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## SPEAKERS PANEL (LIQUOR LICENSING)

**Day:** Thursday  
**Date:** 25 February 2021  
**Time:** 10.00 am  
**Place:** Zoom Meeting

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From: Democratic Services Unit – any further information may be obtained from the reporting officer or from Carolyn Eaton, Principal Democratic Services Officer, to whom any apologies for absence should be notified.

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## Response to Representation from Public Health re Audenshaw Service Station

### **Representation from James Mallion, on behalf of Public Health**

To quote Mr Mallion:

“There is a growing body of evidence which demonstrates that the availability of alcohol contributes to increased levels of alcohol related harm. It therefore follows that alcohol available to be purchased and then immediately consumed either prior to or when driving a motor vehicle, or indeed by passengers within the vehicle, is likely to increase the risk of harm (Anderson, 2009).

There is extensive research highlighting that there is a direct link between density of licensed premises and alcohol related harm in the surrounding environment (Livingston, 2011); (Richardson, 2014). This evidence suggests that the density and prevalence of alcohol retail outlets influences alcohol-related harms including: creating greater physical availability of alcohol within a local area; reducing the prices of alcohol products due to localised competition; and increasing the visibility of alcohol availability in the local area.”

“Overall, we have assessed this LSOA within which this premises is located, as having relatively low levels of alcohol-related harm compared to other parts of the borough for both health and crime, however nearby areas do experience much higher levels of harm. The wider alcohol related harms experienced by people across Tameside should be considered as well as the evidence suggesting that further increasing the density of licensed premises can increase alcohol related harms in general”

Mr Mallion refers to/has supplied 11 documents:

1. Anderson, P. and others (2009), *‘Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol’*.
2. Bryden, A. and others (2012), *‘A systematic review of the influence of community level social factors on alcohol use’*.
3. Gruenewald, P.J. and others (2006), *Ecological models of alcohol outlets and violent assaults: crime potential and geo-spatial analysis’*. (Not supplied).
4. Livingston, M. and others (2007), *‘Changing the density of alcohol outlets to reduce alcohol-related problems’*.
5. Livingston, M. (2011), *‘A longitudinal analysis of alcohol outlet density and assault’*.
6. Livingston, M. (2011), *‘Alcohol Density and Harm: Comparing the Impacts on Violence and Chronic Harms’*. (Not supplied).
7. Pasch, K.E. and others (2008), *‘Alcohol outlets and youth alcohol use: exposure in suburban areas’*.
8. Pereira, G. and others (2013), *‘Access to Alcohol Outlets, Alcohol Consumption and Mental Health’*.
9. Richardson, E.A. and others (2015), *‘Is local alcohol outlet density related to alcohol-related morbidity and mortality in Scottish cities?’*.
10. Theall, K.P. and others (2009), *‘The neighbourhood alcohol environment and alcohol-related morbidity’*.

11. Begun, A.L. and Clapp, J.D. (2016), *'Reducing and preventing alcohol misuse and its consequences: A Grand Challenge for social work'*. (Supplied but not referenced).

**1. Anderson, P. and others, 'Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol'**

This article is by various authors including one who is associated with the World Health Organisation (D Chisholm PHD).

The article finds that regulations can be effective in reducing alcohol related harm and legislation can reduce drink driving.

A proposed policy is taxation, being a cost-effective method to implement with substantial health benefits.

The article suggests there should be a global treaty on alcohol.

**2. Bryden, A. and others, 'A systematic review of the influence of community level social factors on alcohol use'**

This review looked at 48 studies from 1973 to 2011. The studies used were:

- One from Amazonian villages in Bolivia
- 33 in the US
- Three in Canada
- Three in the UK

The study found inconclusive results on the influence on alcohol use of social economic factors such as deprivation, poverty, income and unemployment. Similarly, inclusive findings were found for the influence of social disorder and crime on alcohol uses. These findings reflect the varied outcome and exposure methods used and the broader limitations with the evidence bases.

**3. Gruenewald, P.J. and others, 'Ecological models of alcohol outlets and violent assaults: crime potential and geo-spatial analysis'**

Referenced but not supplied.

**4. Livingston M. and others, 'Changing the density of alcohol outlets to reduce alcohol-related problems'**

This study is from Melbourne, Australia but examines multiple studies in various countries.

Until 1981, British licensing rules provided for the suppression of licences deemed to be surplus to an area, with compensation to the owners.

Studies have shown mixed results. There are more bars and off licences in deprived areas but there is more alcohol consumption in more privileged areas.

Most studies relate to Nordic countries where alcohol is restricted in availability.

The studies examine what happens if a village in Finland opens an off licence where previously there were none and what happens is laws are changed to allow supermarkets to sell beer. In Norway, there is little impact when outlet density is changed.

Restrictions result in an increase in illegal alcohol and no change in consumption levels.

The privatisation of alcohol sales in five US states showed no substantial change in beer/spirit sales.

The discussion of whether alcohol density effects violence has mixed and inconsistent results. The density of bars in neighbouring regions is associated with violence.

The theoretical foundations of outlet density studies have not yet been fully developed. A substantial number of cross-sectional studies have examined the relationship between outlet density and a variety of alcohol related problems. Recent studies which have examined the link between outlet density, drink driving, and motor vehicle accidents have generally found positive relationships, although other studies show no such relationship. In 1992 after civil unrest in Los Angeles there was a suggestion of a link between alcohol density and an increase in gonorrhoea.

The article identifies a major weakness in studies, being that the underlying assumption is that every outlet within a licence category is equivalent. For example, a small bar is equal to a sprawling nightclub and a small off licence is equal to a hypermarket.

The article concludes that in areas where the number of alcohol outlets is already relatively dense, small changes in density are unlikely to affect alcohol consumption or the rate of chronic health problems.

### **5. Livingston, M., 'A Longitudinal Analysis of Alcohol Outlet Density and Assault'**

This article looks at three types of outlets between the years of 1996 and 2005:

- Hotel/pub;
- Packaged liquor; and
- On-premises.

There is a small body of evidence which suggests a significant link between the density of alcohol outlets in an area and the area's rate of domestic violence.

An early study in New Jersey found a positive relationship between total alcohol density and police recorded rates of domestic violence, but this relationship was no longer evident once socio-demographic control variables (e.g. social disadvantage etc.) were allowed for.

These findings suggest that the geographical relationship between alcohol outlet density and domestic violence is due to a common relationship with other socio-demographic factors.

While there are a growing number of cross-sectional studies suggesting that alcohol outlet density is related to domestic violence, there remains a need for an assessment of this relationship over time.

The article recommends a change to the liquor licensing policy in Victoria Australia.

#### **6. Livingston, M., 'Alcohol Density and Harm: Comparing the Impacts on Violence and Chronic Harms'**

Referenced but not supplied

#### **7. Pasch K.E. and others, 'Alcohol outlets and youth alcohol use: exposure in suburban areas'**

This article focuses upon Minnesota and how exposure to alcohol outlets around homes and schools influences alcohol use amongst 242 high school students.

The results found no relationship between alcohol outlet exposure, using a measure of both distance to and density around students' homes and schools, and alcohol use. Alcohol outlet exposure may not influence alcohol use among mostly white middle class and suburban youth.

The literature suggests that young adolescents primarily obtain access to alcohol from their parents.

#### **8. Pereira, G. and others, 'Access to Alcohol Outlets, Alcohol Consumption and Mental Health'**

This article comprised a study of 6837 adults in Perth, Western Australia for the period of 2006-2009.

The article finds there is a small association between residential exposure to liquor stores and harmful consumption of alcohol and gives some support for a moderate sized effect on hospital contacts for anxiety, stress and depression.

The article highlights the importance of policy approaches that limit the number of liquor stores and the geographic density of outlets as a means to improve mental health and reduce other alcohol related harm.

Further research is needed to test and better understand these pathways.

#### **9. Richardson, E.A. and others, 'Is local alcohol outlet density related to alcohol-related morbidity and mortality in Scottish cities?'**

This article is from the University of Glasgow and states that there is a misplaced focus on the night-time economy.

It recommends support for MUP.

The article recognises limitations including a failure to distinguish between different types of outlets and that people are not static.

The article states that there is little evidence that the public health licensing objective is being used frequently.

#### **10. Theall, K.P. and others, 'The neighbourhood alcohol environment and alcohol-related morbidity'**

This article was produced by US Universities and looks at the relationship between neighbourhood alcohol outlet density and health outcomes to determine the relationship between morbidity and alcohol consumption, and to explore the relationship between more density and observed racial and ethnic differences in morbidity.

There is an accepted limitation as the article does not distinguish the influence of different types of outlets e.g. a liquor store versus a grocery store.

The article states that alcohol availability may have an influence on individuals according to race or ethnicity, but additional research is needed.

#### **11. Begun, A.L. and Clapp, J.D., 'Reducing and preventing alcohol misuse and its consequences: A Grand Challenge for social work'**

Supplied but not referenced.

This is an article from Ohio State University

The article states that models that integrate pharmacological motivational or cognitive/behavioural therapies with biometric monitoring and "smart technology" might prove effective but they will require new training for professionals, reimbursement models and case management systems.

Large scale data mining efforts with human services data development of culturally sensitive measurement and intervention, and applying epigenetic research to risk assessment, are important, innovative steps in moving alcohol misuse prevention and treatment forward.

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**Elaine Finlay**

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**From:** Robert Botkai  
**Sent:** 19 January 2016 12:52:57  
**To:** Elaine Finlay, Sabrina Cader  
**Subject:** FW: Query re s.182 guidance

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**From:** Dawson Anna [mailto:Anna.Dawson@homeoffice.gsi.gov.uk]  
**Sent:** 15 April 2015 16:15  
**To:** Robert Botkai  
**Subject:** Query re s.182 guidance

Mr Botkai,

I am writing in response to your query about the guidance issued to licensing authorities under section 182 of the Licensing Act 2003. The guidance was revised and published on 27 March 2015. Changes have been made to paragraphs 5.22 and 5.23 concerning the sale of alcohol at garages and you have asked me to clarify the position described at paragraph 5.23.

At paragraph 5.22 the guidance is now clearer that a decision on whether to grant a premises licence should be based on the documents and information listed in section 17(3) and 17(4) of the Licensing Act 2003; and that in common with all licensing decisions, the statutory licensing objectives form the basis for this decision.

Paragraph 5.23 describes action that may be taken after the licence has been granted. For example, if the primary use of the premises becomes that of a garage rather than a shop then it would no longer be legal to sell alcohol from the premises (prohibited by section 176 of the Licensing Act 2003). This situation may give rise to a review, and paragraph 5.23 states that if a relevant representation is made, the licensing authority must decide whether or not the premises is used primarily as a garage.

You have raised a concern that use of the term 'representation' in this paragraph may cause some confusion as to whether this paragraph relates to representations made *before* the grant of a premises licence, or representations in relation to a review of an *existing* licence. Paragraph 5.23 is concerned with representations made *after* a licence has been granted or in respect of an existing licence. The term 'representation' is also used in this sense in chapter 11 of the guidance which deals with reviews. Chapter 11 refers to representations given in relation to a review, and representations which give rise to a review (also referred to as an application for a review).

I hope this helps to clarify the position.

Regards,  
Anna

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## Premise Licence Applications – Primary Use

### **New Licence Application**

#### *Licensing Act 2003, section 17 – Application for a premises licence*

- (1) An application for a premises licence must be made to the relevant licensing authority.
- (2) Subsection (1) is subject to regulations under –
  - (a) section 54 (form etc. of applications etc.);
  - (b) section 55 (fees to accompany applications etc.)
- (3) An application under this section must also be accompanied –
  - (a) by an operating schedule,
  - (b) by a plan of the premises to which the application relates, in prescribed form, and
  - (c) if the licensable activities to which the application relates (“the relevant licensable activities”) include the supply of alcohol, by a form of consent in the prescribed form given by the individual whom the applicant wishes to have specified in the premises licence as the premises supervisor.
- (4) An “operating schedule” is a document which is in the prescribed form and includes a statement of the following matters –
  - (a) all the relevant licensable activities,
  - (b) the times during which it is proposed that the relevant licensable activities are to take place,
  - (c) any other times during which it is proposed that the premises are to be open to the public,
  - (d) where the applicant wishes the licence to have effect for a limited period, that period,
  - (e) where the relevant licensable activities include the supply of alcohol, prescribed information in respect of the individual whom the applicant wishes to have specified in the premise licence as the premises supervisor,
  - (f) where the relevant licensable activities include the supply of alcohol, whether the supplies are proposed to be for consumption on the premises or off the premises, or both,
  - (g) the steps which it is proposed to take to promote the licensing objectives,
  - (h) such other matters as may be prescribed.
- (5) The Secretary of State must by regulations –
  - (a) require an applicant to advertise his application within the prescribed period –
    - i. in the prescribed form, and
    - ii. in a manner which is prescribed and is likely to bring the application to the attention of the persons who are likely to be affected by it, and
  - (b) -
  - (c) prescribe the period during which responsible authorities and other persons may make representations to the relevant licensing authority about the application.
- (6) The Secretary of State may by regulations
  - (a) require an applicant to give notice of his application to each responsible authority, and such other persons as may be prescribed, within the prescribed period, and
  - (b) in a case where the application is made by means of a relevant electronic facility, require the relevant licensing authority to give notice of the application to such persons as may be prescribed, within the prescribed period.

#### *Licensing Act 2003, section 18 – Determination of application for premises licence*

- (1) This section applies where the relevant licensing authority
  - (a) receives an application for a premises licence made in accordance with section 17, and

- (b) is satisfied that the applicant has complied with any requirement imposed on him under subsection (5) of that section.
- (2) Subject to subsection (3), the authority must grant the licence in accordance with the application subject only to—
  - (a) such conditions as are consistent with the operating schedule accompanying the application, and
  - (b) any conditions which must under section 19, 20 or 21 be included in the licence.
- (3) Where relevant representations are made, the authority must—
  - (a) hold a hearing to consider them, unless the authority, the applicant and each person who has made such representations agree that a hearing is unnecessary, and
  - (b) having regard to the representations, take such of the steps mentioned in subsection (4) (if any) as it considers appropriate for the promotion of the licensing objectives.
- (4) The steps are—
  - (a) to grant the licence subject to—
    - i. the conditions mentioned in subsection (2)(a) modified to such extent as the authority considers appropriate for the promotion of the licensing objectives, and
    - ii. any condition which must under section 19, 20 or 21 be included in the licence;
  - (b) to exclude from the scope of the licence any of the licensable activities to which the application relates;
  - (c) to refuse to specify a person in the licence as the premises supervisor;
  - (d) to reject the application.
- (5) For the purposes of subsection (4)(a)(i) the conditions mentioned in subsection (2)(a) are modified if any of them is altered or omitted or any new condition is added.
- (6) For the purposes of this section, “relevant representations” means representations which—
  - (a) are about the likely effect of the grant of the premises licence on the promotion of the licensing objectives,
  - (b) meet the requirements of subsection (7),
  - (c) if they relate to the identity of the person named in the application as the proposed premises supervisor, meet the requirements of subsection (9), and
  - (d) are not excluded representations by virtue of section 32 (restriction on making representations following issue of provisional statement).
- (7) The requirements of this subsection are—
  - (a) that the representations were made by a responsible authority or other person within the period prescribed under section 17(5)(c),
  - (b) that they have not been withdrawn, and
  - (c) in the case of representations made by a person who is not a responsible authority, that they are not, in the opinion of the relevant licensing authority, frivolous or vexatious.
- (8) Where the authority determines for the purposes of subsection (7)(c) that any representations are frivolous or vexatious, it must notify the person who made them of the reasons for its determination.
- (9) The requirements of this subsection are that the representations –
  - (a) were made by a chief officer of police for a police area in which the premises are situated, and
  - (b) include a statement that, due to the exceptional circumstances of the case, he is satisfied that the designation of the person concerned as the premises supervisor under the premises licence would undermine the crime prevention objective.
- (10) In discharging its duty under subsection (2) or (3)(b), a licensing authority may grant a licence under this section subject to different conditions in respect of—
  - (a) different parts of the premises concerned;
  - (b) different licensable activities.

## Primary Use

*Licensing Act 1964, section 9(4A) – Persons and premises disqualified for holding or receiving justices' licence (Repealed)*

Premises shall be disqualified for receiving a justices' licence if they are primarily used as a garage or form part of premises which are so primarily used.

*Licensing Act 2003, section 176 – Prohibition of alcohol sales at service areas, garages etc.*

- (1) No premises licence, club premises certificate or temporary event notice has effect to authorise the sale by retail or supply of alcohol on or from excluded premises.
- (2) In this section “excluded premises” means—
  - (a) premises situated on land acquired or appropriated by a special road authority, and for the time being used, for the provision of facilities to be used in connection with the use of a special road provided for the use of traffic of class I (with or without other classes); or
  - (b) premises used primarily as a garage or which form part of premises which are primarily so used.
- (3) The Secretary of State may by order amend the definition of excluded premises in subsection (2) so as to include or exclude premises of such description as may be specified in the order.
- (4) For the purposes of this section—
  - (a) “special road” and “special road authority” have the same meaning as in the Highways Act 1980 (c. 66), except that “special road” includes a trunk road to which (by virtue of paragraph 3 of Schedule 23 to that Act) the provisions of that Act apply as if the road were a special road,
  - (b) “class I” means class I in Schedule 4 to the Highways Act 1980 as varied from time to time by an order under section 17 of that Act, but if that Schedule is amended by such an order so as to add to it a further class of traffic, the order may adapt the reference in subsection (2)(a) to traffic of class I so as to take account of the additional class, and
  - (c) premises are used as a garage if they are used for one or more of the following—
    - i. the retailing of petrol,
    - ii. the retailing of derv,
    - iii. the sale of motor vehicles,
    - iv. the maintenance of motor vehicles.

*Statutory Guidance – Garages and motorway service areas*

April 2018 Guidance – introduced in 2015

5.22 Section 176 of the 2003 Act prohibits the sale or supply of alcohol at motorway service areas (MSAs) and from premises which are used primarily as a garage, or are part of premises used primarily as a garage. Premises are used primarily as a garage if they are used for one or more of the following:

- the retailing of petrol;
- the retailing of derv (diesel);
- the sale of motor vehicles; and
- the maintenance of motor vehicles.

5.23 It is for the licensing authority to decide, based on the licensing objectives, whether it is appropriate for that premises to be granted a licence, taking into account the documents and information listed in section 17(3) and (4) which must accompany the application.

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5.24 If a licence is granted in respect of a premises and the primary use of that premises subsequently changes (for example, the primary use becomes that of a garage rather than a shop) it would no longer be legal to sell alcohol on that premises. If a relevant representation is made, the licensing authority must decide whether or not the premises are used primarily as a garage. The licensing authority may ask the licence holder to provide further information to help establish what the primary use of the premises is.

#### Previous Guidance (2013)

5.21 Section 176 of the 2003 Act prohibits the sale or supply of alcohol at motorway service areas (MSAs) and from premises which are used primarily as a garage, or are part of premises used primarily as a garage. Premises are used as a garage if they are used for one or more of the following:

- the retailing of petrol;
- the retailing of derv;
- the sale of motor vehicles; and
- the maintenance of motor vehicles.

5.22 The licensing authority must decide whether or not premises are used primarily as a garage. The accepted approach is based on “intensity of use” to establish “primary use”. For example, if a garage shop in any rural area is used more intensely by customers purchasing other products than by customers purchasing the products or services listed above, it may be eligible to seek authority to sell or supply alcohol.

5.23 Where there is insufficient evidence to establish primary use, it is for the licensing authority to decide whether to grant the licence and deal with any issues through enforcement action and it may be able to use its case management powers to enable further evidence to be obtained.

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# A longitudinal analysis of alcohol outlet density and domestic violence

Article in *Addiction* · December 2010

DOI: 10.1111/j.1360-0443.2010.03333.x · Source: PubMed

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**Short title:** Alcohol outlet density and domestic violence

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Word Count for Abstract: 237

Word Count for Body Text: 3,350

Number of Tables: 3

Number of Figures: 0

## **A longitudinal analysis of alcohol outlet density and domestic violence**

Michael Livingston

*Aims:* A small number of studies have identified a positive relationship between alcohol outlet density and domestic violence. These studies have all been based on cross-sectional data and have been limited to assess ecological correlations between outlet density and domestic violence rates. This study provides the first longitudinal examination of this relationship.

*Design:* The study uses data for 186 postcodes from within the metropolitan area of Melbourne, Australia for the years 1996 to 2005. Alcohol outlet density measures for three different types of outlets (hotel/pub, packaged liquor, on-premise) were derived from liquor licensing records and domestic violence rates were calculated from police recorded crime data, based on postcode of the victim. The relationships between these three types of alcohol outlet density and domestic violence were assessed over time using a fixed-effects model. Controls for the spatial autocorrelation of the data were included in the model.

*Findings:* Alcohol outlet density was significantly associated with rates of domestic violence, over time. In particular, the density of hotel (pub) licences and the density of packaged liquor licences were positively related to domestic violence rates and the density of on-premise licences was negatively related to domestic violence.

*Conclusions:* In Melbourne, changes in density of hotel (pub) licenses and packaged liquor licenses have been positively associated with changes in rates of domestic violence whereas the rates of on-site liquor licenses have been negatively associated with domestic violence.

*Keywords:* Alcohol availability, outlet density, domestic violence, panel methods

## Introduction

Domestic violence is a significant problem in Australia, with the 2005 Personal Safety Survey estimating that 15% of women aged 15 or older had experienced violence by a current or previous partner (1), and research suggesting domestic violence is a precursor of more than a quarter of homicides in Australia (2). In 2003, Begg et al. (3) estimated that intimate-partner violence was responsible for 1.1% of the burden of disease and injury amongst Australian women. While there remain debates about the causal role of alcohol in domestic violence (4), there is a substantial body of evidence relating alcohol consumption to domestic violence with, for example, Leonard (5) finding that alcohol is involved in between 25% and 50% of domestic violence incidents. Leonard also discusses the role of general alcohol policy approaches in reducing rates of domestic violence, suggesting that measures focussing on alcohol availability are likely to reduce violence rates. This is given support by one study finding a negative effect of the price of alcohol on domestic violence (6) and some studies in remote Australian towns which are suggestive of reductions in domestic violence following restrictions in trading hours (7, 8).

The main theoretical reasons to expect the density of alcohol outlets in an area to be related to domestic violence derive from simple availability theory (9), which, at its most straightforward suggests that alcohol consumption will increase as alcohol becomes more available. Thus, increases in off-premise alcohol outlets in an area may lead to increased overall consumption (through more convenient access, lower prices due to competition or increasingly visible advertising), which in turn will lead to increased heavy drinking occasions and intoxication, thus increasing the risk of domestic violence. Contrastingly, increases in outlets with a focus on on-premise alcohol consumption may alter drinking

practices such that more alcohol is consumed at these venues, which are typically the location of heavier drinking occasions (10), again increasing intoxication and risk of domestic violence taking place.

Similarly, there is a small body of evidence which suggests a significant link between the density of alcohol outlets in an area and the area's rate of domestic violence. This link is an intuitive extension of the previously discussed role of alcohol in domestic violence and the repeated studies demonstrating clear relationships between community-level factors (predominantly measures of disadvantage or social disorganisation) and domestic violence (11-15). An early study in New Jersey (16) found a positive relationship between total alcohol outlet density and police-recorded rates of domestic violence, but this relationship was no longer evident once socio-demographic control variables (e.g. social disadvantage, population movement etc) were controlled for. These findings suggest that the geographical relationship between alcohol outlet density and domestic violence is due to a common relationship with other socio-demographic factors. However, two recent studies have found a persistent relationship between alcohol outlet density and domestic violence, even with socio-demographic factors controlled for. In particular, a recent study by McKinney et al. (17) combined data from a national (U.S.) population survey and administrative data sources to assess whether self-reported experiences of intimate partner violence were related to alcohol availability, finding a positive link between alcohol outlet density and male-to-female partner violence. McKinney et al. also examined whether particular outlet types were problematic, finding that on-premise outlet density was significantly related to partner violence, but not off-premise. McKinney et al. (17) adjusted for a wider range of socio-economic and demographic characteristics, across individual, couple and community levels, finding that the relationship between outlet density and partner violence persisted with these factors

controlled for. Similarly, recent work by Livingston (18) in Melbourne, Australia found that while socio-demographic factors reduced the size of the relationship between outlet density and domestic violence, a significant effect remained. This study found a positive relationship between general (pub or hotel) licences and domestic violence and a negative link between on-premise (restaurant, bar, cafe) licences and domestic violence, suggesting very different roles for different types of alcohol outlets.

The development of this literature follows a substantial number of studies demonstrating that alcohol outlet density and rates of assaultive violence in general are related (see 19, 20, 21 for reviews). This link has been particularly strengthened by a series of studies which have examined the relationship between alcohol outlet density and violence over time, finding that changes in outlet density are related to changes in violence rates (22-25). These longitudinal findings provide stronger evidence that the relationship between outlets and violence is causal, and not related to other underlying factors not controlled for in cross-sectional analyses. Thus, while there are a growing number of cross-sectional studies suggesting that alcohol outlet density is related to domestic violence, there remains a need for an assessment of this relationship over time.

This study involves the first longitudinal analysis of the relationship between alcohol outlet densities and rates of domestic violence. The study uses data at the postcode level from Melbourne, Australia from 1996 to 2005 and uses spatial panel data methods. This time period and setting provide a particularly interesting frame for the study, with significant increases in alcohol availability taking place in Melbourne across the late 1990s and early 2000s (26).

#### Methods

This study is a population level analysis of domestic violence, focussing particularly on the longitudinal relationship between alcohol availability and domestic violence rates at a neighbourhood level.

### *Geographical units*

Postcode level aggregate data on alcohol outlets and domestic violence were used to assess whether annual changes in alcohol outlet density were related to annual changes in rates of domestic violence. The study uses data from the 186 postcodes from the greater Melbourne region that have not had boundary changes over the ten years of the study (1996 to 2005). While some postcodes within the greater Melbourne area were excluded due to boundary changes ( $n = 37$ ), the postcodes used in the study included approximately 85% of the population of Melbourne at the 2001 Census. In 2005, the average postcode was 14.7 kilometres square, with a resident population of 15,600 people. These are approximately half the size of US zip codes, but much larger than postal areas in the United Kingdom. Postcodes are the best administrative approximation of local suburbs or communities available, although in some of the outer areas of the city some include large non-residential areas such as state parks or industrial areas.

