territories and over time. This ongoing national project is funded by the Australian Government Department of Health and Ageing's National Drug Strategy and is conducted by the National Drug Research Institute (NDRI) in collaboration with Turning Point Alcohol and Drug Centre.

The NAIP accesses a range of data systematically collected by other agencies which can be used to estimate trends in alcohol-related harms and consumption over time and place. All the data used by NAIP are collected routinely by other agencies (e.g. police, liquor licensing departments, hospitals); some are already collated at a national level (e.g. state/territory deaths are collated by the ABS); while others must be independently accessed from each state/territory (e.g. police data).

The NAIP has identified and applied several indicators of alcohol-related hams and consumption including:

(i) Morbidity data (hospitalisations); preferably sourced from the Australian Institute of Health and Welfare (AIHW) which collates and standardises hospital separation records for all states/territories. This requires independent approval from each jurisdiction before AIHW will release; process facilitated by AIHW.

(ii) Mortality data (deaths); preferably sourced from the Australian Bureau of Statistics (ABS) which collates death records from all states/territories. ABS data release generally requires a single approval form to be completed.

(iii) Assault offence data; sourced directly from state/territory police departments, generally involves lengthy data release approval procedures. Some collation undertaken by ABS but does not include required fields.

(iv) Serious road injury; in previous years sourced from the Australian Transport and Safety Bureau (ATSB) which collated police-reported road crashes. ATSB access problems severely affected collection for some jurisdictions and this is unlikely to change. Access to serious road crash records requires independent negotiation with state/territory police departments.

(v) Wholesale alcohol purchases; limited availability, current collections only undertaken in Western Australia, the Northern Territory and Queensland. Data access negotiated independently with state/territory liquor licensing departments.

(Data sets described in further detail in Chapter 5).

In addition to the indicators applied by the NAIP, there are other data collections which may provide relevant and valuable information including but not necessarily limited to: state and national surveys; emergency department records; ambulance call-outs; police drunk and disorderly reports; liquor infringement notices; reports of child abuse; sobering-up shelter admission; admissions to women's refuges; and liquor industry data (e.g. Liquor Merchants of Australia, Distilled Spirits Industry Council of Australia Inc.). For the most part, current application of these data across all jurisdictions and for comparative purposes is limited. The absence of systematic and standardised recording procedures and sometimes reliance on pen and paper systems limit their practicality. In the case of national surveys, it is often the case that outside of major city centres (especially eastern states), numbers of respondents are too few to be effectively disaggregated for analytical purposes. Nevertheless, a recent New South Wales-based study showed that responses to a national crime survey could be effectively applied to model the relationship between outlet density and neighbourhood amenity (Donnelly et al. 2006).

Each of the data sets described above has its own strengths and weaknesses, and for this reason, when applied for analytical purposes, such indicators are best examined in concert. For example, mortality data, when used to estimate alcohol-attributable deaths is one of the most accurate indicators of alcohol-related harm. Death records tend to be well documented, have a standardised code for cause of death and can be readily compared between regions. However, despite the fact that the data tend to be accurate and comprehensive (few deaths are missed), they occur relatively infrequently, especially when measured at a local level. The limited numbers of cases available may be too few for small area analysis in many cases. (Infrequent events tend to show greater variability and thereby also tend to be less robust than measures with greater frequency.) By comparison, police reports of assaults are highly frequent. Many events are captured, but many more may escape police attention and so reported cases may not be an accurate estimate of the true magnitude of violence in a community. Moreover, unlike death statistics, standard police reports are rarely able to precisely identify whether or not alcohol was a ‘causal’ factor in the incident. Some reporting systems include ‘alcohol flags’, but these may not be mandatory and the validity and reliability of subjective reports may be highly variable. Nonetheless, among a range of other possible indicators of alcohol-related harms, each with its own shortcomings, the high frequency of police-reported incidents may present the most robust alternative.

There are a range of practical factors which may influence the potential for these data to be employed in future outlet density research for informing policy.

Process of collection

The first of these issues relates to the fundamental process of collection. In the case of wholesale alcohol purchase data, state and territory liquor licensing departments were responsible for ongoing annual collections for many years as a means of determining licensing fees. However, most jurisdictions stopped collecting wholesale alcohol purchase data when, in 1997 the High Court of Australia ruled that liquor licensing fees and levies (and similar imposts on tobacco and petrol) previously imposed by the states and territories were, in fact, excise duties. As such they were illegal as – under the terms of the Australian Constitution – only the Commonwealth Government is empowered to impose excise duties. While the High Court decision did not preclude the collection of wholesale alcohol purchase data by liquor licensing authorities, for many jurisdictions the incentive for continued collection was apparently no longer in place. Only Western Australian and the Northern Territory continued to collect wholesale alcohol purchases data, with Queensland reinstating the process some years later.

Financial cost

The financial cost of obtaining information from different sources needs to be considered. By and large, government organisations such as the AIHW and the ABS charge a ‘cost recovery’ fee for data they provide. Others, particularly key stake-holders, may be able to provide information free of charge to other government-funded agencies. Costly private sector industry data is generally beyond the financial resources of most grant- and government-funded research.

Time and effort required for accessing information

The time and effort required to access information from data providers is also important. When data on a single measure needs to be sourced from multiple providers (e.g. state and territory government departments) rather than one single collection agency (e.g. ABS), access and transfer delays often exceed reasonable limits and may lead to criticism about the timeliness and relevance of findings. The value of a single body for facilitating smooth data transfer to the agency responsible for evaluation/analysis should not be underestimated.

Standard practice for recording events

A more complex problem relates to the degree of standard practice for reporting events among collection agencies. By and large, where state and territory information is brought together by a single collection agency (e.g. death data collation by the ABS), data parameters and definitions are more likely to be standardised and therefore comparisons between regions are generally reliable. Where centralised collection does not exist, significant effort needs to be expended on behalf of the analyst in order to reach an acceptably standardised measure. It may be the case that variable reporting and recording systems preclude any reliable comparison between regions. For example, in their investigation of trends in alcohol-related assaults across Australia, Mathews and colleagues (2004) found that due to the high level of variable reporting and recording practices by police jurisdictions, police assault data could not be used to reliably compare rates between jurisdictions. However, assault offences proved a useful measure for examining levels of harms within jurisdictions.

Chapter four: Methods for investigating relationships between outlet density and alcohol-related harms

This chapter details the methods applied throughout the analytical component of the project. All data sets and results pertain specifically to Western Australia.

The first stage in the process examined the strength and direction of associations between three alternative measures of outlet density, including:

(i) simple raw count of the number of licensed outlets located within each LGA (count);

(ii) the number of licensed outlets divided by the total land area contained within the LGA (area); and

(iii) the volume of wholesale alcohol purchases made by retail outlets located within the LGA (volume of alcohol).

There was a range of alcohol-related harm indicators, including:

(i) police-reported assaults;

(ii) police-reported drink-driving breath tests;

(iii) alcohol-attributable deaths; and

(iv) alcohol-attributable hospitalisations.

For the first part of the analysis, simple bi-variate correlation tests were applied (Pearson's r). The correlation between two variables can be measured on a scale extending from one (1) to negative one (-1). Where a linear association exists between two variables such that as one increases, the other increases, the correlation is referred to as 'positive'. The strongest possible positive correlation between two variables is denoted as one (1). When the association is such that as the measure of one variable increases, the other decreases, the correlation is referred to as 'negative' and the strongest possible negative correlation between two variables is negative one (-1). When there is no correlation at all between two variables, Pearson's r will be zero. The likelihood that an apparent correlation between two variables is due to chance is expressed by the p value, such that where $p < 0.05$, the likelihood that the result is due to chance is less than 5%.

Simple bi-variate correlations provide a basis for determining whether further testing or exploration of proposed relationships are warranted, but they are not adequate for modelling or predictive purposes. The second stage of the analytical process therefore involves the use of multiple linear regression (MLR) technique to demonstrate how potential outlet density models could be derived. Like Pearson's r, linear regression analysis tests for the presence of linear associations between variables, but also allows the inclusion of additional 'predictor' variables. For this reason, MLR and similar approaches are often referred to as 'multivariate' tests.

One of the major benefits of the multivariate test is that adjustments can be made for the effect of confounding or mediating factors on apparent associations between two variables of interest (e.g. outlet density and assaults). The inclusion of demographic and socio-economic factors is crucial to modelling geographical relationships. Thus, model estimation is an iterative process whereby the association between a 'predictor' variable of interest (i.e. independent variable; e.g. outlet density) is tested against the 'response' variable (i.e. dependent variable; e.g. assaults, road crashes) in the presence of other potential contributing variables (i.e. population size, average age). Ultimately, predictor variables which make a statistically significant contribution to predicting the response variable are retained in the final model, while those that do not are removed. One of the other advantages of MLR is that it estimates the magnitude of association between two variables (i.e. beta coefficients) while taking into account the effect of the other predictor variables present in the model. In other words the 'beta coefficient' (a functional estimate of correlation) between two variables can be said to be of a certain order (e.g. 0.5) while all other predictor variables in the model are 'held constant'.

The resultant beta-coefficients for each of the predictor variables retained in the final model can then be used in the standard MLR formula (see Chapter 7) to estimate an outcome for the dependent variable.

In a geographical analysis, there are many ways in which data may be organised in 'space' (e.g. grouped by suburb or local government area) and there are positive and negative aspects to each approach. Moreover, outcomes may be highly dependent on the choice of geographic unit. Geographic units should be chosen to reflect functional areas such that the mobility between adjacent areas is minimised while maintaining homogeneity within areas. In an Australian context, Local Government Areas (LGAs) or Statistical Local Areas tend to operate as functional units and are often the measure of choice in systematic reporting systems (e.g. hospital records).

For this study, the geographic unit of preference was LGA. Using these regions, two different analytical approaches were explored: (i) state-wide analysis of all LGAs and (ii) aggregation and analysis by Health Regions.

Geographical units

For data collection and analysis purposes, Statistical Local Area (SLA) offers the most readily available means of classifying areas across Western Australia; SLAs are equivalent to or aggregate wholly to Local Government Areas (LGAs). Local Government Areas are relatively stable, with new ones or changes to boundaries occurring infrequently. In 2001 there were 156 SLAs in WA which equated to 143 LGAs after allowing 13 part-LGAs to be aggregated to whole LGAs. Local Government Areas are predominantly rural in nature with 114 of the 143 located outside the Perth metropolitan area. Local Government Areas are coded as shires (S), towns (T) or cities (C) depending upon their population size.

It was necessary to further aggregate a small number of LGAs because data from police sources was coded by address rather than SLA or LGA and as such could not discriminate between LGAs that had the same name but different classifiers. This was the case for Northam (S) and Northam (T) and Albany (S) and Albany (T). These areas are organised such that there is the geographically smaller township separately administered from the larger, more sparsely populated, rural shire surrounding them. Because addresses fields in the harm data tend to simply record 'Albany' or 'Northam' it was not possible to discriminate between the towns and shires and it was necessary to add them together for all data sets to ensure consistency of analysis. It was also necessary to combine Wanneroo (C) and Joondalup (C) because the administrative division between the two areas had not been recognised in the data sources for 2001. As a result there were 140 LGAs used in the present analysis.

The regional analysis conducted in this study was based on Health Department of Western Australia Health Regions, which classify LGAs for the state into 13 Health Regions, of which 5 are metropolitan. For the present analysis, the 5 metropolitan regions were added together to form a single health region. The remaining 7 regions divided the rest of the state into rural regional areas: Goldfields, Great Southern, Midwest-Murchison, Kimberley, Pilbara, South West and Wheatbelt.

Spatial autocorrelation

Moran's I is a statistical measure of whether geographical data is clustered, dispersed or randomly distributed across space. The measure determines whether the results of analysis arise from the spatial pattern of the data rather than the characteristics of the data itself (Rogerson 2001). Two major factors can influence whether spatial autocorrelation will be identified as a contributing factor for any given data set. How the area of interest is divided into geographical units, sometimes referred to as resolution, is critical, e.g. whether measured as census tracts, LGAs or states. The overall size of the area of interest is also important as larger areas tend to encounter greater variability across geographical units; for example, a region of interest made up entirely of metropolitan suburbs may yield different results to another region containing only country areas. A large region which includes both metropolitan and country areas will have its own distinctly different spatial autocorrelation (Chou et al.1991).

It is important to identify whether spatial autocorrelation is a possible factor contributing to apparent associations, because it can influence the magnitude of the coefficients in regression analyses (e.g. regression). When a data set is highly clustered and has a positive spatial autocorrelation it may inflate the beta coefficients of the predictor variables and lead to Type I error; when the data are highly dispersed, the beta coefficients may be reduced and lead to Type II error.

Once it has been established that spatial autocorrelation may be a factor in a particular analysis, it is then possible to control for this using coefficients generated by the residuals applicable to each geographical unit. Nonetheless, the absence or presence of spatial autocorrelation does not necessarily mean that apparent associations found in statistical models are merely an artefact of geographical spread. Sometimes, controlling for spatial autocorrelation may have no impact on the model or its coefficients. This may arise when the other predictor variables (i.e. in addition to spatial autocorrelation) in the analysis account for much of the variation in the dependent variable (i.e. harm indicator).

Interpretation of the Moran's I statistic is relatively simple. The statistic varies along a scale of negative one (-1) to one (1), with zero indicating a completely random pattern. A negative outcome indicates that the data are dispersed and a positive score indicates clustering. Estimated p-values indicate whether dispersion or clustering patterns are statistically significant (i.e. likelihood that the observation is due to chance). For this study, ArcGis version 9.3 was used to determine Moran's I for the residuals produced from each of the final state-wide and regional multivariate models identified.

Rationale for model building

The bi-variate correlations shown in Chapter 6 are comprehensive and cover all possible combinations of density measures and selected harm indicator sets. The demonstration models that follow these do not, however, include all possible combinations of harm indicators and outlet density measures. The demonstration models have been restricted to including only those outlet density and harm indicators which were identified in the bi-variate analyses as having the most robust relationships. A full exploration and comprehensive analysis of all possible combinations and outcomes was beyond the scope of this feasibility study. It should also be noted that the intention of this project is not to provide a single working model applicable to all jurisdictions but to demonstrate potential applications. The examples that follow will hopefully serve to highlight the major issues and potential directions for further progress in this area.

Statistical analyses

There are a number of ways to build a linear regression model for predicting outcomes. Results presented in the modelling sections of this report relied on the 'forward selection' method. (Alternative methods include backward elimination and stepwise selection which, if done correctly, should all result in similar final models.) The forward selection approach proceeds by entering variables into the model sequentially – beginning with the variable with the largest positive or negative correlation with the dependent variable. If the apparent association between the entered independent and dependent variable meet inclusion criteria (significance), then the independent variable is retained and the next most correlated variable is entered. This process continues until all variables have been tested and either retained or excluded. Since the addition of one variable can affect the relationship between other variables in the model, this analysis must be re-run after each addition until only significant variables remain.

Independent variables which indicate a 'collinear' association must also be considered. Collinearity refers to a set of independent variables which are moderately/highly correlated with each other and therefore are very similar in the way that they relate to the dependent variable. In other words, they provide the model with very similar information. When collinearity is present a choice must be made about which variable to maintain in the model, with preference often given to the variable with the most intuitive appeal.

The results presented in Chapter 7 of this report therefore represent parsimonious models, excluding non-contributing variables and collinear associations (rarely exhibited in these data). (Consideration of potential interaction effects was beyond the scope of this project.) SPSS version 12 was used for all analyses.

Chapter five: Data descriptions: indicators of outlet density and alcohol-related harms for Western Australia

This chapter describes, in detail, the data sets used to examine associations between alternative measures of outlet density and alcohol-related harm indicators and is divided into three main sections: (i) potential measures of outlet density; (ii) indicators of alcohol-related harm; and (iii) socio-economic and demographic data.

All of the data presented in this and the following section relate to Western Australia. The state of Western Australia was selected as a test-case for three main reasons:

- Western Australia currently has the most comprehensive alcohol consumption and alcohol-related harm data in the country (i.e. collected wholesale alcohol purchase data, last place of drink data, assault data, morbidity and mortality data), thus presenting the best possible opportunity for a feasibility analysis.
- Facilitated data access assisted in meeting the project's short time line.
- There was close collaboration of the Western Australian Health Department's Drug and Alcohol Office (DAO) and the Western Australian Police Service in developing this feasibility project.

Although Western Australia currently has the most comprehensive collection of consumption and alcohol-related harms data, these data are not without their limitations. In order to develop a set of measures suitable for comparative analysis it was necessary to limit the investigation to the most recent year for which all indicators and the requisite data fields (e.g. geographic location) were available. Fortuitously, the most suitable year proved to be the financial year 2000/2001 – also a census year – thereby enabling access to temporally appropriate socio-economic and demographic information.

It is important to note that none of the harm indicator data sets applied in this feasibility project required the identification of individuals and all unit records were accordingly de-identified prior to transfer from the relevant collection agency.

Measures of outlet density

Detailed information pertaining to licensed retail outlets operating in the state of Western Australia in 2000/01 was obtained from the Liquor Licensing Division of the Western Australian Office of Racing, Gaming and Liquor. The data identified the trading names of licensed premises, full street address and postcode, and detailed information on the wholesale alcohol purchases made by each retail outlet. The wholesale alcohol purchases data were divided into total volumes (litres) of regular strength beer, low strength beer, wine and spirits. With the application of a concordance table, the street address for each licensed premises was used to aggregate outlets by LGA. These data were used to examine the efficacy of three alternative measures of outlet density:

(i) simple raw count of the number of licensed outlets located within each LGA (count);

(ii) the number of licensed outlets divided by the total land area contained within the LGA (area); and

(iii) the volume of wholesale alcohol purchases made by retail outlets located within the LGA (volume of alcohol).

(i) Count of outlets

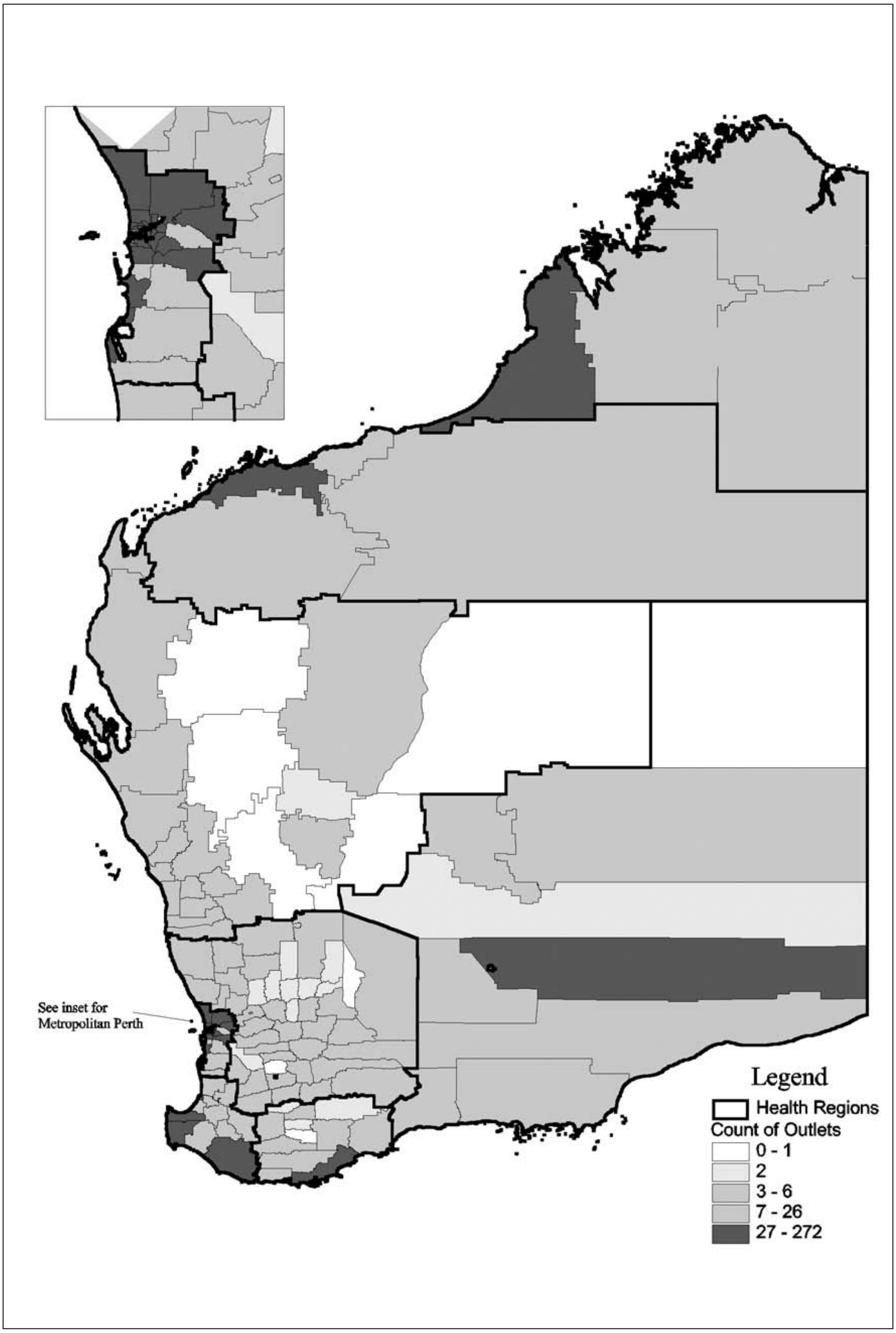
The simplest measure of outlet density, unadjusted by population or area denominators, is a straight frequency count of the total number of retail outlets operating in each SLA at any given time. As described in Table 1, in addition to counts of total outlets, counts of premises were divided into six sub-categories based on licence type. The average total number of outlets per SLA was about 18 and only one SLA had no licensed outlets at all. About 50% of SLAs had six or fewer licensed outlets. Map 1 shows the distribution of total counts of licensed outlets among LGAs and thicker lines identify health region boundaries.

Table 1 Descriptive statistics for count of outlets as outlet density measure, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min outlets per LGA	Max outlets per LGA	Mean outlets per LGA	Stnd. Dev.
Total number of outlets	TotOutlt	0	272	18	31
Number of hotels/ taverns	Outlet1	0	40	4	5
Number of liquor stores	Outlet2	0	32	3	5
Number of club licences	Outlet3	0	25	3	4
Number of restaurants	Outlet4	0	117	4	12
Number of nightclubs	Outlet5	0	22	1	2
Number of other outlets[1]	Outlet6	0	71	3	8

[1]Other includes: special facility licences, wine distributors, canteens

Map 1: Geographic distribution of total counts of licensed outlets, Local Government Areas, Western Australia, 2000/01



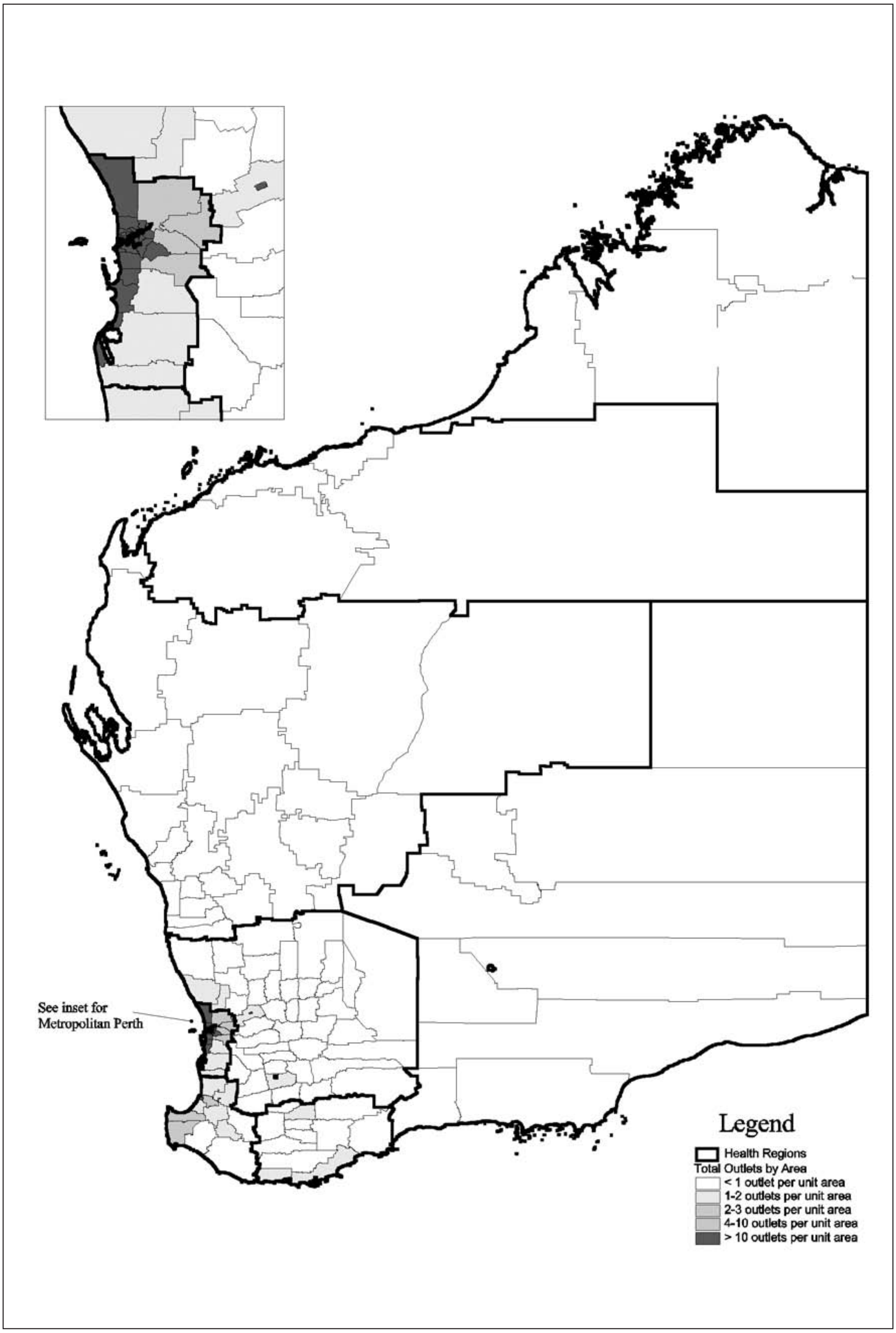
(ii) Density of outlets by unit land area

An alternative approach to measuring outlet density is to divide the number of outlets operating within a geographical unit (i.e. LGA) by the land area contained within that geographical unit. As described in Table 2, licensed premises were divided into six sub-categories based on licence type. It should be noted that due to technical limitations, 'area' was an arbitrary unit standardised and designated by ArcGis mapping software as opposed to a 'real' land area measurements (e.g. hectares). Thus, the data presented in Table 2 are useful for comparative purposes only. Map 2 shows the distribution of licensed outlets per unit of land area among LGAs and thicker lines identify health region boundaries.

Table 2 Descriptive statistics for outlets per unit land area as outlet density measure, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min per LGA	Max per LGA	Mean per LGA	Stnd. Dev.
Number total outlets divided by land area	TotOutltArea	0	2248	55	220
Hotels/ taverns divided by area	Outlet1Area	0	331	8	32
Liquor stores divided by area	Outlet2Area	0	99	7	18
Club licences divided by area	Outlet3Area	0	133	7	21
Restaurants divided by area	Outlet4Area	0	967	21	95
Nightclubs divided by area	Outlet5Area	0	182	2	16
Other outlets divided by area	Outlet6Area	0	587	10	53

Map 2: Geographic distribution of total licensed outlets per unit land area, Local Government Areas, Western Australia, 2000/01



(iii) Volume of wholesale alcohol purchases

Wholesale alcohol purchase data provided by the Liquor Licensing Division of the Western Australian Office of Racing, Gaming and Liquor enabled a further dimension of outlet density to be explored. In this report, wholesale data was examined as the volume (litres) of alcoholic product purchased and was not adjusted for alcohol content. The transformation of sales data into pure alcohol estimates is a common practice where the ultimate aim of the analysis is to estimate per-capita pure alcohol consumption (e.g. Catalano et al. 2001). This is because the conversion of volumes of different beverages (i.e. beer, spirits, wine etc.) into ethanol allows that they be validly summed into an overall measure. In an indirect way, the conversion of all beverages to pure alcohol also assumes that the effect that the consumption of alcoholic beverages may have on harm indicators, if any, can be reduced to alcohol content alone, yet there is some evidence to suggest that certain beverages are more likely to be associated with higher levels or particular types of alcohol-related harms (e.g. MAPP 1995). Given these considerations, in the analyses that follow, it was our preference to examine the relationship between harm indicators and each of the beverage types independently.

Moreover, we elected not to adjust for population estimates by converting volumes to per-capita estimates but, alternatively, to examine whether in fact estimated residential population (ERP) was a significant predictor within the context of the three alternative measures of outlet density considered. The conversion of volume of purchase data into a per-capita estimate necessarily assumes that when population estimates (i.e. ERP) are taken as a denominator, they are an accurate measure of the population responsible for actually consuming the measured volume of alcohol. In many parts of Australia, this is not the case and unfortunately, ERP can be an unreliable measure of the size of the drinking population – otherwise referred to as the Estimated Service Population (ESP) (Catalano et al. 2001). This is because people do not always consume alcohol within the geographical region where they reside – or to be more precise – where they nominate their usual place of residence on ABS Census forms every five years. The inaccuracy of ERP as a measure of ESP is particularly problematic in regions where there is high population mobility, such as: entertainment districts; large numbers of fly-in-fly-out workers; high levels of international, inter-state or inter-regional tourism; high proportions of itinerant dwellers.

Catalano et al. (2001) have estimated that the degree of discrepancy between ERP and ESP can be as large as 7% at a metropolitan/non-metropolitan level. Given the greater ease and more frequent movement of populations between smaller local neighbourhoods or LGAs, the degree of discrepancy between ERP and actual drinking populations is likely to significantly undermine attempts to statistically model associations between volume of alcohol purchases and levels of harm. Thus, rather than statistically 'force' volume of alcohol purchases for any particular region into an unreliable and potentially misleading per-head of residential population measure, our approach was to apply ERP as a predictor variable in regression analyses.

Since wholesale purchase data were divided by beverage type and each outlet identifiable by licence type, it was possible to examine a range of volume by beverage type combinations, as described in the matrix below (Table 3). Descriptive statistics for the volume density measure by beverage and licence type for LGAs have been shown in Table 4. Table 5 shows descriptive statistics where the unit of analyses was licensed premises (as opposed to LGAs). Maps 3 to 7 describe the geographical distribution of beverage purchase volumes (in litres) by LGA for each of the beverage categories and MAP 8 shows total volume of pure alcohol purchased (i.e. beverages converted to pure alcohol content [ethanol] and summed).

Table 3 Matrix of data categories examined, volume of wholesale alcohol purchases

Licence type	Regular beer	Low beer	Regular wine	Low Wine[1]	Spirits
Total outlets	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Hotel/tavern	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Liquor store	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Club licence	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Restaurant	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Nightclub	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)
Other outlet	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)	Volume (ltrs)

[1]Low wine refers to small amounts of low alcohol content or de-alcoholised wine (e.g. Maison, Yaldara Wines Lambrusco Sparkling Red De Alcoholised Wine)

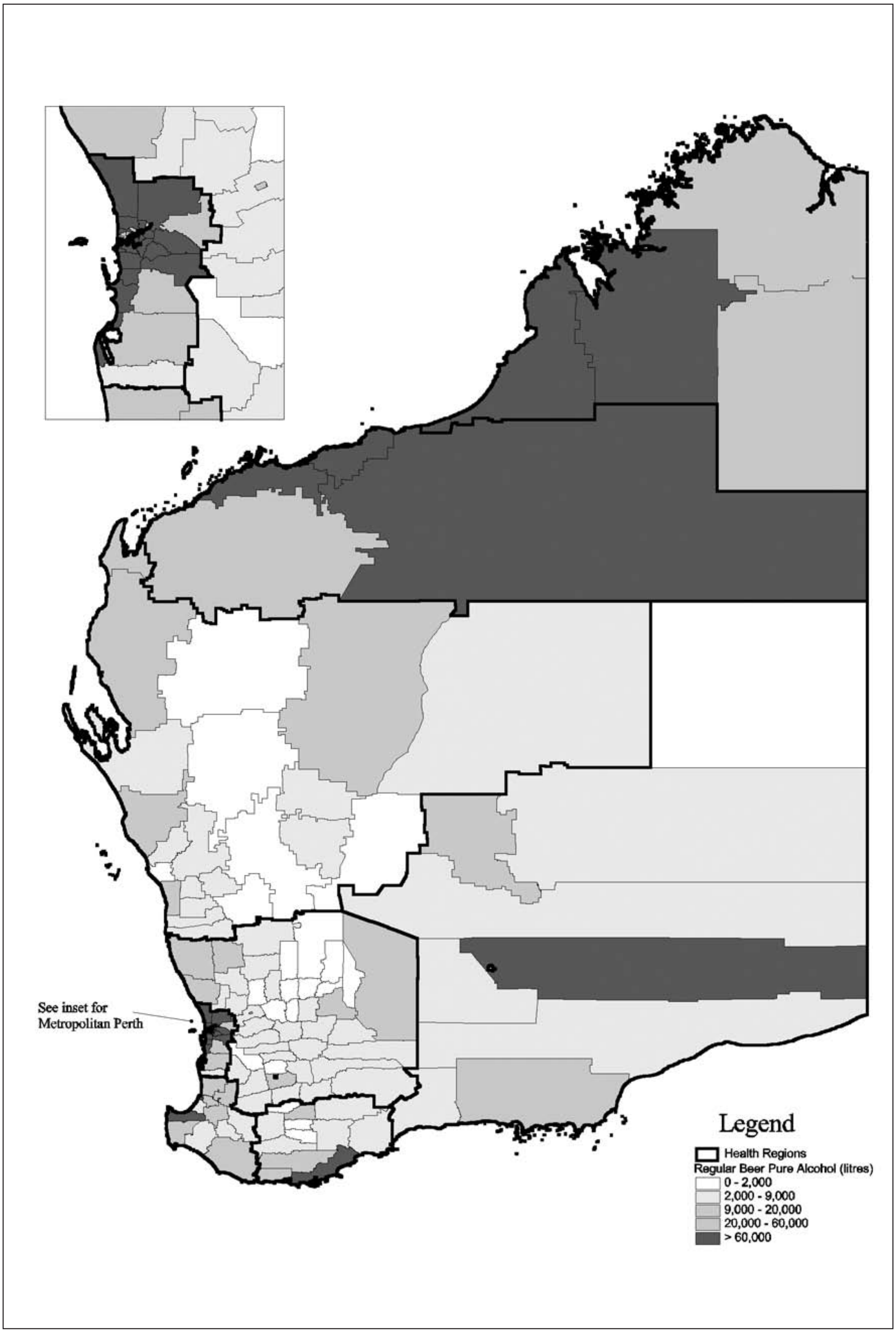
Table 4 Descriptive statistics for volume (litres) of wholesale alcohol purchased by licence type and beverage type, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min total volume per LGA	Max total volume per LGA	Mean total volume per LGA	Stnd. Dev.
Regular strength beer					
All licensed outlets	VTotHiBeer	0	9805643	807048	1455978
Hotels/ taverns	VHiBeer1	0	3675741	356022	599424
Liquor stores	VHiBeer2	0	5588186	347140	691628
Club licences	VHiBeer3	0	324865	25423	41316
Restaurants	VHiBeer4	0	265902	7119	27289
Nightclubs	VHiBeer5	0	574821	7756	51041
Other outlets	VHiBeer6	0	2790401	63589	305090
Low strength beer					
All licensed outlets	VTotLoBeer	0	1548597	161851	266302
Hotels/ taverns	VLoBeer1	0	4348014	290094	571167
Liquor stores	VLoBeer2	0	266264	27610	42307
Club licences	VLoBeer3	0	79914	2773	9035
Restaurants	VLoBeer4	0	35391	512	3130
Nightclubs	VLoBeer5	0	2981168	44630	285985
Other outlets	VLoBeer6	0	6189054	527469	958309
Regular strength wine					
All licensed outlets	VTotHiWine	0	17055544	408363	1625973
Hotels/ taverns	VHiWine1	0	1003575	64506	132398
Liquor stores	VHiWine2	0	5670359	166893	544111
Club licences	VHiWine3	0	63043	3990	8635
Restaurants	VHiWine4	0	324043	9570	33911
Nightclubs	VHiWine5	0	37873	543	3372
Other outlets	VHiWine6	0	16143893	162860	1374947
Low strength wine					
All licensed outlets	VTotLoWine	0	39122	2656	6344
Hotels/ taverns	VLoWine1	0	10575	647	1708
Liquor stores	VLoWine2	0	23639	1514	3503
Club licences	VLoWine3	0	1557	54	205
Restaurants	VLoWine4	0	1134	27	130
Nightclubs	VLoWine5	0	1296	24	149
Other outlets	VLoWine6	0	28720	389	2770
Spirits					
All licensed outlets	VTotSpirit	0	3313482	169394	383158
Hotels/ taverns	VSpirit1	0	882753	73209	135304
Liquor stores	VSpirit2	0	847735	63328	128060
Club licences	VSpirit3	0	31731	2365	3861
Restaurants	VSpirit4	0	16650	507	1707
Nightclubs	VSpirit5	0	176908	2662	15855
Other outlets	VSpirit6	0	2685195	27323	228673

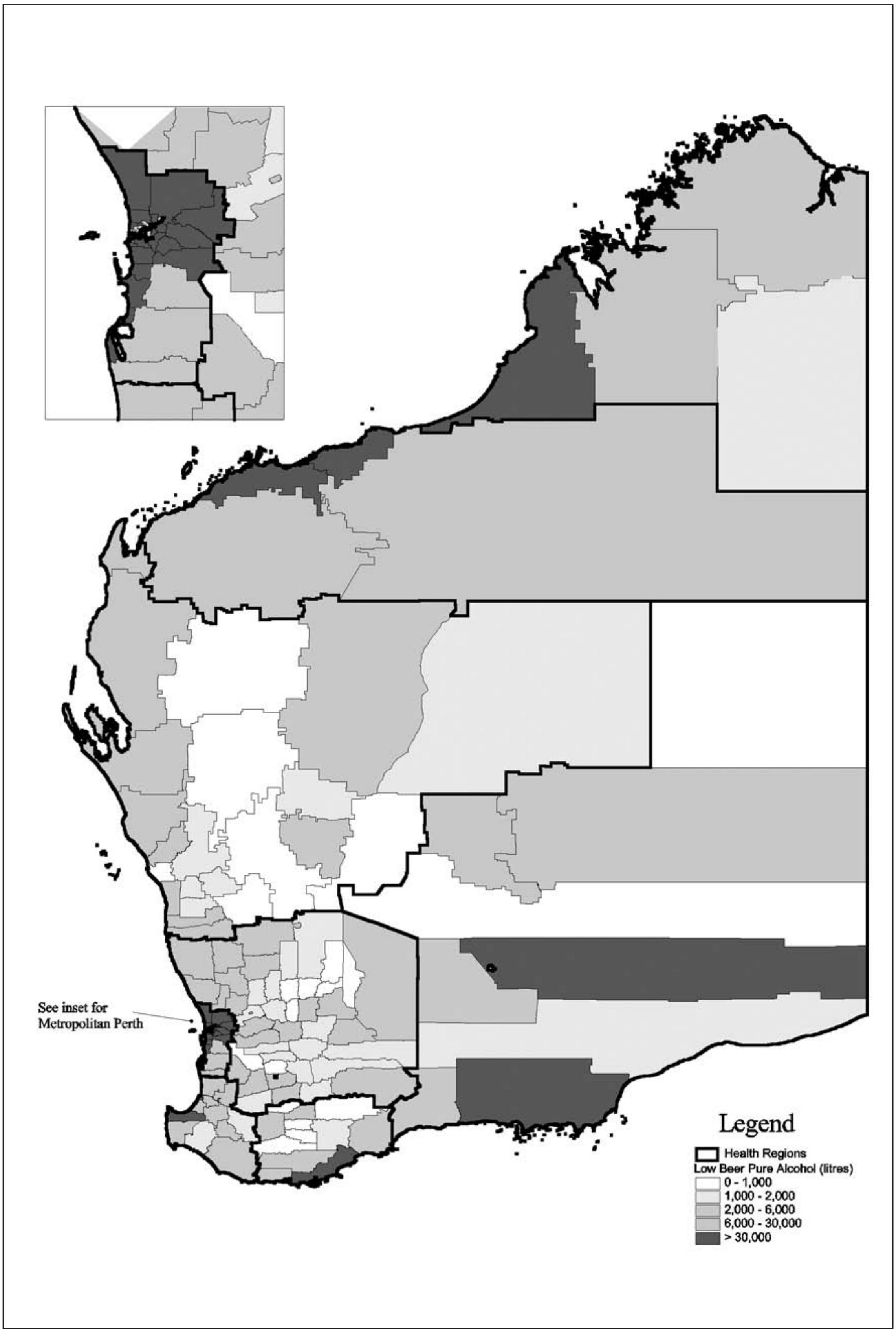
Table 5 Mean, minimum and maximum volume (litres) of wholesale alcohol purchases per licensed outlet by beverage type and licence type, Western Australia, 2000/01

Description	Data set variable name	Mean volume per outlet	Min volume per outlet	Max volume per outlet
Regular strength beer				
All licensed outlets	VTotHiBeer	35326	0	177440
Hotels/ taverns	VHiBeer1	64667	3735	307418
Liquor stores	VHiBeer2	80751	0	282096
Club licences	VHiBeer3	9265	27	39551
Restaurants	VHiBeer4	987	0	6202
Nightclubs	VHiBeer5	18903	135	107311
Other outlets	VHiBeer6	13232	0	253057
Low strength beer				
All licensed outlets	VTotLoBeer	23064	0	131793
Hotels/ taverns	VLoBeer1	30123	2219	223395
Liquor stores	VLoBeer2	69850	0	282598
Club licences	VLoBeer3	10248	0	32398
Restaurants	VLoBeer4	523	0	6476
Nightclubs	VLoBeer5	1329	0	4192
Other outlets	VLoBeer6	10598	0	425881
Regular strength wine				
All licensed outlets	VTotHiWine	11646	0	299220
Hotels/ taverns	VHiWine1	10293	3	76110
Liquor stores	VHiWine2	34535	0	708795
Club licences	VHiWine3	1325	0	16759
Restaurants	VHiWine4	1314	0	7077
Nightclubs	VHiWine5	1353	29	6082
Other outlets	VHiWine6	28523	0	1153135
Low strength wine				
All licensed outlets	VTotLoWine	84	0	1151
Hotels/ taverns	VLoWine1	86	0	1763
Liquor stores	VLoWine2	321	0	3245
Club licences	VLoWine3	31	0	1557
Restaurants	VLoWine4	4	0	99
Nightclubs	VLoWine5	78	0	473
Other outlets	VLoWine6	84	0	2208
Spirits				
All licensed outlets	VTotSpirit	6294	0	58131
Hotels/ taverns	VSpirit1	12026	55	77123
Liquor stores	VSpirit2	14659	0	96656
Club licences	VSpirit3	1006	0	7933
Restaurants	VSpirit4	110	0	1467
Nightclubs	VSpirit5	6900	177	20408
Other outlets	VSpirit6	5082	0	191800

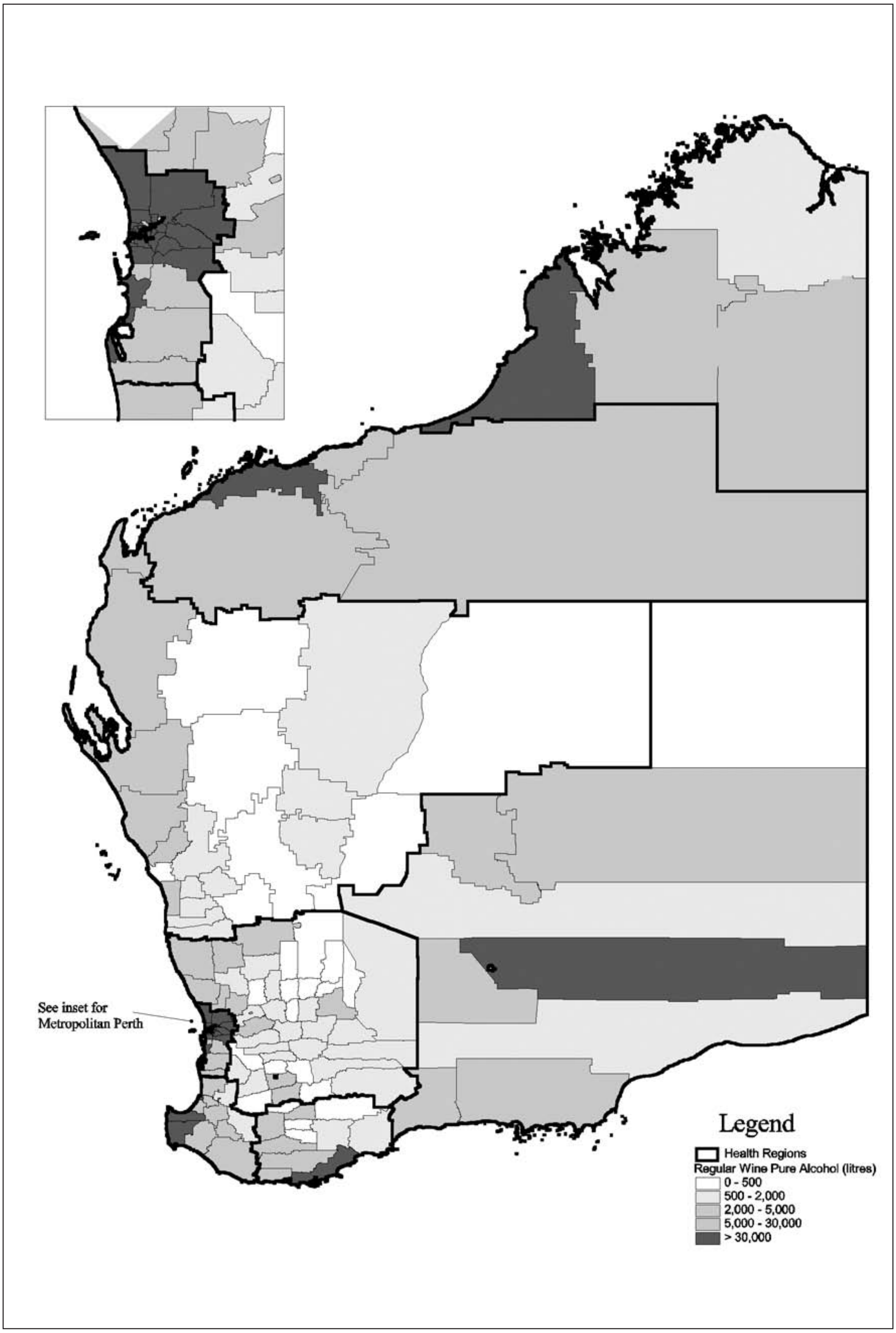
Map 3: Geographic distribution of volume of regular strength beer purchases, Local Government Areas, Western Australia, 2000/01