### *Licensing data*

Data on active liquor licences for the 30<sup>th</sup> of June for each year of the study were provided by the Licensing Branch of the Victorian Department of Consumer Affairs. These data included the postcode in which each premise was located, and this field was used to assign outlets to postcodes. A check on the addresses of 200 random records across the study time-period found that the postcode data were accurate in 98% of cases. This study focussed on three

categories of liquor outlets: those with general licences, those with on-premise licence and those with packaged licences. These licences made up 67% of all licences in Victoria over the study period, with the rest made up of club licences, wholesalers and wineries. General licences (793 in the study area in 2005) allow the sale of alcohol for both on- and off-premise consumption and apply to hotels, pubs and taverns. On-premise licences (3,502 in the study area in 2005) allow for on-premise sales only and apply to a diverse range of outlets, including cafes, restaurants, bars and nightclubs. Packaged licences (974 in the study area in 2005) are for outlets that sell alcohol for off-premise consumption only, including retail liquor stores and some small grocery stores. Because this study was concerned with an outcome occurring in domestic settings, alcohol outlet density was calculated for each of these categories as the number of outlets per 1,000 residents.

#### *Domestic violence data*

Domestic violence incident data were provided by the Victorian Police Service from their Law Enforcement Assistance Program (LEAP) database. The data used are counts of 'family incidents' (incidents of domestic violence) recorded by the police for each postcode in the study area for the period 1996 to 2005. These incidents fall somewhere between calls and arrests – they are incidents where the police deem that an offence has taken place and will thus not include all calls, but will include offences that do not result in an arrest. It should be noted that using a policing driven measure of domestic violence creates the potential for biases in the analyses (e.g. reporting rates may be higher in some areas and thus higher rates recorded in those areas). In addition, many incidents of domestic violence are likely to be excluded from police-based statistics with, for example, the Australian 2005 Personal Safety Survey (27) finding that just 36 per cent of female victims of physical assault reported the

incident to the police. This represents a significant source of potential bias to the study, particularly if reporting rates vary along with the availability of alcohol. There is little published research on which factors influence the reporting of domestic violence in Australia, although there is research from the US indicating, for example, that non-white victims are more likely to report domestic violence, so the risk of bias from this measure is not negligible. However, police data is often used in these kinds of analyses (e.g. 11, 28-30), and the use of a range of control variables related to police reporting rates (e.g. socio-economic disadvantage) will ameliorate this bias somewhat. While some previous studies have used counts or rates based on geographic measures (e.g. 23, 24), the fact that these offences took place in residential settings meant that it made the most sense to use rate per 1,000 residents per year.

#### *Population data*

Population data for each postcode came from Census data for 1996 and 2001 and Estimated Residential Population data for 2005 (31, 32). For the remaining years (1997-2000, 2002-2004) population estimates were estimated using linear interpolation. While these population figures were thus estimates, they provided a reasonable approximation of population change over the study period.

#### *Socio-economic data*

Data on the socio-economic disadvantage of each postcode were derived from the Australian Bureau of Statistics Socio-Economic Index for Areas (SEIFA) index of relative disadvantage (33). This index is based on a range of variables collected during the five-yearly national

Census and provides a composite measure of socio-economic disadvantage in a neighbourhood. SEIFA scores range from a low of around 700 (most disadvantaged) up to a high of around 1200 (least disadvantaged) SEIFA data were available for 1996, 2001 and 2006 and data were linearly interpolated for the intervening years.

### *Analysis*

The dependent variable for the regression analyses undertaken in this study was the annual rate of police-recorded domestic violence incidents across each of the 186 postcodes in the study area. The independent variables were the alcohol outlet density rates (both the overall rate and the rates of individual licence categories) along with the residential postcode of the population and the SEIFA index of relative disadvantage. The main aim of the study was to assess how changes in postcode-level outlet density related to changes in domestic violence rates over a ten year period (1996-2005). As the time-period under analysis is too short to develop reliable time-series models, it was necessary to make use of panel data analysis methods. These methods make up for the small number of time points in the study by replicating the analyses across the geographical units. This study uses fixed-effects models, which are asymptotically consistent, and appropriate for situations such as this where the units are not part of a random sample from a larger population. In addition, fixed-effects models focus on maximising the explained variance within units, reducing the possibility that cross-sectional differences between units will bias the results. To ensure that city-wide trends did not influence the results, the model included time-period fixed-effects as well as postcode-level fixed effects. Thus, this is a very conservative modeling strategy, ignoring cross-sectional differences between postcodes and overall trends, and instead only making use of variation within postcodes. The first model developed examines the relationship

between total licence density and domestic violence. This is followed by three models examining each type of licence in turn. Finally, all three licence categories were included in a single model to try to determine which were the most important in explaining rates of domestic violence.

Using spatially-based data such as those used in this study can result in a violation of the independence of the study's units, a key assumption of regression modeling. This is due to the presence of spatial autocorrelation in the data. This occurs when data for one region are related in some non-random way to data for nearby regions. If spatial autocorrelation is present in the data but not controlled for in analyses, the regression results can be substantially biased. Thus, this study used a spatial fixed-effects modeling procedure based on maximum likelihood estimators to ensure that non-biased regression results were produced. Conditional Auto-Regressive (CAR) models were developed, using simple Queen's contiguity weights, whereby the influence of all directly neighbouring postcodes is considered, but not any influence of non-neighbouring postcodes. These models were developed using the Matlab spatial econometrics toolbox developed by Paul Elhorst (34).

## Results

Descriptive statistics for each of the measures used in the study are presented in Table 1. There is clearly sufficient variation over time within the postcode units to be able to assess the temporal relationship between outlet density and domestic violence. Even for on-premise outlet density, which has doubled in the study area over the time-frame studied, enough postcodes (10%) have experienced reductions in on-premise density to provide sufficient variance for the fixed-effects modeling.

The results of the fixed-effects regression models are presented in Table 2. For the sake of clarity, the year dummy variables (which control for overall trends) are not presented. These dummies were generally significant and positive in all models, indicating the city-wide increasing trend in domestic violence rates over the time-period.

The overall model found a small but significant positive effect for total licence density, with an increase in the overall rate of alcohol outlet density of 1 outlet per 1,000 residents resulting in an increase in the domestic violence rate of 0.08 per 1,000 residents. When the separate outlet categories were analysed, there were significant positive effects for each of the categories examined. The positive effects for general and on-premise licences were relatively small – an increase of one general outlet per 1,000 residents in a postcode was associated with an increase of 0.28 domestic violence incidents per 1,000, while an increase of one on-premise outlet per 1,000 residents was associated with an increase in the domestic violence rate of 0.11. The most substantial effect was found for packaged liquor outlets, with an increase of one packaged outlet per 1,000 related to an increase of 1.36 in the domestic violence rate. To provide some context, these effect sizes represent increases of 5.9%, 2.3% and 28.6% respectively from the overall mean of the domestic violence rate (4.76/1,000 residents).

When all three outlet categories were entered into the same model (Table 3), only packaged outlets remained significant, with an increase of 0.66 incidents of domestic violence per 1,000 residents for each additional packaged outlet. It is worth noting that the changes in availability across the three types of outlet are correlated over time. The correlation between the changes in packaged liquor density and general licence density are the highest (0.67,  $p < 0.01$ ), while the remaining correlations were non-significant.

Across all five models, the effect of the SEIFA index of relative disadvantage was significant and negative, highlighting the relationship between increased levels of disadvantage and increased rates of recorded domestic violence. The results also indicated significant positive spatial autocorrelation in the data across all the models. The spatial autocorrelation coefficients reported are substantial ( $\sim 0.6$ ), suggesting that rates of domestic violence are highly correlated between neighbouring postcodes and highlighting the risks of modeling these data with non-spatial methods.

### Conclusions

This study adds to the small body of literature examining the connections between alcohol availability and domestic violence, providing the first longitudinal evidence of a relationship between alcohol outlet density and domestic violence. The study's findings contrast with previous cross-sectional work in this jurisdiction (18), which found that only general licences were positively linked to domestic violence, while on-premise licences were negatively linked. This highlights the possibility of misleading results in cross-sectional analyses, with the results of this longitudinal study providing a more intuitive set of relationships. In particular, the longitudinal analyses highlighted the substantial role of packaged liquor outlets in domestic violence, a relationship that was not detected in previous cross-sectional work.

The relationships found by this study suggest that all three types of alcohol outlets are related to increased levels of domestic violence, with general (or pub) licences and on-premise licences having a relatively small effect and packaged (off-premise) licences having a more substantial impact. These findings fit with theoretical justifications of the link between

alcohol outlet-density and domestic violence. Firstly, the strongest link is found for the type of outlet that sells alcohol for off-premise consumption. If the density of alcohol outlets is related to consumption levels (as suggested by some previous studies (35)), then it is plausible that increasing density of these particular outlets will result in increasing consumption of off-premise alcohol. This consumption is likely to take place within the home, increasing the risk of domestic violence. It is worth noting that, while general licences allow off-premise sales, they also sell a significant amount of alcohol for drinking on premises. These licences have been linked previously to general levels of assault (23, 36), and are often venues in which alcohol consumption is the main activity. There is some evidence that these types of premises are the site of particularly heavy drinking (37), and increasing densities of these kinds of outlets may result in higher frequencies of intoxication, and then to higher risks of domestic violence.

Both of these rationales rely on a link between outlet density and consumption, which remains somewhat contested (e.g. 38). This contrasts with studies focusing on outlet density and public violence, where a variety of theoretical justifications have been put forward to explain the link without requiring changes in consumption (19, 21, 39). While it is hard to imagine alcohol outlets affecting rates of domestic violence without affecting consumption in some way (e.g. by changing the amount, pattern or location of drinking), it is possible that the relationships found in this study reflect changes in socio-demographic factors which are correlated with both alcohol outlet density and domestic violence, although the incorporation of a broad measure of socio-economic disadvantage in the current study reduces the likelihood of this happening. The positive relationship between on-premise licences and domestic violence rates is harder to interpret, with these outlets selling all of their alcohol for consumption on-premises. It is possible that increases in restaurants and bars in an area may

change the way in which residents drink (e.g. encouraging heavier on-premise drinking), although, consistent with this study's results, this would be likely to have only a small effect.

The major limitation of the study is its use of a single composite measure of socio-economic disadvantage, due to the limitations of data available between Censuses in Australia.

However, given the utility of this measure for assessing overall disadvantage and the conservative modeling design, this limitation is not likely to have influenced the alcohol effects observed.

The results of this study are consistent with a growing number of studies linking alcohol outlet density and domestic violence (17, 18, 40), adding to the evidence that alcohol availability is risk factor for domestic violence. In particular, the study finds longitudinal relationships between outlet densities and domestic violence rates, while utilising a very conservative study design, with cross-sectional variation, overall trends and spatial auto-correlation controlled, providing the strongest evidence yet for a direct effect of outlet density on domestic violence. The study particularly implicates hotel packaged liquor licences which, along with previous analyses linking these outlets to general rates of violence (23), suggests the need for changes to liquor licensing policy in Victoria that will stem the proliferation of these outlets.

#### Acknowledgements

Helpful comments on this manuscript were provided by Paul Lemmens, Robin Room, Paul Dietze and two anonymous reviewers.

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Table 1 – Descriptive statistics of study measures

	Mean	S.D.	Min	Max	Total change	Proportion postcodes decreasing
Domestic violence rate (per 1,000)	4.76	0.06	0	19.81	18.30%	33.9%
General licence rate (per 1,000)	0.39	1.29	0	18.52	-1.00%	63.4%
On-premise licence rate (per 1,000)	0.28	0.21	0	2.06	100.70%	10.2%
Packaged licence rate (per 1,000)	1.15	3.35	0	49.35	41.60%	20.3%
SEIFA index of disadvantage	1032.55	78.30	706.96	1162.48	-0.4%	66.7%
Population (x 1,000)	15.61	10.02	0.39	55.92	11.90%	18.9%

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Table 2 – Fixed-effects model results – total licence density and separate models for each licence category

Model 1 – Total licences				Model 2 – General licences				Model 3 – Packaged licences				Model 4 – On-premise licences			
Variable	B	t-value	p	Variable	B	t-value	p	Variable	B	t-value	p	Variable	B	t-value	p
Residential population (1000s)	-0.01	-1.18	0.24	Residential population (1000s)	-0.01	-1.23	0.22	Residential population (1000s)	-0.01	-0.94	0.35	Residential population (1000s)	-	-	-
SEIFA	-0.02	28.25	<0.01	SEIFA	-0.02	27.99	<0.01	SEIFA	-0.02	-27.51	<0.01	SEIFA	0.02	28.32	<0.01
Total licence density	0.08	7.32	<0.01	General licences	0.28	6.93	<0.01	Packaged licences	1.36	5.45	<0.01	On-premise licences	0.11	7.21	<0.01
Spatial autocorrelation	0.60	26.11	<0.01	Spatial autocorrelation	0.59	25.33	<0.01	Spatial autocorrelation	0.59	25.50	<0.01	Spatial autocorrelation	0.60	26.37	<0.01

Table 3 – Fixed-effects model results – licence categories in multivariate model

<b>Variable</b>	<b>B</b>	<b>t-value</b>	<b>p</b>
Residential population (1000s)	-0.01	-0.86	0.39
SEIFA	-0.02	-27.67	<0.01
General licence density	0.05	0.46	0.64
Packaged licence density	0.66	2.35	0.02
On-premise licence density	0.07	1.66	0.10
Spatial autocorrelation	0.60	25.67	<0.01

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Word Count for Abstract: 237

Word Count for Body Text: 3,350

Number of Tables: 3

Number of Figures: 0

## **A longitudinal analysis of alcohol outlet density and domestic violence**

Michael Livingston

*Aims:* A small number of studies have identified a positive relationship between alcohol outlet density and domestic violence. These studies have all been based on cross-sectional data and have been limited to assess ecological correlations between outlet density and domestic violence rates. This study provides the first longitudinal examination of this relationship.

*Design:* The study uses data for 186 postcodes from within the metropolitan area of Melbourne, Australia for the years 1996 to 2005. Alcohol outlet density measures for three different types of outlets (hotel/pub, packaged liquor, on-premise) were derived from liquor licensing records and domestic violence rates were calculated from police recorded crime data, based on postcode of the victim. The relationships between these three types of alcohol outlet density and domestic violence were assessed over time using a fixed-effects model. Controls for the spatial autocorrelation of the data were included in the model.

*Findings:* Alcohol outlet density was significantly associated with rates of domestic violence, over time. In particular, the density of hotel (pub) licences and the density of packaged liquor licences were positively related to domestic violence rates and the density of on-premise licences was negatively related to domestic violence.

*Conclusions:* In Melbourne, changes in density of hotel (pub) licenses and packaged liquor licenses have been positively associated with changes in rates of domestic violence whereas the rates of on-site liquor licenses have been negatively associated with domestic violence.

*Keywords:* Alcohol availability, outlet density, domestic violence, panel methods

## Introduction

Domestic violence is a significant problem in Australia, with the 2005 Personal Safety Survey estimating that 15% of women aged 15 or older had experienced violence by a current or previous partner (1), and research suggesting domestic violence is a precursor of more than a quarter of homicides in Australia (2). In 2003, Begg et al. (3) estimated that intimate-partner violence was responsible for 1.1% of the burden of disease and injury amongst Australian women. While there remain debates about the causal role of alcohol in domestic violence (4), there is a substantial body of evidence relating alcohol consumption to domestic violence with, for example, Leonard (5) finding that alcohol is involved in between 25% and 50% of domestic violence incidents. Leonard also discusses the role of general alcohol policy approaches in reducing rates of domestic violence, suggesting that measures focussing on alcohol availability are likely to reduce violence rates. This is given support by one study finding a negative effect of the price of alcohol on domestic violence (6) and some studies in remote Australian towns which are suggestive of reductions in domestic violence following restrictions in trading hours (7, 8).

The main theoretical reasons to expect the density of alcohol outlets in an area to be related to domestic violence derive from simple availability theory (9), which, at its most straightforward suggests that alcohol consumption will increase as alcohol becomes more available. Thus, increases in off-premise alcohol outlets in an area may lead to increased overall consumption (through more convenient access, lower prices due to competition or increasingly visible advertising), which in turn will lead to increased heavy drinking occasions and intoxication, thus increasing the risk of domestic violence. Contrastingly, increases in outlets with a focus on on-premise alcohol consumption may alter drinking

practices such that more alcohol is consumed at these venues, which are typically the location of heavier drinking occasions (10), again increasing intoxication and risk of domestic violence taking place.

Similarly, there is a small body of evidence which suggests a significant link between the density of alcohol outlets in an area and the area's rate of domestic violence. This link is an intuitive extension of the previously discussed role of alcohol in domestic violence and the repeated studies demonstrating clear relationships between community-level factors (predominantly measures of disadvantage or social disorganisation) and domestic violence (11-15). An early study in New Jersey (16) found a positive relationship between total alcohol outlet density and police-recorded rates of domestic violence, but this relationship was no longer evident once socio-demographic control variables (e.g. social disadvantage, population movement etc) were controlled for. These findings suggest that the geographical relationship between alcohol outlet density and domestic violence is due to a common relationship with other socio-demographic factors. However, two recent studies have found a persistent relationship between alcohol outlet density and domestic violence, even with socio-demographic factors controlled for. In particular, a recent study by McKinney et al. (17) combined data from a national (U.S.) population survey and administrative data sources to assess whether self-reported experiences of intimate partner violence were related to alcohol availability, finding a positive link between alcohol outlet density and male-to-female partner violence. McKinney et al. also examined whether particular outlet types were problematic, finding that on-premise outlet density was significantly related to partner violence, but not off-premise. McKinney et al. (17) adjusted for a wider range of socio-economic and demographic characteristics, across individual, couple and community levels, finding that the relationship between outlet density and partner violence persisted with these factors

controlled for. Similarly, recent work by Livingston (18) in Melbourne, Australia found that while socio-demographic factors reduced the size of the relationship between outlet density and domestic violence, a significant effect remained. This study found a positive relationship between general (pub or hotel) licences and domestic violence and a negative link between on-premise (restaurant, bar, cafe) licences and domestic violence, suggesting very different roles for different types of alcohol outlets.

The development of this literature follows a substantial number of studies demonstrating that alcohol outlet density and rates of assaultive violence in general are related (see 19, 20, 21 for reviews). This link has been particularly strengthened by a series of studies which have examined the relationship between alcohol outlet density and violence over time, finding that changes in outlet density are related to changes in violence rates (22-25). These longitudinal findings provide stronger evidence that the relationship between outlets and violence is causal, and not related to other underlying factors not controlled for in cross-sectional analyses. Thus, while there are a growing number of cross-sectional studies suggesting that alcohol outlet density is related to domestic violence, there remains a need for an assessment of this relationship over time.

This study involves the first longitudinal analysis of the relationship between alcohol outlet densities and rates of domestic violence. The study uses data at the postcode level from Melbourne, Australia from 1996 to 2005 and uses spatial panel data methods. This time period and setting provide a particularly interesting frame for the study, with significant increases in alcohol availability taking place in Melbourne across the late 1990s and early 2000s (26).

#### Methods

This study is a population level analysis of domestic violence, focussing particularly on the longitudinal relationship between alcohol availability and domestic violence rates at a neighbourhood level.

### *Geographical units*

Postcode level aggregate data on alcohol outlets and domestic violence were used to assess whether annual changes in alcohol outlet density were related to annual changes in rates of domestic violence. The study uses data from the 186 postcodes from the greater Melbourne region that have not had boundary changes over the ten years of the study (1996 to 2005). While some postcodes within the greater Melbourne area were excluded due to boundary changes ( $n = 37$ ), the postcodes used in the study included approximately 85% of the population of Melbourne at the 2001 Census. In 2005, the average postcode was 14.7 kilometres square, with a resident population of 15,600 people. These are approximately half the size of US zip codes, but much larger than postal areas in the United Kingdom. Postcodes are the best administrative approximation of local suburbs or communities available, although in some of the outer areas of the city some include large non-residential areas such as state parks or industrial areas.

### *Licensing data*

Data on active liquor licences for the 30<sup>th</sup> of June for each year of the study were provided by the Licensing Branch of the Victorian Department of Consumer Affairs. These data included the postcode in which each premise was located, and this field was used to assign outlets to postcodes. A check on the addresses of 200 random records across the study time-period found that the postcode data were accurate in 98% of cases. This study focussed on three

categories of liquor outlets: those with general licences, those with on-premise licence and those with packaged licences. These licences made up 67% of all licences in Victoria over the study period, with the rest made up of club licences, wholesalers and wineries. General licences (793 in the study area in 2005) allow the sale of alcohol for both on- and off-premise consumption and apply to hotels, pubs and taverns. On-premise licences (3,502 in the study area in 2005) allow for on-premise sales only and apply to a diverse range of outlets, including cafes, restaurants, bars and nightclubs. Packaged licences (974 in the study area in 2005) are for outlets that sell alcohol for off-premise consumption only, including retail liquor stores and some small grocery stores. Because this study was concerned with an outcome occurring in domestic settings, alcohol outlet density was calculated for each of these categories as the number of outlets per 1,000 residents.

#### *Domestic violence data*

Domestic violence incident data were provided by the Victorian Police Service from their Law Enforcement Assistance Program (LEAP) database. The data used are counts of 'family incidents' (incidents of domestic violence) recorded by the police for each postcode in the study area for the period 1996 to 2005. These incidents fall somewhere between calls and arrests – they are incidents where the police deem that an offence has taken place and will thus not include all calls, but will include offences that do not result in an arrest. It should be noted that using a policing driven measure of domestic violence creates the potential for biases in the analyses (e.g. reporting rates may be higher in some areas and thus higher rates recorded in those areas). In addition, many incidents of domestic violence are likely to be excluded from police-based statistics with, for example, the Australian 2005 Personal Safety Survey (27) finding that just 36 per cent of female victims of physical assault reported the

incident to the police. This represents a significant source of potential bias to the study, particularly if reporting rates vary along with the availability of alcohol. There is little published research on which factors influence the reporting of domestic violence in Australia, although there is research from the US indicating, for example, that non-white victims are more likely to report domestic violence, so the risk of bias from this measure is not negligible. However, police data is often used in these kinds of analyses (e.g. 11, 28-30), and the use of a range of control variables related to police reporting rates (e.g. socio-economic disadvantage) will ameliorate this bias somewhat. While some previous studies have used counts or rates based on geographic measures (e.g. 23, 24), the fact that these offences took place in residential settings meant that it made the most sense to use rate per 1,000 residents per year.

#### *Population data*

Population data for each postcode came from Census data for 1996 and 2001 and Estimated Residential Population data for 2005 (31, 32). For the remaining years (1997-2000, 2002-2004) population estimates were estimated using linear interpolation. While these population figures were thus estimates, they provided a reasonable approximation of population change over the study period.

#### *Socio-economic data*

Data on the socio-economic disadvantage of each postcode were derived from the Australian Bureau of Statistics Socio-Economic Index for Areas (SEIFA) index of relative disadvantage (33). This index is based on a range of variables collected during the five-yearly national

Census and provides a composite measure of socio-economic disadvantage in a neighbourhood. SEIFA scores range from a low of around 700 (most disadvantaged) up to a high of around 1200 (least disadvantaged) SEIFA data were available for 1996, 2001 and 2006 and data were linearly interpolated for the intervening years.

### *Analysis*

The dependent variable for the regression analyses undertaken in this study was the annual rate of police-recorded domestic violence incidents across each of the 186 postcodes in the study area. The independent variables were the alcohol outlet density rates (both the overall rate and the rates of individual licence categories) along with the residential postcode of the population and the SEIFA index of relative disadvantage. The main aim of the study was to assess how changes in postcode-level outlet density related to changes in domestic violence rates over a ten year period (1996-2005). As the time-period under analysis is too short to develop reliable time-series models, it was necessary to make use of panel data analysis methods. These methods make up for the small number of time points in the study by replicating the analyses across the geographical units. This study uses fixed-effects models, which are asymptotically consistent, and appropriate for situations such as this where the units are not part of a random sample from a larger population. In addition, fixed-effects models focus on maximising the explained variance within units, reducing the possibility that cross-sectional differences between units will bias the results. To ensure that city-wide trends did not influence the results, the model included time-period fixed-effects as well as postcode-level fixed effects. Thus, this is a very conservative modeling strategy, ignoring cross-sectional differences between postcodes and overall trends, and instead only making use of variation within postcodes. The first model developed examines the relationship

between total licence density and domestic violence. This is followed by three models examining each type of licence in turn. Finally, all three licence categories were included in a single model to try to determine which were the most important in explaining rates of domestic violence.

Using spatially-based data such as those used in this study can result in a violation of the independence of the study's units, a key assumption of regression modeling. This is due to the presence of spatial autocorrelation in the data. This occurs when data for one region are related in some non-random way to data for nearby regions. If spatial autocorrelation is present in the data but not controlled for in analyses, the regression results can be substantially biased. Thus, this study used a spatial fixed-effects modeling procedure based on maximum likelihood estimators to ensure that non-biased regression results were produced. Conditional Auto-Regressive (CAR) models were developed, using simple Queen's contiguity weights, whereby the influence of all directly neighbouring postcodes is considered, but not any influence of non-neighbouring postcodes. These models were developed using the Matlab spatial econometrics toolbox developed by Paul Elhorst (34).

## Results

Descriptive statistics for each of the measures used in the study are presented in Table 1. There is clearly sufficient variation over time within the postcode units to be able to assess the temporal relationship between outlet density and domestic violence. Even for on-premise outlet density, which has doubled in the study area over the time-frame studied, enough postcodes (10%) have experienced reductions in on-premise density to provide sufficient variance for the fixed-effects modeling.

The results of the fixed-effects regression models are presented in Table 2. For the sake of clarity, the year dummy variables (which control for overall trends) are not presented. These dummies were generally significant and positive in all models, indicating the city-wide increasing trend in domestic violence rates over the time-period.

The overall model found a small but significant positive effect for total licence density, with an increase in the overall rate of alcohol outlet density of 1 outlet per 1,000 residents resulting in an increase in the domestic violence rate of 0.08 per 1,000 residents. When the separate outlet categories were analysed, there were significant positive effects for each of the categories examined. The positive effects for general and on-premise licences were relatively small – an increase of one general outlet per 1,000 residents in a postcode was associated with an increase of 0.28 domestic violence incidents per 1,000, while an increase of one on-premise outlet per 1,000 residents was associated with an increase in the domestic violence rate of 0.11. The most substantial effect was found for packaged liquor outlets, with an increase of one packaged outlet per 1,000 related to an increase of 1.36 in the domestic violence rate. To provide some context, these effect sizes represent increases of 5.9%, 2.3% and 28.6% respectively from the overall mean of the domestic violence rate (4.76/1,000 residents).