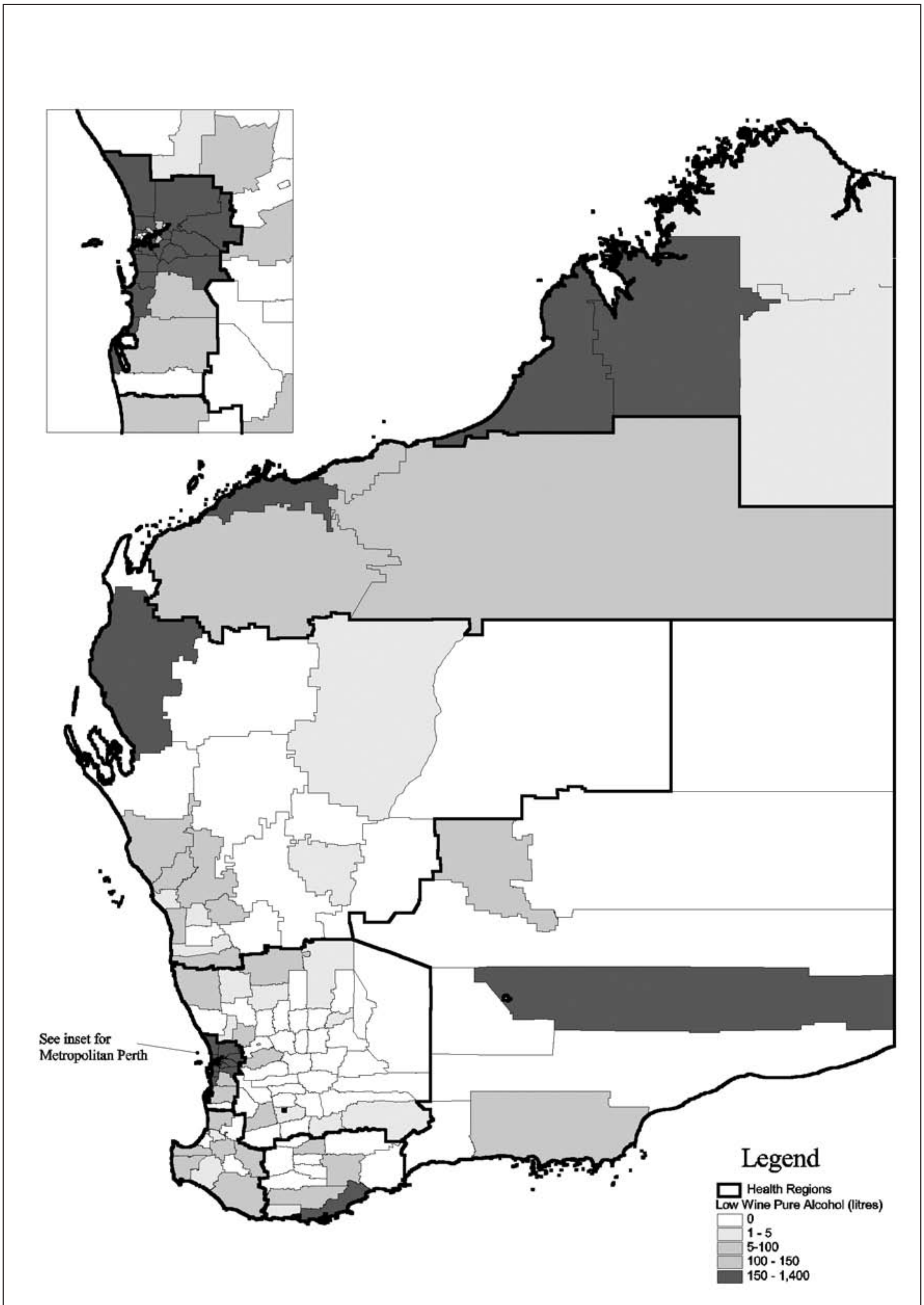
Map 4: Geographic distribution of volume of low strength beer purchases, Local Government Areas, Western Australia, 2000/01



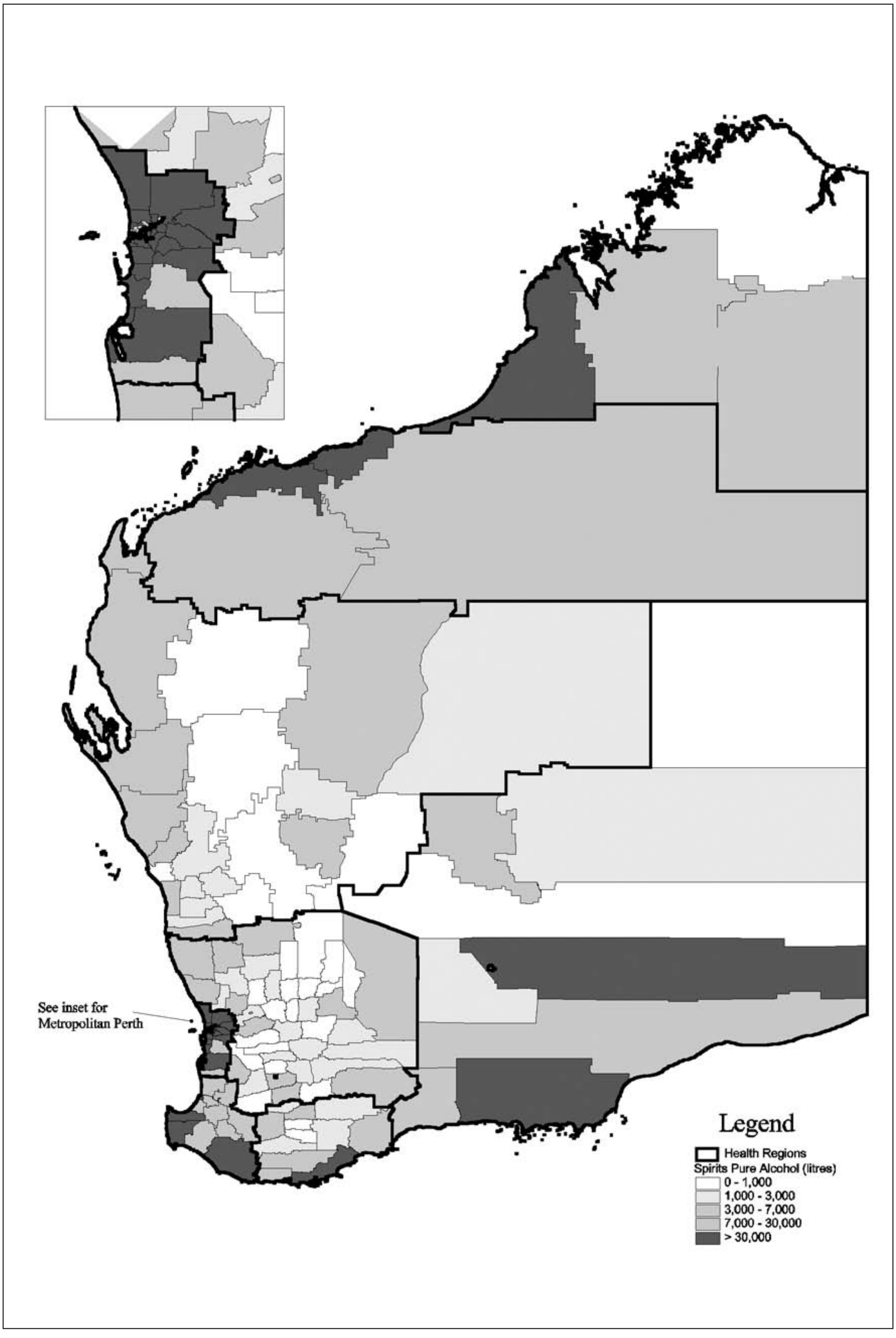
Map 5: Geographic distribution of volume of regular strength wine purchases, Local Government Areas, Western Australia, 2000/01



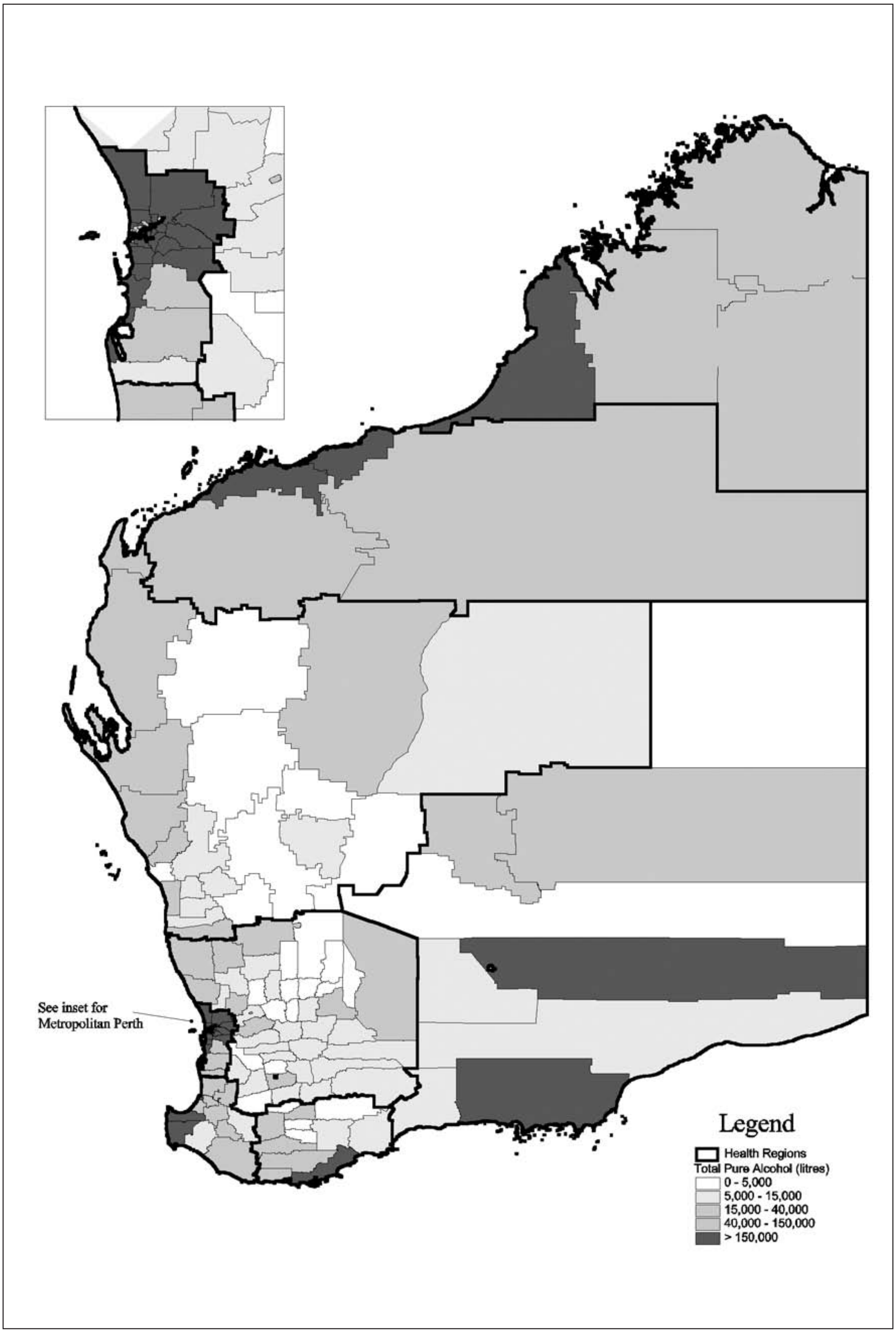
Map 6: Geographic distribution of volume of low strength wine purchases, Local Government Areas, Western Australia, 2000/01



Map 7: Geographic distribution of volume of spirit purchases, Local Government Areas, Western Australia, 2000/01



Map 8: Geographic distribution of pure alcohol beverage purchases, Local Government Areas, Western Australia, 2000/01



Indicators of alcohol-related harm

(i) Western Australian Police Service assault data

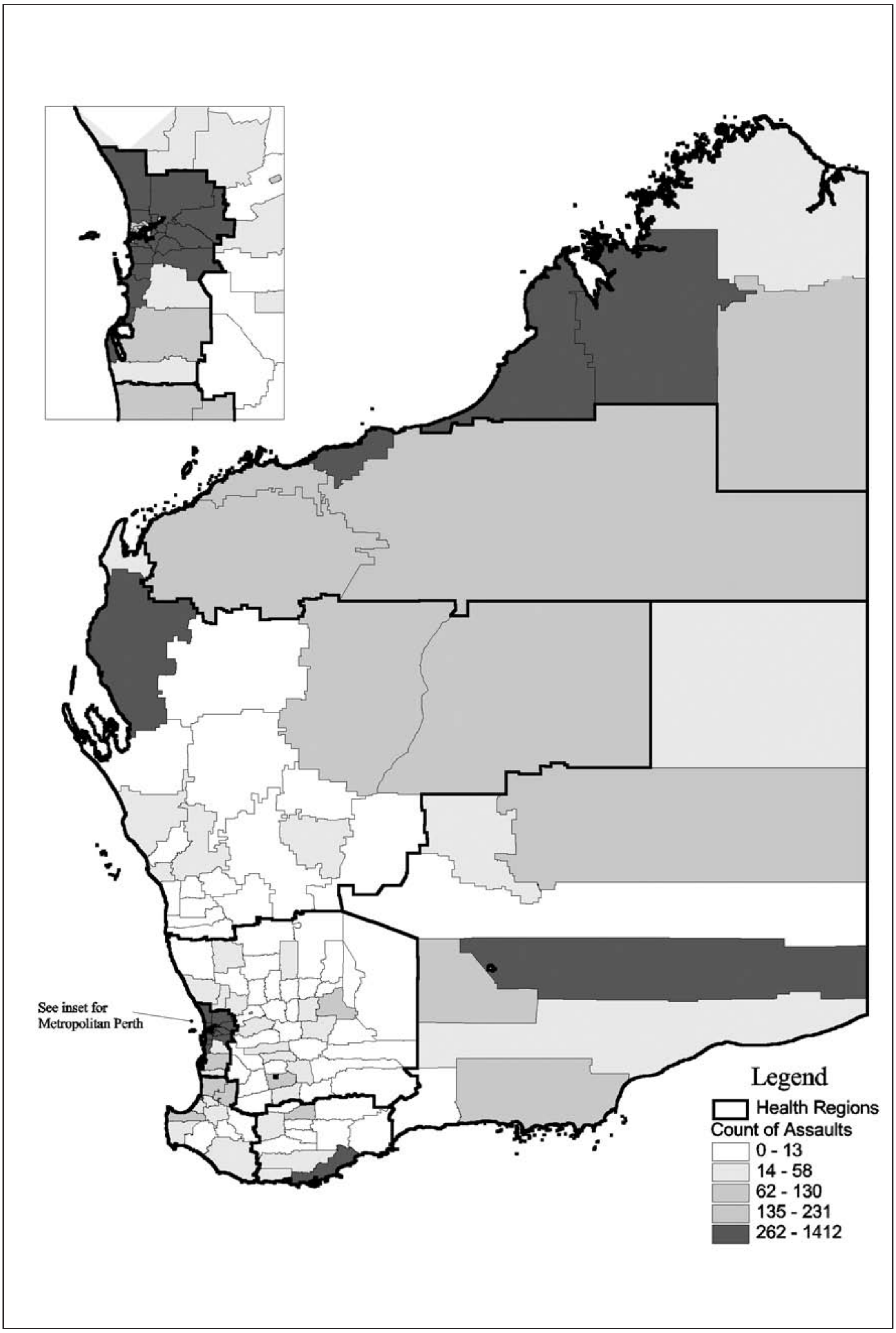
Data on police-reported assaults identified the following information: date of incident; time of day; geographical location (i.e. suburb/town); venue of assault (e.g. nightclub, private residence, park, shopping centre); and type of assault (e.g. common assault, wounding, grievous bodily harm). A concordance table was created to convert the suburb/town format identifying the geographical location of the incident to LGA. The remaining data fields were aggregated into meaningful categories for further analysis as listed in Table 6. Map 9 shows the geographical distribution of reported assault frequency by LGA.

Applying a similar rationale to that described above in relation to volume of alcohol purchases, we used counts of assaults rather than population-based assault rates. We note that, in preference to residential population rates, recent US studies have tended to prefer roadway miles as a denominator for outlet density and/or harms and offences associated with driving (e.g. road crashes, drink-driving offences, pedestrian fatalities). Unfortunately, similar data on roadway kilometres are not currently readily available in Australia. In any case, the efficacy of using roadway miles as a denominator for assaults, which are functionally distinct from harms associated with driving, remains unclear.

Table 6 Assault offence data descriptive statistics, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min assault per LGA	Max assault per LGA	Mean assault per LGA	Stnd. Dev.
Location					
Total assaults	TotAssaults	0	1412	130	245
Assaults at licensed premises	AssltLic	0	281	10	28
Assaults at private addresses	AssltRes	0	733	63	117
Assaults at other premises	AssltOth	0	868	57	119
Timing					
Assaults on a week day (Monday through Thursday)	WeekAsslt	0	718	66	124
Assaults on the weekend (Friday through Sunday)	WkEndAsslt	0	694	64	122
Assaults from 10.01pm through 2.00am	NightAsslt	0	1078	99	187
Assaults from 2.01am through 10.00pm	DayAsslt	0	413	31	60
Offence					
Assaults against public officers (police)	TotAPO	0	239	10	25
Minor assaults	TotMinor	0	859	73	143
Serious assaults	TotSerious	0	313	31	57
Sexual assaults	TotSexual	0	163	16	31

Map 9: Geographic distribution of police-reported assaults, Local Government Areas, Western Australia, 2000/01



(ii) Western Australian Police Service drink-driving offence data

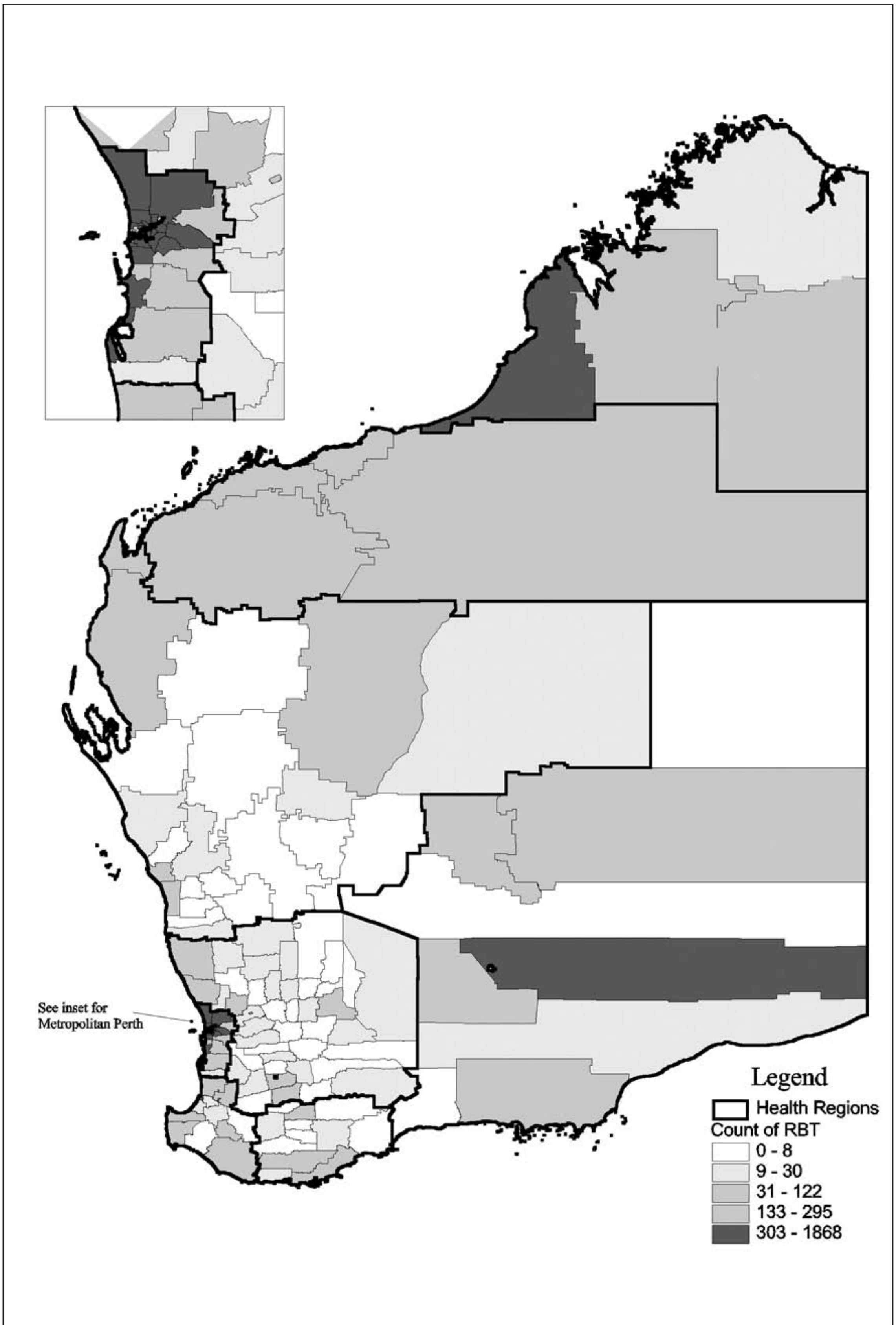
These data contained unit records of positive breath test charges (exceeding 0.05mg/ml) and road crash records where the driver produced a positive breath test. Critical information included drivers' last place of drinking. On failing a roadside breath test, all offenders were asked (i) 'Where was your last place of drinking?' and (ii) if a driver's 'last place of drinking' was a licensed outlet, then the name of the venue was recorded. This information was used to identify whether place of last drinking was a licensed outlet, private premises (e.g. house, unit, flat) or some other type of location (e.g. park, street). The RBT data set also included blood alcohol concentration (BAC) and geographical location of the offence (suburb/town) which was converted to LGA by use of a concordance table. As shown in Table 7, data were aggregated into accident and non-accident related offences and BAC data were used to aggregate offences into four categories based on the driver's level of intoxication. Maps 10 and 11 show the geographic distribution of random breath test (non-road crash) and road crash drink-driving offences across LGAs respectively. Throughout the analyses that follow drink-driver offence data were measured in terms of counts (frequencies) as opposed to population-based or roadway miles-based rates.

Table 7 Drink-driving offence data descriptive statistics, Western Australian Local Government Areas (LGAs), 2000/01

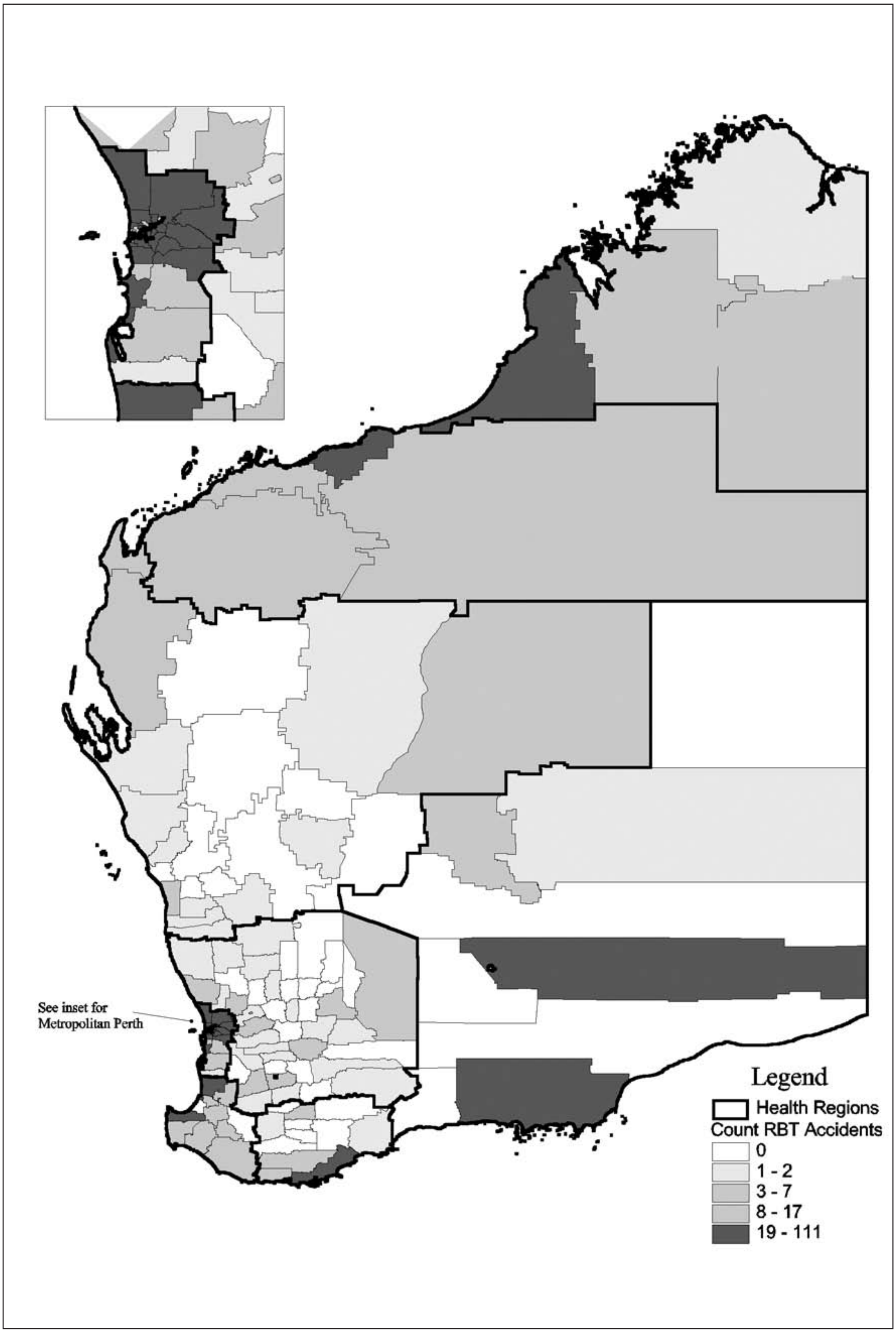
Description	Data set variable name	Min offence per LGA	Max offence per LGA	Mean offence per LGA	Stnd. Dev.
Location					
Last place of drinking, licensed premise	RBTLic	0	1453	63	164
Last place of drinking, residence	RBTRes	0	991	75	144
Last place of drinking, other[1]	RBTOth	0	251	20	38
Last place of drinking, unknown	RBTUnk	0	33	2	5
Incident type					
Road crashes	NonAcc	0	1868	150	300
RBT	Acc	0	111	11	19
BAC level					
BAC less than 0.05	RBT0	0	256	20	42
BAC between 0.05 and 0.08	RBT50-79	0	734	44	109
BAC between 0.08 and 0.15	RBT80-149	0	819	67	131
BAC exceeded 0.15	RBT150	0	230	30	47

[1]Other includes: parks, universities, sports grounds, work places, vehicles, campsites etc.

Map 10: Geographic distribution of random breath test drink-driving offences, Local Government Areas, Western Australia, 2000/01



Map 11: Geographic distribution of road crash drink-driving offences, Local Government Areas, Western Australia, 2000/01



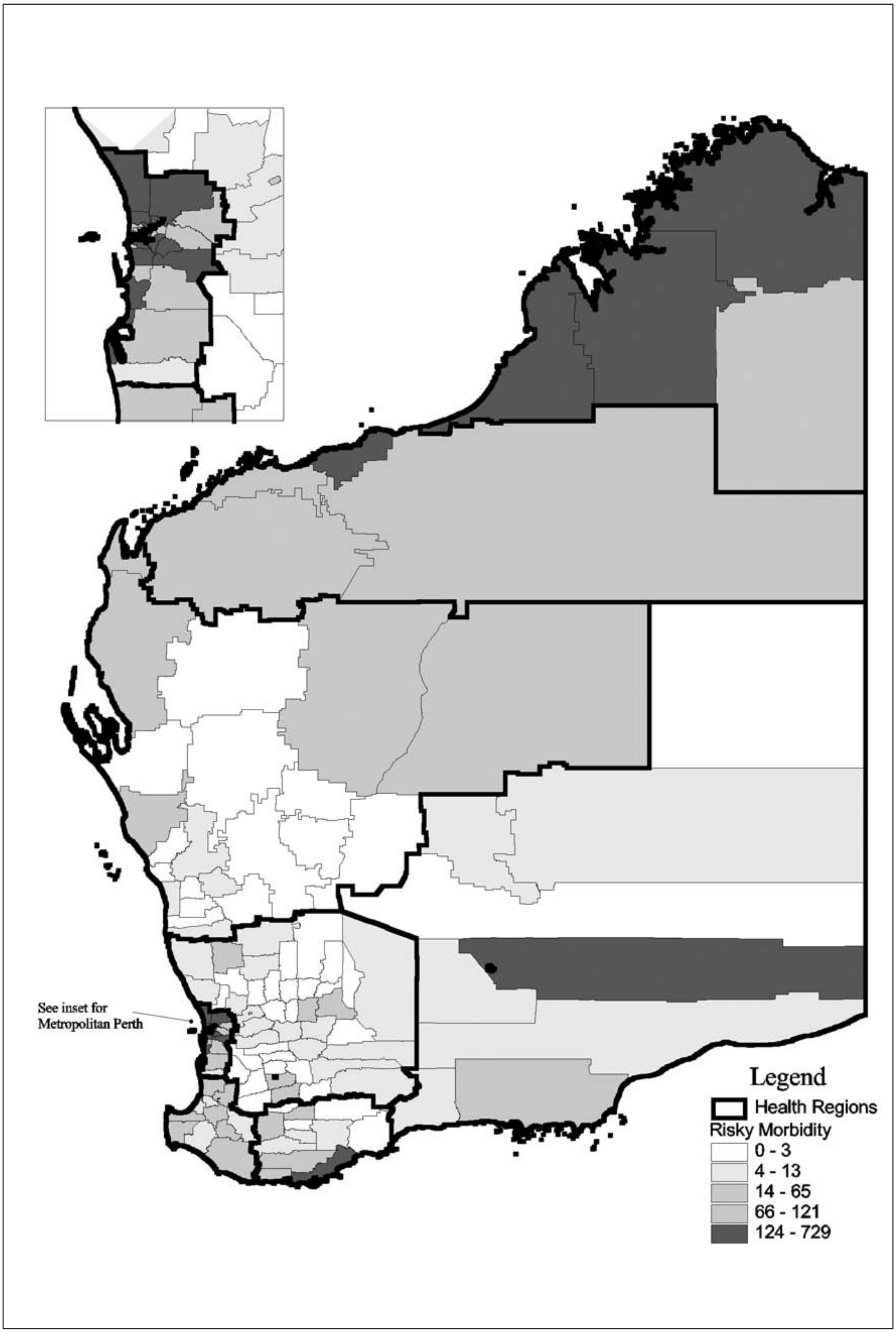
(iii) Western Australian morbidity data

Morbidity data containing unit records of hospital separations were obtained from the National Alcohol Indicators Project database. The data set contained unit record relating to individual episodes of hospitalisation, place of residence (SLA converted to LGA) of the patient and the primary cause of hospitalisation (ICD-9 coded). Unit records were adjusted using aetiologic fraction methodology so as to estimate numbers of cases attributable to risky/high-risk alcohol consumption (see Chikritzhs et al. 2003 for further information on the aetiologic fraction method). Hospitalisations were identified as either chronic (e.g. alcoholic liver cirrhosis, liver cancer) or acute (e.g. assault injury, road injury, falls) in nature (Chikritzhs et al. 2003). Three sentinel conditions were also independently examined: alcohol-attributable road crashes, alcohol-attributable assault injury and alcoholic liver cirrhosis (see Table 8). Map 12 shows the geographical distribution of alcohol-attributable hospitalisations due to risky/high-risk drinking by LGA. Throughout the analyses that follow morbidity data were measured in terms of counts (frequencies) as opposed to population-based or roadway miles-based rates.

Table 8 Morbidity data descriptive statistics, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min hospital per LGA	Max hospital per LGA	Mean hospital per LGA	Stnd. Dev.
Acute/chronic					
Total alcohol-attributable hospitalisations	MorbTotRisky	0	729	52	90
Acute alcohol-attributable hospitalisations	MorbTotRiskyAcute	0	556	41	71
Chronic alcohol-attributable hospitalisations	MorbTotRiskyChronic	0	173	11	21
Sentinel conditions					
Alcohol-attributable road crash injury	MorbRiskyAlc1	0	43	4	7
Alcohol-attributable assault injury	MorbRiskyAlc3	0	119	10	19
Alcoholic liver cirrhosis	MorbRiskyAlc8	0	39	2	4

Map 12: Geographic distribution of alcohol-attributable hospitalisations due to risky/high -risk drinking, Local Government Areas, Western Australia, 2000/01



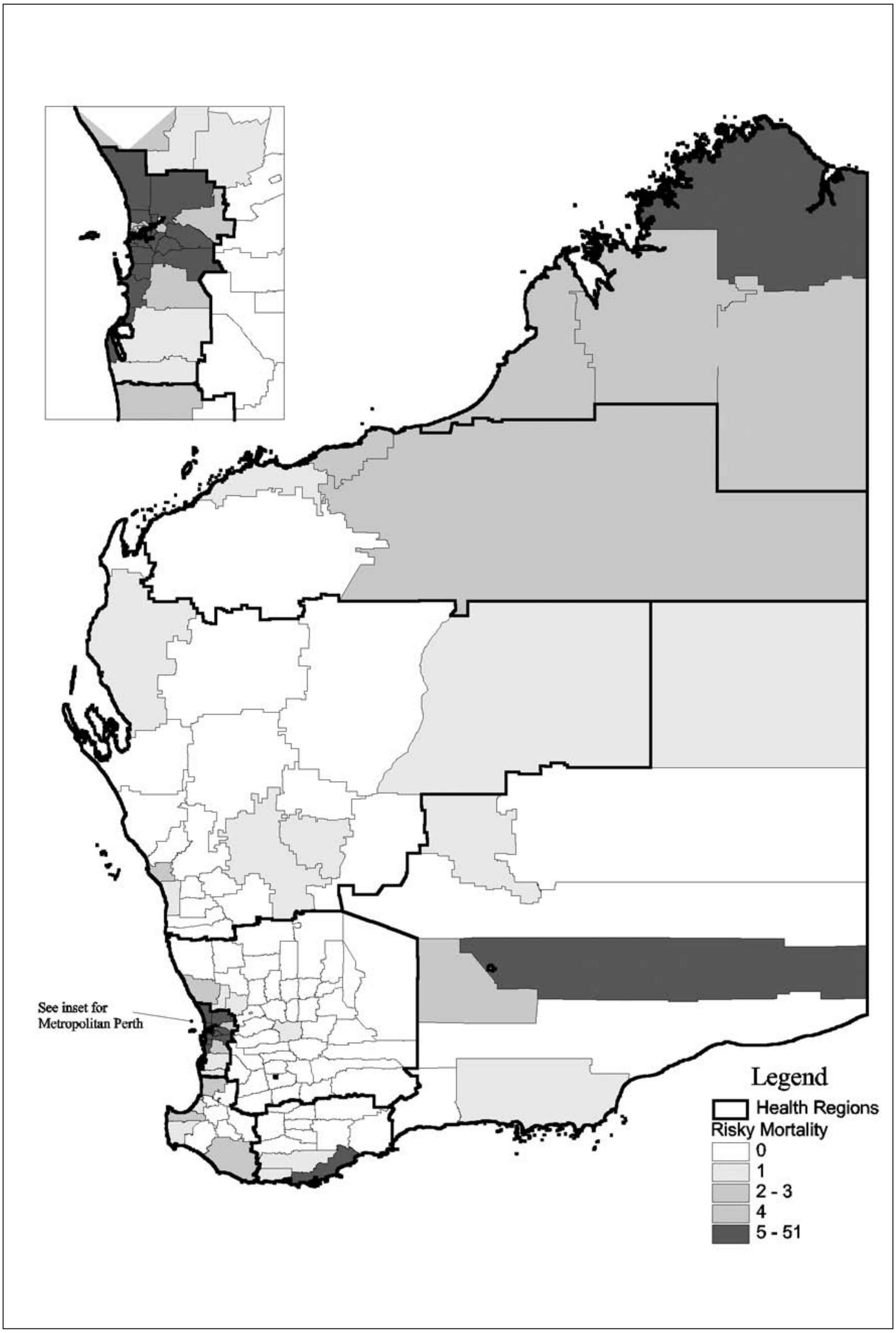
(iv) Western Australian mortality data

Death data were obtained from the National Alcohol Indicators Project database. The data set contained unit record relating to individual deaths, place of residence (SLA) of the deceased and the primary cause of death (ICD-9 coded). Unit records were adjusted using aetiologic fraction methodology so as to estimate numbers of deaths attributable to risky/high-risk alcohol consumption (see Chikritzhs et al. 2003 for further information on the aetiologic fraction method). Deaths were identified as caused by either chronic (e.g. alcoholic liver cirrhosis, liver cancer) or acute (e.g. assault injury, road injury, falls) conditions (Chikritzhs et al. 2003). Three major causes of alcohol-attributable death were also independently examined: alcohol-attributable road crashes, alcohol-attributable assault and alcoholic liver cirrhosis (see Table 9). Map 13 shows the geographical distribution of alcohol-attributable deaths due to risky/high-risk drinking by LGA. Throughout the analyses that follow mortality data were measured in terms of counts (frequencies) as opposed to population-based or roadway miles-based rates.

Table 9 Mortality data descriptive statistics, Western Australian Local Government Areas (LGAs), 2000/01

Description	Data set variable name	Min death per LGA	Max death per LGA	Mean death per LGA	Stnd. Dev.
Acute/chronic					
Total alcohol-attributable deaths	MtTotRisky	0	51	2	6
Acute alcohol-attributable deaths	MtRiskyAcute	0	27	1	3
Chronic alcohol-attributable deaths	MtRiskyChronic	0	24	1	3
Sentinel conditions					
Alcohol-attributable road crash deaths	MtRiskyAlc1	0	9	1	1
Alcohol-attributable assault injury deaths	MtRiskyAlc3	0	3	0	0
Alcoholic liver cirrhosis deaths	MtRiskyAlc8	0	15	0	2

Map 13: Geographic distribution of alcohol-attributable deaths due to risky/high-risk drinking, Local Government Areas, Western Australia, 2000/01



Demographic and socio-economic indicators

A range of socio-economic and demographic data was obtained from the Australian Bureau of Statistics (ABS) to examine whether these factors influenced the associations, if any, between alcohol-related harm indicators and outlet density measures in exploratory multivariate analyses. Two main data sets of interest were identified: the Socio-Economic Indexes for Areas (SEIFA); and 2001 Census data. These have been described in detail below.

(i) Socio-Economic Indexes for Areas (SEIFA)

SEIFA information for Western Australia was obtained from the 2004 Australian Bureau of Statistics publication 'Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA)'. Two main SEIFA measures were applied: the Index of Disadvantage; and the Index of Advantage/Disadvantage. The Index of Disadvantage is defined as an extension of socio-economic status (typically measured only by education, occupation and income) and includes the core measure of education, occupation and income as well as direct measures of socio-economic disadvantage such as: the number of motor vehicles, rooms in dwelling, unemployment, type of residence and English language proficiency. More indirect measures that may reflect disadvantage are also included, such as Indigenous status and whether adults are divorced/separated.

These indexes are designed such that the larger the score, the more advantaged is the area under consideration. So, for the Index of Disadvantage, at the SLA level, Australia as a whole scores an average of 999. Relative to the national score, the ACT is the most advantaged state/territory, scoring an average of 1,079 by SLA, and Tasmania is the most disadvantaged at 949. WA scores an average of 977 by SLA.

Originally used as a means to compare between rural and urban areas, the Index of Advantage/Disadvantage is based on the Index of Disadvantage but essentially combines advantage and disadvantage to arrive at a 'net effect'. Variables specifically targeting a measure of advantage or disadvantage are excluded. At the SLA level the average score for Australia is 994. The average SLA score in WA is 970, with the highest average being in the ACT at 1,121 and the lowest being in Tasmania at 928. Table 10 shows the means across LGAs for the two SEIFA measures.

Table 10 SEIFA Disadvantage and Advantage/Disadvantage measures, Western Australian Local Government Areas (LGAs), 2000/01

Variable	Min	Max	Mean	Stnd. Dev.
SEIFA-Disadvantage	406.42	1,144.70	972.26	88.38
SEIFA-Advantage/Disadvantage	703.42	1,208.97	965.63	67.50

(ii) Census data

In order to maintain temporal consistency with the harm indicator data and outlet density measures, a selection of socio-economic and demographic data aggregated by SLA were obtained from the 2001 census. Data selections were informed by the outlet density literature and were based on age and gender, household tenure and income, family status, private stability, unemployment and Indigenous status. Table 11 identifies each of the variables examined and how they were calculated.

Table 11 Socio-economic and demographic variables from the Australian Bureau of Statistics, Western Australian Local Government Areas (LGAs), 2001 census

Variable name	Description	Method of calculation	Min	Max	Mean	Stnd. Dev.
TotPop	Total population	Equivalent to estimated resident population (ERP)	133.0	176710.0	12465.0	24195.4
Popdensity	Density of population	Land Area/Estimated Resident Population *10000				
Urbanity	Urbanity Index	(1 = major city; 2 = inner regional; 3 = outer regional; 4 = remote; 5 = very remote; 6 = migratory)	1.0	5.0	3.0	1.3
UnempRate	Unemployment rate	Unemployed/employed	0.0	0.2	0.1	0.0
IndigRate	Indigenous rate	Indigenous/Non-Indigenous	0.0	5.4	0.2	0.6
DiffRes1	Usual residence 1 year ago differs from present residence	Different address/Same address	0.1	0.5	0.3	0.1
DiffRes5	Usual residence 5 years ago differs from present residence	Different address/ Same address	0.0	1.5	0.1	0.3
OneParent	One parent household rate	No. one parent household/ No. other families household	0.0	0.4	0.1	0.1
BuyHouse	Rate of house buyers	No. persons buying house/ No. persons renting or other	0.0	5.1	1.9	1.0
Hinc200	Rate household income < $200 per week	No. household incomes less than $200 per week/ No. household incomes > $200 per week	0.0	0.6	0.1	0.1
Hinc1000	Rate household income > $1,000 per week	No. household incomes greater than $1,000 per week/ No. household incomes < $1,000 per week	0.1	2.0	0.5	0.4
AveAge	Average age	Sum of all ages among residents/ total private population	26.2	40.7	35.1	3.0
A60p	Proportion of residents aged 60 years and older among total population	No. persons aged 60+ / Total population	0.0	0.2	0.2	0.1
AtoC	Ratio of adults to children	No. adults (15 years plus) / No. children (< 15 years)	1.7	16.6	3.6	1.5
YMtoTP	Proportion of males aged 15-24 years among total population	No. males aged 15-24 / Total population	0.0	0.1	0.1	0.0
MtoF	Ratio of males to females	Total no. males / total no. females	0.7	2.4	1.1	0.2

Chapter six: Size and direction of associations between outlet density measures and alcohol-related harms in Western Australia

This chapter is organised according to harm indicators, i.e. assaults, drink-driving offences, alcohol-attributable hospitalisations and alcohol-attributable deaths. Within each harm indicator section, the results from each of the three alternative outlet density measures have been provided. The large number of possible combinations created a substantial volume of information, much of which is best presented in table form. To facilitate the comprehension of these results, summaries of main findings appear in shaded boxes at the top of each sub-section.

Table 12 below summarises the overall associations apparent between each of the harm indicators and each of the three density measures when all licensed premises are combined. Outlet density (however it was measured) had a positive association with all the harm indicators measured – that is, as the outlet density increases so too does harm. However, the strength of the apparent associations was highly variable. All three outlet density measures indicate strong associations with assaults, drink-driver road crashes and RBT offences; the strongest of these linear associations arising with regular strength beer purchases (consistently > 0.90), especially for assaults. Count of outlets and outlets per land area indicate only moderate/weak associations with alcohol-attributable hospitalisations and deaths, however, regular strength beer purchases appear to be strongly associated with these harm indicators.

The strength of associations between wholesale purchases of regular strength beer and harm indicators varied by licence type: (i) hotels/taverns and liquor stores consistently indicated strong positive associations across all alcohol-related harm indicators; (ii) club licences and restaurants indicated moderate associations with offences (with the notable exception of restaurants and RBTs with a correlation of over 80%) and weaker associations with hospitalisations/deaths; and (iii) nightclub and other licences (i.e. special facility licences, wine distributors, canteens) indicated moderate to weak associations across all harm indicators.

The overall patterns of results summarised in Tables 12 and 13 are largely representative of the more detailed findings presented in Tables 14 through 29, where wholesale purchases of regular strength beer consistently indicate the strongest linear associations across sub-categories of harm indicators and licence types.

Table 12 Associations between harm indicator totals and alternative density measures (Pearson's r), all licensed premises combined

		Density measures	
Harm indicator	**Count of outlets**	**Count of outlets per unit land area**	**Wholesale purchases of regular strength beer**
Total assaults	0.718	0.909	0.945
Total road crashes	0.802	0.935	0.923
Total RBT	0.848	0.889	0.905
Total alcohol-attributable hospitalisations	0.386	0.407	0.827
Total alcohol-attributable deaths	0.318	0.202	0.824

Table 13 Associations between harm indicator totals and wholesale purchases of regular strength beer (Pearson's r), by licence type

Harm indicator	*Density measure: wholesale purchases of regular strength beer*						
	All licensed outlets	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Total assaults	0.945	0.951	0.865	0.654	0.650	0.499	0.451
Total road crashes	0.923	0.927	0.842	0.709	0.731	0.587	0.414
Total RBT	0.905	0.936	0.780	0.732	0.808	0.629	0.434
Total alcohol-attributable hospitalisations	0.827	0.848	0.764	0.594	0.385	ns	0.410
Total alcohol-attributable deaths	0.824	0.840	0.843	0.661	0.349	ns	0.236

Assaults

Summary of results: Tables 14–17

When outlet density was measured as a count of outlets per LGA:

- assaults were highly correlated with total licensed outlets but less so for private premises;
- overall total assaults correlated highly with hotels/taverns and liquor stores but less so with restaurants and nightclubs;
- assaults on public officers (police) correlated strongly with all licensed outlets except liquor stores;
- sexual assaults were most strongly correlated with liquor stores;
- weekend assaults were more highly correlated with all outlet types than weekday assaults; and
- assaults which occurred from 2.01am – 10.00pm were more highly correlated with all outlets than assaults which occurred from 10.01pm – 2.00am.

When outlet density was measured as the number of licensed outlets by land area per LGA:

- assaults were highly correlated with total licensed outlets but less so with total private premises; and
- overall total assaults correlated highly with hotels/taverns, restaurants, nightclubs, other licence types (i.e. special facility licences, wine distributors, canteens) but less so with liquor stores and club licences.

When outlet density was measured as volume of wholesale beverages purchases (by beverage type) per LGA:

- assaults correlated most strongly, positively and consistently with volume of regular strength beer purchases and least with regular strength wine; and
- assaults which occurred from 10.01pm – 2.00am were more highly correlated with volume of wholesale alcohol purchases than assaults which occurred from 2.01am – 10.00pm.