When all three outlet categories were entered into the same model (Table 3), only packaged outlets remained significant, with an increase of 0.66 incidents of domestic violence per 1,000 residents for each additional packaged outlet. It is worth noting that the changes in availability across the three types of outlet are correlated over time. The correlation between the changes in packaged liquor density and general licence density are the highest (0.67,  $p < 0.01$ ), while the remaining correlations were non-significant.

Across all five models, the effect of the SEIFA index of relative disadvantage was significant and negative, highlighting the relationship between increased levels of disadvantage and increased rates of recorded domestic violence. The results also indicated significant positive spatial autocorrelation in the data across all the models. The spatial autocorrelation coefficients reported are substantial ( $\sim 0.6$ ), suggesting that rates of domestic violence are highly correlated between neighbouring postcodes and highlighting the risks of modeling these data with non-spatial methods.

### Conclusions

This study adds to the small body of literature examining the connections between alcohol availability and domestic violence, providing the first longitudinal evidence of a relationship between alcohol outlet density and domestic violence. The study's findings contrast with previous cross-sectional work in this jurisdiction (18), which found that only general licences were positively linked to domestic violence, while on-premise licences were negatively linked. This highlights the possibility of misleading results in cross-sectional analyses, with the results of this longitudinal study providing a more intuitive set of relationships. In particular, the longitudinal analyses highlighted the substantial role of packaged liquor outlets in domestic violence, a relationship that was not detected in previous cross-sectional work.

The relationships found by this study suggest that all three types of alcohol outlets are related to increased levels of domestic violence, with general (or pub) licences and on-premise licences having a relatively small effect and packaged (off-premise) licences having a more substantial impact. These findings fit with theoretical justifications of the link between

alcohol outlet-density and domestic violence. Firstly, the strongest link is found for the type of outlet that sells alcohol for off-premise consumption. If the density of alcohol outlets is related to consumption levels (as suggested by some previous studies (35)), then it is plausible that increasing density of these particular outlets will result in increasing consumption of off-premise alcohol. This consumption is likely to take place within the home, increasing the risk of domestic violence. It is worth noting that, while general licences allow off-premise sales, they also sell a significant amount of alcohol for drinking on premises. These licences have been linked previously to general levels of assault (23, 36), and are often venues in which alcohol consumption is the main activity. There is some evidence that these types of premises are the site of particularly heavy drinking (37), and increasing densities of these kinds of outlets may result in higher frequencies of intoxication, and then to higher risks of domestic violence.

Both of these rationales rely on a link between outlet density and consumption, which remains somewhat contested (e.g. 38). This contrasts with studies focusing on outlet density and public violence, where a variety of theoretical justifications have been put forward to explain the link without requiring changes in consumption (19, 21, 39). While it is hard to imagine alcohol outlets affecting rates of domestic violence without affecting consumption in some way (e.g. by changing the amount, pattern or location of drinking), it is possible that the relationships found in this study reflect changes in socio-demographic factors which are correlated with both alcohol outlet density and domestic violence, although the incorporation of a broad measure of socio-economic disadvantage in the current study reduces the likelihood of this happening. The positive relationship between on-premise licences and domestic violence rates is harder to interpret, with these outlets selling all of their alcohol for consumption on-premises. It is possible that increases in restaurants and bars in an area may

change the way in which residents drink (e.g. encouraging heavier on-premise drinking), although, consistent with this study's results, this would be likely to have only a small effect.

The major limitation of the study is its use of a single composite measure of socio-economic disadvantage, due to the limitations of data available between Censuses in Australia.

However, given the utility of this measure for assessing overall disadvantage and the conservative modeling design, this limitation is not likely to have influenced the alcohol effects observed.

The results of this study are consistent with a growing number of studies linking alcohol outlet density and domestic violence (17, 18, 40), adding to the evidence that alcohol availability is risk factor for domestic violence. In particular, the study finds longitudinal relationships between outlet densities and domestic violence rates, while utilising a very conservative study design, with cross-sectional variation, overall trends and spatial auto-correlation controlled, providing the strongest evidence yet for a direct effect of outlet density on domestic violence. The study particularly implicates hotel packaged liquor licences which, along with previous analyses linking these outlets to general rates of violence (23), suggests the need for changes to liquor licensing policy in Victoria that will stem the proliferation of these outlets.

#### Acknowledgements

Helpful comments on this manuscript were provided by Paul Lemmens, Robin Room, Paul Dietze and two anonymous reviewers.

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Table 1 – Descriptive statistics of study measures

	Mean	S.D.	Min	Max	Total change	Proportion postcodes decreasing
Domestic violence rate (per 1,000)	4.76	0.06	0	19.81	18.30%	33.9%
General licence rate (per 1,000)	0.39	1.29	0	18.52	-1.00%	63.4%
On-premise licence rate (per 1,000)	0.28	0.21	0	2.06	100.70%	10.2%
Packaged licence rate (per 1,000)	1.15	3.35	0	49.35	41.60%	20.3%
SEIFA index of disadvantage	1032.55	78.30	706.96	1162.48	-0.4%	66.7%
Population (x 1,000)	15.61	10.02	0.39	55.92	11.90%	18.9%

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Table 2 – Fixed-effects model results – total licence density and separate models for each licence category

Model 1 – Total licences				Model 2 – General licences				Model 3 – Packaged licences				Model 4 – On-premise licences			
Variable	B	t-value	p	Variable	B	t-value	p	Variable	B	t-value	p	Variable	B	t-value	p
Residential population (1000s)	-0.01	-1.18	0.24	Residential population (1000s)	-0.01	-1.23	0.22	Residential population (1000s)	-0.01	-0.94	0.35	Residential population (1000s)	-	-	-
SEIFA	-0.02	28.25	<0.01	SEIFA	-0.02	27.99	<0.01	SEIFA	-0.02	-27.51	<0.01	SEIFA	0.02	28.32	<0.01
Total licence density	0.08	7.32	<0.01	General licences	0.28	6.93	<0.01	Packaged licences	1.36	5.45	<0.01	On-premise licences	0.11	7.21	<0.01
Spatial autocorrelation	0.60	26.11	<0.01	Spatial autocorrelation	0.59	25.33	<0.01	Spatial autocorrelation	0.59	25.50	<0.01	Spatial autocorrelation	0.60	26.37	<0.01

Table 3 – Fixed-effects model results – licence categories in multivariate model

<b>Variable</b>	<b>B</b>	<b>t-value</b>	<b>p</b>
Residential population (1000s)	-0.01	-0.86	0.39
SEIFA	-0.02	-27.67	<0.01
General licence density	0.05	0.46	0.64
Packaged licence density	0.66	2.35	0.02
On-premise licence density	0.07	1.66	0.10
Spatial autocorrelation	0.60	25.67	<0.01

# Access to Alcohol Outlets, Alcohol Consumption and Mental Health

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## Abstract

The objective of this study was to investigate residential exposure to alcohol outlets in relation to alcohol consumption and mental health morbidity (anxiety, stress, and depression). This was a cross-sectional study of 6,837 adults obtained from a population representative sample for the period 2006–2009 in Perth, Western Australia. The number of alcohol outlets was ascertained for a 1600 m service area surrounding the residential address. Zero-inflated negative binomial and logistic regression were used to assess associations with total alcohol consumption, harmful alcohol consumption (7–10 drinks containing 10 g of alcohol for men, 5–6 drinks for women) and medically diagnosed and hospital contacts (for anxiety, stress, and depression), respectively. The rate ratio for the number of days of harmful consumption of alcohol per month and the number of standard drinks of alcohol consumed per drinking day was 1.06 (95% CI: 1.02, 1.11) and 1.01 (95% CI: 1.00, 1.03) for each additional liquor store within a 1600 m service area, respectively. The odds ratio of hospital contact for anxiety, stress, or depression was 1.56 (95% CI: 0.98, 2.49) for those with a liquor store within the service area compared to those without. We observed strong evidence for a small association between residential exposure to liquor stores and harmful consumption of alcohol, and some support for a moderate-sized effect on hospital contacts for anxiety, stress, and depression.

**Citation:** Pereira G, Wood L, Foster S, Haggag F (2013) Access to Alcohol Outlets, Alcohol Consumption and Mental Health. PLoS ONE 8(1): e53461. doi:10.1371/journal.pone.0053461

**Editor:** Marianna Mazza, Catholic University of Sacred Heart of Rome, Italy

**Received:** September 25, 2012; **Accepted:** November 29, 2012; **Published:** January 16, 2013

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**Funding:** The research was undertaken as part of a grant funded by the Western Australian Health Promotion Foundation (Healthway) (project grant #18922). LW and SF are supported by Healthway Health Promotion Research Fellowships (#20693 and #21363, respectively). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

**Competing Interests:** The authors have declared that no competing interests exist.

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## Introduction

Alcohol is the leading risk factor for disease burden in the Western Pacific and the Americas, and the second largest in Europe [1]. Globally the harmful use of alcohol is responsible for approximately 2.5 million deaths annually, yet there has been no decrease in worldwide per capita consumption [1]. Australia is no exception, with a recent report noting that despite public education efforts relating to the harmful effect of alcohol use, there was no observed decrease between 2001 and 2007 in the proportion of Australians drinking at 'risky' or 'high-risk' levels for long-term harm, which represented approximately 10% of the population [2]. In terms of consumption frequency, a 2007 national survey found that 40% of Australians drank alcohol weekly, and 8% drank on a daily basis [3]. In Western Australia, 39% of the population aged 14 years and over consume alcohol at levels that placed them at risk of short-term harm, and 11% reported drink levels that place them at risk of harm in the long-term [4]. Further, wholesale alcohol sales data indicate that the trend in per capita alcohol consumption in Western Australia is increasing [4].

The ready availability of alcohol is prominent among factors associated with higher levels of alcohol consumption and harm [5,6,7], with density of alcohol sales outlets the most frequently used measure of availability [7]. There are also community level

consequences, with violence and crime among the most investigated community level outcomes to date. For instance, greater alcohol outlet density has been linked to higher rates of violence [8], violent crime [9], assaults [10] child maltreatment and physical abuse [11],[12], and homicides [13]. While most of the published studies to date have been conducted in the US, similar relationships between density and assault rates have been observed in Australia [14,15,16] [17]. Studies have also highlighted a relationship between outlet density and other traffic-related consequences, including drinking and driving, and riding with intoxicated drivers [18], alcohol-involved pedestrian collisions [19], traffic injury rates requiring hospitalisation [20] and alcohol-related crash fatalities [21].

Given growing research and public health interest in socio-economic disparities in health and health risk factors, a number of studies have investigated and documented associations between higher density of alcohol retail outlets and low SES or minority neighbourhoods [22,23,24,25]. This parallels similar findings in the tobacco control literature which have reported higher densities of tobacco outlets in neighbourhoods characterized by social and economic disadvantage [26] [27] [28]. Ogneva-Himmelberger *et al* looked at both alcohol and tobacco outlet density within the same study and found that Massachusetts neighbourhoods with the highest levels of low-income populations and minorities tended to

have the highest density of stores that sell tobacco and alcohol [29].

While there is a small but growing body of research investigating the relationship between alcohol outlet density and health, the focus has most often been on injury related harms [7] [30]. In a systematic review of studies undertaken by Popova *et al* in 2009, few of the 44 cross-sectional studies reviewed investigated non-injury related health outcomes [7]. Comparatively, there has been a paucity of studies into the relationship between other health morbidity and mortality and alcohol outlet density [15], with investigations pertaining to mental health outcomes a particular evidence gap. Livingston's [17] study is a rare exception, as it examined conditions related to the long term consumption of alcohol, including 'mental and behavioural disorders'. Findings highlight a significant association between off-premises alcohol outlets and hospital admission rates for alcohol use disorders overall, however there was no separate reporting for mental health.

The potential impact of excessive alcohol consumption on mental health is widely accepted, with the majority of alcohol-related disease burden due to neuropsychiatric disorders, which include alcohol use disorders and depression [1]. The relationship between alcohol and mental health is also bi-directional, with evidence suggesting that among individuals more predisposed to harmful alcohol consumption are those prone to episodes of depression, anxiety and stress [31,32]. However, there is a dearth of studies that have directly investigated individuals' access to alcohol outlets in relation to both their alcohol consumption and mental health disorders.

The aim of this study was to examine the effect of residential access to alcohol outlets on alcohol consumption, and determine whether elevated outlet density is associated with greater prevalence of mental health morbidity (anxiety, stress and depression).

## Methods

### Ethics approval

The Western Australian Department of Health obtained participant consent for use of their survey information for research purposes and for consent to linkage with other health data held by the department. The Western Australian Department of Health was responsible for obtaining ethics approval of the consent procedure. The authors obtained approval from the Human Research Ethics Committees of the Western Australian Department of Health and The University of Western Australia (#2010/1) to obtain and use this data for the research undertaken in this study. This research conforms to the ethical principles for medical research of the Declaration of Helsinki.

### Study design and participants

A cross-sectional study design was used to examine the association between individual-level alcohol outlet density and participants': (1) alcohol consumption; and (2) mental health morbidity. The sample comprised 6,837 adults aged 18 and over, who completed the Western Australian Health and Wellbeing Surveillance System (HWSS) Survey between 2006 and 2009 and were residents of the Perth metropolitan area. This monthly computer-assisted telephone interview was administered by the Western Australian Department of Health and responses were obtained for a stratified random sample of the state population (N = 1,959,088; 2006 Census).

**Liquor store locations.** The geocoded locations of off-premises alcohol retail establishments (referred to hereafter as

liquor stores) were obtained from SENSIS Pty Ltd for 2005 and 2007. The 2005 SENSIS dataset was used for participants surveyed for the HWSS in the first six months of 2006. The 2007 SENSIS dataset was used for other participants. Each participant's residential address was also geocoded, and the number of liquor stores was calculated for their individual 1600 m road network distance service area [33]. The 1600 m service area represents the neighbourhood environment, and is based on the distance a participant could walk to and back (i.e., a return trip) at moderate to vigorous intensity pace, within 30 minutes. Liquor store location data were matched to the year participants completed the HWSS survey. We focused on liquor stores (i.e., alcohol sales to be consumed away from the establishment), as previous research has highlighted a stronger association between postcode-level packaged alcohol sales and chronic alcohol-caused hospitalisation, than for establishments where alcohol is consumed on-premises [17].

**Mental health outcomes.** We examined mental health morbidity outcomes from two sources. Self-report of prior medical diagnosis with anxiety, stress and depression was obtained from the HWSS Survey and analysed as a single outcome. Hospital admissions, outpatient contacts and emergency mental health contacts were obtained from the Department of Health for all participants who granted permission for data linkage (74%). Anxiety, stress and depression were identified from hospital records as a primary diagnosis coded 300, 309 and 311 according to the International Classification of Diseases 09 (ICD-09) and F30-99 according to ICD-10-CM. Participants were considered to have been hospitalised for anxiety, stress or depression if the admission occurred within a three year window centred on the year that the participant completed the HSWW Survey.

**Alcohol consumption outcomes.** The number of standard drinks of alcohol consumed per drinking day and the number of days of harmful consumption of alcohol in the past four weeks were obtained from the HWSS Survey. A standard drink was defined as a drink containing 10 grams of alcohol. Harmful consumption was defined by the Department of Health in this survey as 7 to 10 standard drinks in a day for men and 5 to 6 standard drinks in a day for women. These correspond to the definition of 'risky drinking' as specified in the National Health and Medical Research Council Australian Alcohol Guidelines, [34],[35].

### Statistical analysis and adjustment

Analyses adjusted for participant age, sex, education and household income (obtained from the HWSS Survey). For the mental health outcomes, logistic regression was used to calculate Odds Ratios (OR) comparing participants with a liquor store within the service area to those without a liquor store in the service area. For the alcohol consumption outcomes, zero-inflated negative binomial regression was used to calculate rate ratios (RR) per additional liquor store in the service area. A zero-inflated negative binomial model was selected to account for both over-dispersion and excess zeroes (abstainers from alcohol). The choice of model was confirmed using Vuong's test [36]. Participant age, sex, education and household income were used as predictors in the logit component of the zero-inflated negative binomial model.

District-level socioeconomic status was ascertained using the socioeconomic index for areas (SEIFA) score obtained from the Australian Bureau of Statistics [37]. The SEIFA score is based on the census collection district of the participant residence and is an area-based index of relative socioeconomic advantage and disadvantage. Census collection districts contain an average of 250 dwellings. Lower SEIFA scores indicate relative socioeco-

**Table 1.** Study characteristics of adults resident in Perth, Western Australia, who responded to the Health and Wellbeing Survey 2006–2009 for the study cohort that consented to data linkage (N = 6,837), and the non-linkable population who did not consent to data linkage and subsequently excluded.

	Study Population N = 6,837	Non-linkable Population N = 2,409
	Mean (SD)	Mean (SD)
<b>Number of standard drinks of alcohol consumed per drinking day<sup>a</sup></b>	1.95 (2.27)	1.79 (2.07)
<b>Number of days of harmful consumption of alcohol in the past four weeks<sup>b</sup></b>	0.89 (2.99)	0.60 (2.43)
<b>Number of liquor stores within a 1600 m service area of the residential address<sup>c</sup></b>	1.39 (1.79)	NA
	<b>N (%)</b>	<b>N (%)</b>
<b>Anxiety, stress, depression</b>		
Ever diagnosed	957 (14)	351 (15)
Hospital contact	100 (1)	NA
<b>Sex</b>		
Female	4,051 (59)	1,520 (63)
Male	2,786 (41)	889 (37)
<b>Age group</b>		
18–24 years	505 (7)	161 (7)
25–34 years	566 (8)	260 (11)
35–44 years	1,040 (15)	390 (16)
45–54 years	1,186 (17)	489 (20)
55–64 years	1,474 (22)	530 (22)
65 years and over	2,066 (30)	579 (24)
<b>Highest attained level of education</b>		
Less than year 10	548 (8)	211 (9)
Year 10 or 11	1,134 (17)	385 (16)
Year 12	838 (12)	342 (14)
Trade qualification	2,764 (40)	852 (35)
Tertiary degree	1,528 (22)	605 (25)
<b>Household Income</b>		
Less than \$20,000	1,063 (16)	287 (12)
\$20,001–40,000	1,325 (19)	350 (15)
\$40,001–\$60,000	878 (13)	254 (11)
\$60,001–\$80,000	878 (13)	262 (11)
More than \$80,000	2,000 (29)	555 (23)

<sup>a</sup>. A standard drink is defined as any drink containing 10 grams of alcohol.

<sup>b</sup>. Harmful consumption was defined by the Department of Health in this survey as 7–10 standard drinks in a day for men, and 5–6 standard drinks in a day for women.

<sup>c</sup>. The service area was defined as the area accessible to a distance of 1600 m from the residential address along the road network.

NA. No data available because the participants did not agree to linkage of the HWSS survey responses to either hospital records or to environmental data (liquor store locations).

doi:10.1371/journal.pone.0053461.t001

conomic disadvantage and higher scores indicate relative advantage. The SEIFA index has a national mean of 1000 and a standard deviation of 100. The number of liquor stores within each census collection district was summed and the mean numbers of liquor stores were calculated and compared across each SEIFA tertile. All analyses were conducted in SAS v9.2.

## Results

The study population consisted of 6,837 adult participants, resident in the Perth metropolitan area of Western Australia (Table 1). There were 100 (1%) adults with a hospital contact for

anxiety, stress or depression and 957 (14%) adults that reported a prior medical diagnosis with these conditions. The mean number of standard drinks consumed on a drinking day was 1.95 (standard deviation (SD) 2.27) and the mean number of days of harmful drinking in the preceding four weeks was 0.89 (SD 2.99). The mean number of liquor stores within a 1600 m service area was 1.39 (SD 1.79).

The “non-linkable population” consisted of 26% (N = 2,409) of the total population who did not provide consent to link their HWSS survey responses to hospital records or environmental variables (liquor store locations) using their residential address (Table 1). Compared to the study population the non-linkable

**Table 2.** Rate ratios (RR) and 95% confidence intervals (CI) of total and harmful alcohol consumption for increases in the number of liquor stores within a 1600 m service area about the residential address.

	Unadjusted		Adjusted <sup>a</sup>	
	RR (95% CI)	p-value	RR (95% CI)	p-value
<i>Number of standard drinks of alcohol consumed per drinking day<sup>b</sup></i>				
Per liquor store in the service area	1.00 (0.99, 1.02)	0.617	1.01 (1.00, 1.03)	0.054
<i>Number of days of harmful consumption of alcohol in the past four weeks<sup>c</sup></i>				
Per liquor store in the service area	1.06 (1.02, 1.10)	0.007	1.06 (1.02, 1.11)	0.006

<sup>a</sup>. Adjusted for age, sex, income and education.

<sup>b</sup>. The standard drink is defined as any drink containing 10 grams of alcohol.

<sup>c</sup>. Harmful consumption was defined by the Department of Health in this survey as 7–10 standard drinks in a day for men, and 5–6 standard drinks in a day for women. doi:10.1371/journal.pone.0053461.t002

population engaged in fewer days of harmful alcohol consumption, had a greater proportion of female participants and had a lower proportion of participants in the 65+ age category. There was also indication that they had attained a higher level of education, with proportionally more participants educated to year 12 or with a tertiary degree, and fewer with a trade qualification.

**Association between residential exposure to liquor stores and alcohol consumption**

After adjustment for age, sex, education and household income, there was marginal support ( $p = 0.054$ ) for an association between the number of standard drinks of alcohol consumed per drinking day and the number of liquor stores within the service area; RR 1.01 (95% CI: 1.00, 1.03) (Table 2). Evidence was stronger ( $p = 0.006$ ) for an association with harmful consumption of alcohol in the past four weeks, with harmful alcohol consumption increasing by 6% for every additional liquor store within the 1600 m neighbourhood; RR 1.06 (95% CI: 1.02, 1.11).

**Association between residential exposure to liquor stores and mental health morbidity**

There was negligible evidence of an association between self-reported prior medical diagnosis with a mental health disorder (anxiety, stress or depression) and presence of a liquor store in the 1600 m service area (Table 3). However, the unadjusted odds ratio for hospital contact with a mental health disorder was 1.58 (95%

CI: 1.04, 2.41), comparing participants with at least one liquor store in the service area to those without a liquor store. The strength of the evidence of this effect attenuated after adjustment for age, sex, education and household income (from  $p = 0.032$  to 0.059), and the odds ratio attenuated slightly 1.56 (95% CI: 0.98, 2.49).

**Association between prevalence of liquor stores and district-level socioeconomic status**

The mean number of *liquor stores* in census collection districts with the lowest SEIFA values (i.e., lowest tertile) was 1.62 (95% CI: 1.42, 1.82). For census collection districts with moderate (middle tertile) and high SEIFA values (highest tertile), the mean number of liquor stores was 1.45 (95% CI: 1.25, 1.64) and 1.55 (95% CI: 1.35, 1.75).

**Discussion**

In this study, we investigated the relationship between liquor store density and alcohol consumption, and between density and risk of hospital admissions for anxiety, stress and depression. These associations were observed after accounting for socio-demographics, including correlates of socioeconomic status. The number of liquor stores in the neighbourhood was weakly associated with total alcohol consumption, but more strongly associated with harmful alcohol consumption. Each additional liquor store in the neighbourhood was associated with an increase by 1% in the mean

**Table 3.** Odds ratios (OR) and 95% confidence intervals (CI) of mental health morbidity (anxiety, stress and depression) for presence of a liquor stores within a 1600 m service area about the residential address.

	Unadjusted		Adjusted <sup>a</sup>	
	OR (95% CI)	p-value	OR (95% CI)	p-value
<i>Hospital admission, outpatient or emergency contact for anxiety, stress or depression<sup>b</sup></i>				
No liquor stores	1	Ref	1	ref
At least 1 liquor store	1.58 (1.04, 2.41)	0.032	1.56 (0.98, 2.49)	0.059
<i>Self-reported prior medical diagnosis of anxiety, stress or depression</i>				
No liquor stores	1	Ref	1	ref
At least 1 liquor store	1.07 (0.93, 1.23)	0.336	1.07 (0.92, 1.24)	0.400

<sup>a</sup>. Adjusted for age, sex, income and education.

<sup>b</sup>. Hospital contacts within a 3-year period centred on the year of completion of the Health and Wellbeing Survey.

doi:10.1371/journal.pone.0053461.t003

number of standard drinks of alcohol consumed per drinking day and by 6% in the mean number of days of harmful consumption of alcohol. The public health impact of liquor stores on alcohol consumption depends not only on the magnitude of these risk estimates, but also the distribution of exposure across the population. Therefore, if our results represent a true effect, the 1% increase in the mean number of standard drinks would affect the 83% [3] of the national population (aged 14+) who drink, and the 10% [3] of the national population (aged 14+) who already drink at levels that place their health at risk.

Our study also sought to address a gap in the literature by specifically investigating the relationship between liquor store density and mental health, with a data set that enabled us to look at this at the individual level. Further information as to the pathways between liquor store density and mental health is provided in the Supporting Information (Text S1). We observed that the odds of hospital contact for anxiety, stress or depression was 56% greater among participants with a liquor store within the neighbourhood compared to those without. The statistical non-significance of this adjusted effect estimate was possibly a result of reduced statistical power arising from the rarity of a hospital contact for these mental health conditions and subsequent small number of events ( $N = 100$ , 1%).

These results are compelling in terms of public health advocacy and policy, and support arguments to limit the number of liquor stores in a given area as a means to limit (i.e. further regulate) alcohol availability and minimise alcohol-related harm [7]. In Western Australia, decisions to grant new liquor licenses in a given area require consideration of the public interest [38]. Demonstration of an association between presence of liquor stores, harmful alcohol consumption and mental health morbidity motivates progressing from the economic-centric view of the 'public interest' to better incorporate the public *health* interest. The WHO Global Strategy to Reduce the Harmful Use of Alcohol lists regulation of alcohol availability as an important way to reduce the general level of harmful use of alcohol, and listed regulating the number and location of liquor stores as a possible option [39]. Moreover, as the mean number of liquor stores was slightly higher in areas of with a lower socioeconomic index, the findings of this study are particularly relevant for policy-related interventions to level socioeconomic gradients in outlet density. A limitation of the cross-sectional nature of this study was that we could not discern whether the association between liquor stores and alcohol consumption was attributable to (i) the presence of the outlets promoting increased consumption, or (ii) whether the outlets were attracted to the more profitable (possibly more socioeconomically disadvantaged) neighborhoods. However, closer scrutiny of new liquor licenses is warranted in either case.

While one of the strengths of this study was the inclusion of objective hospital health data, hospital admissions clearly under-represents the overall burden of mental health as it does not capture diagnoses of depression, anxiety or other mental health problems made through a GP, nor those that may go undetected. Although this issue cannot be completely resolved we also included

self-reported doctor diagnoses to supplement outcome assessment. A further limitation of this study was that although we could ascertain the level of alcohol consumption, we did not have information on the location where this alcohol was purchased and we recommend this information be obtained in future cohort studies. For ecological studies, it has been demonstrated that use of alcohol sales data might be an appropriate proxy [14]. However, it is likely that such misclassification would have attenuated our effect-estimates. A related limitation of this study was the lack of adjustment for locations that sold alcohol for on-premises consumption considered in previous studies [14,17], which might have been geographically clustered with locations that sold alcohol for off-premises consumption. However, Livingston observed much stronger associations between chronic alcohol-caused hospitalization and locations of off-premises outlets than on-premises outlets [17]. It is also possible that further attenuation of effect-estimates would have been introduced due to reduced time relevance of the liquor store locations dataset for participants surveyed for the HWSS at the end of the study period in 2009.

## Conclusions

Participants with greater access to liquor stores were more likely to consume alcohol at harmful levels and to have had a hospital contact for anxiety, stress or depression. The findings underscore the importance of policy approaches that limit both the number of liquor store licences and the geographic density of outlets as a means to improve mental health and reduce other alcohol related harm. We proposed a range of explanatory pathways to advance understanding of how proximate access to alcohol sales outlets might impact drinking levels and residents' mental health, ranging from availability, affordability and normative cues, through to the impact of liquor stores on local amenity and social capital. Further research is needed however to test and better understand these pathways, with a view to informing policy measures to reduce the negative effects of ubiquitous alcohol access in local communities.

## Supporting Information

**Text S1 Potential pathways between alcohol outlet density and mental health.**  
(DOCX)

## Acknowledgments

The authors acknowledge Ms Sharyn Hickey and Mr Nicholas Middleton for the calculation of GIS measures and Dr Sarah Joyce and the Data Linkage Unit from the Department of Health WA for provision of the health data. The research assistance of Catherine Coletsis is also acknowledged.

## Author Contributions

Conceived and designed the experiments: GP LW SF FH. Performed the experiments: GP. Analyzed the data: GP. Contributed reagents/materials/analysis tools: GP LW SF. Wrote the paper: GP LW SF FH.

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*Health Place*. 2009 June ; 15(2): 642–646. doi:10.1016/j.healthplace.2008.10.002.

## Alcohol outlets and youth alcohol use: Exposure in suburban areas

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### Abstract

The purpose of this study was to explore how exposure to alcohol outlets (around home and school) influenced alcohol use among 242 high-school students (mean age 16.4, 48.8% male, 93.4% White). Results found no relationship between alcohol outlet exposure, using a measure of both distance to and density around students' homes and schools, and alcohol use. This study suggests that outlet exposure may not influence alcohol use among mostly White, middle-class, and suburban youth. However, the lack of association may also reflect the lower level of alcohol outlets present in low-density residential environments as well as differences in accessibility.

### Keywords

alcohol outlet density; adolescent alcohol use; alcohol outlet exposure

### Introduction

Alcohol use is common among youth. By twelfth grade, 72.7% of adolescents report ever using alcohol and 56.4% report having been drunk at least once (Johnston et al., 2007). However, alcohol use in adolescence is associated with a wide array of negative consequences (Stueve and O'Donnell, 2005), such as adolescent injuries, drinking and driving and an increased rate of other risk behaviors, including sexual activity, violence and drug use (DiClemente et al., 2001, Romer, 2003, Jessor, 1998).

There are three main social and environmental factors that have been suggested as risks for adolescent alcohol use. First, family factors have been found to be important predictors of adolescent substance use (Coombs et al., 1991, Resnick et al., 1997, Wills et al., 2003). Second, peers have been shown to influence alcohol use through modeling behavior (Field et al., 2002, Hawkins et al., 1997, Kosterman et al., 2000, Simons-Morton et al., 2001) peer influence (Sieving et al., 2000) and peer norms (Maney et al., 2002).

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The third factor of influence is the physical environment. Some forms of communication and influence are located in space. Alcohol advertising on billboards, buses, and similar places is one such environmental influence that has been found to shape adolescent's beliefs, attitudes and alcohol behaviors (Ellickson et al., 2005, Fleming et al., 2004, Grube and Waiters, 2005, Grube and Wallack, 1994, Mazis, 1995, Pasch et al., 2007, Snyder et al., 2006, Stacy et al., 2004). Exposure to alcohol outlets due to distance, densities in a specific area, or liberal opening hours and low drinking age requirements may be another important adverse environmental influence. Higher alcohol outlet densities have been found to be related to self-reported youth drinking and driving (Treno et al., 2003) and associated with heavy drinking, frequent drinking, and drinking-related problems among college students (Weitzman et al., 2003).

This spatial relationship of alcohol-related problems and alcohol outlet density has been well explored among adults, as have the predictive nature of alcohol outlet density to alcohol consumption patterns and the relationship of alcohol-related mortality and morbidity and social context (Freisthler et al., 2003, Gruenewald et al., 1996, Hanson and Wieczorek, 2002, Millar and Gruenewald, 1997, Wieczorek and Hanson, 1997, Livingston et al., 2007). Research has also shown that increased density of neighborhood alcohol outlets has been associated with decreases in social capital (Theall et al., 2008), increased violence in suburban areas (Livingston, 2008), increased assault rates (Livingston, 2007, Reid et al., 2003), increased violent crime rates (Zhu et al., 2004), increased rates of child maltreatment (Freisthler et al., 2005), and increased rates of motor vehicle crashes (Treno et al., 2007). Yet, there is a paucity of published literature on youth alcohol use and distance to and density of alcohol outlets. The exposure to alcohol outlets is important among adolescents, particularly as the distance to and density of alcohol outlets may increase access for youth and alter perceptions of an environment such that alcohol use is seen as normative. As Gruenewald (2007) has suggested "alcohol outlets are environmental features of communities that expose populations to opportunities to drink and socially model others' drinking behavior (p.870)".

Therefore, the purpose of this study was to explore how exposure to alcohol outlets was associated with adolescent alcohol use. In particular, this study examined the density of alcohol outlets around the adolescent's home and school, distance to outlets from home and school and exposure en-route from school to home. We hypothesized that exposure to increased alcohol outlets would be related to increased past month alcohol use and drunkenness.

## Methods

### Participants

The data for this study are from the Transdisciplinary Research on Energetics and Cancer - Identifying Determinants of Eating and Activity study (Lytle, under review). Adolescents and one of their parents (n=349 student/parent pairs) were recruited from within the seven-county metropolitan area of Minneapolis-St. Paul, Minnesota. The adolescents were primarily White (93.4%), with a mean age of about 15 years. Approximately half (48.8%) were male, and nearly 80% of the sample lived with both parents. Students attended schools mostly in suburban areas (83.6% suburban, 16.4% urban). Given the very low prevalence of risk behaviors among junior high and middle school students in this sample (0% for past month drunkenness and 2% for past month alcohol use), the participants in this analysis were limited to those who were in high school (9–11<sup>th</sup> grades) (n=242). See Table 1 for demographic information.

### Measures

Geographic Information System (GIS) data were used to calculate the distance to and density of alcohol outlets from a participant's house, his/her school and the path between. Distance measures closest exposure, density the likely frequency of exposure. (Forsyth and Lytle, Under

review). Dun and Bradstreet 2006 (www.dnb.com) business data provided an address for any bar or store selling alcohol. Distances and density were calculated in two ways, network and straight line. Network refers to a path from the source (participant's home, school, route) and the alcohol outlet that can be reached by someone on foot along a street network. A straight line distance refers to the straight line distance to or density of alcohol outlets from the source (participant's home, school, route), regardless of street patterns. Using ArcGIS v.9 (ESRI, 2005), network and straight line distances were calculated from the participant's home and school to the nearest store or bar selling alcohol. Densities or numbers of stores were also calculated in network and straight line buffer distances by dividing the total number of stores or bars selling alcohol by the land area, excluding water. Buffer distances calculated ranged from a 200 meter buffer to a 3000 meter buffer. For the purposes of this study, largely due to the suburban geography and to maximize variability, we chose to examine the 3000 meter buffers (i.e., nearly 2 miles). In addition, the youth in our sample are more mobile and may be better able to travel further from the home or school environment, therefore, the 3000 meter buffer was also chosen to reflect this potential increased exposure.

Students completed a questionnaire which included two questions adopted from the Monitoring the Future Study to assess alcohol use (Johnston et al., 1998). The first question asked how many times in the past month they had alcohol to drink, including beer, wine and liquor (not including sips) with response options ranging from 0 to 40 or more. The second question asked how many times in the past month they had "gotten really drunk" from drinking alcoholic beverages. Response options ranged from 0 to 10 or more times. The Institutional Review Board at the University of Minnesota approved all study methods.

## Analysis

Descriptive analyses of the exposure (alcohol outlets) and outcome (alcohol use) variables were conducted to determine the distribution of each of the variables. Cross-sectional linear regression analyses using PROC GLM in SAS (version 9.1) (SAS, 2005) were conducted to assess how exposure to alcohol outlets (density around home and school, distance from home and school, and density of home to school route) influenced past month alcohol use and past month drunkenness. Several covariates (gender, school grade, and parent's highest level of education) were selected for inclusion in the models, based on previously documented associations with the exposures and outcomes of interest here and their potential role as confounders (U. S. Department of Health and Human Services, 2007, Donovan, 2007, Pemberton et al., 2008). Parent's highest level of education represented the highest level of education for the parents who resided in the house (assessed on the parent survey). For the analyses assessing exposure to alcohol outlets around schools, additional analyses were conducted with school level covariates (% of students receiving free/reduced lunch and % White). These additional covariates did not change the final results; therefore the results from the more parsimonious models are presented here.

Missing data on individual survey items ranged from 0.01% (parent's education) to 0.004% (past month alcohol use). Observations with missing data were excluded from models; thus while the total sample size was 242, individual models do vary in sample size.

## Results

The prevalence of alcohol use in the past month was 26.1% and past month drunkenness was 8.7%. The density of alcohol outlets within 3000 meters around the student's home, both on a network route and a straight route, was low (see Table 2). The average count of alcohol outlets within 3000 meters street network distance of the student's home was 3.9 (range 0–57) and the mean within 3000 meters straight line distance was 6.7 (range 0–26). The average distance

from the student's home to the nearest alcohol outlet on a network route was 2835.6 meters (just over 1 3/4 miles). On a straight route the distance was 2121.2 meters (almost 1 1/3 miles).

The density of alcohol outlets within 3000 meters of schools was similar to that around homes (see Table 2). The average count of alcohol outlets within 3000 meters street network distance around schools was 5.6 (range 0–30) on straight line and 7.7 (range 0–39) on a straight route. The average distance from the student's school to the nearest alcohol outlet on a network route was 1432.6 meters (0.9 miles). On a straight route the average distance was 1837.2 meters (1.14 miles). On the shortest street network route from home to school, students encountered on average 1 alcohol outlet (range 0–1).

The results of the cross-sectional linear regression analyses found that the density of alcohol outlets around the student's home on either a network or straight route was not related to past month alcohol use or past month drunkenness (see Table 3). The same null findings resulted for the count of alcohol outlets around the student's home and the distance to the nearest alcohol outlet from the student's home as well as outlets around the student's school.

## Discussion

Little research to date has examined the relationship between outlet density and alcohol use among youth. Literature suggests that young adolescents primarily obtain access to alcohol from their parents, but as they progress into high school, the sources of alcohol begins to shift toward peers, older friends and commercial sources (Hearst et al., 2007), therefore supporting the hypothesis that as density increases and distance decreases (increased access), alcohol use may increase. The lack of association found in this study may be related to the lower prevalence of the exposure and outcome, or that alcohol density and distance to outlets does not play a role in alcohol use for these ages. Certainly, the traditional zoning regulation of suburban areas, by design, restricts access to commercial resources in general. In addition, suburban youth may continue to rely on parents for access to alcohol both because of distance and potentially due to stricter enforcement of access regulations in suburban areas.

This paper uses individualized measures of geographical variables—alcohol outlet distance and density. That is, people are not assigned to pre-existing geographical units that may well have unequal sizes and where several individuals may well be clustered. Rather measurement geographies are built around individuals using fine-grained, parcel-level data on the built environment. Then the geographical measures are entered into the analysis like other individual measures. While there is some overlap of buffers in the study due to proximity of respondents, further accounting for this overlap is likely to have reduced the significance of the already insignificant findings.

The lower prevalence of alcohol use and the limited exposure to alcohol outlets around home, school and on the way to school may have led to reduced power to detect an effect. While the prevalence of alcohol use was lower in this sample, research does suggest that suburban youth are not at decreased risk for alcohol use than urban youth (Levine and Coupey, 2003) and suburban youth have been shown to have higher rates of ever using alcohol than national samples (Larkin et al., 2007). Another limitation of this study is the lack of diversity in the sample. Our sample is largely White, middle-class with low prevalence of risk behaviors in general. This restricts our ability to generalize findings.

This study contributes to the larger body of literature by highlighting research on the effect of the built environment on mostly suburban adolescents. Although we found that there were relatively lower rates of alcohol use among the students in our sample, we also found fairly low exposure to alcohol outlets. While literature on suburban communities has largely focused on negative issues of transportation (Cervero and Duncan, 2003), social connectedness

(Leyden, 2003) and limitations to physical activity (Saelens et al., 2003), to our knowledge no work to date has been conducted to examine at the reduced access to alcohol outlets. In general, the body of built environment literature focusing on proximity to fast food, alcohol outlets and convenience store food access will have to contend with the low density of businesses in large, encapsulated residential neighborhoods. Additional work is needed to identify what environmental features have an influence on adolescent health outcomes as well as what distances are meaningful to be considered exposures for adolescents. In addition, research on the effect of exposure to outlets on the normative beliefs of adolescents is also needed to determine if exposure may influence adolescent's perceptions of the normative nature of alcohol use. Finally, other important next steps will be to replicate this study in an urban environment with greater proximity to alcohol outlets and a more diverse sample.

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**Table 1**

Descriptive demographic characteristics of the study sample (n=242)

Age, years	16.4
	%
Gender	
Male	48.8
Female	51.2
Grade level	
9 <sup>th</sup> grade	19.8
10 <sup>th</sup> grade	23.1
11 <sup>th</sup> grade	57.0
School type	
Public	84.7
Private	13.6
Home-schooled	1.7
School location	
Suburban	89.0
Urban	11.0
Race/ethnicity	
White	93.4
African American	1.2
Asian	0.4
Mixed <sup>1</sup>	5.0
Family structure	
Mother and father together	79.3
Mother and father equally, but separate	2.9
Parent and step-parent	4.6
Mother mostly	11.8
Parent Education	
Less than HS	0.0
HS or GED	3.4
Some college	18.4
College degree	33.1
Training beyond college	45.2

<sup>1</sup>Report more than one ethnicity

**Table 2** Distance, Density, and Count of Alcohol Outlets around Homes and Schools (n=242)

Home				School			
<i>Density (total number of alcohol outlets/total land area)</i>							
	Mean	SD	Range	Mean	SD	Range	
3000 m network buffer	0.003	0.0	0-0.02	0.004	0.0	0-0.02	
3000 m straight line buffer	0.003	0.0	0-0.02	0.003	0.0	0-0.01	
<i>Count of Outlets</i>							
	Mean	SD	Range	Mean	SD	Range	
3000 m network buffer	3.9	4.8	0-26	5.6	5.3	0-30	
3000 m straight line buffer	6.7	8.0	0-57	7.7	7.6	0-39	
<i>Distance to closest outlet (meters)</i>							
	Mean	SD	Range	Mean	SD	Range	
Network	2853.6	2865.7	106.0-26,988.8	1837.2	1962.1	191.3-16536.6	
Straight line	2121.2	2249.8	84.9-19,941.1	1432.6	1638.2	155.7-14430.1	

**Table 3**  
 Association between Alcohol Outlet Density and Distance to Alcohol Outlets for both Home and School (n=242)

	Past 30 Day Alcohol Use			Past Month Drunkenness		
	Estimate <sup>I</sup>	SE	p-value	Estimate <sup>I</sup>	SE	p-value
<b>Home</b>						
<i>Density</i>						
3000 m network buffer	-1.47	12.34	0.91	7.30	8.39	0.39
3000 m straight line buffer	2.85	15.32	0.85	13.30	10.40	0.20
<i>Count of Outlets</i>						
3000 m network buffer	0.003	0.01	0.77	0.008	0.01	0.22
3000 m straight line buffer	0.001	0.01	0.81	0.005	0.00	0.20
<i>Distance</i>						
Network	-0.00002	0.00	0.17	-0.00001	0.00	0.17
Straight	-0.00003	0.00	0.19	-0.00002	0.00	0.15
<b>School</b>						
<i>Density</i>						
3000 m network buffer	-2.03	15.56	0.90	0.83	10.46	0.94
3000 m straight line buffer	1.60	17.80	0.93	-0.55	11.96	0.96
<i>Count of Outlets</i>						
3000 m network buffer	-0.002	0.01	0.87	-0.001	0.01	0.87
3000 m straight line buffer	0.0003	0.01	0.97	-0.001	0.00	0.85
<i>Distance</i>						
Network	-0.00004	0.00	0.14	-0.00003	0.00	0.19
Straight	-0.00004	0.00	0.23	-0.00002	0.00	0.35
<i>Route from Home to School</i>	0.44	0.71	0.54	0.17	0.48	0.72

<sup>I</sup> adjusted for grade, gender, socio-economic status

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**TITLE: A SYSTEMATIC REVIEW OF THE INFLUENCE OF COMMUNITY LEVEL SOCIAL FACTORS ON ALCOHOL USE**

## **ABSTRACT**

### **Purpose**

To explore evidence on the influence of community level social factors on alcohol use among adults and adolescents.

### **Methods and results**

Major bibliographic databases were searched for quantitative studies meeting inclusion criteria. After screening, narrative synthesis and a quality review were applied. 48 studies met the eligibility criteria. While the findings were inconclusive for associations between alcohol use and deprivation, poverty, income, unemployment, social disorder and crime, there was some indication that social capital characteristics were protective.

### **Conclusions**

Social capital has a potentially important association with reducing alcohol use. Further studies are required to better understand social influences on alcohol use.

## **KEYWORDS**

Alcohol; community; neighbourhood; social; deprivation, poverty, social capital, systematic review

**TITLE: A SYSTEMATIC REVIEW OF THE INFLUENCE OF COMMUNITY LEVEL SOCIAL FACTORS ON ALCOHOL USE**

**INTRODUCTION**

Alcohol is one of the leading contributors to the global burden of disease, and the leading contributor to premature death and disability worldwide in the 15–59 age group (World Health Organization, 2009, 2011). Alcohol consumption also has major psychosocial consequences, including breakdown of relationships and families, violence, crime, child neglect and abuse, and reduced individual and community productivity (Babor, Caetano, & Casswell, 2010; Cercone, 1994; Graham & West, 2001).

Many studies have attempted to identify risk- and protective-factors associated with alcohol misuse. Most of these studies have focused on individual, peer, parental and genetic correlates of alcohol use. However, an individual’s behaviour may also be shaped by the physical and social environment in which they live (Chow, Lock, Teo, Subramanian, McKee, & Yusuf, 2009; Jencks & Meyer, 1990), an issue of growing interest to researchers. In a recent systematic review (Bryden, Roberts, McKee, & Petticrew, 2012) we have examined the influence of availability and advertising of alcohol within a community on the drinking behaviour of local residents. In order to provide as complete a summary as possible of evidence on potentially modifiable community-level factors, this partner paper focuses on community level social factors that may influence alcohol consumption locally. These include socio-economic factors (deprivation, income and employment), disorder and crime (including disorder, safety, violence/crime), social capital (community attachment, closeness & supportiveness and community participation) and social norms – all of which are factors that may offer scope for interventions to complement those targeted individually. There has been no previous systematic review specifically focusing on how these community level social factors influence alcohol use. In combination with its partner paper on availability and advertising of alcohol, such a review could help guide policy makers seeking to tackle hazardous drinking at a local level, as together they highlight potentially modifiable community-level factors that affect alcohol misuse.

This systematic review examines the associations between community level social factors and alcohol use. The specific research objectives were to: (i) describe the methodological and other characteristics of the studies identified following a systematic search (including study locations, populations, research methods, outcomes and exposures of interest); (ii) assess the methodological quality of the studies included, (iii) and assess the strength of the evidence that community level social factors are significantly associated with alcohol use in adults and adolescents.

**METHODOLOGY**

A systematic review of observational (cross-sectional and longitudinal) and intervention studies was conducted according to PRISMA systematic review guidelines (Liberati, Altman, Tetzlaff, Mulrow, Gøtzsche, Ioannidis et al., 2009); a completed checklist is provided in Web Annex 5. Primary research studies published in peer-reviewed journals or which were found in grey literature were eligible to be included. Only quantitative studies were included in order to quantify any associations between community level social factors and alcohol use.

The population of interest was adult and adolescent males and females (adolescents were included specifically because the determinants may differ from adults) (Cicchetti & Rogosch, 2002; Leventhal & Brooks-Gunn, 2003). The outcomes of interest included quantity or

frequency of alcohol consumption, binge drinking, alcohol dependency and problem drinking, with specific attention to the prevalence of drinking among adolescents as this may determine problem drinking in later life (Heron, Macleod, Munafò, Melotti, Lewis, Tilling et al., 2012).

Following an initial scoping of the literature on community level social factors, four main exposures of interest were identified: (i) socio-economic deprivation (e.g. average income, unemployment rate); (ii) disorder and crime, including social disorder (e.g. drug activity, divorce rate), physical disorder (e.g. graffiti), safety, crime & violence in the community; (iii) social capital (e.g. trust, membership, support from neighbours), and (iv) community norms about alcohol use (e.g. acceptability of drinking). Intervention studies addressing any of these community level exposures were included in the review (but not interventions addressing individual change). Some other factors that can be measured at a community level, such as ethnicity and religion, were excluded from this review. Although these can have an important influence on alcohol use, they are far less amenable to policy or practice interventions and their effects are likely to be experienced at an individual or family level rather than at a whole community level.

Communities were defined as neighbourhoods, villages, towns or residential college campuses. Exposures were included if they were specifically about a local community (e.g. asking people if they feel safe in their community) or if they were aggregated to a community level from individual level measures (e.g. average income). Studies which only explored individual level factors (e.g. individual level demographic or socio-economic characteristics), parental or peer characteristics (e.g. drinking norms among friends) or genetic characteristics (e.g. family history of harmful alcohol use) were excluded.

## **Search strategy**

Studies were initially identified by searching the electronic databases Medline, Web of Science, IBSS and PsycInfo on 26<sup>th</sup> August 2011. Limits were applied to include titles only, but no limits were applied for language, country or publication start date. The core search strategy is shown below, and search terms were amended for use as necessary in the different databases:

(area\* OR geogr\* OR place OR local\* OR neighborhood\* OR neighbourhood\* OR community OR communities OR environment OR environments OR environmental OR determinant\* OR depriv\* OR poverty OR disadvantage\* OR economic OR socioeconomic OR income OR employment OR unemployment OR crim\* OR acceptab\* OR norm OR norms OR social capital) AND (alcohol\* OR drink\* OR liquor\* OR liqor\*) NOT water

Four other search terms were not included (risk, disorder, violence and safety) as they identified studies that were mostly not relevant.

Additional studies were identified by manual searches of bibliographies of included studies and review articles.

## **Selection of studies**

There were four stages in selecting studies for inclusion in the review: (i) identification of studies from bibliographic databases and references; (ii) screening of titles and abstracts; (iii) review of full papers to identify eligibility, and (iv) in-depth review and narrative synthesis of final selected papers. Papers which failed to distinguish exposures, or separating alcohol from substance use (e.g. tobacco and drugs) in general, were deemed ineligible.

Stages 1 and 2 were independently conducted for all databases by AB & BR. Any discrepancies in screening results were discussed with reference to the eligibility criteria, and a final list of full papers to be reviewed was agreed upon.

A data extraction form was piloted using a small number of studies, refined accordingly and used subsequently to extract data from all full papers and to record any potentially relevant references. Data were extracted from each paper on study characteristics (e.g. country, year, location, study design), sample characteristics (e.g. age range of sample, sample size), exposure and outcome measures, results (including statistical significance of results) and evidence of bias or confounding. The fields in the data extraction form were based upon STROBE criteria for reporting of observational studies (Von Elm, Altman, Egger, Pocock, Gøtzsche, & Vandenbroucke, 2007). A quality assessment tool was then used to review the methodological quality of studies. This tool was adapted from the 'Quality Assessment Tool for Quantitative Studies' developed specifically to assess quantitative public health studies, which has successfully undergone testing for reliability and validity (Effective Public Health Practice Project, 1998; National Collaborating Centre for Methods and Tools, 2011; Thomas, Ciliska, Dobbins, & Micucci, 2004). Although a small number of studies were rated as 'weak' using this tool, none were excluded in order to provide a complete overview of studies in this area. However, less methodologically robust studies are highlighted in the results and in the tables. A summary of the quality assessment process is provided in Web Annex 6-9.

## **Data extraction and analysis**

The findings of the primary studies were grouped into the four main categories of exposure (socio-economic factors, disorder and crime, social capital and social norms). Studies with multiple exposures were included in more than one category where appropriate. Due to substantial methodological diversity, differences in methodological quality and in the exposure and outcomes measures used in the primary studies, a narrative synthesis is used to describe the studies and their results. It was not possible to carry out a meta-analysis as part of this review due to the substantial heterogeneity of the studies so results are therefore only provided for individual studies. This is consistent with advice on dealing with heterogeneity in the Cochrane Handbook (The Cochrane Collaboration, 2011). The effect sizes reported in the original studies are presented in Tables 1, 2, 3 and 4 (regression coefficients, correlation coefficients, odds ratios and risk ratios). When confidence intervals were not provided in the papers these were calculated where possible. If no p value is given for a specific result it indicates that these results were only described as 'significant' or 'not significant' in the original paper. All data presented from the studies were adjusted for the influence of other variables by the authors of the primary studies unless stated otherwise.