When outlet density was measured as volume of regular strength beer purchases (by outlet type) per LGA:

- assaults were highly correlated with both total licensed outlets and private premises;
- overall total assaults correlated highly with hotels/taverns, liquor stores, restaurants and club licences) but less so with nightclubs and other licensed outlets; and
- assaults occurring from10.01pm – 2.00am were more highly associated with all licensed outlets than those occurring from 2.01am – 10.00pm, with the exception of restaurants and nightclubs.

Table 14 Significant correlations (Pearson's r) between numbers of police-reported assault offences (by offence type) and counts of licensed outlets (by outlet type) for 140 Western Australian Local Government Areas, 2000/01

	Density measure: count of outlets						
Assault measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
All assaults	0.718	0.683	0.747	0.635	0.514	0.280	0.520
Location							
Licensed premises	0.862	0.766	0.316	0.362	0.877	0.827	0.766
Private premises	0.388	0.399	0.762	0.587	0.189	ns	0.218
Other location	0.842	0.775	0.629	0.562	0.642	0.474	0.676
Timing							
weekday	0.670	0.639	0.744	0.610	0.459	0.236	0.481
weekend	0.755	0.718	0.734	0.647	0.558	0.317	0.547
10.01pm – 2.00am	0.674	0.643	0.762	0.632	0.463	0.231	0.482
2.01am – 10.00pm	0.803	0.760	0.647	0.589	0.645	0.436	0.603
Offence							
Public officer (police)	0.807	0.749	0.330	0.341	0.787	0.735	0.721
Minor	0.667	0.615	0.778	0.648	0.461	0.215	0.468
Serious	0.651	0.701	0.620	0.551	0.456	0.291	0.471
Sexual	0.520	0.461	0.717	0.559	0.328	0.134	0.358

Table 15 Significant correlations (Pearson's r) between numbers of police-reported assault offences (by location, time of day, offence type) and counts of licensed outlets per unit land area (by outlet type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: count of outlets per unit land area						
Assault measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
All assaults	0.909	0.940	0.563	0.331	0.861	0.831	0.917
Location							
Licensed premises	0.905	0.906	0.408	0.232	0.894	0.966	0.965
Private premises	0.458	0.509	0.675	0.406	0.380	0.220	0.364
Other location	0.909	0.932	0.469	0.276	0.876	0.902	0.952
Timing							
weekday	0.883	0.924	0.570	0.323	0.830	0.798	0.888
weekend	0.926	0.948	0.552	0.337	0.882	0.855	0.937
10.01pm – 2.00am	0.896	0.932	0.593	0.356	0.840	0.792	0.892
2.01am – 10.00pm	0.914	0.933	0.482	0.271	0.887	0.901	0.952
Offence							
Public officer (police)	0.838	0.861	0.315	0.180	0.817	0.964	0.946
Minor	0.896	0.924	0.624	0.378	0.844	0.760	0.873
Serious	0.901	0.943	0.544	0.319	0.853	0.829	0.915
Sexual	0.845	0.874	0.605	0.314	0.787	0.759	0.840

Table 16 Significant correlations (Pearson's r) between numbers of police-reported assault offences (by location, time of day, offence type) and volume of wholesale alcohol purchases (by beverage type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: volume of wholesale alcohol purchases				
Assault measure	**Reg. beer**	**Low beer**	**Reg. wine**	**Low wine**	**Spirits**
All assaults	0.893	0.749	0.174	0.455	0.545
Location					
Licensed premises	0.447	0.248	ns	0.145	0.174
Private premises	0.832	0.820	0.164	0.489	0.570
Other location	0.805	0.606	0.169	0.377	0.467
Timing					
weekday	0.895	0.764	0.195	0.482	0.574
weekend	0.876	0.721	0.150	0.420	0.508
10.01pm – 2.00am	0.905	0.780	0.193	0.481	0.577
2.01am –10.00pm	0.794	0.604	0.110	0.349	0.416
Offence					
Public officer (police)	0.478	0.288	ns	0.168	0.202
Minor	0.908	0.766	0.192	0.465	0.573
Serious	0.777	0.651	0.126	0.405	0.452
Sexual	0.801	0.780	0.179	0.466	0.552

Table 17 Significant correlations (Pearson's r) between numbers of police-reported assault offences (by location, time of day, offence type) and volume of wholesale purchases of regular strength beer (by licence type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: wholesale purchases of regular strength beer (volume in litres)						
Assault measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
All assaults	0.945	0.951	0.865	0.654	0.650	0.499	0.451
Location							
Licensed premises	0.668	0.723	0.746	0.433	0.904	0.896	0.401
Private premises	0.912	0.904	0.923	0.644	0.358	ns	0.339
Other location	0.897	0.904	0.767	0.615	0.778	0.665	0.503
Timing							
weekday	0.946	0.945	0.872	0.642	0.610	0.460	0.462
weekend	0.936	0.948	0.851	0.661	0.686	0.534	0.435
10.01pm – 2.00am	0.951	0.949	0.882	0.664	0.611	0.451	0.455
2.01am – 10.00 pm	0.891	0.921	0.780	0.605	0.748	0.631	0.422
Offence							
Public officer (police)	0.692	0.732	0.518	0.436	0.855	0.839	0.412
Minor	0.953	0.950	0.885	0.675	0.612	0.440	0.455
Serious	0.882	0.902	0.801	0.596	0.617	0.492	0.400
Sexual	0.895	0.882	0.865	0.607	0.495	0.335	0.395

Drink-driving offences

Summary of results: Tables 18–21

When outlet density was measured as counts of outlets per LGA:

- Positive drink-drive breath test offences were highly correlated with all licensed outlets when the driver's last place of drinking was either a licensed outlet or a non-residential location.
- Correlations between positive breath tests for both road crash and RBT offences were similar across all outlet types.
- Among all outlet types, restaurant density had the highest correlation with breath test offences, followed by other licensed outlets and hotels/taverns.
- Nightclubs produced the weakest correlations with breath test offences overall (possibly due to small numbers of nightclub licences).

When outlet density was measured as the number of licensed outlets by land area per LGA:

- Positive drink-drive breath test offences were highly correlated with all licensed outlets when the driver's last place of drinking was either, a licensed outlet, a non-residential location or, unknown.
- Correlations between positive breath tests for both road crash and RBT offences were similar across all outlet types.
- Club licences produced the weakest correlations with breath test offences overall.

When outlet density was measured as volume of wholesale beverages purchases (by beverage type) per LGA:

- Positive drink-drive breath test offences correlated most strongly, positively and consistently with volume of regular strength beer purchases and least with regular strength wine.

When outlet density was measured as volume of regular strength beer purchases (by outlet type) per LGA:

- Positive drink-drive breath test offences were strongly correlated with most outlet types, 'other' licensed outlets being the main exception.

Table 18 Significant correlations (Pearson's r) between numbers of positive drink-driver blood-alcohol tests (by location, type, BAC) and counts of licensed outlets by outlet type for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: count of outlets						
Drink-drive measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Location							
Last place of drinking, licensed premise	0.880	0.711	0.379	0.431	0.904	0.672	0.768
Last place of drinking, residence	0.488	0.452	0.830	0.682	0.277	ns	0.293
Last place of drinking, other	0.860	0.701	0.614	0.646	0.751	0.411	0.691
Last place of drinking, unknown	0.521	0.561	0.200	0.224	0.469	0.458	0.486
Incident type							
Road crashes	0.802	0.716	0.744	0.634	0.635	0.355	0.588
RBT	0.848	0.720	0.683	0.664	0.710	0.381	0.652
BAC level							
BAC less than 0.05	0.810	0.655	0.683	0.629	0.684	0.352	0.625
BAC between 0.05 and 0.08	0.832	0.619	0.597	0.602	0.764	0.407	0.660
BAC between 0.08 and 0.15	0.857	0.756	0.702	0.672	0.706	0.390	0.649
BAC exceeded 0.15	0.553	0.604	0.559	0.521	0.342	0.176	0.384

Table 19 Significant correlations (Pearson's r) between numbers of positive drink-driver blood-alcohol tests (by location, type, BAC) and counts of licensed outlets per unit land area by outlet type for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: count of outlets per unit land area						
Drink-drive measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Location							
Last place of drinking, licensed premise	0.914	0.899	0.661	0.440	0.901	0.698	0.829
Last place of drinking, residence	0.552	0.540	0.874	0.679	0.488	0.196	0.377
Last place of drinking, other	0.935	0.885	0.761	0.624	0.902	0.647	0.805
Last place of drinking, unknown	0.916	0.922	0.423	0.251	0.915	0.933	0.953
Incident type							
Road crashes	0.935	0.910	0.780	0.561	0.886	0.680	0.831
RBT	0.889	0.870	0.770	0.546	0.858	0.594	0.763
BAC level							
BAC less than 0.05	0.819	0.794	0.749	0.554	0.794	0.509	0.673
BAC between 0.05 and 0.08	0.886	0.834	0.760	0.556	0.874	0.584	0.745
BAC between 0.08 and 0.15	0.908	0.904	0.761	0.523	0.867	0.633	0.801
BAC exceeded 0.15	0.842	0.900	0.784	0.529	0.757	0.560	0.751

Table 20 Significant correlations (Pearson's r) between numbers of positive drink-driver blood-alcohol tests (by location, type, BAC) and volume of wholesale alcohol purchases (by beverage type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: volume of wholesale alcohol purchases				
Drink-drive measure	**Reg. beer**	**Low beer**	**Reg. wine**	**Low wine**	**Spirits**
Location					
Last place of drinking, licensed premise	0.513	0.267	0.066	ns	0.192
Last place of drinking, residence	0.886	0.784	0.162	0.438	0.553
Last place of drinking, other	0.761	0.520	0.161	0.316	0.400
Last place of drinking, unknown	0.306	0.194	0.024	ns	0.122
Incident type					
Road crashes	0.851	0.673	0.142	0.382	0.470
RBT	0.819	0.569	0.132	0.322	0.409
BAC level					
BAC less than 0.05	0.819	0.575	0.156	0.330	0.423
BAC between 0.05 and 0.08	0.709	0.443	0.118	0.241	0.331
BAC between 0.08 and 0.15	0.833	0.600	0.129	0.340	0.423
BAC exceeded 0.15	0.694	0.575	0.098	0.347	0.380

Table 21 Significant correlations (Pearson's r) between numbers of positive drink-driver blood-alcohol tests (by location, type, BAC) and volume of wholesale purchases of regular strength beer (by licence type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: wholesale purchases of regular strength beet (volume in litres						
Drink-drive measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Location							
Last place of drinking, licensed premise	0.716	0.767	0.523	0.595	0.946	0.849	0.420
Last place of drinking, residence	0.941	0.940	0.936	0.730	0.458	0.228	0.344
Last place of drinking, other	0.873	0.898	0.721	0.748	0.842	0.648	0.479
Last place of drinking, unknown	0.553	0.612	0.413	0.377	0.652	0.629	0.287
Incident type							
Road crashes	0.923	0.927	0.842	0.709	0.731	0.587	0.414
RBT	0.905	0.936	0.780	0.732	0.808	0.629	0.434
BAC level							
BAC less than 0.05	0.905	0.917	0.786	0.726	0.792	0.613	0.464
BAC between 0.05 and 0.08	0.842	0.872	0.698	0.692	0.852	0.667	0.441
BAC between 0.08 and 0.15	0.913	0.942	0.797	0.735	0.798	0.634	0.422
BAC exceeded 0.15	0.833	0.871	0.770	0.648	0.536	0.382	0.319

Hospitalisations attributable to risky/high-risk drinking

Summary of results: Tables 22–25

- Notable is the overall lower correlations between outlet density and morbidity measures of both assault and traffic injury compared to police-reported incidents (above). Nightclubs typically produced weak or non-significant associations with alcohol-attributable hospitalisations which may be due in part to low numbers of such licenses.

When outlet density was measured as counts of outlets per LGA:

- Significant correlations occurred between outlet counts and alcohol-attributable hospitalisations. However, the relationship between assaults and outlet count was notably weaker.
- Liquor stores had the strongest relationship with morbidity; club licences also evidenced a strong relationship. Hotels/taverns and restaurants tended to have a weaker association with morbidity.
- Nightclubs had a weak or non-significant correlation with morbidity.

When outlet density was measured as licensed outlets by land area per LGA:

- Morbidity was significantly related to outlet count by area. However, chronic conditions such as liver cirrhosis showed weaker associations.
- Liquor stores and club licences had the strongest relationships with morbidity. Hotels and restaurants demonstrated weaker associations.
- Nightclubs had a weak or non-significant correlation with morbidity.

When outlet density was measured as volume of wholesale alcohol purchases per LGA:

- There were strong associations between all alcohol types and morbidity. However, low beer and to an extent regular wine had somewhat weaker correlations with morbidity.
- There was a strong correlation between regular strength beer and morbidity for most outlet types, with the exception of nightclubs.

Table 22 Significant correlations (Pearson's r) between numbers of alcohol-attributable hospitalisations (by condition type) and counts of licensed outlets (by outlet type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: count of licensed outlets						
Morbidity measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Acute/chronic							
Total alcohol-attributable hospitalisations	0.386	0.341	0.633	0.618	0.211	ns	0.249
Acute alcohol-attributable hospitalisations	0.391	0.360	0.651	0.622	0.207	ns	0.252
Chronic alcohol-attributable hospitalisations	0.301	0.224	0.467	0.494	0.183	ns	0.197
Sentinel conditions							
Alcohol-attributable road crash injury	0.346	0.312	0.741	0.619	0.154	ns	0.212
Alcohol-attributable assault injury	0.181	0.222	0.300	0.308	ns	ns	0.115
Alcoholic liver cirrhosis	0.246	0.189	0.450	0.480	0.136	ns	0.143

Table 23 Significant correlations (Pearson's r) between numbers of alcohol-attributable hospitalisations (by condition type) and counts of licensed outlets per unit land area (by outlet type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: counts of licensed outlets per unit land area						
Morbidity measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Acute/chronic							
Total alcohol-attributable hospitalisations	0.407	0.364	0.737	0.527	0.339	0.148	0.299
Acute alcohol-attributable hospitalisations	0.472	0.444	0.807	0.606	0.388	0.187	0.350
Chronic alcohol-attributable hospitalisations	0.233	0.180	0.490	0.310	0.201	ns	0.167
Sentinel conditions							
Alcohol-attributable road crash injury	0.263	0.291	0.697	0.526	0.189	ns	0.153
Alcohol-attributable assault injury	0.377	0.403	0.622	0.478	0.284	0.166	0.300
Alcoholic liver cirrhosis	0.143	0.158	0.434	0.183	0.116	ns	0.085

Table 24 Significant correlations (Pearson's r) between numbers of alcohol-attributable hospitalisations (by condition type) and volume of wholesale alcohol purchases (by beverage type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: volume of wholesale alcohol purchases				
Morbidity measure	**Reg. beer**	**Low beer**	**Reg. wine**	**Low wine**	**Spirits**
Acute/chronic					
Total alcohol-attributable hospitalisations	0.604	0.207	0.405	0.535	0.684
Acute alcohol-attributable hospitalisations	0.639	0.228	0.432	0.575	0.710
Chronic alcohol-attributable hospitalisations	0.398	0.115	0.258	0.331	0.485
Sentinel conditions					
Alcohol-attributable road crash injury	0.722	0.260	0.475	0.652	0.721
Alcohol-attributable assault injury	0.349	0.088	0.263	0.276	0.385
Alcoholic liver cirrhosis	0.499	0.191	0.329	0.422	0.511

Table 25 Significant correlations (Pearson's r) between numbers of alcohol-attributable hospitalisations (by condition type) and volume of wholesale purchases of regular strength beer (by licence type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: wholesale purchases of regular strength beer (volume in litres)						
Morbidity measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Acute/chronic							
Total alcohol-attributable hospitalisations	0.827	0.848	0.764	0.594	0.385	ns	0.410
Acute alcohol-attributable hospitalisations	0.843	0.855	0.784	0.606	0.381	ns	0.426
Chronic alcohol-attributable hospitalisations	0.696	0.745	0.628	0.497	0.364	ns	0.317
Sentinel conditions							
Alcohol-attributable road crash injury	0.849	0.819	0.844	0.619	0.283	ns	0.408
Alcohol-attributable assault injury	0.621	0.660	0.571	0.421	0.240	ns	0.281
Alcoholic liver cirrhosis	0.715	0.720	0.652	0.512	0.323	ns	0.413

Deaths attributable to risky/high-risk drinking

Summary of results: Tables 26–29

- Results show a similar pattern to morbidity.

When outlet density was measured as counts of outlets per LGA:

- significant associations occurred between outlet count and mortality, though the relationship with assault was weaker; and
- liquor stores had the strongest association with mortality, and nightclubs had the weakest association.

When outlet density was measured as licensed outlets by land area per LGA:

- weaker associations were evident between outlet count by area and mortality; and
- liquor stores had the strongest relationship with mortality.

When outlet density was measured as volume of wholesale alcohol purchases per LGA:

- there was a strong correlation between mortality and volume of regular strength beer purchases and to some extent, spirits purchases but the associations did not appear to be as strong as for hospitalisations; and
- the correlations between wine consumption and mortality were low.

Table 26 Significant correlations (Pearson's r) between numbers of alcohol-attributable deaths (by condition type) and counts of licensed outlets (by outlet type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

Mortality measure	*Density measure: counts of licensed outlets* All licensed outlets	Hotel/ Tavern	Liquor Store	Club licence	Rest.	Nightclub	Other licensed
Acute/chronic							
Total alcohol-attributable deaths	0.318	0.271	0.706	0.625	0.161	ns	0.147
Acute alcohol-attributable deaths	0.327	0.313	0.744	0.644	0.153	ns	0.145
Chronic alcohol-attributable deaths	0.262	0.184	0.560	0.514	0.148	ns	0.129
Sentinel conditions							
Alcohol-attributable road crash deaths	0.260	0.221	0.737	0.104	0.157	ns	0.140
Alcohol-attributable assault deaths	0.169	0.190	0.239	0.327	0.086	ns	0.105
Alcoholic liver cirrhosis deaths	0.209	0.147	0.499	0.428	0.108	ns	0.101

Table 27 Significant correlations (Pearson's r) between numbers of alcohol-attributable deaths (by condition type) and counts of licensed outlets per unit land area (by outlet type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

Mortality measure	*Density measure: counts of licensed outlets per unit land area* All licensed outlets	Hotel/ Tavern	Liquor Store	Club licence	Rest.	Nightclub	Other licensed
Acute/chronic							
Total alcohol-attributable deaths	0.202	0.168	0.598	0.611	0.140	ns	0.107
Acute alcohol-attributable deaths	0.180	0.144	0.458	0.394	0.150	ns	0.090
Chronic alcohol-attributable deaths	0.130	0.112	0.419	0.510	0.076	ns	0.072
Sentinel conditions							
Alcohol-attributable road crash deaths	ns	ns	0.297	0.112	ns	ns	0.024
Alcohol-attributable assault deaths	ns	0.074	0.099	0.082	ns	ns	Ns
Alcoholic liver cirrhosis deaths	ns	ns	0.229	0.252	ns	ns	Ns

Table 28 Significant correlations (Pearson's r) between numbers of alcohol-attributable deaths (by condition type) and volume of wholesale alcohol purchases (by beverage type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: volume of wholesale alcohol purchasess				
Mortality measure	**Reg. beer**	**Low beer**	**Reg. wine**	**Low wine**	**Spirits**
Acute/chronic					
Total alcohol-attributable deaths	0.680	0.587	0.087	0.266	0.399
Acute alcohol-attributable deaths	0.696	0.635	0.089	0.302	0.422
Chronic alcohol-attributable deaths	0.564	0.448	0.072	0.186	0.315
Sentinel conditions					
Alcohol-attributable road crash deaths	0.628	0.580	0.110	0.314	0.429
Alcohol-attributable assault deaths	0.257	0.240	ns	0.152	0.136
Alcoholic liver cirrhosis deaths	0.546	0.447	0.082	0.184	0.332

Table 29 Significant correlations (Pearson's r) between numbers of alcohol-attributable deaths (by condition type) and volume of wholesale purchases of regular strength beer (by licence type) for 140 Western Australian Local Government Areas (LGAs), 2000/01

	Density measure: wholesale purchases of regular strength beer (volume in litres)						
Mortality measure	**All licensed outlets**	**Hotel/ Tavern**	**Liquor Store**	**Club licence**	**Rest.**	**Nightclub**	**Other licensed**
Acute/chronic							
Total alcohol-attributable deaths	0.824	0.840	0.843	0.661	0.349	ns	0.236
Acute alcohol-attributable deaths	0.834	0.845	0.869	0.661	0.326	ns	0.218
Chronic alcohol-attributable deaths	0.751	0.771	0.748	0.613	0.353	ns	0.243
Sentinel conditions							
Alcohol-attributable road crash deaths	0.792	0.772	0.851	0.577	0.239	ns	0.225
Alcohol-attributable assault deaths	0.507	0.569	0.439	0.441	0.281	ns	0.217
Alcoholic liver cirrhosis deaths	0.739	0.750	0.745	0.530	0.289	ns	0.255

Chapter seven: Multivariate analyses: demonstration models for licensed outlet density

Overview

This chapter describes the results from the multivariate analyses and is divided into two main parts. The first part describes the results of a state-wide model approach that tests the efficacy of alternative measures of outlet density for both hotels/taverns and liquor stores on levels of police-reported assaults. The second part describes the results from the regional analyses. Each of the regional models show the relationships between volume of regular strength beer purchases as a measure of physical availability of alcohol and police-reported assaults. The range of models not only demonstrates potential outcomes but highlights a range of issues in relation to modelling the effect of changes to outlet density.

It is important that the reader keep in mind that the models presented here are not intended to be fully inclusive nor conclusive but hopefully serve to demonstrate the potential strengths, limitations and possible outcomes from such an approach.

State-wide demonstration models

Tables 30 and 31 show the final model parameters indicating the strength and direction of the relationship between assault offences occurring at licensed premises, private premises, all locations combined and three alternative measures of outlet density (i.e. count, area, volume) while controlling for significant socio-economic and/or demographic variables.

Key results

- Overall, the greatest proportion of variance in assaults was accounted for by models applying volume of regular strength beer as the density measure.
- The strength of association between assaults and measures of outlet density depends on both: (i) the type of licensed outlet being examined (e.g. hotel/tavern, liquor store) and (ii) location where assaults occurred (e.g. licensed outlets or private premises).
- For all models tested, both volume or beer purchases and count of outlet density measures were significantly associated with levels of assaults after adjustment for socio-economic and demographic variables.
- For more than half of the final models applying outlets by area as a measure of density, socio-economic and demographic factors alone accounted for much of the variance in reported assaults.
- Demographic and socio-economic factors in general were important to all models, although the specific predictive variables remaining in the final models varied. Common to most final volume models (but not all) were: total residential population (Totpop); average age of the residential population (Aveage); and the ratio of people residing in a different residence to the one they lived in five years ago to those who had not changed residence in that time (Diffres5).
- Some demographic and socio-economic variables showed a negative linear association with reported assaults (protective) while others showed positive linear associations (causative).

- Despite the predictive power of demographic and socio-economic variables, volume of regular strength beer purchases predicted the greatest amount of variance in reported assaults and was the most influential of all predictor variables in five out of six final volume models.
- Spatial autocorrelation was significant among the residuals of only one of the final models (hotel/tavern purchase volume by assaults on licensed premises). When controlled for in analyses, serial autocorrelation did not have any meaningful impact on the final model coefficients. Given the generally high proportion of variance accounted for in these models, it is not surprising that there was little evidence of autocorrelation to be found among the residuals.
- Notable among the models described in Tables 30 and 31 are the very high levels of variance explained, especially by the volume of purchases models, most of which exceed 0.90. This suggests that, among these data, the underlying associations between reported assaults and various predictor variables are primarily linear. In most final models, volume of beer purchased was the strongest single predictor variable for assaults.