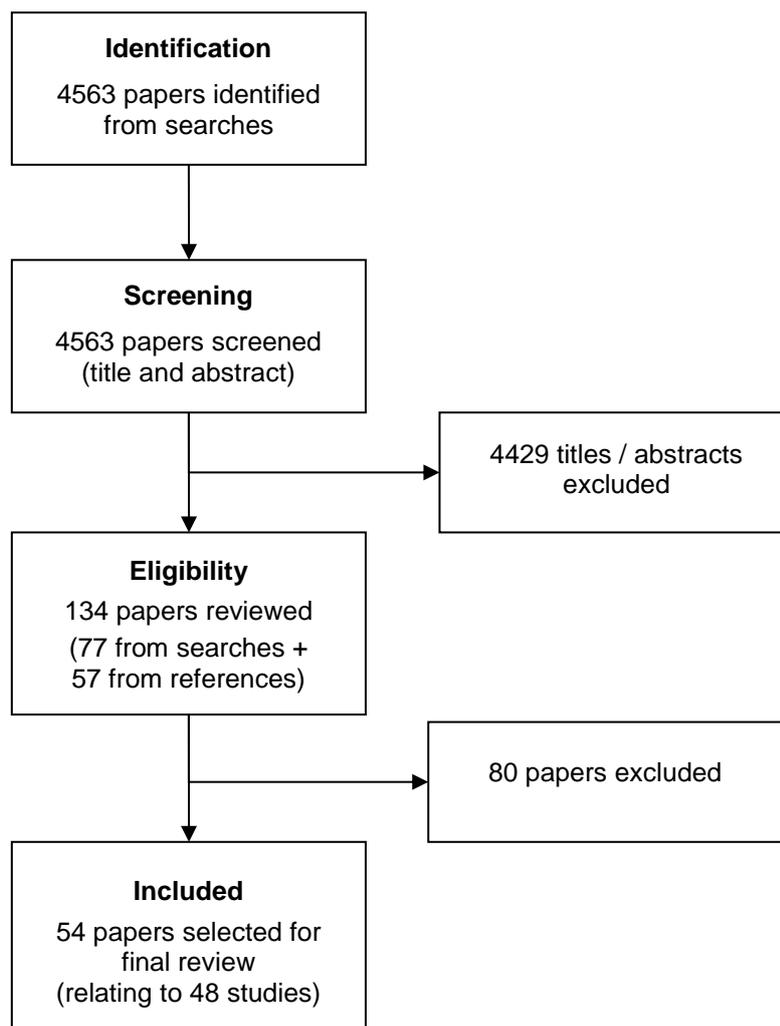
Duplicate data were excluded, for example if there were multiple papers from the same study reporting the same results. However, if there were papers that related to the same studies but used different measures of exposure or outcome and/or time periods, then both papers were included. Based on the details given in the papers, there appear to be six studies with more than one paper included in this review. These were a study of adolescents in rural communities in the U.S (De Haan, Boljevac, & Schaefer, 2009; DeHaan & Boljevac, 2010); a study of a community trial on enforcing underage drinking laws in the U.S (Reboussin, Preisser, Song, & Wolfson, 2010; Song, Reboussin, Foley, Kaltenbach, Wagoner, & Wolfson, 2009); a study on mental health after the 2001 attacks in New York (Bernstein, Galea, Ahern, Tracy, & Vlahov, 2007; Galea, Ahern, Tracy, & Vlahov, 2007); a study from a national U.S. college alcohol survey (Elissa R. Weitzman & Chen, 2005; E. R. Weitzman & Kawachi, 2000); a study of adults in New York (Ahern, Galea, Hubbard, Midanik, & Syme, 2008; Le, Ahern, & Galea, 2010); and a longitudinal study of adults in Michigan State (A. Buu, Mansour, Wang, Refior, Fitzgerald, & Zucker, 2007; Anne Buu, Wang, Wang, Puttler, Fitzgerald, & Zucker, 2011).

## RESULTS

### Results of study selection process

The study selection process is summarised in Figure 1. A total of 4,563 papers (excluding duplicates) were identified by the database searches (Stage 1). Of these, 4,429 studies were excluded based on their titles and abstracts (Stage 2). The use of combined exposure or outcome measures resulted in some studies being rejected at this stage. For example, some studies focused on all substance use (including alcohol, tobacco and drugs). 134 full papers were eligible for preliminary review (Stage 3), consisting of 77 papers from the database searches and 57 additional papers identified from references. It was not possible to access one of these papers (Dembo, Schmeidler, Burgos, & Taylor, 1985) and another paper from the same study was excluded as it used a combined outcome measure. One paper could only be accessed in a poster format, but this provided enough information to be included in the review (Reyes, Colon, Robles, Negron, Marrero, Matos et al., 2006). The main reasons for rejecting studies at this stage were that they were not carried out at a community level or that outcome variables other than alcohol use were used (e.g. drink driving or alcohol-related deaths). After completing the data extraction forms, a total of 54 papers (relating to 48 studies) met the eligibility criteria and were included in the detailed review (Stage 4). A list of excluded studies is available from the lead author.

Figure 1. Results of study selection process



## Results of studies included

The 48 studies selected were carried out between 1973 and 2011. Thirty-six were cross-sectional, ten were longitudinal and two were before-after intervention studies. Twenty-four studied adults, 26 adolescents and two students, with some including both adults and adolescents.

All of the studies were carried out in high-income settings except for one which was conducted in a low-income setting (Amazonian villages in Bolivia). Thirty-three studies were carried out in the United States, three in Canada, three in United Kingdom and nine in other countries. A range of community types were included in the studies, with 26 in urban communities, two in rural and 17 in mixed urban-rural communities. A further two studies were conducted on residential college campuses and one on an American Indian reservation. Most studies used multi-level regression models or correlation calculations to analyse associations between variables. Further details of each of the final studies selected are provided in Web Annex 1, 2 and 3.

The outcome, alcohol use, was measured in a variety of ways but these can be grouped into three broad categories.

- The first category was the quantity and/or frequency of drinking, which we have labelled as 'increased drinking' in the results tables. These measures were used in studies of both adolescents and adults as an indication of the impact of community level social factors on how much, or how frequently, alcohol is consumed. They were constructed in various ways – for example, quantity was assessed by the number of drinks or units per week; frequency was assessed by the number of days in the past week or month that alcohol was consumed or how many times adolescents had consumed alcohol in their lifetime. Some studies combined quantity and frequency.
- The second category was heavy or problem drinking. Binge drinking (usually defined as 5 or more drinks on one occasion) was the most common measure used, among both adults and adolescents. Some studies also used measures such as drinking more than the recommended number of units, drunkenness (whether, or how often, people get drunk), 'problem drinking' (e.g. using the CAGE questionnaire (Ewing, 1984) or 'alcohol abuse symptoms'; all of these were defined in various ways.
- The third was prevalence of drinking, which we have reported for adolescents only, as this may indicate problem drinking in later life (Heron et al., 2012). This was often separated into whether individuals had ever had an alcoholic drink (lifetime prevalence) and whether they had had an alcoholic drink in the past month (current prevalence) in the studies.

For clarity and simplicity, outcomes are presented in the results tables as 'increased drinking', 'problem drinking' or 'prevalence' (for adolescents only).

## **Socio-economic factors**

This review found a total of 28 studies (30 papers) on the association between community level socio-economic factors and alcohol use, summarised in Table 1. The specific measures of deprivation are described in Web Annex 1. Using the quality assessment tool, 26 papers on socio-economic factors were rated as 'medium' quality and four papers were rated as 'strong' (see Web Annex 6). No papers were rated as 'weak'. Overall, the findings provided inconclusive results for the association between community-level socio-economic factors and alcohol use, with some indication that alcohol use may be greater in high-income communities but also in communities with higher unemployment levels. The findings are differentiated below according to deprivation, income, and employment.

## Deprivation

Eighteen studies (20 papers with 36 effect estimates) examined the association between deprivation and alcohol use. In both adults and adolescents, they produced inconclusive results.

### *Adults:*

Among adults, six studies found no significant association between alcohol use and the level of deprivation in a community, all of which investigated heavy or problematic drinking. These studies included one in New York rated as 'strong' in the quality assessment (Fauth, Leventhal, & Brooks-Gunn, 2004); one in Australia with a very large (sample size >10,000) and randomly selected sample population (Livingston, Laslett, & Dietze, 2008), a study in Scotland (Ecob & Macintyre, 2000); a study in the United States (Carpiano, 2007), and two studies with relatively small sample sizes (< 1000) – one in the U.S.A. with a very restricted sample (Anne Buu et al., 2011) and one in London with a low response rate and no detailed results (Steptoe & Feldman, 2001).

One study found that men were significantly more likely to experience alcoholism symptoms if they had lived in a more deprived community ( $b = 0.77$ ) (A. Buu et al., 2007). This study had a very high follow-up rate but the sample size was relatively small and the sample was very restricted.

A study of a random sample of pairs of adolescents and their parents from across the U.S. found that the daily quantity of alcohol consumed by adults was significantly lower in more deprived communities ( $r = -0.14$ ), but the results were not adjusted for any potential confounders (Chuang, Ennett, Bauman, & Foshee, 2005).

Three studies of adults found mixed results for different exposures or outcomes. A study of young adults in the U.S. that was rated as 'strong' in the quality assessment found that females were less likely to drink alcohol in more affluent communities ( $b = -0.091$ ) but there was no significant association for males (Kling, Liebman, & Katz, 2007). In a longitudinal study of urban adults in the U.S.A., cumulative exposure to community level poverty over the course of the study was associated with a 53% increase in the number of drinks consumed per week (RR = 1.53), but was not significantly associated with binge drinking (RR = 1.60) (Cerdeira, Diez-Roux, Tchetgen, Gordon-Larsen, & Kiefe, 2010). In the same study, currently living in a community with higher levels of poverty was associated with an 86% increase in the odds of binge drinking (RR = 1.86) but was not significantly associated with the weekly amount of alcohol consumed (RR = 1.29). A study of randomly selected adults in California found that living in the least deprived communities was associated with a 32% increase in the likelihood of drinking above recommended limits (OR = 1.32), but the likelihood of drinking above recommended limits was not significantly lower in the most deprived communities (OR = 0.99), compared to moderately deprived communities (Pollack, Cubbin, Ahn, & Winkleby, 2005).

### *Adolescents:*

Among adolescents, five studies found no significant association between alcohol use and the level of deprivation in a community. These were a study in the U.S. that used a combined measure, rated as 'strong' in the quality assessment (Tobler, Komro, & Maldonado-Molina, 2009); a study with a relatively small sample size in Michigan focused on the change in alcohol use over time (Brenner, Bauermeister, & Zimmerman, 2011); two studies in the U.S. on lifetime prevalence (ever tried) or current prevalence (Ennett, Flewelling, Lindrooth, & Norton, 1997; Song et al., 2009), one of which had a very high response rate but did not adjust the results for any potential confounders (Ennett et al.,

1997); and a study of drinking frequency among Native American adolescents (HeavyRunner-Rioux & Hollist, 2010).

A study of pairs of adolescents and their parents (as above) found that the amount of alcohol ever consumed by adolescents was statistically significantly lower in more deprived communities ( $r = -0.11$ ), but the results were not adjusted for any potential confounders (Chuang et al., 2005).

Four studies of adolescents found mixed results for different exposures or outcomes. A longitudinal study of familial alcoholism in the U.S. that was rated as 'strong' found that living in a less affluent community was associated with a higher rate of increase in the amount of alcohol consumed among children of alcoholics over time ( $b = -0.20$ ), but the opposite association was found for children of non-alcoholics ( $b = 0.19$ ) (Trim & Chassin, 2008). A very large study of adolescents and young adults in the U.S. found that drunkenness was most common in communities with the lowest poverty rates, but there was no significant association with the prevalence of drinking or binge drinking (Reboussin et al., 2010). A study of rural adolescents in the U.S.A. found that living in a deprived community was associated with a 23% increase in the frequency of drinking, but frequency was not significantly different in the least deprived communities and there were no significant associations with lifetime prevalence (ever tried) (De Haan et al., 2009). A study of a random sample of adolescents in New Zealand found that the quantity of alcohol consumed was higher in more deprived communities ( $b = 0.002$ ), but found no significant association with the frequency of drinking ( $b = 0.001$ ) (Huckle, Huakau, Sweetsur, Huisman, & Casswell, 2008).

### Income

Nine studies (ten papers with 22 effect estimates) examined the association between community income levels and alcohol use. The studies generated mixed results but there is some indication that higher quantities and frequencies of drinking are more likely among adults living in communities with higher income levels.

#### *Adults:*

Two studies found no significant association between adult alcohol use and income. One, looking at urban adults in Australia, compared the proportion of low-income households and a high frequency or quantity of drinking (Giskes, Turrell, Bentley, & Kavanagh, 2011). A study in New York compared median household income and the quantity of drinking (Le et al., 2010).

Three studies found that adult alcohol use and alcohol problems were significantly more likely in wealthier communities. A study of a random sample of adults in New York found a higher frequency of drinking ( $b = 3.01$ ) in higher-income communities (Galea et al., 2007); urban adults from lower-income communities in Ontario, Canada were less likely to consume more than the recommended amount of alcohol (OR = 0.81) (Locker, Payne, & Ford, 1996), and in a representative sample of adults in Belgium, problem drinking was more likely to occur in higher-income communities ( $b = 1.875$ ) (van Praag, Bracke, Christiaens, Levecque, & Pattyn, 2009).

There were mixed findings on adult alcohol use from the three studies that focused specifically on income inequality within communities. A study of randomly selected adults in New York found that greater income inequality was significantly associated with a greater frequency of drinking ( $b = 159.46$ ) (Galea et al., 2007), but another study in New York found no significant association between income inequality and quantity of drinking (Le et al., 2010). In a relatively small study in a very different population, greater income inequality

within Amazonian villages was significantly associated with a lower frequency of drinking ( $b = -2.39$ ) (Godoy, Reyes-Garcia, McDade, Huanca, Leonard, Tanner et al., 2006). The authors of this last study explained that this finding could be due to traders contacting the more remote and egalitarian villages exchanging alcohol for forest and farm goods.

#### *Adolescents:*

Among adolescents, two studies in urban areas found no significant association between alcohol use and community level income. The first study investigated prevalence of drinking and binge drinking in a randomly selected, representative sample in the U.S. (Truong & Sturm, 2009). The second study investigated the frequency of drinking in Canada, but provided no information on the sample size (Smart, Adlaf, & Walsh, 1994).

A study of urban adolescents and young adults in the U.S.A. found different results for different outcomes. This large study found that a higher median income in a community was associated with a greater clustering of drunkenness, but found no significant association with prevalence of drinking in the past month or with binge drinking (Reboussin et al., 2010). This study also found that adolescents in high income areas had a 68% greater likelihood of drinking within the past month ( $OR = 1.68$ ), but found no significant association with binge drinking (Song et al., 2009).

#### Employment

Five studies (six papers with 17 effect estimates) were identified which reported on the association between community employment levels and alcohol use, most being studies of adolescents. The studies provided mixed results, but there is some indication that alcohol use may be higher in communities with higher unemployment levels.

#### *Adults:*

Only one study on community level employment rates was carried out in an adult population – a very large randomly selected, representative survey of older adolescents and adults in Belgium found that problem drinking was more likely in communities with high unemployment ( $b = 0.060$ ) (van Praag et al., 2009).

#### *Adolescents:*

Two studies of urban adolescents and young adults in Canada and the U.S. found no significant associations of employment in the community with prevalence, frequency, binge drinking or drunkenness – one of these had a very large sample size (Reboussin et al., 2010) but it was not possible to find any information on the sample size for the other study (Smart et al., 1994).

Three studies of adolescents obtained varied results for different exposures or outcomes. A very large study of adolescents in Sweden found that a higher unemployment rate was significantly associated with a lower frequency of drinking and binge drinking among girls (borderline significant), but not among boys (Svensson & Hagquist, 2010). This effect seems to occur at lower levels of drinking, with more adolescents not drinking at all in communities with a high unemployment rate, and was not associated with numbers of adolescents who drink regularly. A study in the U.S.A. found that urban adolescents and young adults were 29% less likely to be drinkers in communities with higher employment rates ( $OR = 0.71$ ), but found no significant associations with binge drinking (Song et al., 2009). A study of a representative sample of adolescents in Finland found that prolonged unemployment in a community was association with a tripling of the likelihood of drunkenness among boys ( $OR = 3.26$ ), but found no significant association of prolonged unemployment and drunkenness among girls or the frequency of alcohol consumption, and also found no significant associations for unemployment rates (Karvonen & Rimpela, 1997).

Table 1: The influence of community level socio-economic factors on alcohol use, by exposure type

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<b>Exposure: Deprivation</b>							
<b>Adults</b>							
Buu et al, 2007	US (Michigan)	Mixed	206 men	Disadvantage	Problem drinking	b = 0.77 (0.12-1.42)	<0.01*
Buu et al, 2011	US (Michigan)	Mixed	273 women	Disadvantage	Problem drinking	---	>0.05
Carpiano, 2007	US (Los Angeles)	Mixed	2620 adults	Disadvantage	Problem drinking	OR = 0.96 (0.70-1.32)	>0.05
Cerdea et al, 2010	US	Urban	5115 adults	Cumulative poverty	Increased drinking	RR = 1.53 (1.02-2.27)	<0.05*
				Current poverty	Increased drinking	RR = 1.29 (0.92-1.80)	>0.05
				Cumulative poverty	Problem drinking	RR = 1.60 (0.87-2.95)	>0.05
				Current poverty	Problem drinking	RR = 1.86 (1.14-3.03)	<0.05*
Chuang et al, 2005	US	Mixed	959 pairs of adolescents & their parents	Low SES	Adults – increased drinking	r = - 0.14 ^	<0.05*
Ecob & Macintyre, 2000	Scotland (Glasgow area)	Urban	3036 adults	Deprivation	Increased drinking	b = 0.053 (-0.04 – 0.14)	>0.05
				Deprivation	Problem drinking	b = 0.054 (-0.04 – 0.15)	>0.05
Fauth et al, 2004	US (New York)	Urban	315 adults	Disadvantage	Problem drinking	OR = 0.48 (0.23-1.05)	>0.05

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
Pollack et al, 2005	US (California)	Urban	8197 adults	Most deprived	Problem drinking	OR = 0.99 (0.74-1.33)	>0.05
				Least deprived	Problem drinking	OR = 1.32 (1.09-1.59)	<0.05*
Step toe & Feldman, 2001	England (London)	Urban	654 adults	Socio-economic status	Problem drinking	---	>0.05
<b>Adolescents</b>							
Brenner et al, 2011	US (Michigan)	Urban	711 adolescents	Disadvantage	Increased drinking	b = 0.03	>0.05
Chuang et al, 2005	US	Mixed	959 pairs of adolescents & their parents	Low SES	Adolescents – increased drinking	r = - 0.11 ^	<0.05*
De Haan et al, 2009	US (Wisconsin, South Dakota, Wyoming)	Rural	1424 adolescents	Concentrated disadvantage	Increased drinking	OR = 1.23 (1.06-1.42)	<0.01*
				Concentrated advantage	Increased drinking	---	>0.05
				Concentrated disadvantage & advantage	Prevalence	---	>0.05
Ennett et al, 1997	US (mid-western state)	Mixed	1801 adolescents	Deprivation	Prevalence (ever tried)	r = - 0.10 ^	>0.05
				Deprivation	Prevalence (in past month)	r = 0.01 ^	>0.05
HeavyRunner-Rioux & Hollist (2010)	US (Montana)	Mixed	1341 adolescents	Poverty	Increased drinking (in past month)	b = -0.022	>0.05
Huckle et al, 2008	New Zealand	Mixed	1179 adolescents	Deprivation	Increased drinking (frequency)	b = 0.001	>0.05
				Deprivation	Increased drinking (quantity)	b = 0.002	<0.05*

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
Kling et al, 2007	US (Baltimore, Boston, Chicago, Los Angeles, and New York)	Urban	1807 older adolescents and young adults	Poverty rate	Females – prevalence	b = -0.091 (-0.02 – -0.17)	<0.05*
				Poverty rate	Males – prevalence	---	>0.05
Livingston et al, 2008	Australia (Victoria)	Mixed	10879 older adolescents and young adults	Least vs. most disadvantaged	Problem drinking	OR = 0.944 (0.770-1.156)	>0.05
Reboussin et al, 2010	US	Urban	18730 adolescents and young adults	Poverty	Prevalence	---	0.2633
				Poverty	Problem drinking (binge drinking)	---	0.8597
				Poverty	Problem drinking (drunkenness)	---	0.0366*
Song et al, 2009	US	Urban	6636 adolescents and young adults	Poverty Poverty	Prevalence Problem drinking	---	>0.05 >0.05
Tobler et al, 2009	US (Chicago)	Urban	5655 adolescents	Deprivation	Problem drinking	---	>0.05
Trim & Chassin, 2008	US (Arizona)	Urban	361 adolescents	Socio-economic status	Children of non- alcoholics – increased drinking	b = 0.19	<0.05*
				Socio-economic status	Children of alcoholics – increased drinking	b = - 0.20	<0.05*

**Exposure: Income**

**Adults**

Galea et al, 2007	US (New York)	Urban	1355 adults	Median income	Increased drinking	b = 3.01 (0.64-5.39)	0.01*
				Income inequality	Increased drinking	b = 159.46 (47-272)	0.01*
Giskes et al, 2011	Australia (Melbourne)	Urban	2349 adults	% low income	Males - Problem drinking	OR = 0.70 (0.44-1.12)	>0.05
				% low income	Females - Problem drinking	OR = 0.77 (0.47-1.28)	>0.05
				% low income		OR = 1.20 (0.80-1.77)	>0.05

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
				% low income	Males – Increased drinking (quantity per session)	OR = 0.68 (0.46-1.02)	>0.05
				% low income	Females – Increased drinking (quantity per session)	OR = 1.11 (0.53-2.32)	>0.05
				% low income	Males – Increased drinking (quantity per week)	OR = 0.93 (0.44-1.95)	>0.05
					Females – Increased drinking (quantity per week)		
Godoy et al, 2006	Bolivia	Rural	655 adults	Income inequality	Increased drinking	b = - 2.39 (-0.88 – -3.90)	<0.01*
Le et al, 2010	US (New York)	Urban	4000 adults	Median household income	Increased drinking	OR = 1.00 (0.89, 1.13)	>0.05
				Income inequality	Increased drinking	OR = 1.07 (1.02, 1.12)	>0.05
Locker et al, 1996	Canada (Ontario)	Urban	1050 adults	Median income	Problem drinking	OR = 0.81	0.0075*
<b>Adolescents</b>							
Reboussin et al, 2010	US	Urban	18730 adolescents and young adults	Median income	Prevalence	---	0.0711
				Median income	Problem drinking (binge drinking)	---	0.3947
				Median income	Problem drinking (drunkenness)	---	0.0043*
Smart et al, 1994	Canada	Urban	?? adolescents	% low income	Increased drinking	b = 0.00	>0.05
				Average income	Increased drinking	b = 0.00	>0.05
Song et al, 2009	US	Urban	6636 adolescents and young adults	Median income	Prevalence	OR = 1.68 (1.40-2.02)	<0.01*
				Median income	Problem drinking	---	>0.05
Truong & Sturm, 2009	US (California)	Urban	3660 adolescents	Median income	Prevalence	OR = 0.94 (0.62-1.43)	>0.05
				Median income	Problem drinking	OR = 1.02 (0.50-2.08)	>0.05
Van Praag et al, 2009	Belgium	Mixed	21367 older adolescents & adults	Median income	Problem drinking	b = 1.875 (0.67-3.08)	<0.01*

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<b>Exposure: Employment</b>							
<b>Adolescents</b>							
Karvonen & Rimpela, 1997	Finland (Helsinki)	Urban	1048 adolescents	Unemployment & prolonged unemployment	increased drinking	--- ^	>0.05
				Unemployment Prolonged unemployment (boys)	Problem drinking	--- ^	>0.05
				Prolonged unemployment (girls)	Problem drinking	OR = 3.26	<0.05*
Reboussin et al, 2010	US	Urban	18730 adolescents and young adults	Employment	Prevalence	---	0.5694
				Employment	Problem drinking (binge drinking)	---	0.9136
				Employment	Problem drinking (drunkenness)	---	0.3570
Smart et al, 1994	Canada	Urban	?? adolescents	Unemployment	Increased drinking	b = 0.00	>0.05
Song et al, 2009	US	Urban	6636 adolescents and young adults	Employment	Prevalence	OR = 0.71 (0.61-0.83)	<0.05*
				Employment	Problem drinking	---	>0.05
				Unemployment	Prevalence	--- ^	>0.05
Svensson & Hagquist, 2010	Sweden	Mixed	15,206 adolescents	Unemployment	Problem drinking	--- ^	>0.05
				Unemployment	Males – Increased drinking	OR = 0.99 (0.94-1.04)	>0.05
				Unemployment	Females – Increased drinking	OR = 0.95 (0.90-0.99)	<0.05*
				Unemployment	Males - Problem drinking	OR = 0.99 (0.93-1.05)	>0.05
Unemployment	Females - Problem drinking	OR = 0.91 (0.86-0.97)	<0.05*				
Van Praag et al, 2009	Belgium	Mixed	21367 older adolescents & adults	Unemployment	Problem drinking	b = 0.060 (0.02-0.10)	<0.001*

- \* Denotes statistical significance at the 5% level  
^ Denotes that result was not adjusted for potential confounders  
b Regression coefficient  
r Correlation coefficient

OR Odds Ratio

RR Relative Risk

Studies in italics those which were assessed as being of 'weak' quality

Please see Web Annex 1 for full details of each paper

## Disorder & crime

The review identified 19 studies on the association between community level disorder/crime and alcohol use; the findings are presented in Table 2. The specific measures used are described in Web Annex 2. Using the quality assessment tool, 13 papers on disorder and crime were rated as 'medium' quality, one paper was rated as 'strong' and five papers were rated as 'weak' (see Web Annex 7). Overall, the studies provided some indication that alcohol use may be higher in communities with greater social disorder and that community safety may have a protective effect.

### Disorder

Sixteen studies (16 papers with 29 effect estimates) investigated the association between social and physical disorder and alcohol use. The exposure measures for disorder varied greatly between studies and were often based on combinations of factors, for example neighbourhood problems, single-parent families, drug activity and groups that don't get along. The studies generated mixed results, but there is some indication that alcohol use among both adults and adolescents may be higher in communities experiencing greater social disorder.