Table 30 Final parameters for alternative models estimating associations between assault offences and three measures of hotel/tavern outlet density, controlling for socio-economic and demographic variables (variables in order of relative contribution to model)

	Density measure for hotels/taverns		
	Count	**Area**	**Volume of regular beer (litres)**
All assault offences			
Variables in final model	Outlet1; TotPop; Aveage; AtoC; Hinc1000	TotPop; Out1area; Aveage; Diffres5	Vhibeer1; Diffres5; YmtoTP
Adjusted R^2 of model	0.89	0.82	0.91
T value for outlet measure	12.17***	8.28***	15.67***
Beta for outlet measure	23.71	2.69	0.00036
95% C.I. for outlet measure	19.86, 27.57	2.05, 3.33	0.00034, 0.00039
Moran's I on residuals	0.10 (z=0.5, ns)	0.12 (z=0.6, ns)	-0.22 (z=-1.1, ns)
Assaults on licensed premises			
Variables in final model	Outlet1; AtoC; Aveage; A60p; YMtoTP; Diffres5; Diffres1	Out1area; Diffres5; TotPop; Aveage; MtoF; A60p	Vhibeer1; AtoC; Diffres5; TotPop; Aveage; A60p; YmtoTP; Oneparent;
Adjusted R^2 of model	0.90	0.84	0.90
T value for outlet measure	13.76***	5.73**	10.72***
Beta for outlet measure	2.98	0.617	0.000031
95% C.I. for outlet measure	2.55, 3.41	0.55, 0.68	0.000025, 0.000036
Moran's I on residuals	-0.25 (z=-1.2, ns)	-0.05 (z=-0.2, ns)	-0.34 (z=-1.7, ns)
Assaults on private premises			
Variables in final model	TotPop; Outlet1; AtoC; Oneparent; MtoF	TotPop; Aveage; Unemprate; Diffres5	Vhibeer1; TotPop; AtoC; Oneparent; MtoF; Unemprate
Adjusted R^2 of model	0.86	0.82	0.91
T value for outlet measure	7.85***	-	13.02***
Beta for outlet measure	7.70	-	0.00013
95% C.I. for outlet measure	5.75, 9.63	-	0.00011, 0.00015
Moran's I on residuals	0.10 (z=0.5, ns)	0.04 (z=0.2, ns)	-0.13 (z=-0.6, ns)

Statistical significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
NOTE: see Table 11 for description of variables

Table 31 Final parameters for alternative models estimating associations between assault offences and three measures of liquor store outlet density, controlling for socio-economic and demographic variables (variables in order of relative contribution to model)

	Density measure for liquor stores		
	Count	**Area**	**Volume of regular beer (litres)**
All assault offences			
Variables in final model	Outlet2; AtoC; Aveage; Totpop; A60p; Diffres5	TotPop; Diffres5; AtoC; Aveage; Unemprate	VHibeer2; AtoC; Aveage; TotPop; Diffres5; A60p;
YMtoTP			
Adjusted R^2 of model	0.85	0.81	0.90
T value for outlet measure	6.14***	-	11.38***
Beta for outlet measure	23.27	-	0.00021
95% C.I. for outlet measure	15.78, 30.76	-	0.00017, 0.00024
Moran's I on residuals	0.06 (z=0.3, ns)	-0.14 (z=-0.7, ns)	-0.19 (z=-0.9, ns)
Assaults on licensed premises			
Variables in final model	AtoC; Diffres5; Outlet2; Aveage; A60p; YMtoTP;	AtoC; Diffres5; Aveage; TotPop A60p; YMtoTP	AtoC; Diffres5; VHibeer2; Aveage; A60p; YMtoTP
Adjusted R^2 of model	0.84	0.81	0.85
T value for outlet measure	8.44***	-	9.04***
Beta for outlet measure	1.80	-	0.000013
95% C.I. for outlet measure	1.38, 2.27	-	0.000010, 0.000016
Moran's I on residuals	-0.31 (z=-1.5, ns)	-0.32 (z=-1.6, ns)	-0.40 (z=-1.9,p < 0.1)
Assaults on private premises			
Variables in final model	TotPop; Outlet2; Aveage; Oneparent	TotPop; Aveage; Unemprate; Diffres5	VHibeer2; TotPop; Aveage; Oneparent,
Adjusted R^2 of model	0.85	0.82	0.90
T value for outlet measure	5.97***	-	11.15***
Beta for outlet measure	9.46	-	0.000095
95% C.I. for outlet measure	6.33, 12.60	-	0.000078, 0.000011
Moran's I on residuals	0.20 (z=1.0, ns)	-0.10 (z=-0.5, ns)	0.0 (z=0.0, ns)

Statistical significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

NOTE: see Table 11 for description of variables

Model expression and interpretation

The beta coefficients for each of the hotel/tavern and liquor store volume models (Tables 30 and 31) reveal that the strength of association depends not only on the type of outlet but also on whether assaults occurred at licensed outlets or private premises.

Assuming that the average volume of regular strength beer purchases made by hotels/taverns in 2000/01 was 64,667 litres (see Table 5). The final equations for the hotels/taverns volume of purchase models can be expressed as follows:

Basic multiple linear regression equation: $y = \text{constant} + b_1x_1 + b_2x_2 + \dots b_nx_n$

Thus: reported assaults on licensed premises = 183.22 + b_1(Vhibeer1) + b_2 (AtoC) + b_3 (Diffres5) + b_4 (Totpop) + b_5 (Aveage) + b_6 (A60p) + b_7 (YMtoTP) + b_8 (Oneparent).

Where: $b_1 = 0.000031$; $b_2 = 13.19$; $b_3 = 21.15$; $b_4 = -0.00028$; $b_5 = -7.29$; $b_6 = 305.62$; $b_7 = -204.16$; and $b_8 = -32.76$.

If: $x_1 = 64{,}667$ (litres); $x_2 = 3$; $x_3 = 0.01$; $x_4 = 25000$; $x_5 = 32$(yrs); $x_6 = 0.10$; $x_7 = 0.01$; $x_8 = 0.10$, then reported assaults on licensed premises = 1.8

In other words, given a hypothetical LGA with socio-economic and demographic characteristics defined by x_2 to x_8, the addition of one hotel/tavern with an annual wholesale regular beer purchase of 64,667 litres will result in 1.8 reported assaults on licensed premises per year.

Similarly, an equation expressing the relationship between assaults on private premises and hotel/tavern purchase volumes inclusive of socio-economic and demographic controls can be described as follows:

Basic multiple linear regression equation: $y = \text{constant} + b_1x_1 + b_2x_2 + \dots b_nx_n$

Thus: reported assaults on private premises = -25.36 + b_1(Vhibeer1) + b_2 (Totpop) + b_3 (AtoC) + b_4 (Oneparent) + b_5 (MtoF) + b_6 (Unemprate).

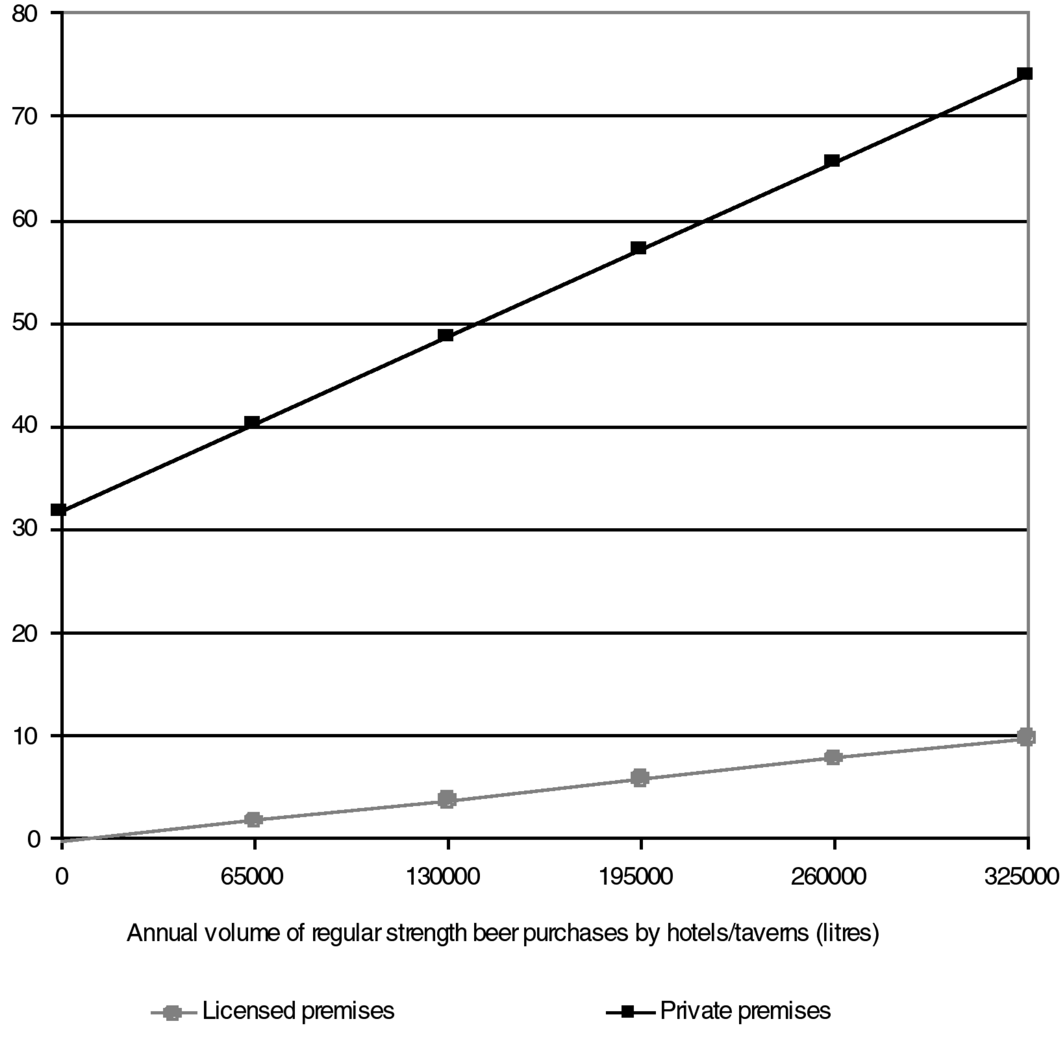
Where: $b_1 = 0.00013$; $b_2 = 0.002$; $b_3 = -15.89$; $b_4 = 96.40$; $b_5 = 41.89$; and $b_6 = 256.95$.

If: $x_1 = 64{,}667$ (litres); $x_2 = 25000$; $x_3 = 3.0$; $x_4 = 0.10$; $x_5 = 1.0$; $x_6 = 0.05$; $x_7 = 0.01$, then reported assaults on licensed premises = 41.4

Figure 1 provides an example of how the relationship between volumes of regular strength beer purchases by hotels/taverns and reported levels of assault occurring at licensed and private premises might appear, assuming that all demographic and socio-economic variables remain constant. (Should any one of the demographic and socio-economic variables change, total estimated assaults would vary accordingly.) The volumes of regular strength wholesale beer purchases begin at zero litres and increase at intervals of 65,000 (about one additional hotel/tavern with an average annual beer purchase). The upper limit of 325,000 litres approximates the maximum volume of beer purchased by a single hotel/tavern in WA in 2001; equivalent to about five average hotels/taverns (see Table 5). Beginning at zero litres and increasing to 65,000 litres of beer purchases, assaults on licensed premises correspondingly increase from just below zero to two. Since the association is linear and the scale intervals are equal, from 65,000 to 130,000 litres, the predicted number of assaults increases by a further two, summing to a total of four. Thus, all other things being equal, the addition of 65,000 litres wholesale beer purchases by hotel/taverns to one LGA will result in an estimated increase of two assaults on licensed premises per year.

As shown in Figure 1, the predicted increase in assaults due to increased purchase volumes by hotels/tavern in an LGA is many times larger for assaults occurring on private premises than for those occurring at licensed premises. At zero litres, about 41.4 assaults per LGA are expected; with the addition of 65,000 litres of regular strength beer purchases by hotels/taverns an increase of about 8.4 assaults is expected, bringing the total to about 49.8 assaults. Thus, all other things being equal, the addition of 65,000 litres of wholesale beer purchases by hotels/taverns to one LGA will result in an estimated increase of 8.4 assaults on licensed premises per year.

Figure 1 Estimated linear relationship between volumes of regular strength beer purchases made by hotels/taverns and reported levels of assault occurring at licensed and private premises, Western Australia, 2000/01



Assuming that the average volume of regular strength beer purchases made by liquor stores in 2000/01 was 80,751 litres (see Table 5), the final equations for the liquor store volume of purchase models can be expressed as follows:

Basic multiple linear regression equation: $y = constant + b_1x_1 + b_2x_2 + \ldots b_nx_n$

Thus: reported assaults on licensed premises = 218.67 + b_1(Vhibeer1) + b_2 (Diffres5) + b_3(YMtoTP) + b_4(Aveage) + b_5(A60p) + b_6(AtoC)

Where: $b_1 = 0.000013$; $b_2 = 29.47$; $b_3 = -328.447$; $b_4 = -8.78$; $b_5 = 351.02$; and $b_6 = 17.63$.

If: $x_1 = 80751$ (litres); $x_2 = 0.01$; $x_3 = 0.05$; $x_4 = 32$(yrs); $x_5 = 0.1$; $x_6 = 3.0$; then, reported assaults on licensed premises = 10.62

Similarly, the association between assaults on private premises and liquor store volume of regular strength beer purchase can be estimated thus:

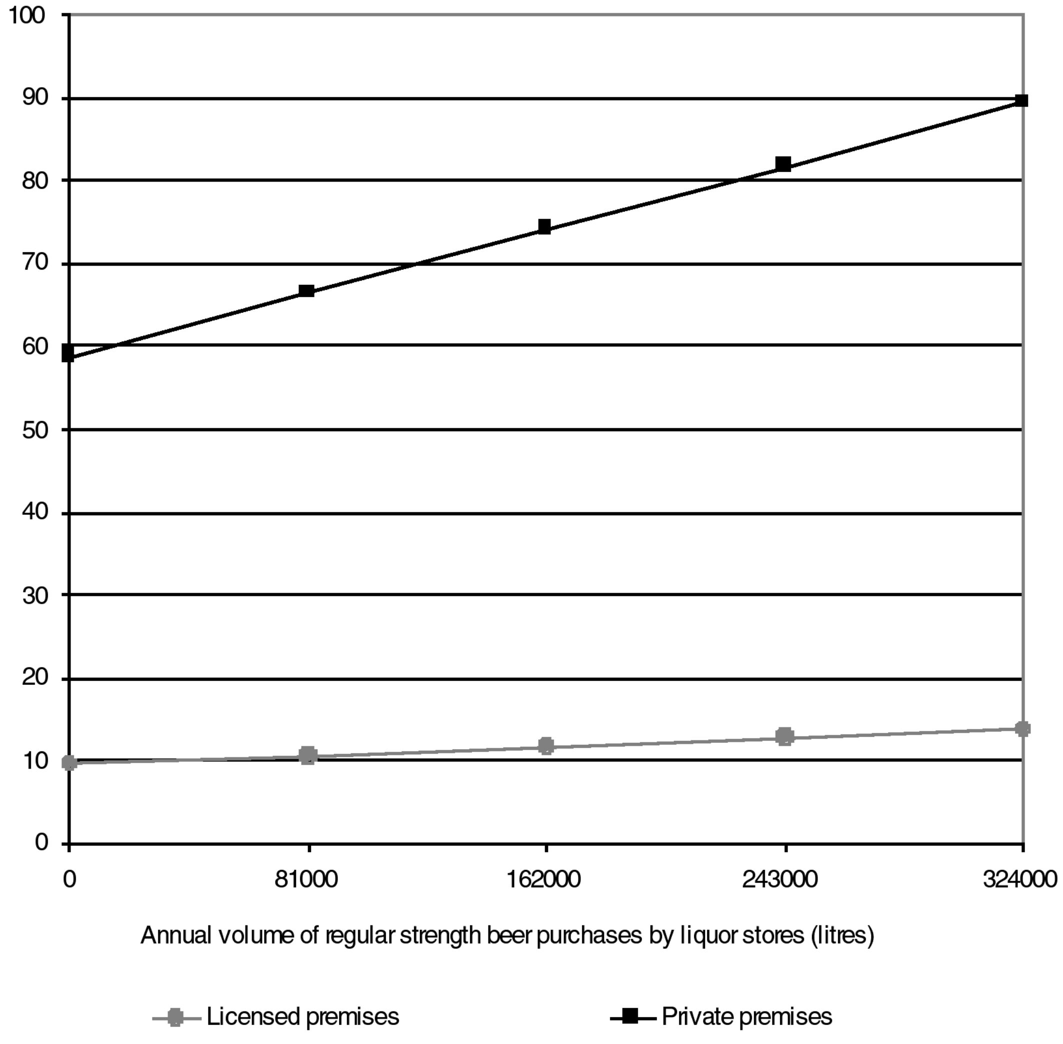
reported assaults on private premises = 83.09 + b_1(Vhibeer1) + b_2(Aveage) + b_3(Totpop) + b_4 (Oneparent)

Where: $b_1 = 0.000095$; $b_2 = -2.76$; $b_3 = 0.002$; and $b_4 = 139.55$.

If: $x_1 = 80751$ (litres); $x_2 = 32$; $x_3 = 25000$; $x_4 = 0.1$; then, reported assaults on private premises = 66.4

As shown in Figure 2 when the volume of regular strength beer purchases in an LGA is zero litres, about 9.6 assaults are expected to occur on licensed premises. With the addition of 81,000 litres of beer purchases (average total purchase per liquor store in 2000/01), assaults on licensed premises increase to about 10.6. Thus, all other things being equal, for every 81,000 litres of wholesale beer purchases by liquor stores, there will be an estimated increase of about 1 assault on licensed premises per year. By comparison, the increase in assaults on private premises per 81,000 litres of wholesale beer purchases by liquor stores is much larger – about 7.7 assaults for the affected LGA per year.

Figure 2 Estimated linear relationship between volumes of regular strength beer purchases made by hotels/taverns and reported levels of assault occurring at licensed and private premises, Western Australia, 2000/01



Regional demonstration models

For this part of the analysis, all 140 LGAs across the state were grouped into one of eight regions corresponding to Western Australian Health Regions including: Metropolitan, Goldfields, Great Southern, Kimberley, Midwest and Murchison, Pilbara, South West and Wheatbelt. The number of LGAs contained within each Health Region varied widely (see Table 32). Unfortunately, in the case of the Pilbara and Kimberley Health Regions, too few LGAs were available for analysis. For example, in 2000/01 the Pilbara Health Region contained some 28 hotels/taverns and 17 liquor stores spread over only four large LGAs – too few geographical units from which to derive even marginally reliable coefficient estimates.

As with the preceding state-wide analyses, the relationships between volumes of wholesale beer purchases made by hotels/taverns and liquor stores and police-reported assaults were examined using multiple linear regression, including adjustment for socio-economic and demographic factors. Maps 14 and 15 show the distribution of volumes of wholesale beer purchases made by hotels/taverns and liquor stores across WA LGAs respectively. Heath regions can be identified by thick borders around groups of LGAs.

Tables 33 (hotels/taverns) and 34 (liquor stores) show the final linear regression models for six health regions. Table 35 provides a summarised interpretation of the beta coefficients from the final models.

Key results

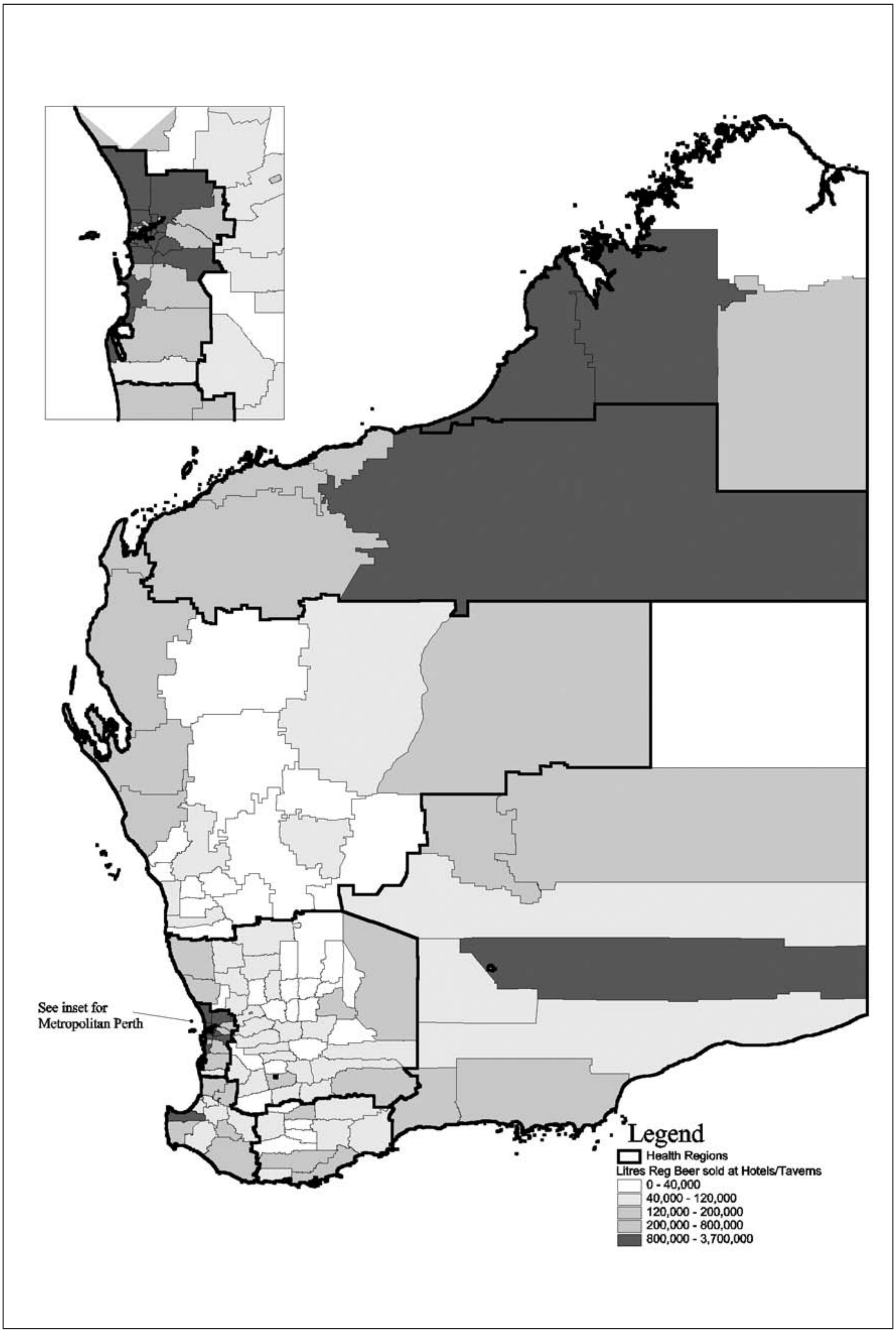
- In some regions, the available data did not support a role for volume of beer purchases in predicting assaults (e.g. assaults on licensed premises in the South West; assaults on licensed premises in the Metropolitan Health Region). Demographic and socio-economic characteristics appeared to be more important for predicting reported assaults in these regions.
- For other regions, volume of beer purchases was the most important predictor variable, socio-economic and demographic factors having little apparent bearing on levels of reported assaults (e.g. liquor stores and assault on private premises in the Goldfields).
- Across the six regions tested, the contribution of regular strength beer purchases by licensed outlets to levels of reported assault was highly variable and dependent on licence type as well as location of the offence.
- The importance of licence type and location of assault was exemplified by the variability in the final Metropolitan models. For the Metropolitan Health Region, regular strength beer purchases by hotels/taverns had no apparent association with assaults occurring on licensed premises, although over 90% of the variance in assaults was explained by: the proportion of males to females; the proportion of young males to the total population; and population mobility. However, regular beer purchases by liquor stores in the Metropolitan Health Region predicted some 75% of the variance in assaults occurring on private premises, with the size of the estimated residential population contributing a further 12%.

- When compared to the expected increase in assaults estimated from LGAs across the whole state, some regions were excessively burdened while others were less so (Table 35). For example, for the whole state, the total expected increase in assaults for every one additional hotel/tavern with average annual regular strength beer purchases was about 10.4 (2 on licensed premises + 8.4 on private premises). In both the South West and the Wheatbelt the estimated impact of an additional average hotel/tavern on assaults was negligible. However, the estimated increase in assaults from one additional liquor store in the Wheatbelt (31.7) was almost four times that estimated across the whole state (8.7). For the Metropolitan region, additional hotels/taverns (16.6) were associated with greater than expected increases in assaults but the impact of liquor stores (7.9) was on a par with the state-wide average. Levels of assault in the Midwest and Murchison region also appeared to be more affected by increased numbers of hotels/taverns (17.4) than liquor stores (0). Overall, expected increases in assaults in the South West and Goldfields regions (excluding Kalgoorlie Boulder as an outlying LGA, see below) were lower than the state-wide average.

Table 32 Western Australian Health Region profiles, 2000/01

Health Region (Outlier LGAs)	LGAs (including outliers)	Hotels/ taverns	Liquor stores	Club licences	Rest.	Nightclubs	Other licensed premises	Assaults on licensed premises	Assaults on private premises	Mean volume reg. beer purchases hotels/taverns	Mean volume reg. beer purchases liquor stores
Metropolitan (none)	32	260	288	192	462	37	292	909	5757	128040	107709
Goldfields (Kalgoorlie Boulder; Ngaanyatjarraku)	9	53	18	18	19	2	15	35	221	56205	77761
Great Southern (Albany)	12	31	27	26	23	2	18	13	103	40206	47523
Kimberley (none)	4	11	8	2	8	2	14	62	448	58926	93461
Midwest and Murchison (Geraldton; Carnarvon)	23	52	34	25	20	2	15	35	166	175411	205066
Pilbara (none)	4	28	17	16	8	3	17	74	509	28577	30038
South West (none)	12	54	37	41	48	1	55	74	451	41577	39036
Wheatbelt (Northam)	44	98	32	58	17	0	9	46	322	81655	126087

Map 14 Geographic distribution of volumes of wholesale beer purchases made by hotels/taverns, Local Government Areas, Western Australia, 2000/01



Map 15 Geographic distribution of volumes of wholesale beer purchases made by liquor stores, Local Government Areas, Western Australia, 2000/01

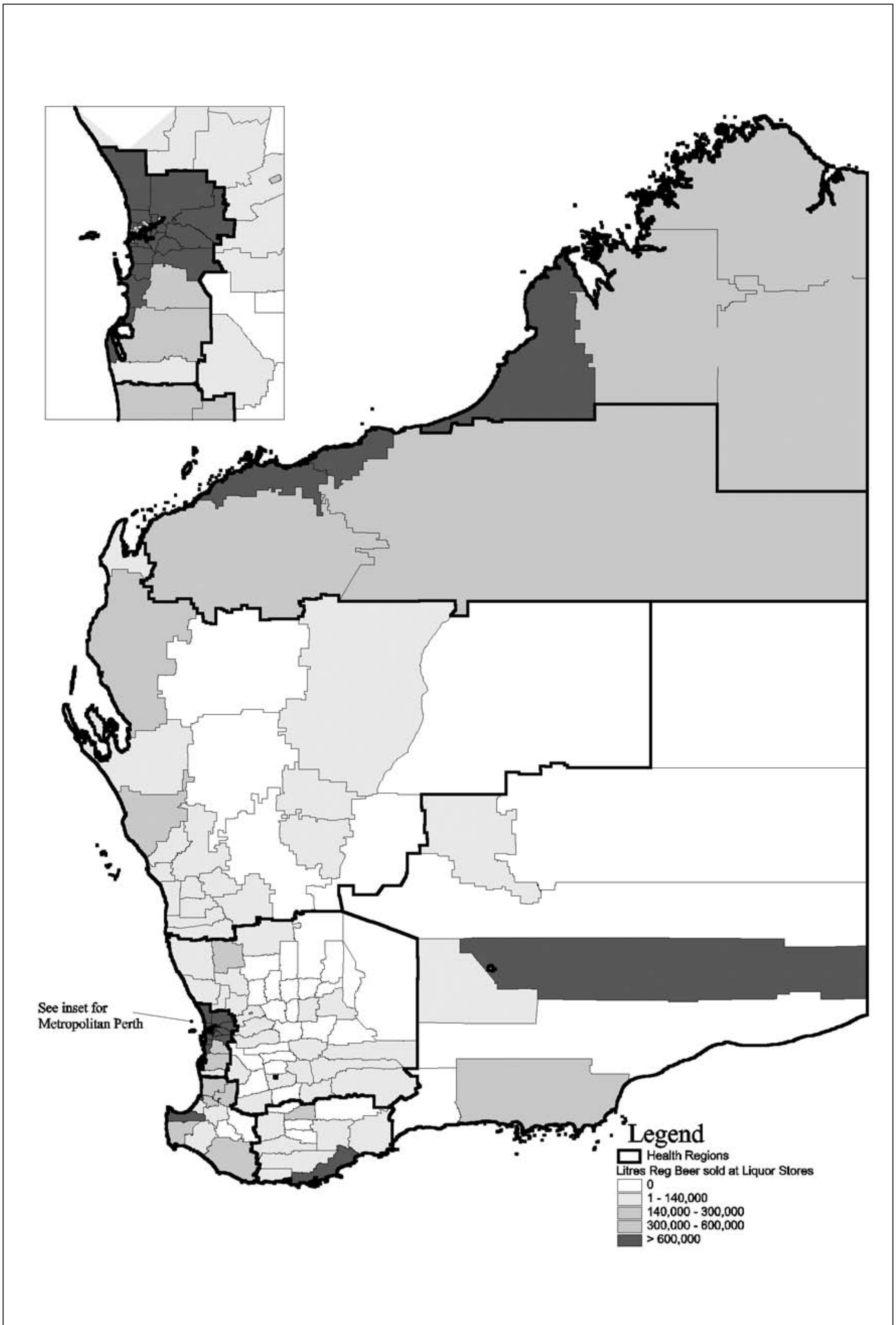


Table 33 Final model parameters for assault offences occurring at licensed/private premises and volume of regular strength beer purchases made by hotels/taverns, controlling for socio-economic and demographic variables, Western Australian Health Regions, 2000/01

Health Regions (outlier LGAs)	Metropolitan (none) 1	Goldfields (Kalgoorlie Boulder) 2	Great Southern (Albany) 3	Midwest and Murchison (Geraldton; Carnarvon) 5	South West (none) 7	Wheatbelt (Northam) 8
Assaults on licensed premises						
Variables in final model	Diffres5; YMtoTP; MtoF	VHibeer1; SEIFAAdvDis	Buyhouse	Hinc200; Hinc1000; Vhibeer1	Totpop; Diffres5	Diffres5; Totpop; Indigrate
Adjusted R2 of model	0.93	0.81	0.43	0.88	0.90	0.52
T value for outlet measure	-	8.40***	-	4.89***	-	-
Beta for outlet measure	-	0.000041	-	0.000011	-	-
95% C.I. for outlet measure	-	0.000021, 0.000062	-	0.000002, 0.000021	-	-
Moran's I on residuals	-	0.019 (z=0.3, ns)	-	-0.41 (z=-1.3, ns)	-	-
Assaults on private premises						
Variables in final model	Totpop; Vhibeer1; AtoC; Indigrate	No significant predictors when outliers removed	Totpop; Aveage; Hinc1000; Buyhouse	YMtoTP; VHibeer1; Hinc1000; A60p	Totpop; SEIFAAdvDis; Indigrate: MtoF	Totpop; Oneparent; YMtoTP
Adjusted R2 of model	0.90	-	0.91	0.81	0.97	0.51
T value for outlet measure	6.36***	-	-	4.60***	-	-
Beta for outlet measure	0.00013	-	-	0.000088	-	-
95% C.I. for outlet measure	0.00009, 0.00017	-	-	0.000047, 0.00013	-	-
Moran's I on residuals	0.020 (z=0.3, ns)	-	-	-0.41 (z=-1.3, ns)	-	0.10 (z=1.5, ns)

Table 34 Final model parameters for assault offences occurring at licensed/private premises and volume of regular strength beer purchases made by liquor stores, controlling for socio-economic and demographic variables, Western Australian Health Regions, 2000/01

Health Regions (outlier LGAs)	Metropolitan (none) 1	Goldfields (Kalgoorlie Boulder) 2	Great Southern (Albany) 3	Midwest and Murchison (Geraldton; Carnarvon) 5	South West (none) 7	Wheatbelt (Northam) 8
Assaults on licensed premises						
Variables in final model	Diffres5; YMtoTP; MtoF	Vhibeer2	Vhibeer2; Indigrate; A60p	Hinc200; Hinc1000	Totpop; Diffres5	Vhibeer2; Diffres5; Indigrate
Adjusted R2 of model	0.93	0.69	0.93	0.84	0.90	0.63
T value for outlet measure	-	3.86*	10.72***	-	-	4.89***
Beta for outlet measure	-	0.000024	0.000028	-	-	0.000023
95% C.I. for outlet measure 0.000033	-	0.000008, 0.000041	0.000022, 0.000035	-	-	0.000014,
Moran's I on residuals	-	0.06, (z=1.0, ns)	0.20 (z= 1.5, ns)	-	-	0.80 (z=1.1, ns)
Assaults on private premises						
Variables in final model	Vhibeer2; Totpop	No significant predictors when outliers removed	Vhibeer2	YMtoTP; Hinc1000	Vhibeer2; Indigrate	Vhibeer2; Oneparent; YmtoTP
Adjusted R2 of model	0.87	-	0.62	0.61	0.94	0.68
T value for outlet measure	5.58***	-	4.16**	-	7.63***	5.97***
Beta for outlet measure	0.000090	-	0.00022		-0.000092	0.00017
95% C.I. for outlet measure	0.000057, 0.000123	-	0.00010, 0.00033	-	0.000065 0.000120	0.00011, 0.00022
Moran's I on residuals	0.00 (z=0.2, ns)	-	0.06 (z=1.0, ns)	-	0.25 (z=2.0, p<0.05)	0.10 (z=1.3, ns)

Statistical significance: * p < 0.05; ** p < 0.01; *** p < 0.001

NOTE: see Table 11 for description of variables

Table 35 Estimated increase in reported assaults per Health Region for every one additional hotel/tavern or liquor store with average annual regular strength beer purchases

Health Region (Outlier LGAs excluded)	*Hotel/tavern*		*Liquor Store*	
	Assaults on licensed premises	**Assaults on private premises**	**Assaults on licensed premises**	**Assaults on private premises**
Metropolitan (none)	0.0	16.6	0.0	7.9
Goldfields (Kalgoorlie Boulder, Ngaanyatjarraku)	2.3	0.0	1.9	0.0
Great Southern (Albany)	0.0	0.0	1.3	11.9
Kimberley (none)	-	-	-	-
Midwest and Murchison (Geraldton, Carnarvon)	2.0	15.4	0.0	0.0
Pilbara (none)	-	-	-	-
South West (none)	0.0	0.0	0.0	3.4
Wheatbelt (Northam)	0.0	0.0	2.9	28.8
WA	**2.0**	**8.4**	**1.0**	**7.7**

Consideration of 'outlying' LGAs

As the number of geographical units available for analysis decline, detection of atypical units, otherwise known as 'outliers', becomes increasingly important. The presence of outliers can often be revealed from a simple scatter plot. Where outliers can be shown to have an undue influence on statistical outcomes, they are often dealt with by removal from further analysis. This has the unfortunate effect of reducing the sample size and therefore affecting statistical power to detect associations. Among the eight health regions examined in the regional analyses, at least half indicated the presence of one or two outlying LGAs. In most cases, the number of LGAs within each affected region was large enough so as not to cause serious concern about reduced sample size. However, the Goldfields Health Region contained only nine LGAs, two of which – Kalgoorlie Boulder and Ngaanyatjarraku – undoubtedly had atypical levels of alcohol availability.

In 2000/01 the LGA of Ngaanyatjarraku had zero hotels/taverns, zero liquor stores and consequently did not record any regular strength alcohol purchases. (Ngaanyatjarraku was the only LGA in WA to contain no licensed premises at all in 2000/01.) Conversely, within the LGA of Kalgoorlie Boulder, there were 29 hotels/taverns contributing to over 1.3 million litres of beer purchases and 12 liquor stores contributing almost 1.5 million litres of beer purchases. Kalgoorlie Boulder reported a total of 255 assaults on private premises and 71 on licensed premises in 2000/01. Among the remaining LGAs in this Health Region, the mean volume of regular strength beer purchases from hotels/taverns and liquor stores in 2000/01 was about 150,000 litres and 100,000 litres respectively; the overall average number of assaults on private and licensed premises were about 28 and 5 respectively. Thus, had the Kalgoorlie Boulder outlier not been detected prior to statistical modelling, it would have unduly influenced (inflated) the coefficients for the Goldfields Health Region such that the outcomes would be less representative of the remaining LGAs. The corollary is that the exclusion of the outlying Kalgoorlie Boulder LGA from the estimation process ultimately results in coefficients that under-estimate the true magnitude of the association between volume of beer purchases and reported assaults for that specific LGA.

Chapter eight: Synthesis and recommendations: a national framework for estimating the impacts of changes to outlet density on alcohol-related harms

Throughout Australia, liquor licensing decisions relating to outlet density have been typically made on an ad hoc basis. For the foreseeable future, however, there is likely to be a growing trend toward the application of public interest tests by liquor licensing decision-makers. In the absence of objective, data-driven evidence, effective progress in this area is likely to be impeded. This study has identified a range of key requirements which need to be met in order to achieve viable working models for estimating outlet density outcomes across Australia. This chapter brings together what has been learnt from both the literature review and from the exploratory analyses described above and makes recommendations for moving forward.

Establish a working group

An initial step toward further work on models for alcohol outlet density might include the identification of individuals with relevant expertise in this area and the establishment of a committed working group. The working group should ideally include: (i) individuals with a national perspective who also bring relevant national and international collaborative research links, and (ii) local practitioners who can inform on ground-level community issues.

Establish ongoing systematic data collection and facilitated data access across all states and territories

The results of the exploratory analyses described in this report clearly preclude the viability of a 'one-size-fits-all' model which can be applied to all regions at all times to predict the impact of changes to licensed outlet density on levels of alcohol-related harms. Ideally, specific models based on local data should be constructed for each state/territory and each identified functional region (e.g. Health Regions). In order to achieve this, region-specific data measuring a range of harm, demographic and socio-economic variables must be systematically collected and accessible.

This study examined the veracity and feasibility of applying a range of indicators for measuring both outlet density and alcohol-related harms using Western Australian data. This state was deliberately chosen because it has the most complete set of relevant data. Some of the data used are also readily available for other states and territories; other data sets, however, are currently only available for Western Australia.

Both morbidity and mortality unit record data used in this study were collated by official nation-wide collection systems. The AIHW (morbidity) and the ABS (mortality) update state and territory data on a regular basis. The collated data contain crucial information on place of residence (not street address) and underlying cause of death/illness/injury of individuals. It is likely that access to these data sets by external agencies will remain possible in the foreseeable future. The ABS is also able to provide census data, including a range of demographic and socio-economic measures, at various geographic levels.

It is unfortunate that similar systems do not currently exist for the other data sets identified in this report – that is, police data (e.g. assault offences, last place of drinking for drink-drivers) and liquor licensing data (i.e. wholesale alcohol purchases made by retailers). This is of particular concern because both police and wholesale alcohol purchase data appear to be necessary components for reliably estimating the impact of outlet density changes on alcohol-related harms. In the short term at the very least, the absence of a centralised collection system for each of these rich sources of information is likely to impede progress toward outlet density modelling on a national scale. Procedures and delays in accessing data can also be time consuming and costly. The practical arrangements required to successfully collect data for all jurisdictions in a timely fashion will require planned consideration and concerted co-operative efforts by key stakeholders.

Requirements and recommendations

- Establish a licensed outlet density reference group to support the working group. The reference body should comprise key high-level representatives from health, police, and liquor licensing bodies from each state and territory. Each representative should be in a position to facilitate data transfer between their own department and the working group.
- In the first instance, the reference body should identify the collection of wholesale alcohol purchase data by individual jurisdictions as a priority action.
- The reference body should work towards establishing routine mechanisms for regularly scheduled data transfer to the working group.
- The reference body should encourage and support work towards standardisation of data collection systems and records across all jurisdictions, especially with regard to wholesale alcohol purchase data and police records.

Utilise responsive and accurate measures of 'outlet density'

The most efficacious measure of alcohol 'outlet density' is in fact not a measure of density *per se*, but a powerful and pointed indicator of the magnitude of alcohol consumption directly linked to specific licence types. To date, most outlet density studies have been restricted to using inflexible outlet 'density' measures – that is, counts of licensed outlets in the numerator and some standardising measure as the denominator (e.g. number of outlets per geographic land area, number of outlets per estimated private population, number of outlets per kilometre of roadway). Where possible, such density measures have been estimated separately for on- versus off- premises outlets. Unfortunately, whatever the analyst's choice of denominator, any 'density' measure which relies on frequency counts of outlets as the numerator necessarily assumes that all outlets (or types of outlets) are equivalent. Clearly, this is not the case – there is a great deal of variability among licensed outlets, not only between licence types but within licence categories. Variation may occur at many levels including but not restricted to: management practices; venue characteristics; patron characteristics; police activity and enforcement; and crucially, levels of alcohol sales. For the purposes of estimating the impact of new licenses on a community, the most salient of these factors must be the latter, which can only be accounted for where information relating to sales or purchases by individual outlets can be readily obtained.

Compared to typically applied outlet density measures, as an indicator of the physical availability of alcohol within a community, volume of alcoholic beverage purchases not only has the unique advantage of being intrinsically sensitive to individual differences between outlets, but when measured over time, also has the potential to integrate changeable external factors such as economic activity.

Without concerted effort to collect and provide comprehensive wholesale beverage purchase information, progress toward the development of outlet density models will be limited. At present, only Western Australia routinely collects and allows that wholesale alcohol purchases by individual retailers be made available for research purposes. Although the Northern Territory Liquor Commission also currently collects wholesale purchase information, the data are typically aggregated by location, and in the past, specific information on individual licensed premises has not been readily available to researchers.

Requirements and recommendations

- It is our strong recommendation that state and territory liquor authorities be encouraged and supported to implement routine systems for collecting annual wholesale beverage purchases made by individual licensed retailers in their jurisdiction. The minimum information required to inform outlet density research includes the following: name of licensed premises; type of licensed premises; street address of licensed premises; local government area or Statistical Local Area of premises; annual volume of regular strength beer purchases; annual volume of low strength beer purchases; annual volume of mid strength beer purchases, annual volume of regular strength bottled wine purchases; annual volume of regular strength cask wine purchases; annual volume of low strength wine purchases; annual volume of straight spirit purchases; and annual volume of pre-mixed spirit purchases.
- Quarterly data collections and value of purchases by beverage type would further enhance the utility of wholesale beverage purchase information.
- The accuracy of these data would need to be ensured. Random auditing and/or cross-checking with wholesaler sales records may facilitate this.

Indicators of alcohol-related harm

This feasibility study examined the associations between outlet density and a range of alcohol-related harm indicators. The study purposely relied on information that was already available or which could readily be collected in a systematic manner by official agencies. In comparison to the costs involved in primary data gathering, application of secondary data sources can be highly cost-effective.

Among the range of harm indicators examined, police-reported assault offences emerged as having one of the strongest and most consistent relationships with outlet density. In part, this is likely to be due to the high frequency of reported offences relative to the smaller numbers of alcohol-attributable hospitalisations and deaths. However, it is also the case that throughout the research literature, the most robust relationships between outlet density and alcohol-related harms have been repeatedly documented for assaults. Clearly, therefore, police-reported assault data has a central role to play in the measurement of alcohol-related harms.

One of the benefits of the Western Australian Police Service assault reports examined in this project was the ability to identify whether an assault had occurred at a licensed or a private premise by use of a location field completed by responding officers. Indeed, the results of the demonstration models have consistently indicated the importance of distinguishing between incidents occurring on licensed versus private premises.

Assault data should be considered an essential part of understanding the effect of changes to outlet density on communities but, on its own, it ought not to be considered sufficient. An exhaustive examination of the impact of changes to outlet density under controlled analyses was beyond the scope of this project. Nevertheless, when volume of wholesale beverage purchases was the outlet density measure, strong associations were demonstrated for all other alcohol-related harm indicators tested. Moreover, the impact of changes to alcohol outlet density may be manifest differently across time and place such that indicators which exhibit strong associations with outlet density in one area may fail to be significant in another. For instance, it would be a mistake to assume that because statistical analyses failed to demonstrate a significant relationship between assaults and outlet density in a particular region at one point in time, that no relationship exists between road crashes or pedestrian fatalities and outlet density in that region.

Thus, the best approach to forecasting the impact of changes to outlet density on the public health, safety and amenity of a community is one which allows as fulsome a view of the range of possible outcomes as is reasonably possible. This study examined four reliable alcohol-related harm indicators, and within those a range of sub-groups, any one, none, or all of which may be affected by outlet density under certain conditions. Admittedly, however, the harm indicators selected for this project were partly determined by practical considerations including ease of access – as has generally been the case for the vast majority of research in this area. This 'selection bias' is likely to generate only a partial picture of the actual impact of outlet density. Emergency department data is a case in point; these data are a rich source of information and hold particular potential. Emergency department data has a particular capacity to capture alcohol-related injuries which do not appear in official hospital admission records (and possibly include large numbers of less serious injuries). The high frequency of events and the broad spectrum of conditions captured by such records could prove especially instructive where hospital admissions and/or deaths are relatively infrequent (e.g. small communities, rural areas). Unfortunately, unlike hospital separations, there is currently no national systematic or standardised approach to recording emergency department presentations. The use of electronic record management packages (e.g. EDIS) which potentially identify presentations by ICD code is typically left to the discretion of individual hospitals and as a result, application is generally piece-meal. Thus, for most regions, any use of these data for modelling purposes is currently constrained by inconsistent administrative practice.

Requirements and recommendations

- Future progress toward working models for outlet density should consider a minimum set of alcohol-related harm indicators including: police-reported assault offences; police-reported road crash and drink-driving data; alcohol-attributable hospital separations; and alcohol-attributable deaths.
- This minimum data set does not preclude the use of other supplementary data sets, which in some regions may be especially useful. These may include but should not be restricted to: state and national crime/health/substance use surveys; emergency department presentations; ambulance call-outs; police drunk and disorderly reports; liquor infringement notices; reports of child abuse; sobering-up shelter admission; and admissions to women's refuges.
- Police-reported assault offences should include the following information at a minimum: date of incident; time of day of incident; geographical location (i.e. suburb/town/local government area); venue of assault (e.g. hotel/tavern, nightclub, private residence, park, shopping centre); and type of assault (e.g. common assault, wounding, grievous bodily harm).
- Police-reported road crash and drink-driving offences should include the following at a minimum: date of incident; driver's blood-alcohol level; driver's last place of drinking; geographical location of the offence (i.e. suburb/town/local government area); and identification of whether offence involved road crash or otherwise.
- Unit record morbidity and mortality data should include at a minimum: date of admission/ death; place of registration (e.g. LGA); place of residence (e.g. LGA); primary cause (ICD); and external cause hospitalisation (ICD).
- The reference group should work towards encouraging routine electronic recording systems for all state/territory emergency departments (e.g. EDIS).