#### *Adults:*

Among adults, one study found no significant association between neighbourhood problems (including noise and antisocial behaviour) and regular heavy drinking in London, but this had a low response rate and gave no detailed results (Steptoe & Feldman, 2001). In two studies of women in deprived areas in the U.S.A., drunkenness and problem drinking were more likely to occur in urban communities experiencing greater disorder (including assaults and teenage pregnancy) ( $b = 0.007$  (Hill & Angel, 2005);  $OR = 1.94$  (Mulia, Schmidt, Bond, Jacobs, & Korcha, 2008)). The latter study was rated as 'strong' in the quality assessment, although the sample size was relatively small, and psychological distress was found to explain most of the association in this study (Mulia et al., 2008). Another study among adults in the U.S.A. and rated as 'weak' in the quality assessment found that a higher level of drug activity in the neighbourhood was significantly associated with binge drinking (Kadushin, Reber, Saxe, & Livert, 1998). A study of physical disorder in New York found that half of the environmental measures included were associated with increased binge drinking ( $OR = 2.02 - 2.55$ ) (Bernstein et al., 2007).

#### *Adolescents:*

Among studies of adolescents, there were mixed results on the association between community disorder and alcohol use. Five studies found no significant association between disorder and alcohol use. Two were very large studies investigating prevalence of drinking among adolescents and young adults in the U.S.A. (Arthur, Hawkins, Pollard, Catalano, & Baglioni, 2002; Reboussin et al., 2010), but the results of one of these were not adjusted and no tests of statistical significance were conducted (Arthur et al., 2002); two studies in New York investigated frequency and quantity of drinking (Blount & Dembo, 1984; Byrnes, Chen, Miller, & Maguin, 2007), one of which had a relatively small sample size (Byrnes et al., 2007), and another study in the U.S.A. focused on prevalence, but the results were not adjusted for any potential confounders (Ennett et al., 1997). However, six other studies of adolescents found that alcohol use was significantly higher in communities with greater disorder. In a very large comparative study, adolescents in the U.S.A. ( $OR = 1.46$ ) and in Australia ( $OR = 1.36$ ) used alcohol more frequently in communities with greater disorganisation (including high population density and crime) (Beyers, Toumbourou, Catalano, Arthur, & Hawkins, 2004). In studies of adolescents in the U.S.A., prevalence and frequency of drinking were higher in communities with greater drug activity in New Jersey ( $OR = 1.8$ ) (Abdelrahman, Rodriguez, Ryan, French, & Weinbaum, 1999) and in Baltimore ( $r = 0.21$ ) (Lambert, Brown, Phillips, & Jalongo, 2004). However, the sample size in the latter

study was relatively small and the results were not adjusted for any potential confounders (Lambert et al., 2004). Adolescents in the U.S. were also more likely to drink if they experienced greater stress from neighbourhood disorder (Scheier, Botvin, & Miller, 1999). A study rated as 'weak' found that prevalence was higher among adolescents in the U.S.A. in communities with higher levels of disorder (e.g. if they had seen someone getting robbed) (Wilson, Syme, Boyce, Battistich, & Selvin, 2005). A relatively small study of urban adolescents in Puerto Rico that was rated 'weak' in the quality assessment found that social disorder was associated with an increase in the prevalence of alcohol use but there was no significant association with physical disorder (Reyes et al., 2006). However, the full version of this paper could not be obtained and the associated poster included little information about how the sample was selected.

### Safety

This review found four studies (four papers and six effect estimates) on the association between community safety and alcohol use, all from the United States. The studies provided some indication that greater community safety is associated with lower alcohol use.

#### *Adults:*

There was only one study of the association between community safety and alcohol use among adults – a study of U.S. air force personnel that was rated as 'weak' found an association between neighbourhood safety and lower hazardous drinking (Foran, Heyman, Slep, & Usaf, 2011).

#### *Adolescents:*

Among adolescents, a study in the U.S.A. found no significant association between lifetime prevalence (ever tried) or current prevalence (in past month) and how safe adolescents feel in their neighbourhood (Ennett et al., 1997). However, two other studies of adolescents found an association between neighbourhood safety and lower alcohol use, but the results were not adjusted for any potential confounders. A relatively small study in an urban adolescent population in the USA. found that the less safe adolescents felt in their neighbourhood, the more frequently they used alcohol ( $r = -0.13$ ) (Lambert et al., 2004). A study rated as 'weak' in the quality assessment found an association between neighbourhood safety and a lower prevalence of drinking among Native American adolescents living on a reservation (Nalls, Mullis, & Mullis, 2009).

### Violence & crime

#### *Adolescents:*

There were three studies (three studies with six effect estimates) on the association between community level violence/crime and adolescent alcohol use (none on adults). The studies were all carried out in urban communities in the U.S.A. and provided mixed results. One study found that the frequency of alcohol use was significantly higher among adolescents in communities that were perceived to have higher levels of violence ( $r = 0.17$ ), but the sample size was relatively small and the results were not adjusted for any potential confounders (Lambert et al., 2004). A very large study of adolescents and young adults found that lower levels of crime in a community were associated with greater clustering of drinking and drunkenness among adolescents, but found no significant association with binge drinking (Reboussin et al., 2010). Another study in an urban adolescent population had a relatively small sample size and found that higher levels of witnessing violence in the community were associated with a greater likelihood of initiating alcohol use ( $b = 0.379$ ), whereas being a victim of violence was associated with a lower likelihood ( $b = -0.375$ ) (Mrug & Windle, 2009).

Table 2: The influence of community level disorder & crime on alcohol use, by exposure type

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<b>Exposure: Disorder</b>							
<b>Adults</b>							
Bernstein et al, 2007	US (New York)	Urban	1355 adults	Window problems	Problem drinking	OR = 2.05 (1.03-4.09)	<0.05*
				Stairway problems	Problem drinking	OR = 2.34 (1.13-4.86)	<0.05*
				>3 heating breakdowns in winter	Problem drinking	OR = 2.42 (1.33-4.43)	<0.05*
				Additional heat needed in winter	Problem drinking	OR = 2.18 (1.21-3.93)	<0.05*
				Peeling paint or plaster	Problem drinking	OR = 2.02 (1.18-3.46)	<0.05*
				Water leakage	Problem drinking	OR = 2.55 (1.61-4.05)	<0.05*
				Other environment measures	Problem drinking	---	>0.05
Hill & Angel, 2005	US (Boston, Chicago & San Antonio)	Urban	2400 women	Neighbourhood disorder	Problem drinking	b = 0.007 (0.001-0.013)	<0.01*
Kadushin et al, 1998	US	Urban	9762 adults	Drug activity	Problem drinking	b = 0.2112	0.001*
Mulia et al, 2008	US (California)	Urban	392 women	Neighbourhood disorder	Problem drinking	OR = 1.94 (1.24-3.03)	<0.01*
Steptoe & Feldman, 2001	England (London)	Urban	654 adults	Neighbourhood problems	Problem drinking	---	>0.05
<b>Adolescents</b>							
Abdelrahman et al, 1999	US (New Jersey)	Mixed	2849 adolescents	Drug activity	Prevalence	OR = 1.8 (1.3-2.3)	<0.01*

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
Arthur et al, 2002	US (Oregon)	Mixed	11162 adolescents	Community disorganisation	Prevalence (ever tried)	$r = 0.13^{\wedge}$	---
					Community disorganisation	Prevalence (in past month)	$r = 0.15^{\wedge}$
Beyers et al, 2004	US (Maine & Oregon)	Mixed	16,861 adolescents in Maine; 15,542 in Oregon	Community disorganisation	Increased drinking	OR = 1.46	<0.01*
	Australia (Victoria)				8442 adolescents	Community disorganisation	Increased drinking
Blount & Dembo, 1984	US (New York)	Urban	1045 adolescents	Low toughness/drug use	Increased drinking	$b = 0.022$	>0.05
				High toughness/drug use	Increased drinking	$b = 0.092$	>0.05
Byrnes et al, 2007	US (New York)	Urban	499 adolescents	Neighbourhood problems	Increased drinking	---	>0.05
Ennett et al, 1997	US (mid-western state)	Mixed	1801 adolescents	Social disorganisation	Prevalence (ever tried)	$r = -0.15^{\wedge}$	>0.05
				Social disorganisation	Prevalence (in past month)	$r = 0.18^{\wedge}$	>0.05
Lambert et al, 2004	US (Baltimore)	Urban	521 adolescents	Drug activity	Increased drinking	$r = 0.21^{\wedge}$	<0.01*
Reboussin et al, 2010	US	Urban	18730 adolescents and young adults	Vacant housing units	Prevalence	---	0.1652
				Vacant housing units	Problem drinking (binge drinking)	---	0.4707
				Vacant housing units	Problem drinking (drunkenness)	---	0.3424
Reyes et al, 2006	Puerto Rico	Urban	691 adolescents	High vs. low social disorder	Prevalence	OR = 18.1 (5.7-57.8)	$p < 0.001^*$
				High vs. low physical disorder	Prevalence	OR = 0.8 (0.3-1.9)	0.618
Scheier et al, 1999	US	Urban	1138 adolescents	Neighbourhood stress	Increased drinking	$b = 0.08-0.16$	<0.05
Wilson et al, 2005	US	Mixed	369 adolescents	Neighbourhood disorder	Prevalence	$b = 0.09 (0.03-0.15)$	0.01*

**Exposure: Safety**

**Adults**

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<i>Foran et al, 2011</i>	<i>US air force bases (worldwide)</i>	<i>Mixed</i>	<i>52,780 adults (air force members)</i>	<i>Neighbourhood safety Neighbourhood safety</i>	<i>Males - Problem drinking Females - Problem drinking</i>	<i>r = - 0.12 ^ r = - 0.14 ^</i>	<i>&lt;0.001* &lt;0.001*</i>
<b>Adolescents</b>							
Ennett et al, 1997	US (mid-western state)	Mixed	2548 adolescents	Neighbourhood safety Neighbourhood safety	Prevalence (ever tried) Prevalence (in past month)	b = 0.01 r = 0.03 ^	>0.05 >0.05
Lambert et al, 2004	US (Baltimore)	Urban	521 adolescents	Neighbourhood safety	Increased drinking	r = - 0.13 ^	<0.01*
<i>Nalls et al, 2009</i>	<i>US (south-western state)</i>	<i>Reservation</i>	<i>148 American Indian adolescents</i>	<i>Neighbourhood safety (feeling less safe)</i>	<i>Prevalence</i>	<i>OR = 1.18 (1.03-1.36)</i>	<i>0.015*</i>

#### Exposure: Violence & crime

##### Adolescents

Lambert et al, 2004	US (Baltimore)	Urban	521 adolescents	Violence	Increased drinking	r = 0.17 ^	<0.001*
Mrug & Windle, 2009	US (Alabama)	Urban	603 adolescents	Witness of violence Victim of violence	Prevalence Prevalence	b = 0.379 b = - 0.375	<0.01* <0.01*
Reboussin et al, 2010	US	Urban	18730 adolescents and young adults	Crime Crime Crime	Prevalence Problem drinking (binge drinking) Problem drinking (drunkenness)	--- --- ---	0.0488* 0.2236 0.0206*

\* Denotes statistical significance at the 5% level

^ Denotes that result was not adjusted for potential confounders

b Regression coefficient

r Correlation coefficient

OR Odds Ratio

RR Relative Risk

Studies in italics are those which were assessed as being of 'weak' quality

Please see Web Annex 2 for full details of each paper

## Social capital

This review identified 11 studies (13 papers) on the association between community level social capital and alcohol use, with findings presented in Table 3. The specific measures of social capital are described in Web Annex 3. Using the quality assessment tool, 11 papers were rated as 'medium' quality, one paper was rated as 'strong' and one paper rated as 'weak' (see Web Annex 8). The studies used a variety of measures, often combining a number of factors, and focused on aspects such as community attachment and community participation. The studies mainly focused on adolescent and student alcohol use. Overall, the studies provided some indication of a protective effect of social capital on alcohol use.

### Community attachment, closeness & supportiveness

Ten studies (ten papers and 26 effect estimates) were found on the association between community attachment, closeness and supportiveness and alcohol use. The findings of these studies generally indicated a protective effect.

#### *Adults:*

Among adults, a study in Taiwan found that community closeness was associated with a 43% reduction in the frequency of drinking (OR = 0.57), but found no significant association for social trust (OR = 0.86) (Chuang & Chuang, 2008). A study of adults in the U.S.A. found that higher levels of social support were significantly associated with an increased odds of binge drinking (OR = 1.79) but higher levels of informal social control (e.g. neighbours would do something about local children skipping school or spraying graffiti) were associated with a decreased odds (OR = 0.44) (Carpiano, 2007). In this study, no significant associations were found for social leverage (neighbours asking each other for advice) or social cohesion. A study in England found that living in a community where neighbours look after each other was associated with a 52% increase in the odds of moderate drinking (OR = 1.52), compared to heavier drinking, but found no significant association with the likelihood of not drinking at all (OR = 0.49) (Poortinga, 2006). A study of U.S. air force members that was 'rated' as weak in the quality assessment found that higher levels of community cohesion were significantly correlated with reduced levels of hazardous drinking, but higher levels of support from neighbours were significantly correlated with reduced levels of hazardous drinking in men only (Foran et al., 2011). A relatively small study in Amazonian villages found that the average number of acts of generosity was found to be protective – an increase of one act in a village per week was associated with 0.22 fewer times drinking alcohol in a week ( $b = -0.22$ ) (Godoy et al., 2006).

#### *Adolescents:*

Among adolescents, two studies in the U.S. found no significant association between community attachment and the prevalence of drinking (Arthur et al., 2002; Ennett et al., 1997), but one of these studies had a very large sample size and its results were not adjusted for any potential confounders and no tests of statistical significance were conducted (Arthur et al., 2002). However, two other studies of adolescents found an association with lower alcohol use. The first, on urban adolescents in the U.S.A., that was rated as 'strong' in the quality assessment, found that neighbourhood strength (a combination of community identity, action to prevent adolescent alcohol use and drug activity) was associated with a decrease in drinking among adolescents ( $b = -0.078$ ) (Tobler et al., 2009). In a very large comparative study of adolescents in the U.S.A. and Australia, low community attachment was associated with around a 20% increase in the risk of regular drinking (OR = 1.19-1.22) (Beyers et al., 2004). A study of rural communities in the U.S.A. found that community supportiveness (as assessed by adolescents) was associated with an 18% reduction in the likelihood of having ever tried alcohol (OR = 0.82) and a 54% reduction in the frequency of drinking (OR = 0.46). However, community supportiveness, as assessed by adults, and

collective efficacy (social cohesion and taking actions against disorder) were not significantly associated with adolescent alcohol use (De Haan et al., 2009).

### Community participation

The review found six studies (seven papers and 19 effect estimates) on the association between community participation and alcohol use. In general, these studies found a protective effect.

#### *Adults:*

Among adults, a study in the U.S. found no association between participating in neighbourhood meetings and binge drinking (Carpiano, 2007). A study in Taiwan found that greater social participation was significantly associated with a 43% increased frequency of drinking (OR = 1.43), but found no significant association for social contact or political influence (Chuang & Chuang, 2008).

#### *Adolescents:*

Among adolescents and students, a very large study of college students in the U.S. found no association between volunteering and binge drinking, drunkenness or frequency of drinking (Theall, DeJong, Scribner, Mason, Schneider, & Simonsen, 2009). A very large study of a randomly selected and representative sample of students in the U.S. found that high volunteering rates on college campuses were significantly associated with a 32% increase in the likelihood of typical light drinking (low quantity of alcohol consumed) (OR = 1.32) and a 25% reduction in the likelihood of binge drinking (OR = 0.75) (E. R. Weitzman & Kawachi, 2000). Another very large study in the U.S. found that adolescents were less likely to drink if they lived in communities where they perceived there to be greater rewards for involvement ( $r = -0.19 - -0.22$ ), but the results were not adjusted for any potential confounders and no tests of statistical significance were carried out (Arthur et al., 2002). A very large study of a randomly selected and representative sample of students in the U.S.A. found that binge drinking (OR = 0.38) and drunkenness (OR = 0.58) were significantly lower in college campuses with high volunteering rates, but found no significant association for frequent drinking (OR = 0.90) or for regular binge drinking (OR = 0.72) (Elissa R. Weitzman & Chen, 2005). In another very large study, rewards and opportunities for community involvement were significantly associated with a reduced frequency of drinking among adolescents in the U.S. (OR = 0.69-0.86) but not in Australia (OR = 0.91-0.99) (Beyers et al., 2004).

Table 3: The influence of community level social capital on alcohol use, by exposure type

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<b>Exposure: Community attachment, closeness &amp; supportiveness</b>							
<b>Adults</b>							
Carpiano, 2007	US (Los Angeles)	Mixed	2620 adults	Social support	Problem drinking	OR = 1.79 (1.24, 2.60)	<0.01*
				Informal social control	Problem drinking	OR = 0.44 (0.29, 0.67)	<0.01*
				Social leverage	Problem drinking	OR = 0.92 (0.75, 1.12)	>0.05
				Social cohesion	Problem drinking	OR = 1.34 (0.98, 1.82)	>0.05
Chuang & Chuang, 2008	Taiwan	Mixed	3713 adults	Trust	Increased drinking	OR = 0.86 (0.63-1.17)	>0.05
				Closeness	Increased drinking	OR = 0.57 (0.41-0.81)	<0.01*
Foran et al, 2011	US air force bases (worldwide)	Mixed	52,780 adults (air force members)	Community cohesion	Males - Problem drinking	$r = -0.16^{\wedge}$	$p < 0.001^*$
				Community cohesion	Females - Problem drinking	$r = -0.15^{\wedge}$	$p < 0.001^*$
				Support from neighbours	Males - Problem drinking	$r = -0.13^{\wedge}$	$p < 0.001^*$
				Support from neighbours	Females - Problem drinking	$r = -0.05^{\wedge}$	$p > 0.001$
Godoy et al, 2006	Bolivia	Rural	655 adults	Acts of generosity	Increased drinking	$b = -0.22$ (-0.08 – -0.36)	<0.01*
Poortinga, 2006	England	Mixed	7394 adults	Neighbours look after each other	Increased drinking (moderate vs. heavier drinking)	OR = 1.52 (1.07-2.14)	<0.01*
				Neighbours look after each other	Increased drinking (none vs. heavier drinking)	OR = 0.49 (0.20-1.20)	>0.05
<b>Adolescents</b>							
Arthur et al, 2002	US (Oregon)	Mixed	11,162 adolescents	Low attachment	Prevalence (ever tried)	$r = 0.16^{\wedge}$	---
				Low attachment	Prevalence (in past month)	$r = 0.16^{\wedge}$	---

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
Beyers et al, 2004	US (Maine & Oregon)	Mixed	16,861 adolescents in Maine; 15,542 in Oregon	Low attachment	Increased drinking	OR = 1.22	<0.01*
	Australia (Victoria)		8442 adolescents	Low attachment	Increased drinking	OR = 1.19	<0.01*
De Haan et al, 2009	US (Wisconsin, South Dakota, Wyoming)	Rural	1424 adolescents	Supportiveness (adolescent assessed)	Prevalence	OR = 0.82 (0.72-0.94)	<0.01*
				Supportiveness (adolescent assessed)	Increased drinking	OR = 0.46 (0.32-0.65)	<0.001*
				Supportiveness (adult assessed)	Prevalence	OR = 0.97 (0.80-1.16)	>0.05
				Supportiveness (adult assessed)	Increased drinking	OR = 0.91 (0.78-1.05)	>0.05
				Collective efficacy	Prevalence	OR = 1.72 (0.21-13.86)	>0.05
				Collective efficacy	Increased drinking	OR = 0.34 (0.07-1.53)	>0.05
Ennett et al, 1997	US (mid-western state)	Mixed	1801 adolescents	Attachment	Prevalence (ever tried)	b = - 0.01	>0.05
				Attachment	Prevalence (in past month)	r = 0.22 ^	>0.05
Tobler et al, 2009	US (Chicago)	Urban	5655 adolescents	Neighbourhood strength	Problem drinking	b = - 0.078	<0.05*

#### Exposure: Community participation

##### Adults

Carpiano, 2007	US (Los Angeles)	Mixed	2620 adults	Neighbourhood organization participation	Problem drinking	OR = 1.03 (0.91, 1.16)	>0.05
Chuang & Chuang, 2008	Taiwan	Mixed	3713 adults	Political influence	Increased drinking	OR = 1.14 (0.84-1.56)	>0.05
				Social contact	Increased drinking	OR = 1.08 (0.80-1.45)	>0.05
				Social participation	Increased drinking	OR = 1.43 (1.07-1.92)	<0.05*

##### Adolescents

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
Arthur et al, 2002	US (Oregon)	Mixed	11162 adolescents	Rewards for involvement	Prevalence (ever tried)	$r = -0.22$ ^	---
				Rewards for involvement	Prevalence (in past month)	$r = -0.19$ ^	---
Beyers et al, 2004	US (Maine & Oregon)	Mixed	16,861 adolescents in Maine; 15,542 in Oregon	Rewards for involvement	Increased drinking	OR = 0.69	<0.01*
				Opportunities for involvement	Increased drinking	OR = 0.86	<0.01*
	Australia (Victoria)		8442 adolescents in Victoria	Rewards for involvement	Increased drinking	OR = 0.91	>0.05
				Opportunities for involvement	Increased drinking	OR = 0.99	>0.05
Theall et al, 2009	US	Campus	15875 students	Volunteering	Increased drinking	OR = 0.32 (0.02-5.19)	>0.05
				Volunteering	Problem drinking (binge drinking)	OR = 0.36 (0.02-6.08)	>0.05
				Volunteering	Problem drinking (drunkenness)	OR = 0.95 (0.04-21.02)	>0.05
Weitzman & Chen, 2005	US	Campus	27687 students	Volunteering	Increased drinking	OR = 0.90 (0.55-1.47)	>0.05
				Volunteering	Problem drinking (binge drinking)	OR = 0.38 (0.20-0.69)	<0.01*
				Volunteering	Problem drinking (frequent binge drinking)	OR = 0.72 (0.44-1.19)	>0.05
				Volunteering	Problem drinking (drunkenness)	OR = 0.58 (0.34-0.98)	<0.05*
Weitzman & Kawachi, 2000	US	Campus	17592 students	Volunteering	Increased drinking	OR = 1.32 (1.14-1.53)	<0.001*
				Volunteering	Problem drinking	OR = 0.75 (0.65-0.86)	<0.001*

\* Denotes statistical significance at the 5% level

^ Denotes that result was not adjusted for potential confounders

b Regression coefficient

r Correlation coefficient

OR Odds Ratio

RR Relative Risk

Studies in italics are those which were assessed as being of 'weak' quality

Please see Web Annex 3 for full details of each paper

## **Social norms**

This review identified three studies (four papers and 13 effect estimates) on the association between community level social norms and alcohol use, with findings presented in Table 4. The specific measures of social norms are described in Web Annex 4. Using the quality assessment tool, all four papers were rated as 'medium' quality (see Web Annex 9). The studies used measures which focused on aspects such as the tolerance of communities toward alcohol use and the acceptability of drinking and drunkenness. The study populations were both adolescents and adults. The studies produced varied results, but there is some indication that the prevalence of alcohol use among adolescents may be lower in communities that are less tolerant of drinking.

### *Adults:*

One study of adults (two papers) found mixed results on the association between social norms and alcohol use. After controlling for social network and individual norms, permissive drunkenness norms were associated with higher levels of binge drinking (OR = 1.58) but not with moderate drinking (OR = 1.14), and no associations were found between drinking and communities having permissive drinking norms (where drinking and getting drunk are not seen as unacceptable behaviours) (Ahern et al., 2008). Using the same study population, no association was found between restrictive drinking norms and the quantity of alcohol consumed (Le et al., 2010).

### *Adolescents:*

Among adolescents, a study of a random sample of schools in Canada found that adolescent alcohol use was significantly lower in communities that were less tolerant of drinking ( $r = -0.010$  for prevalence;  $r = -0.253$  for alcohol abuse), although this paper provided no information on how the exposure was measured (Rootman & Oakey, 1973). A study of rural adolescents in the U.S. found mixed results – living in a community that they perceived to have a lower tolerance of drinking was associated with a 28% reduction in the odds of having tried alcohol (OR = 0.72) but an increase in the frequency of drinking ( $b = 1.51$ ), and there were no significant associations with the acceptability of adolescent drinking (DeHaan & Boljevac, 2010).

Table 4: The influence of community level social norms on alcohol use, by exposure type

Paper	Location	Community	Sample	Exposure measure	Outcome measure	Results (95% CI)	P
<b>Exposure: Social norms</b>							
<b>Adults</b>							
Ahern et al, 2008	US (New York)	Urban	4000 adults	Permissive drinking norms	Increased drinking	OR = 1.03 (0.86-1.25)	>0.05
				Permissive drinking norms	Problem drinking	OR = 0.98 (0.62-1.54)	>0.05
				Permissive drunkenness norms	Increased drinking	OR = 1.14 (0.99-1.30)	>0.05
				Permissive drunkenness norms	Problem drinking	OR = 1.58 (1.20 -2.08)	<0.05*
Le et al, 2010	US (New York)	Urban	4000 adults	Restrictive norms	Increased drinking	OR = 0.88 (0.76, 1.01)	>0.05
<b>Adolescents</b>							
DeHaan & Boljevac, 2010	US (Wisconsin, South Dakota, Wyoming)	Rural	1424 adolescents	Acceptability	Prevalence	OR = 0.50 (0.23-1.09)	>0.05
				Acceptability	Increased drinking	b = 0.48 (0.06-4.01)	>0.05
				Tolerance (adolescent assessed)	Prevalence	OR = 0.72 (0.63-0.82)	<0.001*
				Tolerance (adolescent assessed)	Increased drinking	b = 1.51 (1.07-2.14)	<0.05*
				Tolerance (adult assessed)	Prevalence	OR = 1.02 (0.95-1.11)	0.55
				Tolerance (adult assessed)	Increased drinking	b = 0.69 (0.56-0.86)	<0.001*
Rootman & Oakey, 1973	Canada (Alberta)	Mixed	4724 adolescents	Proscriptive norms	Prevalence	r = - 0.010	<0.05*
				Proscriptive norms	Problem drinking	r = - 0.253	<0.05*

\* Denotes statistical significance at the 5% level  
 ^ Denotes that result was not adjusted for potential confounders  
 b Regression coefficient  
 r Correlation coefficient  
 OR Odds Ratio  
 RR Relative Risk  
 Studies in italics are those which were assessed as being of 'weak' quality

Please see Web Annex 3 for full details of each paper

## DISCUSSION

This is, to our knowledge, the first systematic review of the association between alcohol use and community level social factors. The study included a wide range of exposure variables and four databases were searched, along with an extensive search of cited references. The selected studies included a wide variety of community settings and countries and were conducted among adolescent, student and adult populations.

There were inconclusive results on the associations between socio-economic factors and alcohol use, especially among studies that focused on deprivation and poverty. There was some indication that alcohol use is higher in communities with higher income levels, but also in communities with lower employment levels.

All of the studies on disorder and crime were carried out in the United States. Their results were also inconclusive, but suggest that alcohol use may be higher in communities with greater social disorder and where adolescents feel less safe. Harmful drinking may occur as a result of stress from living in a community with high levels of disorder. High social capital was generally found to be associated with lower alcohol use, mostly in studies of adolescents and students that focused on community attachment, closeness and supportiveness as well as community involvement. This finding supports previous research in which social capital in a community seems to be protective against mental ill health (De Silva, McKenzie, Harpham, & Huttly, 2005). No clear result was found for the association between social norms and alcohol use, but there is some indication that the prevalence of alcohol use among adolescents may be lower in communities that are less tolerant of drinking. This supports the need for research that focuses on social norms at a social- or community-level and their influence on health behaviours (Sorensen, Barbeau, & Hunt, 2004).

A key weakness of the evidence base is the lack of information on causality. Most of the evidence collected in this review was from cross-sectional studies. Such data cannot show the direction of the relationship between alcohol consumption and community-level influences. For example, harmful drinking may occur as a result of stress from living in a community with high levels of disorder but harmful drinking may also contribute to community disorder. Heavy drinkers may also migrate to more deprived communities or those with greater disorder. There were only a limited number of longitudinal studies in our review and no discernible differences were observed on the association of community-level social influences on alcohol use between them and the cross-sectional studies which could have strengthened understanding on the issue of temporality. More longitudinal data are required that follow people and communities over time to better estimate temporal associations between alcohol consumption and community level social factors. Approaches such as instrumental variable analysis can also help to address causal inference in cross-sectional studies.

The difficulty in assessing causality, coupled with the lack of interventional studies and the often conflicting results make it difficult to make firm policy recommendations. However, a few lessons emerge. One is the need for a gendered perspective, especially when considering adolescents. There were a number of studies where the behaviour of boys and girls differed. The study by Kling et al. (2007) also looked at a range of other measures and showed that this gender difference was not confined to alcohol. As this was a randomised study in which families moved to different areas it provides strong evidence that there is a true difference. The second, again most relevant to adolescents, is the need to consider clustering of hazardous behaviours, with several studies finding a link between hazardous drinking and drug use. Unfortunately, in many places, those addressing different health issues inhabit separate silos. The third relates to the association between disorder and drinking. As noted, it is not possible with the available data to determine the direction of causality but it is likely to be bidirectional. This implies a need for close collaboration between public health organisations and those responsible for the criminal justice system.

There were also a number of additional limitations in the evidence base. The cross-sectional design of most of the studies, and the variety of exposure and outcome measures examined in the studies, also means that it is very difficult to estimate the size of the overall effect that these community level factors may have on alcohol use. Most studies were carried out in the United States and there remains very limited evidence

on the influence of community level factors on alcohol use in low- and middle-income countries, despite their high levels of alcohol consumption and related burden of disease (World Health Organization, 2009, 2011). Studies have focused predominantly on the influence of socio-economic factors, disorder and social capital on alcohol use. Only a few have examined the influence of safety, violence, crime and social norms on alcohol use so it is difficult to draw robust conclusions about these factors. There were a number of common methodological issues in the included studies, and there was variation in the methodological quality of studies. All of the studies used self-reported alcohol use data, which may have implications for the validity of the outcome measures, particularly due to possible underreporting in communities that are less tolerant of alcohol consumption. It has been shown that respondents tend to understate alcohol consumption (Stockwell, Donath, Cooper-Stanbury, Chikritzhs, Catalano, & Mateo, 2004), but this is clearly context dependent. It may also not be true for adolescents who might overstate alcohol use (Lundborg, 2002). A number of studies also relied on a limited number of questions on alcohol consumption. Some studies had relatively low response rates (range of 24-97%), with possible respondent bias, such as the heaviest drinkers not participating in surveys. In addition, the heaviest drinkers may have died prematurely. To address this bias, alternative methodologies could be employed in future studies such as the collection of information from a relative of the deceased on alcohol consumption by the deceased (as used elsewhere) (Leon, Saburova, Tomkins, Andreev, Kiryanov, & McKee, 2007). Some studies did not adjust their results for any potential confounders. Many also failed to report confidence intervals or specific p values, although most authors stated whether the result was statistically significant at the 5% level.

There are also potential biases associated with the means of rating some of the exposure variables, such as neighbourhood disorder. However, research on neighbourhood characteristics has shown that both objective measures and subjective perceptions have explanatory power for health related behaviours, although capturing different aspects (Chow et al., 2009). For example, evidence suggests that personal perceptions of vulnerability, particularly amongst certain groups such as women and the elderly may be more inclined to rate their neighbourhood environment negatively, or to recall witnessing violence/crime at a greater rate; and that concerns about neighbourhood disorder and crime can reflect broader concerns about social and economic change (Clark, Ryan, Kawachi, Canner, Berkman, & Wright, 2008; Hale, 1996; Sutton & Farrall, 2009).

Although the results of the studies were largely adjusted for the influence of potential confounders, this review did not explore the causal pathways as this would have substantially complicated the presentation and interpretation of results. A number of studies did attempt to develop causal pathways by examining intermediate factors (e.g. psychological distress from community disorder). However, measuring these intermediate factors was beyond the scope of the review, particularly as attribution is a major challenge in examining indirect associations. The results of this review may therefore not capture the totality of associations between community level factors and alcohol use, and further research should examine the range of causal pathways. The findings of qualitative studies should also be reviewed in order to further understanding of the results of this review – for example, to better understand the ways in which social capital and employment levels influence individual decisions on alcohol use.

Future research should also address the less frequently studied social factors, such as safety, violence, crime and social norms. As this area of research is dominated by studies from the U.S.A., more research is needed from elsewhere. Future studies on alcohol use should also consider the health and policy implications of their findings, which have implications for the outcome measures used. For example, prevalence data on whether adults consume or do not consume alcohol is not particularly useful without accompanying data on the patterns of alcohol consumption (e.g. frequency, quantity, type, problem drinking).

The strength of this review is that it disentangles the results of varied and complex studies in order to describe the current evidence on the overall relationships between community level social factors and alcohol use. Although a meta-analysis was not possible due to the heterogeneity of the studies, this review systematically identified, organised, and evaluated relevant studies. Prosperous, supportive, active and safe communities clearly bring many benefits to their inhabitants. The findings from this review provide some evidence that these additional benefits may include healthier patterns of alcohol use. Policy makers

should be aware of these potential benefits of healthier alcohol use and seek to maximise them when developing policies aiming to strengthen communities and also alcohol control and treatment programmes. The findings also suggest that a comprehensive approach is required to addressing community-level influences on alcohol use which recognises the influence of social factors as well as the availability and marketing of alcohol (Bryden et al., 2012).

## Conclusions

This is the first systematic review of community level social influences on alcohol use. It found inconclusive results on the influence on alcohol use of socio-economic factors such as deprivation, poverty, income and unemployment. Similarly inconclusive findings were found for the influence of social disorder and crime on alcohol use. These findings reflect the varied outcome and exposure methods used and the broader limitations with the evidence-base. Clearer associations were found for social capital measures, such as community attachment, supportiveness and participation, and these factors seem to be protective against elevated or harmful alcohol use. Although the limitations of the current evidence base should be recognised, policy makers should be aware of the importance of a supportive and active community on preventing harmful alcohol use, particularly among adolescents.

## FUNDING SOURCE

No external funding was used to conduct this review.

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HARM REDUCTION DIGEST 38

## Changing the density of alcohol outlets to reduce alcohol-related problems

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*Increasingly, it seems, legal and political debates regarding the granting of new liquor licences are turning to the issue of whether the number and density of alcohol outlets makes a difference in rates of alcohol consumption and alcohol-related harm. But what is the state of the evidence on this question? In this Harm Reduction Digest Livingston, Chikritzhs and Room review the research literature on the effects of density of alcohol sales outlets on alcohol consumption and alcohol-related problems; suggest a new way of conceptualising the relationships; and discuss the implications for reducing alcohol-related harm.*

KYP KYPRI

Guest Editor, Harm Reduction Digest

### Introduction

Across many countries and cultures, restricting the number of places where alcohol may be sold has long been used as a strategy to reduce alcohol-related harms. The rationales behind restricting the numbers of alcohol sales outlets have been many. The aim may be to increase the trouble the average drinker has to take to be supplied, as a way of discouraging consumption. The aim may be to limit competition in retail alcohol sales, thus removing incentives for hard-pressed sellers to cut corners, for instance by selling to under-age customers; or the aim may be to leave space between sales establishments, to avoid the trouble that may accompany the bunching of outlets (particularly on-premise outlets).

Restricting the number of liquor outlets creates a loose form of oligopoly, where those with a permit to sell are given an advantage by the state, and other potential sellers are excluded from the market. In times and places with a dominant market liberalism, the

legitimacy of restricting outlet density may be met with scepticism. For instance, the Australian National Competition Policy has brought considerable pressure to bear upon state and territory governments (responsible for the content and administration of Liquor Acts) to replace needs-based tests for new licenses with public-interest tests [1,2]. Similarly, the Guidance issued for the 2003 Licensing Act in England states that ‘need’ is not a proper consideration for licensing authorities in deciding on an application for a new alcohol sales licence: “‘need’ concerns the commercial demand for another pub or restaurant or hotel. This is not a matter for a licensing authority’, but for the market [3].

In this context, the issue of the extent to which the number and density of alcohol outlets makes a difference in rates of alcohol consumption and alcohol-related harm has become a live political issue, fought in Victoria, for instance, case-by-case in licensing hearings. This paper summarises the research literature on the effects of density of alcohol sales outlets on

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Received 28 May 2007; accepted for publication 4 June 2007.

alcohol consumption and alcohol-related problems, and discusses its implications for harm reduction strategies.

### Historical background

Places where alcohol is sold have been linked to alcohol-related harm for many centuries [4], and to a greater or lesser degree have been subject to regulation. One recurrent theme in that history has been the issue of physical ‘density’ of alcohol outlets. Social surveyors in the United States a century ago, considering what might offer competition to the saloon as the ‘working man’s club’, drew maps of the downtown areas of American cities documenting the great density of drinking places, in comparison to the paucity of other attractions [5]. In the 1890s a British government inquiry, after hearing statistical evidence that there was a causal link between the number of licensed premises in a particular area and convictions for offences of drunkenness, recommended that the number of premises should be reduced systematically. Until 1981, the British licensing rules accordingly provided for the suppression of licenses deemed to be surplus, with compensation to the owners [6]. The systems of alcohol licensing and control which were the eventual settlement of the burning disputes of the temperance era accordingly often had provisions limiting the number of one or more types of alcoholic beverage licence. In a number of places, the limit was set as a rate per population; thus in California the number of liquor stores allowed in a county is tied to the county’s population [7]. In other places, the criterion was one of ‘need’, to be adjudicated by a magistrate or other authority.

As already indicated, in recent years in Australia such requirements have been seen as impermissible limits on the free market, and states have been under heavy pressure from the National Competition Council to remove these provisions from state and territory liquor licensing laws [1]. In part reflecting these pressures, changes in Victorian legislation have resulted in a steep rise in recent years in the number of alcohol licenses (unpublished data, Liquor Licensing Branch). Reflecting various commercial and ideological pressures, increases in the number of alcohol outlets have also occurred elsewhere.

Interest in the effects of licensing, and in particular of the density and clustering of alcohol sales outlets, as an issue for both policy and research has been renewed in recent years [8]. The modern literature on the effects of alcohol outlet density [9] can be seen as part of a wider contemporary literature on the effects of alcohol availability, defined in physical, economic and sometimes also psychological terms [10,11]. Limitations on availability which have been studied include taxation

and other price measures [11, pp. 101–15], restrictions on the minimum drinking age [12] and changes to opening hours and days of sale for alcohol outlets [13,14].

### Overview of the outlet density literature

#### *Effects on alcohol consumption*

Studies examining the relationship between outlet density and alcohol consumption have produced mixed results. The studies fall into three broad categories: cross-sectional studies; natural experiments; and time-series analyses. Cross-sectional studies assess the spatial association between outlet density and alcohol consumption at a single point in time. These studies can provide some indication of the link between outlet density and consumption, but provide little insight into what will happen to consumption as outlet density changes within a particular region. Natural experiment studies examine what happens when a discontinuous change in the variable of interest takes place (e.g. allowing alcohol sales from supermarkets). Such studies are the most robust method (short of the chance for a full random-assignment experiment; e.g. [13]), generally allowing causal inferences to be made where subsequent changes in an outcome variable (e.g. consumption) are identified. However, by their nature, natural experiment studies examining outlet density rely on dramatic changes, while outlet density is more likely to change gradually. Time-series studies focus on the gradual, long-term changes in rates of outlets and consumption or problems. Rather than evaluating a specific systemic change, these studies attempt to determine whether, over a certain amount of time, changes in outlet rates are related to changes in problems.

Cross-sectional studies focusing on the relationship between outlet density and alcohol consumption at the local community level have produced mixed results. These studies have been based on multi-level models that combine individual-level data from population sample surveys with aggregate community-level data from administrative sources. Scribner *et al.* [15] found that neighbourhood-level outlet density, but not individual-level measures of accessibility, was related significantly to both drinking norms and consumption levels in 24 New Orleans census tracts. In contrast, an analysis of 82 neighbourhoods in California by Pollack *et al.* [16] found that, while bars and off-premise outlets were concentrated in the most economically disadvantaged neighbourhoods, alcohol consumption was highest in economically advantaged neighbourhoods. A series of studies focusing on college students consistently found a significant link between outlet densities around colleges and rates of binge-drinking and

drinking-relating problems, both for the students and the surrounding community [17–19].

Studies which have capitalised on natural experiments in alcohol availability have come largely from the Nordic countries, where access to alcohol has traditionally been more restricted than in many other developed countries. These studies have examined substantial changes in alcohol availability such as the opening of a store in a community that previously had none, or the introduction of beer or wine into supermarkets. Studies in Finland (summarised in [20]) used the introduction of outlets into rural villages and changes to regulations permitting grocery stores to sell beer to study the impact on changes in consumption. These changes resulted in a marked increase in the consumption of beer, with marginalised and heavy drinkers affected more than the average. Swedish studies have focused similarly on the introduction and removal of medium-strength beer (4.5% by volume) from supermarket shelves, finding substantial effects on consumption as well as alcohol-related hospitalisations, particularly among teenagers [21]. In contrast, similar studies in Norway found little effect on total alcohol consumption when beverage-specific (beer) outlet densities changed. Further studies found that changes in the physical availability of legal alcohol were often related to changes in consumption of illegal alcohol (moonshine), without changing overall consumption levels [20]. Outside the Nordic countries, studies have focused on the dismantling of government retail monopolies, generally resulting in substantial increases in numbers of outlets. The privatisation of the retail wine monopolies in five US states produced significant increases in wine sales, without substantial changes in beer or spirits sales [22]. Similar results were found when the privatisation of wine sales in Quebec was studied [23].

There have been few studies examining the effect of gradual changes in outlet density on alcohol consumption. An econometric analysis by Godfrey [24] in the United Kingdom attempted to ascertain the relationship between demand for alcohol (measured by consumption) and licensing. It aimed to determine whether demand drove licensing (i.e. increased demand resulting in new outlets opening) or vice versa (i.e. more licences producing more demand), using annual time-series data from 1956 to 1980. The analysis used instrumental variable regression to disentangle the simultaneous relationship between outlet density and demand. The study found that licensing and beer consumption were related, with new licences stimulating more demand, but found no relationship for wine and spirits. Gruenewald *et al.* [25] examined a similar question using a cross-sectional time-series analysis of sales, price and outlet data for wine and spirits from 38 US states. Their analyses, using a two-

stage regression model to examine the simultaneous relationships between outlet density and sales, found that outlet densities were related significantly to sales for both wine and spirits, and that the direction of the relationship was strongest from outlets to sales (i.e. increased outlets led to increased sales more than increased sales leading to increased outlets). However, a replication of this study at the neighbourhood level in five Californian communities [26] did not reproduce this result, finding no relationship between outlet densities and consumption. Outside the United States, Trolldal [27] conducted time-series analyses of spirits, wine and beer sales in four provinces of Canada, examining their relationship with price and availability. Price was the strongest predictor of sales, with physical availability significant in only two of 20 analyses, suggesting at most a small effect of outlet density on consumption.

#### *Effects on violence*

Many cross-sectional studies have examined the spatial relationship between outlet density and rates of violence, almost all of which have found significant positive relationships [28–41]. Despite the broad similarities in findings, the specifics of the relationships between outlet and violence vary markedly from place to place and from study to study. Different localities have found different effects by outlet type, with bars significant in some studies [34], off-premise outlets in others [32] and both types (sometimes in differing ways) in others [35,39]. Where interaction effects have been explored, results are also inconsistent. Smith *et al.* [41] found that the relationship between outlets and violence was stronger in socially disorganised areas, while Nielsen & Martinez [35] found that the effect of outlets on violence did not vary with social disorganisation. Gruenewald *et al.* [39] found that bars were related to violence in unstable, poor areas *and* in rural middle-income areas, but not otherwise. Finally, the results from analyses which have examined how surrounding areas affect violence in the target area have been complex. Gorman *et al.* [33] found that outlets in surrounding areas were not related to violence in the target area, while Zhu *et al.* [36] found that outlet density in neighbouring suburbs was related significantly to violence in a particular suburb.

Again, the best evidence on how changes in outlet-density will affect violence rates comes from longitudinal studies. Longitudinal analyses allow the examination of changes in outlet density within a particular region, minimising the possibility that the effects attributed to changes in outlet density are related to other, unobserved, variables. Norström [42] conducted a time-series analysis relating two measures of assault to on-premise outlet density in Norway between

1965 and 1990. This study found significant associations, suggesting that as the density of outlets in Norway changed, assault rates changed correspondingly. Further evidence of a longitudinal relationship was found by Gruenewald & Remer [43], who used 6 years of data from 581 Californian postal areas to undertake cross-sectional time-series analyses of the link between outlet density and assault. The study incorporated a range of environmental controls (e.g. other retail places) and socio-demographic controls (e.g. median household income) across the 6 years, as well as measures of densities of three types of outlet: bars, restaurants and off-premise retailers. The study found significant positive effects for both bars and off-premise outlets on violence, and a negative effect for restaurants. The density of bars in neighbouring regions was also associated positively with violence, suggesting that new bars influence violence not only in their local area, but in surrounding regions as well. The authors estimate that an average reduction of one bar in each of the 581 postal codes analysed would have resulted in 290 fewer assaults over the 6 years studied.

#### *Effects on other alcohol-related problems*

A substantial number of cross-sectional studies have examined the relationship between outlet density and a variety of alcohol-related problems. Recent studies which have examined the link between outlet density, drink-driving and motor vehicle accidents have generally found positive relationships ([44–46]; although see Meliker *et al.* [47] for an exception). In addition, studies have found cross-sectional links between outlet density and pedestrian injury [48], child maltreatment [49,50], neighbourhood amenity problems [17,51] and rates of sexually transmitted disease [52].

Longitudinal studies of these problems have been less common. Trollidal [53] used an interrupted time-series model to examine the impact of the privatisation of retail sales of alcohol in Alberta and found no impact on rates of fatal motor vehicle accidents. A more recent study, focusing on rates of gonorrhoea as a measure of risky sexual behaviour, presents the best evidence from a natural experiment on the effects of a reduction in alcohol outlets [54]. After the 1992 civil unrest in Los Angeles, in which many liquor stores were burned, 270 alcohol outlets surrendered their licenses in the wake of a community campaign to prevent damaged outlets from reopening. This provided an unusually unambiguous natural experiment, with a well-defined ‘intervention’ and a substantial reduction in outlets. Using data at the census tract level, Cohen *et al.* [54] examined the impact that this reduction in outlets had on rates of gonorrhoea. The study attempted to differentiate between alcohol

outlets as a causal factor (through alcohol consumption and risky behaviour) and as a marker of social disorganisation. The results of this study showed a marked impact of alcohol outlets on gonorrhoea rates, suggesting that outlets play a significant role in the spread of gonorrhoea, even when social disorganisation was controlled for. Although confounding effects related to social disorganisation were controlled for, it remains possible that some unmeasured features of the 1992 unrest were responsible for the observed reduction in gonorrhoea rates. None the less, this study provides some of the strongest evidence that reducing the number of alcohol outlets in a community will reduce the incidence of alcohol-related problems.

#### **Alcohol outlet density and theory**

The theoretical foundations of outlet density studies have not yet been developed fully. Many older studies [55,56] have relied heavily on classic ‘availability theory’, which posits three inter-related propositions: (i) as the availability of alcohol in a community increases, the mean consumption of its population also increases; (ii) as the mean alcohol consumption in a population increases so the number of heavy drinkers increases; and (iii) heavy drinking is associated with adverse health and social outcomes and as the number of heavy drinkers in a population increases, so too does the level of alcohol-related health and social problems [57]. There is a wealth of evidence to support the classical postulates of availability theory [58], but in itself the theory does not adequately explain the variable and complex relationships demonstrated by studies of outlet density and harm.

Stockwell & Gruenewald [9] have expanded the basic propositions of availability theory to take into account variation in how changes in availability may be experienced across drinking groups and the contribution of other factors to rates of harm. Changes in availability are redefined more precisely, in terms of changes in the ‘full price’ of alcohol, including the real price adjusted for the cost of living and convenience in terms of the time and effort required to obtain it. Thus Stockwell & Gruenewald’s first postulate states that:

Greater availability of alcohol in a society will increase the average consumption of its population when such changes reduce the ‘full price’ of alcohol, i.e. the real price of beverages at retail markets plus the convenience costs of obtaining them [9, p. 217].

In addition, Stockwell & Gruenewald recognise that alcohol-related harms can be affected by changes in availability that do not necessarily alter overall

consumption levels. Thus Stockwell & Gruenewald's second postulate asserts that:

Greater availability of alcohol in a society will directly affect alcohol-related harm when such changes affect the distribution of 'routine drinking activities'; behaviours drinkers engage in when consuming alcohol (e.g. drinking at bars vs. at home; drinking socially vs. alone) [9, p. 217].

The mention of 'routine activities' in this proposition, a term derived from criminology [59], signals that Stockwell & Gruenewald have moved towards integrating criminological theory with availability theory. This is indicative of the growing focus of analysts on theories which seek to explain how characteristics of drinkers and their neighbourhoods predispose to criminal activity (e.g. routine activities theory; social disorganisation theory). Routine activities theory [59] posits that crime takes place when potential offenders and victims come into contact during their day-to-day activities. Roncek & Maier [28] and Smith *et al.* [41] have both suggested that alcohol outlet density is linked to violence through the ability of the outlets to attract large numbers of uninhibited young males, who serve as ready supplies of both motivated offenders and potential victims. Social disorganisation theory, on the other hand, postulates that violence is more likely to take place in communities lacking in collective efficacy or informal social control [60]. Alcohol outlets have been suggested as a marker for social disorganisation; as well, organised communities may be better equipped than poorly organised ones to resist the addition of outlets to their community through legal and political means [61]. In addition, some researchers have suggested that alcohol outlets represent visible signs of neighbourhood decay, effectively announcing that the community cannot respond to problems collectively, thus making it a more attractive area in which to commit crime [33].

Most studies have discussed plausible theories that may explain their results, but little work has gone into developing how such theories might inform study design. In this section, we suggest a basic theoretical framework for outlet density studies. We propose that the effects of alcohol outlet density can be separated conceptually into: (i) a proximity effect (how easily one can access alcohol); and (ii) an amenity effect (how outlets influence the quality and characteristics of surrounds within the local community). This conceptual separation links the broad availability theory propositions put forward by Stockwell & Gruenewald [9] with the specific issue of outlet density. The proximity effect focuses on the impact of outlet density on the convenience costs described in their first postulate, while the amenity effect provides a specific

link between outlet density and specific types of routine drinking activities discussed in their second postulate.

The proximity effect (i) is the outcome focused upon by much of the work on outlet density, which approached the issue from the perspective of simple availability theory. Increased outlet density—whether for on-premise or off-premise sales—makes alcohol more accessible (each new store makes someone closer to a liquor store), and it is hypothesised that, *ceteris paribus*, this increases consumption and alcohol-related problems. It may also have a second effect in this direction: each new outlet potentially increases the competitive pressures on existing outlets, which may result in price reductions which tend to lead to increased levels of consumption [11].

The amenity effect (ii) relates to the negative effects (e.g. violence, street disturbances, etc.) of licensed premises on the neighbourhoods in which they operate (and possibly adjacent neighbourhoods). From this perspective, alcohol outlets are seen as attractors of trouble, particularly violence, which might or might not have happened elsewhere. This may involve increased alcohol consumption overall, but it may also involve a simple redistribution of where consumption takes place. Both on- and off-premise outlets may have an amenity effect, in terms of who they attract and how they behave, but the primary emphasis in Australia and the United Kingdom [8], for instance, has been on on-premise outlets. The amenity effect of bunches of alcohol outlets in the same district often results from crowds of young people, in various stages of intoxication, moving between outlets or spilling out onto the streets at closing time.

These two different aspects of density of alcohol outlets have different implications for the relationship between outlet density and alcohol-related problems. A proximity effect for alcohol outlets may operate in a similar way to the 'retail gravity model', whereby the effect of a new outlet declines with the square of the distance to the outlet. Norström [62] has demonstrated the applicability of this model to alcohol purchases, finding the effect of the availability of cheaper alcohol in Denmark on Swedish drinking diminished with the square of the distance from the main gateway between the two countries. If a similar effect were to exist for outlet density on consumption, the impact of extra outlets would diminish as the number of outlets per square kilometre increased. This is demonstrated in Figure 1, which illustrates the proximity effect of additional outlets added at random locations within a hypothetical 25-km<sup>2</sup> neighbourhood. Where there are large numbers of alcohol outlets in operation, the community will be in the flat part of the effect shown in Figure 1, with extra outlets adding little in terms of a proximity effect. It should be noted that this figure assumes that extra outlets reduce only convenience

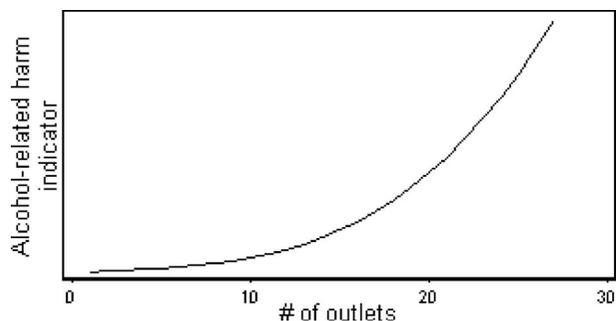
costs, without attention to the possibility of price reductions from increased competition.