Analytical considerations for future model design

There are many important issues to which future analysts will need to give due consideration when formulating predictive statistical models for outlet density. In a scientific sense, one of the most fundamental of these is a requirement to examine not only cross-sectional associations – as was performed in the demonstration models shown here – but to explore how changes to licensed outlet density influence harm indicators over time. Although well constructed models derived from cross-sectional data can be highly instructive, being restricted to a single point in time, they cannot be relied upon to establish causation. In other words, such studies cannot definitively determine which variable ‘causes’ the other. Subsequently, cross-sectional outlet density studies ultimately leave unanswered the question, ‘Does higher licensed outlet density cause greater levels of alcohol-related harm or does greater harm encourage higher licensed outlet density?’ One means of addressing this shortcoming is to investigate how changes to outlet density which take place over time (i.e. many consecutive years) relate to changes in harm indicators over the same period. In the short-term, with only a few exceptions, data limitations preclude the application of time-series designs using the preferred variables described here for most jurisdictions. That is not to say, however, that liquor licensing policy decisions should not be guided by outcomes from well designed cross-sectional studies in the interim.

This issue and the many other issues facing future analysts highlighted in this report have been summarised below.

Requirements and recommendations

- The geographic unit of choice should reflect functional areas as opposed to only administrative areas. The optimal geographic unit may differ among states/territories for a variety of reasons including but not restricted to: land area (physical size); population density; population mobility; demographic and socio-economic variability.
- Future models should foremost consider measures of outlet density that reflect the wide variability in quantity and type of alcohol supplied by licensed premises (i.e. volume of wholesale alcohol purchases).
- Future models should consider measures of outlet density that are more likely to be responsive to economic change and other characteristics of the broader environment which may influence consumption (i.e. volume of wholesale alcohol purchases).
- Separate models for distinct types of licensed outlets (e.g. hotel, liquor store, restaurant) and where applicable, location of alcohol-related event/offence are recommended (e.g. private residence, public place).
- Multivariate analyses should include a comprehensive range of demographic and socio-economic variables, the predictive capacity of which may vary between regions.
- Future models should consider potential interaction effects between predictor variables (e.g. volume of beverage purchases by average age).
- Future models should consider application of non-alcohol-related control variables (e.g. density of non-alcohol-related retail establishments).
- Future models should consider potential non-linear associations.
- Future models should consider potential lagged effects, especially where geographic units are small (e.g. census tracts, neighbourhoods).
- Future models should consider the potential impact of atypical communities/areas on the wider generalisability of modelling outcomes.

- Future models should consider the potential impact of mobile populations (e.g. tourist activity, fly-in-fly-out workers) on model parameters.
- Future models should be adaptable to change and readily able to incorporate updated information and new data.

Potential outcomes and conclusions

This feasibility study has demonstrated the utility of using systematically-recorded data to model relationships between licensed outlet density and alcohol-related harm in Western Australia. This report has described how volume of wholesale alcohol purchase data can be used effectively to: identify existing associations; identify the size and direction of associations; estimate the likely impact that changes to licensed outlet density will have on levels of alcohol-related harms; and demonstrate the variability of relationships among regions. The results also concur with the overall findings from the research literature, that is, greater physical availability of alcohol is associated with higher levels of alcohol-related harms.

Nonetheless, it must be recognised that any model which attempts to estimate the impact of one variable on another will only be as accurate, sensitive and reliable as the data and assumptions upon which it is based. One of the main reasons for selecting Western Australia as a test case for this project was relatively easy access to comprehensive alcohol consumption and alcohol-related harms data. Much of that which has been demonstrated in this report could not be achieved on a national scale given current gaps in data collection. This highlights a fundamental issue which needs to be addressed if work in this area is to move forward – access to data on alcohol purchases by licensed retail outlets.

Tangible progress toward the range of recommendations listed above will potentially benefit a wide range of key stake-holders: state and territory liquor licensing authorities to whom falls the responsibility of administering liquor legislation in a complex and changing environment; police and health services upon whom falls the responsibility to care for and protect those who are affected by their own or another's alcohol consumption; and the communities at large upon which the financial and social burden ultimately falls.

There is no doubt that some communities will be more susceptible to experiencing the negative effects of changes to licensed outlet density than others. Not all communities are the same and not all licensed premises are equal. It is highly likely that decisions about location and number of licensed premises can be guided to good effect by sensitive and reliable analytical models which bear-out this variability. Ultimately, however, it should be left to individual communities and their representatives to determine the 'optimal' balance between the apparent benefits brought by the physical availability of alcohol and the subsequent costs to public health, safety and amenity.

Where to from here?

As a feasibility study, this project has focussed on addressing some basic questions regarding our current understanding of the impact of alcohol outlet density of licensed premises and how this fits in an Australian context. The objectives of this project were to describe previous research in this area, to highlight the main issues and limitations, and to demonstrate how a model for alcohol outlet density might be approached in the future. This study was limited in that it was only able to explore, in-depth, the relationship between police-reported assaults and beer consumption. But – the range of harm from alcohol extends far beyond interpersonal violence, and the impact of outlet density on other alcohol-related problems remains a fertile area for further exploration. The study was also limited to examining the relationships between outlet density measures and alcohol-related harm indicators specific to Western Australia. In all likelihood, given access to the necessary data, similar outcomes could be achieved for other jurisdictions.

Listed below are some suggested short- to long-term actions for ensuring positive future development of Australian outlet density research which may ultimately serve to inform liquor licensing and related decisions in this country. Stage one refers to activities which could be readily undertaken in the short-term and realistically completed within an eighteen month period, assuming that access to the necessary data is granted. The proposed approach for stage two is to focus on adding to the quality of evidence accumulated in stage one with a more robust study design (e.g. time-series as opposed to cross-sectional analyses); this stage could be reasonably completed within 12 to 18 months. Further progression through to stage three is wholly dependent on satisfactory completion of stages one and two and would require considerable time and resource commitment – extending over at least a 24 month period.

Stage 1

Engage and resource an appropriate research group to:

(i) extend and refine the modelling analyses conducted by the feasibility study on Western Australian data to a broader range of harm indicators, including: drink-driver road crashes; alcohol-attributable mortality; and morbidity;

(ii) extend and apply the objectives of the feasibility project to Northern Territory data. This would require access to police assault and road crash data as well as wholesale alcohol purchase records for individual licensed premises in the Northern Territory. The latter has been collected by the Northern Territory Liquor Commission for many years, but access to individual records from licensed premises for research purposes has been severely limited in the past. The viability of work in this area would require considerable in-principle and practical support from both the Liquor Commission and the Northern Territory Police.

(iii) investigate the feasibility of examining the impact of changes to measures of outlet density in Western Australia and/or the Northern Territory over time.

Stage 2

Engage and resource an appropriate research group to:

(iv) given that outcomes from (iii) allow, apply time-series analyses to investigate the impact of changes to outlet density on alcohol-related harm indicators using Western Australian and/or Northern Territory data;

(v) in the light of possible data collection and access developments, re-assess the feasibility of extending and applying the data analysis component of the feasibility project to other states and territories.

Stage 3

(vi) Where the findings from (v) permit, develop outlet density models for the remaining states and territories;

(v) establish ongoing monitoring of outlet density and harm indicators to update models as communities change over time;

(vi) investigate the feasibility and utility of establishing a plain language web-site including on-line access to regionally aggregated (e.g. by LGA) harm-indicator outlet density models across all states and territories for general and/or authorised-only use. (This may facilitate equitable access for all stake-holders with regards to future local 'public interest test' liquor licensing decisions.)

References

Abbey, A., Scott, R.O and Smith M.J. (1993) Physical, subjective and social availability: their relationship to alcohol consumption in rural and urban areas, *Addiction*, 88(4): 489–99.

ABS (2004) *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA)*. Technical Paper, ABS Catalogue Number 2039.0.55.001, Canberra.

Alaniz M.L. (1998) Alcohol availability and targeted advertising in racial/ethnic minority communities, *Alcohol Health and Research World*, 22(4): 286–289.

Anglin, L. Giesbrecht, N. Ialomiteanu, A. McAllister, J. and Ogborne, A. (2003) Public perception of alcohol policy issues relating directly or indirectly to privatization. *Canadian Journal of Public Health*, 94(3): 201–206.

Babor, T. F., Caetano, R., Casswell, S., Edwards, G., Giesbrecht, N., Graham, K., et al. (2003). *Alcohol: No ordinary commodity. Research and public policy*. Oxford: Oxford University Press.

Bleasel J. E. (2003). *An Appraisal of Social Harm Issues Relating to Increasing Liquor Outlet Density*. Unpublished paper commissioned by the Australian Hotels Association – Tasmanian Branch.

Chikritzhs, T., Stockwell, T., Hendrie, D., Ying, F., Fordham, R., Cronin, J., Orlermann, K. and Phillips, M. (1999). *The public health, safety and economic benefits of the Northern Territorys Living With Alcohol Program 1992/2 to 1995/6*. NDRI Monograph No. 2. Perth: National Drug Research Institute, Curtin University of Technology.

Chou, Y.H. (1991). Map resolution and spatial autocorrelation. *Geographical Analysis*, 23: 228–246.

Collins, D. and Lapsley H. (2002). *Counting the cost: estimates of the social costs of drug abuse in Australia in 1998–9*. National Drug Strategy Monograph Series No. 49. Canberra: Commonwealth Department of Health and Ageing.

Colon, I. and Cutter, H. (1983). The relationship of beer consumption and state alcohol and motor vehicle policies to fatal accidents. *Journal of Safety Research*, 14(2): 83–89.

Cook, P.J. and Moore, M.J. (1993). Violence reduction through restrictions on alcohol availability, *Alcohol Health and Research World*, 17(2): 151–156.

Costanza, S.E., Bankston-Williams, B and Shihadeh, E. (2001). Alcohol availability and violent crime rates: a spatial analysis. *Journal of Crime and Justice*, 24(1):71–83.

Escobedo,I.G. and Utiz, M. (2002). The relationship between local outlet density and injury and violence in New Mexico. *Accident Analysis and Prevention*, 34(5): 689–694.

Fitzgerald, J.L. and Mulford, H.A. (1993). Alcohol availability, drinking contexts and drinking problems: the Iowa experience. *Journal of Studies in Alcohol*, 320–325.

Freisthler, B., Midanik, L.T. and Gruenewald, P.J. (2004). Alcohol outlets and child physical abuse and neglect: Applying routine activities theory to the study of child maltreatment. *Journal of Studies on Alcohol*, 65: 586–592.

Freisthler, B., Gruenewald, P.J. Treno, A.J. and Lee, J. (2003). Evaluating alcohol access and the alcohol environment in neighborhood areas. *Alcoholism: Clinical and Experimental Research*, 27, 477–484.

Giesbrecht, N. and Greenfield, T.K. (2003). Preventing alcohol-related problems in the US through policy: Media campaigns, regulatory approaches and environmental interventions. *The Journal of Primary Prevention*, 24(1): 63-104.

Gliksman, L., and Rush, B. (1986). Alcohol availability, alcohol consumption and alcohol-related damage, II. The role of sociodemographic factors. *Journal of Studies on Alcohol*, 47(1): 11–18.

Godfrey, C. (1988). Licensing and the demand for alcohol. *Applied Economics* 20(11): 1541–1558.

Gorman, D.M., Labouvie, E.W., Speer, P.W., and Subaiya, A.P. (1998). Alcohol availability and domestic violence. *American Journal of Drug and Alcohol Abuse*, 24(4): 661-673.

Gorman, D.M., Speer, P.W., Labouvie, E.W. and Subaiya A.P. (1998) Risk of assaultive violence and alcohol availability in New Jersey. *American Journal of Public Health*, 88(1): 97-100.

Gorman, D.M., Speer, P.W. and Gruenewald, P.J. (2001). Spatial dynamics of alcohol availability, neighbourhood structure and violent crime. *Journal of Studies on Alcohol*, 62(5): 628–636.

Gorman, D.M., Gruenewald, P.J., Hanlon, P.J., Mezic, I., Waller, L.A., Castillo-Chavez, C., Bradley, E., and Mezic, J., (2004). Implications of systems dynamic models and control theory for environmental approaches to the prevention of alcohol- and other drug-related problems. *Substance Use and Misuse* 39(12): 1713–1750.

Gruenewald, P., Madden, P. and Janes, K (1992). Alcohol availability and the formal power and resources of state alcohol beverage control agencies. *Alcoholism: Clinical and Experimental Research* 16: 591–597.

Gruenewald, P., Ponicki, W. and Holder, H. (1993). The relationship of outlet densities to alcohol consumption: a time series cross–sectional analysis. *Alcoholism: Clinical and Experimental Research* 17(1): 38–47.

Gruenewald, P. and Ponicki, W. (1995). The relationship of the retail availability of alcohol and alcohol sales to alcohol-related traffic crashes. *Accident Analysis and Prevention*, 27: 249–259.

Gruenewald, P., Millar, A., Treno, A., Yang, Z., Ponicki, W. and Roeper, P. (1996a). The geography of availability and driving after drinking. *Addiction* 91: 967–983.

Gruenewald, P.J., Millar, A.B. and Roeper, P. (1996). Access to alcohol; Geography and prevention for local communities. *Alcohol Health and Research World*, 20(4): 244–251

Gruenewald, P.J., Johnson, F.W. and Treno, A.J. (2002). Outlets, drinking and driving: a multilevel analysis of availability. *Journal of Studies of Alcohol*, 63(4): 460–8.

Gruenewald, P.J. and Treno, A.J. (2000). Local and global alcohol supply: economic and geographic models of community systems. *Addiction*, 95 (Supplement 4): s537–s549.

Gruenewald, P.J., Remer, L.G. and Lipton, R. (2002). Evaluating the Alcohol Environment: Community Geography and Alcohol Problems. *Alcohol Research and Health*, 26(1): 42–48.

Gruenewald, P.J., Freisthler, B., Remer, L., KaScala E.A. and Treno, A. (2006). Ecological models of alcohol outlets and violent assaults: crime potentials and geospatial analysis. *Addiction*, 101: 666–677.

Gyimah-Brempong (2001). Alcohol availability and crime: evidence from census tract data. *Southern Economic Journal*, 68(1): 2–21.

Gyimah-Bremprong K and Racine J (2003). *Alcohol availability and crime: A robust approach*, National Science Foundation.

Hanson, C.E. and Wieczorek, W.F. (2002). Alcohol mortality: A comparison of spatial clustering methods. *Social Science and Medicine*, 55: 791–802.

Hill, L. (2004). *Planning for the Sale of Alcohol*, NZ Drug Foundation. Ministry of Health, www.ndp.govt.nz

Independent Review Committee. (2005). *Report of the independent review committee*. Liquor Licensing Act 1988.

Jewell, R.T. and Brown, R.W. (1995). Alcohol availability and alcohol-related motor vehicle accidents. *Applied Economics*, 27: 759–765.

Kuntsche, E.N. and Kuendig, H (2005). Do school surroundings matter? Alcohol outlet density, perception of adolescent drinking in public and adolescent alcohol use. *Addictive Behaviors*, 30: 151–158.

Keilbach, M. (2000). *Spatial Knowledge Spillovers and the Dynamics of Agglomerationand Regional Growth*, Diss., Heidelberg, New York, Physica-Verl.

LaBouvie, E. and Ontkush, M. (1998). Violent crime and alcohol availability: relationships in an urban community. *Journal of Public Health Policy* 19(3): 303–318.

Laranjera, R. and Hinkley, D. (2002). Evaluation of alcohol outlet density and its relationship with violence, *Revista de saude publica*, 36(4): 455–461.

LaScala, E. A., Johnson, F.W., and Gruenewald, P.J. (2001). Neighborhood Characteristics of Alcohol-Related Pedestrian Injury Collisions: A Geostatistical Analysis. *Prevention Science*, 2(2):123–134.

LaScala, E. A., Gerber, D. and Gruenewald, P.J. (2000). Demographic and environmental correlates of pedestrian injury collisions: A spatial analysis. *Accident Analysis and Prevention*, 32, 651–658.

Lipton, R., Gorman, D.M., Wieczorek, W.F. and Gruenewald, P.J. (2003). The *Application of Spatial Analysis to the Public Health Understanding of Alcohol and Alcohol-Related Problems* In: O. Khan (ed) Geographic Information Systems and Health Applications. Hershey, PA: Idea Group Pub. 2003: 57–80.

Lipton, R and Gruenewald, P.J. (2002). The Spatial Dynamics of Violence and Alcohol Outlets. *Journal of Studies on Alcohol*, 63(2): 187-195.

Lester, D. (1993). Restricting the availability of alcohol and rates of personal violence (suicide and homicide). *Drug and Alcohol Dependence*, 31: 215–217.

MAPP Consortium (1995). *The Measurement of Alcohol Problems for Policy (MAPP): A first report of research in Progress*. Perth: Curtin University of Technology.

Marsden Jacob Associates (2005). *Identifying a framework for regulation in packaged liquor retailing*. Report prepared for the National Competition Council as part of the NCC Occasional Series: Melbourne.

Midford, R., Masters L., Phillips, M., Daly, A., Stockwell, T., Gahegan, M. and Philp A. (1998). Alcohol consumption and injury in Western Australia: a spatial correlation analysis using geographic information systems. *Australian and New Zealand Journal of Public Health*, 22(1): 80–8.

Mulford, H.A. and Fitzgerald, J.L. (1988). Consequences of increasing off-premise wine outlets in Iowa. *British Journal of Addiction*, 83: 1271–127.

Nelson J.P. (1990). State monopolies and alcoholic beverage consumption. *Journal of Regulatory Economic*s, 2: 83-9.

Nielsen, A.L., Martinez, R. and Lee, M.T., (2005). Alcohol, ethnicity and violence. *Sociological Quarterly*, 46(3): 479-50.

Norstrom, T. (2000). Outlet density and criminal violence in Norway, 1960-1995. *Journal of Studies on Alcohol*, 61(6):907–91.

Parker, R.N. and Rebhun, L.A. (1995). *Alcohol and homicide: A deadly combination of two American Traditions*. Albany NY: State University of New York Press.

Parker, R.N. and Auerhahn, K (1998). Alcohol, drugs and violence. *Annual Review of Sociology*, 24: 291–311.

Parker R, Nash R and Cartmill, N.S. (1998). Alcohol and homicide in the US: One reason why US rates of violence may be going down. *Journal of Criminal Law and Criminology*, 88(4): 1369–1398.

Pollack, C.E., Cubbin, C, Ahn, D., and Winkleby, M. (2005). Neighbourhood deprivation and alcohol consumption: does the availability of alcohol play a role? *International Journal of Epidemiology*, 34(4):772–780.

Reynolds R.I., Holder H.D. and Gruenewald P.J. (1997). Community prevention and alcohol retail access. *Addiction*, 92:S261–S269.

Rogerson, P.A. (2001). *Statistical methods for geography*, Sage: London.

Scribner, R., MacKinnon, D. and Dwyer, J. (1994). Alcohol outlet density and motor vehicle crashes in Los Angeles County cities. *Journal of Studies on Alcohol*, 55(4): 447–453.

Scribner, R.A., MacKinnin, D.P. and Dwyer, H.H. (1995). The risk of assaultive violence and alcohol availability in Los Angeles County. *American Journal of Public Health*, 85(3): 335–340

Scribner, R., Cohen, D., Kaplan, S. and Allen, S. (1999). Alcohol availability and homicide in New Orleans: conceptual considerations for small area analysis of the effect of alcohol outlet density. *Journal of Studies on Alcohol*, 60(3): 310–316.

Scribner, R., Cohen D. and Fisher W. (2000). Evidence of a structural effect for alcohol outlet density: a multilevel analysis. *Alcoholism: Clinical and Experimental Research*, 24(2): 188–195.

Smart, R. and Docherty, D. (1976). Effects of the introduction of on-premise drinking on alcohol-related accidents and impaired driving. *Journal of Studies on Alcohol*, 37: 683–686.

Smith, I. (1989). Effect on liver cirrhosis and traffic accident mortality of changing the number and type of alcohol outlets in Western Australia. *Alcoholism: Clinical and Experimental Research*, 13(2):190–195.

Speer, P.W., D.M. Gorman, Erich W. Labouvie, and Mark J. Ontkush. (1998). Violent crime and alcohol availability: relationships in an urban community. *Journal of Public Health Policy*, 19(3):303–318.

Stevenson, R., Lind, B. and Weatherburn, D. (1999). Property damage and public disorder: Their relationship with sales of alcohol in New South Wales, Australia. *Drug and Alcohol Dependence*, 54(3): 163–170.

Stevenson, R., Lind, B. and Weatherburn, D. (1999). The relationship between alcohol sales and assaults in New South Wales, Australia. *Addiction*, 94(3): 397–410.

Stockwell, T. (1995). Do controls on the availability of alcohol reduce alcohol problems? In Stockwell, T. (ed) *Alcohol misuse and violence: an examination of the appropriateness and efficacy of liquor laws across Australia*. Report 5 for the National Symposium on Alcohol Misuse and Violence. Canberra: Australian Government Publishing Service.

Stockwell, T., Somerford, P and Lang, E (1992). The relationship between license type and alcohol related problems attributed to licensed premises in Perth, Western Australia. *Journal of Studies on Alcohol*, 53(5): 495–498.

Stockwell, T. and Gruenewald, P. (2004). *Controls on the Physical Availability of Alcohol* in Heather N and Stockwell T (eds) *The Essential Handbook of Treatment of Alcohol Problems*, John Wiley and Sons.

Stockwell, T., Masters L., Phillips, M., Daly, A, Midford, R., Gahegan, M and Philp, A. (1998). Consumption of different alcoholic beverages as predictors of local rates of assault, road crash and hospital admission. *Australian and New Zealand Journal of Public Health*, 22(2): 237–242.

Treno, A.T., Gruenewald, P.J., and Johnson, F.W. (2001). Alcohol Availability and Injury: The Role of Local Outlet Densities. *Alcohol Clinical Exp Res* 25(10):1467–1471.

Treno, A.J., Grube, J.W. and Martin. S.E. (2003). Alcohol availability as a predictor of youth drinking and driving: A hierarchical analysis of survey and archival data. *Alcoholism: Clinical and Experimental Research*, 27(5): 835–840.

Trolldal, B. (2005). Availability and sales of alcohol in four Canadian provinces: a time-series analysis. *Contemporary Drug Problems*, 32(3): 343–372.

Watts, R. and Rabow, J. (1983). Alcohol availability and alcohol-related problems in 213 Californian cities. *Alcoholism: Clinical and Experimental Research*, 7(1): 47–58.

Wieczorek, W.F. and Coyle, J.J. (1998). Targeting DWI prevention. *Journal of Prevention and Intervention in the Community*, 17: 15–30.

Wieczorek, W.F. and Hansen, C.E. (1997). New modelling methods: geographic information systems and spatial analysis. *Alcohol Health and Research World*, 21: 331–339.

Weitzman, E.R., Folkman, A, Folkman, K.L. and Weschler, H. (2003). The relationship of alcohol outlet density to heavy and frequent drinking and drinking-related problems among college students at eight universities. *Health and Place*, 9: 1–6

Wilkinson, J. (1987). Reducing drunken driving: which policies are most effective? *South Economics Journal* 54(2): 322–334.

Zhu, L., Gorman, D.M. and Horel, S. (2004). Alcohol outlet density and violence: A geospatial analysis. *Alcohol and Alcoholism*, 39(4): 369–375.