The nature of the amenity effect of outlet density is less clear. If each additional outlet attracts the same amount of additional problems, a straightforward linear relationship is plausible (at least until such time as the number of outlets reaches the maximum the market can support). However, addition of outlets in bunches may create a different effect. At a certain point, a growing bunch of outlets, particularly on-premise outlets such as hotels and bars, becomes fixed in people's mental maps as an entertainment district, and thus starts attracting crowds above and beyond what would be attracted by the same number of outlets on their own. In this situation, there are likely to be large numbers of people circulating from outlet to outlet, creating the potential for additional alcohol-related problems. Thus, it is possible that the amenity effect of outlet density on alcohol-related problems has a critical point—the point at which an area is seen as an entertainment district—after which alcohol-related trouble increases more sharply with extra outlets. An example of what this might look like is provided in Figure 2.

Broadly speaking, studies examining levels of consumption should be looking for a proximity effect of



**Figure 1.** Model of proximity effect of outlets based on the square of the average distance to the nearest outlet in a hypothetical community measuring  $5 \times 5$  km.



**Figure 2.** Model of amenity effect of outlets in an area where around 15 outlets stimulates the creation of an entertainment district.

outlet density, while studies focusing on alcohol-related disorder and violence should be looking for an amenity effect. The situation for motor vehicle accidents is less clear. Increased accessibility via the proximity effect will reduce the distance required to drive to the nearest outlet, which will reduce the risk of an accident on a particular trip but might increase the likelihood of someone deciding to make the trip. The amenity effect, particularly the creation of entertainment districts, may increase the number of people driving longer distances to and from licensed premises, although this will depend upon the accessibility of public transport and taxis and social norms regarding driving after drinking.

The implications of this theoretical framework are twofold. First, studies examining the effect of outlet density on alcohol consumption and related problems need to be clear about which type of effect they are studying. This will depend upon the setting, the type of outlet and the type of outcome being examined, and is something that needs to be discussed explicitly. Secondly, there is a good chance that the relationships between outlet density and alcohol-related problems are not strictly linear, and studies should not use statistical analyses that test only for/assume a straight-line relationship.

### Gaps in the literature

The outlet density literature has grown dramatically in recent years, as advances in spatial data and methods for its analysis have taken place. However, the majority of the studies have taken a very similar approach, regressing rates of a particular outcome measure (consumption, violence, etc.) on outlet density, while controlling for socio-economic and demographic factors and statistical biases inherent in spatial analyses. The variety of results suggests that further thought is needed both in formulating an appropriate theoretical framework, as discussed above, and in developing new approaches to tease out the specifics of the relationships being examined.

One of the major weaknesses of most outlet density studies is the underlying assumption that every outlet (within broad licence categories) is equivalent. Thus, in most published studies both a small bar and a sprawling multi-level nightclub would be counted as one on-premise licence. This has obvious limitations. There are two plausible ways in which this can be overcome, at least in part. First, data relating the amount of alcohol sold by premises (or a proxy measure of sales such as wholesale alcohol purchases) would provide an extra dimension for analysis, allowing both density and consumption to be studied. Secondly, data linking alcohol-related harms to specific premises would allow a deeper understanding of the premise-specific drivers of alcohol-related harm.

Only a handful of studies [30,63,64] have incorporated both outlet density and wholesale alcohol purchases into their analyses. Wider application of these data would enable further exploration of how changes in outlet density actually influence levels of consumption. Such data could also be used to examine the degree to which changes in outlet density which affect levels of harm can be explained by changes in volumes of alcohol sales (or not) and in relation to particular types of beverages (e.g. [63]). Unfortunately, the systematic collection of alcohol sales or purchases made by individual licensed premises by administrative authorities is rare. In principle, private wholesalers could volunteer or be required to provide such data, but this is presently also very uncommon. In the main, alcohol consumption data is only available in aggregate for large geographical areas—a country as a whole (United Kingdom, Australia), or a state or province (United States, Canada), based usually on production, imports and exports data or tax collections. In Australia, only two jurisdictions collect wholesale purchase information from licensees and make the information available for research purposes (Northern Territory, Western Australia). Expanded collection of these types of data is essential to enable studies that can illuminate some of the complex effects of outlet density and, ultimately, to predict the likely outcomes of change.

Data relating to specifically identifiable individual premises associated with alcohol-related problems are not routinely collected in many jurisdictions. In many cases, therefore, it is not possible to distinguish rates of harms by type of licence (e.g. on-premise or off-premise) or other characteristics of the premises. However, there is good evidence to suggest that some types of liquor licences contribute disproportionately to alcohol-related harms [65]. Reporting systems such as the Alcohol Linking programme in New South Wales and New Zealand [66] or the recording of ‘place of last drink’ information for impaired drivers in Western Australia could be introduced more widely into standard policing practices. Further work using these types of data could explore the impact of bunching by examining whether or not people involved in alcohol-related problems had visited multiple alcohol outlets prior to the incident. These types of data will also allow for studies examining the impact on alcohol-related problems of changes in licensing conditions (e.g. opening hours) for particular premises by providing before and after data on alcohol-related harms associated with individual premises [67].

Finally, there is a lack of recent longitudinal studies assessing how individual alcohol consumption is affected by changes in outlet density. The Nordic studies provided some evidence that changes in alcohol availability were particularly likely to affect young or

marginalised drinkers [20]. In addition, studies that have examined extensions of opening hours [68,69] have found that problematic drinkers were the most likely to make use of increased availability. This raises the possibility that effects of outlet density which are specific to smaller subgroups may be difficult to detect using population-level data. Neither of the recent longitudinal studies that have examined the effect of outlet density on consumption [25,26] was able to examine the effects on subpopulations. Further study, particularly through longitudinal data collection on individual consumption, is necessary to ascertain whether outlet density is related to problematic consumption and long-term harm among some subgroups of drinkers.

On the whole, there is scant modern evidence applicable to the situation in many countries—where there is an abundance of alcohol outlets—of the effects of outlet density on alcohol consumption levels or on long-term alcohol-related health problems. The most compelling studies to have found positive relationships between outlet density and these outcomes have been undertaken in small-town Scandinavia and have generally examined situations of very low availability (e.g. the addition of a liquor store in a town where none previously existed) [20]. Recent longitudinal studies that have examined the effect of outlet density on consumption in regions with reasonably high alcohol availability found mixed results [25–27].

### **The implications for harm reduction**

Despite this lack of clear evidence we propose that where the network of alcohol outlets is relatively dense, small changes in density are unlikely to affect alcohol consumption levels or rates of alcohol-related *chronic* health problems. There are two important caveats to this proposal. First, it should be noted that increased outlet density leads to an increasingly competitive alcohol market-place, possibly resulting in lower prices. In this circumstance, alcohol consumption levels would be expected to increase (see [11] for a summary of studies examining the impact of changes in price on alcohol consumption). Secondly, some studies [20] have suggested that socially marginalised drinkers are more likely to be influenced by changes in alcohol availability than other drinkers. This implies that changes to outlet density could markedly affect the consumption and long-term health problems of some population subgroups, sometimes without noticeable changes in population-level consumption estimates.

On the other hand, outlet density, and particularly bunching, are more likely to have an effect on rates of binge drinking, on alcohol-related injuries and violence, and on other short-term consequences related to concentrated drinking during discrete occasions. It is

in this area of problems that there are the strongest findings of an effect for outlet density. These effects are likely to take place at a local level: within a postcode or neighbourhood in urban areas. Hadfield [8] documents that, in Britain at least, a pub property is worth twice as much if it is located in proximity to existing attractive pubs and nightspots. There is thus substantial commercial value in bunching. Inherent in such bunching is the idea of night-time customers progressing from site to site in the course of a night out. This means that there are bound to be noise and disturbances in the neighbourhood while the night-time economy is flourishing. Close proximity of licensed premises makes it easier for customers to react to promotions such as cost undercutting. The movement of patrons between bars complicates the assignment of responsibility to any one server or establishment to forestall intoxication by cutting supply. These are all factors that can increase the level of problems from drinking.

Furthermore, although there are only a few cross-sectional studies that focus on it [18,51], the presence of a bar or liquor store can impact negatively upon neighbourhood amenity: noise late at night, street disturbances, disruptive behaviour, litter, vandalism and so on. More bars or liquor stores further reduce neighbourhood amenity. This is the classic situation that brought forward a common Australian response in terms of 'community accords' [70], where local police or authorities try to stimulate agreements among licensees to forswear overselling and limit promotions, with mixed results [71]. In Britain, the response has been provision for 'Alcohol Disorder Zones', where alcohol outlets within the zone are taxed to provide resources to counter alcohol-related disorder occurring as a result of the 'expansion in the night-time economy' [72].

This suggests that, where the primary aim is to limit or reduce rates of injury and other alcohol-related problems, particularly violence, greater attention might be paid to bunching than to density *per se*. Increasing the number of bars or stores close to each other, besides the additive effect from bringing together sources of trouble, is likely to increase competition (not a good thing in alcohol markets from a public health or order perspective), make server intervention more difficult and encourage disruptive strolling from pub to pub, increasing the likelihood of violence. It is worth noting, however, that bunching of alcohol outlets does make the targeted provision of some measures aimed at reducing alcohol related harm, such as policing and public transport, more straightforward.

Comprehensive policies for regulating outlet density and bunching should be based firmly on local level information, sound theoretical framework and well-designed research. Given the consistent links between outlet density and violence rates across a range of settings, study designs and data sources, a liquor

licensing regime serving the interest of public health and order should incorporate consideration of outlet density and bunching into licensing decisions.

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Richardson, E.A., Hill, S.E., Mitchell, R., Pearce, J., and Shortt, N.K.  
(2015) Is local alcohol outlet density related to alcohol-related morbidity  
and mortality in Scottish cities? *Health and Place*, 33, pp. 172-180.

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Version: Published

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Deposited on: 02 April 2015

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# Is local alcohol outlet density related to alcohol-related morbidity and mortality in Scottish cities?

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## ARTICLE INFO

### Article history:

Received 13 August 2014

Received in revised form

17 February 2015

Accepted 24 February 2015

### Keywords:

Alcohol outlets

Drinking

Hospitalization

Mortality

Scotland

## ABSTRACT

Alcohol consumption may be influenced by the local alcohol retailing environment. This study is the first to examine neighbourhood alcohol outlet availability (on- and off-sales outlets) and alcohol-related health outcomes in Scotland. Alcohol-related hospitalisations and deaths were significantly higher in neighbourhoods with higher outlet densities, and off-sales outlets were more important than on-sales outlets. The relationships held for most age groups, including those under the legal minimum drinking age, although were not significant for the youngest legal drinkers (18–25 years). Alcohol-related deaths and hospitalisations were higher in more income-deprived neighbourhoods, and the gradient in deaths (but not hospitalisations) was marginally larger in neighbourhoods with higher off-sales outlet densities. Efforts to reduce alcohol-related harm should consider the potentially important role of the alcohol retail environment.

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## 1. Background

In recent years there has been increasing recognition that place can constrain or enable various health behaviours, including alcohol consumption (Jayne et al., 2010; Pearce et al., 2012). Geographical work has emphasised that a multitude of social, cultural, political and economic factors interact in complex ways to affect alcohol consumption, across spatial scales from the global to the local (Jayne et al., 2008). The importance of geographical context in understanding drinking behaviour is emphasised by the spatial differences in consumption and related health outcomes across Great Britain (Beeston et al., 2014; Leon and McCambridge, 2006). There are various pathways through which place may influence individual behaviours such as alcohol consumption (Bernard et al., 2007; Macintyre and Ellaway, 2000). Various studies attest to the importance of geographical context in drinking behaviours, norms and cultures (Bryden et al., 2013; Holloway et al., 2008; Hughes et al., 2011; Valentine et al., 2008). Alcohol-related health outcomes are also spatially patterned (Emslie and Mitchell, 2009). With alcohol consumption among women and young adolescents increasing in the UK (Meng et al., 2014; Smith

and Foxcroft, 2009), and preferred drinking venues changing across the life course (Information Services Division, 2010), the role of place should not be overlooked.

One geographical factor that may influence alcohol consumption is the availability of alcohol retail outlets. Neighbourhood availability of alcohol retailing may influence local consumption patterns and health outcomes through a number of pathways. Greater local availability of alcohol retailers, and increased visibility of their advertising and promotions, can increase the physical availability of alcohol, reduce the prices of alcohol products due to retailer competition, and shape and reinforce local attitudes and norms around drinking behaviours and drunkenness (Livingston et al., 2007; Pasch et al., 2009, 2007). Increased consumption levels may result; for example lower alcohol prices tend to lead to increased consumption (Babor et al., 2003). Indeed, studies indicate that population-wide consumption of alcohol may be higher in neighbourhoods with higher alcohol outlet densities (Ayuka et al., 2014; Bryden et al., 2012). Local alcohol outlet densities have also been linked to acute alcohol-related health problems such as assault and vehicle collision injuries (Gruenewald et al., 2006; LaScala et al., 2001; Livingston, 2008b; Treno et al., 2007). Chronic alcohol-related health problems have received less attention, although these are a more prevalent health consequence of alcohol consumption in people over 35 years of age (Grant et al., 2009). Recent work in the US and Australia indicates that chronic consequences such as cirrhosis and mental disorders are more

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<http://dx.doi.org/10.1016/j.healthplace.2015.02.014>

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prevalent in neighbourhoods with higher densities of retail outlets licensed to sell alcohol for consumption off the premises (Pereira et al., 2013; Theall et al., 2009).

Different types of alcohol outlet are likely to encourage distinct types of drinking behaviours and hence may influence health in varying ways. A key distinction is whether the outlet is licensed to sell alcohol for consumption on the premises ('on-sales' outlets, such as bars and restaurants) or off the premises ('off-sales' outlets, such as convenience stores and supermarkets). While political and media attention has often been concerned with binge drinking in public spaces dominated by on-sales premises, such as city-centre 'entertainment districts', less attention has been paid to the less visible drinking conducted at home, with alcohol purchased from off-sales premises (Holloway et al., 2008). Indeed, Forsyth and Davidson (2010) argue that off-sales outlets have greater potential for alcohol-related harm than on-sales premises. In an Australian study, Livingston (2011) compared the relationship of acute and chronic alcohol-related health outcomes with local densities of off-sales and on-sales outlets and found that chronic health outcomes (mental and behavioural) were strongly related to off-sales outlet densities. This finding might be because 'problematic' drinkers seek to acquire alcohol from the cheapest available sources (i.e., for off-premise consumption). Moreover, off-sales outlets tend to be disproportionately concentrated in areas of socioeconomic disadvantage (Ellaway et al., 2010; Hay et al., 2009; Livingston, 2012; Romley et al., 2007). In contrast, on-sales outlets are not so clearly patterned, and in some cases are more concentrated in more affluent areas (Ellaway et al., 2010; Hay et al., 2009; Livingston, 2012).

Scotland has one of the highest levels of alcohol-related harm in Western Europe (Beeston et al., 2013). In the 1990s cirrhosis mortality declined in many European countries but increased steeply in Scotland, leading to calls for action to halt the alarming trend (Leon and McCambridge, 2006). Scotland has the highest rate of alcohol-related mortality in the UK (Breakwell et al., 2007); male alcohol-related mortality rates in Scotland were more than double those in England and Wales for most years in the last two decades (Beeston et al., 2013). In Scotland one in every 20 deaths and one in every 20 hospital episodes is attributable to alcohol (Grant et al., 2009). The negative consequences of alcohol use were conservatively estimated to cost Scottish society £3.6 billion in 2007, of which £268 million were incurred by the National Health Service (NHS) (Scottish Government, 2010).

Scotland also has a marked social gradient in both hospitalisations and deaths due to alcohol (Beeston et al., 2013), contributing to widening socioeconomic health inequalities (Audit Scotland, 2012). While alcohol consumption is high across all deciles of deprivation, Scots living in the most deprived neighbourhoods have slightly higher levels of harmful consumption but almost 10 times the rate of both hospitalisation and death due to alcohol, compared with those living in the least deprived areas (Beeston et al., 2013). Of all health inequalities monitored by the Scottish Government the highest are seen for alcohol-related deaths in 45–74 year olds (Scottish Government, 2013).

Given the magnitude of the health, social and economic costs of alcohol-related harm in Scotland, and that the health burden is falling disproportionately upon the most socially disadvantaged communities, there is an urgent need for a better understanding of potential policy levers for reducing high levels of alcohol consumption (Scottish Government, 2009). Scotland's current alcohol strategy relies heavily on education and early intervention, but also recognises the need to address alcohol availability – particularly via off-sales, which are seen as playing a growing role in unhealthy levels of consumption (Scottish Government, 2009). In 2012 the Scottish Parliament made a significant step in this regard, passing legislation introducing a minimum unit price (MUP) for alcohol sales (Forsyth et al., 2014). This initiative met with strong

opposition and a legal challenge from the alcohol industry (led by the Scotch Whisky Association), and plans for implementation of MUP currently remain on hold (Forsyth et al., 2014).

The current Scottish study aimed to address the absence of neighbourhood-level work on alcohol outlet density and chronic health outcomes from countries other than the US or Australia. To date, little is known about the role of the alcohol retail environment in alcohol consumption and health in Scotland. In Australia and the US different urbanisation patterns have tended to result in lower population densities and higher levels of social and ethnic segregation. It might be anticipated that in these national contexts this may result in a lower density of outlets but with a greater social discrepancy due to the concentration of targeted consumers and alternative land use planning strategies. The only Scottish research in this area is limited to research on adolescents in Glasgow (Young et al., 2013). Our study extends the research by considering a larger adult population living in the main urban areas across the country.

The aims of this study were to: (a) examine the association between neighbourhood densities of on-sales and off-sales outlets and alcohol-related morbidity and mortality in Scottish cities; (b) determine whether the relationship differed by age group and sex; and (c) assess whether socioeconomic gradients in alcohol-related health outcomes differed by level of outlet density. In addition to investigating relationships with all alcohol-related health outcomes combined, we also focused on cirrhosis cases specifically as an indicator of chronic alcohol-related harm. We hypothesised that cirrhosis would be more strongly related to off-sales than on-sales outlet densities, because prolonged excessive drinking is likely to be facilitated by cheaper alcohol, such as that sold for off-premise consumption (Livingston, 2011). We expected different relationships by age group and sex based on well-documented differences in the drinking venues and patterns of these groups (Information Services Division, 2010; Valentine et al., 2010; Young et al., 2013) and different disease latency. Alcohol-related health outcomes in young legal drinkers were expected to be less related to their local alcohol environment than those in older drinkers, because younger people's harmful drinking often occurs in central entertainment districts rather than their local neighbourhood (Hayward and Hobbs, 2007). Alcohol-related health outcomes in drinkers under the UK's legal minimum drinking age (18 years) were expected to be more strongly related to off-sales than on-sales outlet densities, due to the majority of their alcohol purchases being made from off-sales outlets (Information Services Division, 2009). Differences in these relationships between males and females were expected to be larger in older age groups, based on evidence that young women's drinking habits have become increasingly similar to young men's (Valentine et al., 2010).

## 2. Data and methods

### 2.1. Design

Alcohol outlet density measures were calculated for the Scottish 'datazone' administrative geography. Datazones are the Scottish Government's smallest geographical unit for the dissemination of administrative data, and were designed to contain populations between 500 and 1000. We then assessed the relationship of outlet density with alcohol-related hospitalisation and mortality, after accounting for relevant covariates.

### 2.2. Alcohol outlet availability

Postcode-referenced records of licensed premises (correct as of 2008) were obtained from the Liquor Licensing Boards of the four

largest cities in Scotland: Glasgow, Edinburgh, Aberdeen and Dundee. Resource constraints precluded collecting outlet data for the whole of Scotland (over 30 licensing boards, with no central register), hence we selected the largest concentrations of outlets and population. The records distinguished premises licensed to sell alcohol for consumption either off or on the premises (off-sales and on-sales premises, respectively). A separate on and off-sales licence was also granted in some cases, but we were advised that sales from these premises would be largely on-premise (Edinburgh licensing board, pers. comm.), hence they were treated as on-sales outlets.

Outlet density measures are often calculated for administrative geographies such as zip codes, census tracts or postcodes (Freisthler et al., 2008; Livingston, 2011; Theall et al., 2009; Treno et al., 2007). Implicit in such measures are the assumptions that (a) the population is evenly distributed across each geographical unit and (b) residents are unaffected by outlets outside of these artificially-imposed boundaries. We also utilised an administrative geography – datazones – but (a) calculated our density measure for the population centre of each unit, in order to capture the alcohol environment that the majority of the population were exposed to, and (b) quantified outlet density within a radius around this point, ensuring that the measure was not constrained to datazone boundaries. We used the technique of kernel density estimation ('KDE', see Carlos et al., 2010) to generate our density measure because it uses distance-decay weighting (outlets closer to the datazone's population centre were weighted higher than those further away), and we conceptualised that outlets closer to the population may have greater influence on consumption and health. KDE measures of alcohol outlet density have been used in studies of the distribution of alcohol outlets (Berke et al., 2010) and of relationships with health outcomes (Major et al., 2014; Pearson et al., 2014).

We created a measure of alcohol outlet density per unit area rather than population, on the basis that an individual's alcohol consumption is more likely to be influenced by the absolute physical availability of an outlet rather than how many people the outlet is shared between. An alcohol outlet density surface was then produced for each city using KDE. First, the cities were divided into  $50 \times 50 \text{ m}^2$  'kernels'. Second, for each kernel the number and proximity of outlets within a 1 km search radius were used to calculate a density measure, with outlets nearer the kernel being given greater weight. Density surfaces were produced for on-sales and off-sales premises, providing a proximity-weighted estimate of the density of each outlet type per  $\text{km}^2$  (termed "proximity-weighted outlets per  $\text{km}^2$ " hereafter, as the weighting process means that the values differ from standard density measures). The outlet data were analysed using ArcMap 9.3 Geographic Information System (GIS) software (ESRI, Redlands, CA).

We extracted outlet density values at the population-weighted centroid of each datazone in the four licensing board areas. Datazones (mean 2001 population 821, range 499–2692) were the smallest spatial units for which sufficiently large health outcome counts could be obtained, to enable reliable statistical modelling. The four areas were not adjacent and we did not have outlet data for surrounding licensing board areas, hence potential density underestimation was avoided by restricting our sample to the 1360 datazones with population-weighted centroids at least 1 km from the landward edge of each licensing board area.

### 2.3. Health outcome data

Anonymised individual occurrences of alcohol-related hospitalisation and death between 2000 and 2009 were obtained from NHS Scotland's Information Services Division (ISD). Each record

included age group (0–17, 18–24, 25–29, 30–49, 50–59, 60–74 and 75 plus) and sex. The ISD definition of alcohol-related health outcomes (Information Services Division, 2009) captures conditions that are wholly attributable to alcohol (ICD10 codes E24.4, E51.2, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K86.0, O35.4, P04.3, Q86.0, R78.0, T51.0, T51.1, T51.9, X45, X65, Y15, Y57.3, Y90, Y91, Z50.2, Z71.4, Z72.1), and combines acute and chronic consequences. In 2007/08, mental and behavioural diagnoses were the most common alcohol-related cause of hospitalisation (71%), followed by cirrhosis (16%) and alcohol poisoning (11%) (Information Services Division, 2009). We also extracted hospitalisations and deaths due to cirrhosis (ICD10 K70) alone, to capture a wholly chronic effect of alcohol use. As our interest was in population response to outlet densities rather than a cumulative measure of impact on individuals we included only the first hospitalisation for each health outcome for each individual. Hospitalisations and deaths with either a main or supplementary diagnosis of interest were included.

### 2.4. Area-level covariates

For each datazone we extracted population counts (2001) by age group and sex, and a measure of area-level deprivation. The Scottish Index of Multiple Deprivation (SIMD) quantifies multiple deprivation on seven domains – employment, income, crime, housing, health, education and access – at the datazone level. The overall score includes an aggregate measure of alcohol-related hospitalisations, hence we selected the SIMD's Income Deprivation domain from 2006. This domain quantifies the percentage of the population in receipt of income support benefits.

### 2.5. Data linkage

Alcohol outlet densities and the covariates were appended to each record by ISD, based on the individual's datazone of residence at the time. ISD then removed the datazone identifiers before providing the linked dataset. The release of individual health data in this form was given ethical approval by the NHS Privacy Advisory Committee.

### 2.6. Temporal coverage

The health data covered 2000–2009, to ensure sufficient counts, although the alcohol outlet data were collected in 2008. We assessed whether 2008 data would adequately capture the alcohol environment over a wider period by comparing with outlet data collected for the same cities in 2012 (Shortt et al., In preparation). We found minimal change over the four years: 88% of the datazones had identical numbers of on-sales premises in the two datasets (89% for off-sales licences).

### 2.7. Analyses

The relationships between alcohol outlet density and health outcomes (counts of hospitalisations or deaths per datazone) were modelled using Poisson regression in Stata/IC 11.1 (StataCorp, College Station, TX). We modelled counts rather than rates because the datazones had small populations, which meant that rates would have been highly sensitive to small differences in the numerator. Baseline models were adjusted for age group, sex, datazone-level income deprivation rate, and city. City was included in the models to check whether the relationships varied between the cities. Age- and sex-specific population counts (from 2001 census) were used as the denominator. Subsequent models were stratified by sex and age group and by outlet density quartiles. Incidence rate ratios were calculated to represent the

relative increase in the incidence rate of the health outcome associated with an interquartile range (IQR) increase in alcohol outlet density. The IQRs – the difference between the 25th and 75th percentiles – were 11.9 proximity-weighted outlets per km<sup>2</sup> for on-sales and 10.6 for off-sales. On-sales and off-sales outlet density measures were highly correlated ( $r > 0.95$ ,  $p < 0.001$ ), hence could not be included in the same models because of multicollinearity issues. Separate models were run for on- and off-sales densities, and Akaike's Information Criterion (AIC) values were compared to assess which of the models produced the best fit to the data.

Such analyses may be biased due to non-independence of the geographical units, or 'spatial autocorrelation', hence it is typical to run spatial error models to adjust for this. However, due to the sensitive nature of these small-area data the geographic identifiers had been removed by the data provider, precluding any assessment of spatial autocorrelation. We note, however, that even where alcohol outlet and harm data have been found to be significantly autocorrelated the corrected results are often not substantively different to those without a spatial error term (Livingston, 2008a, 2010; Tatlow et al., 2000).

### 3. Results

#### 3.1. Descriptive statistics

Descriptive statistics for the 1360 datazones included in the study are given in Table 1. For both alcohol outlet types, densities were highest on average in Edinburgh, and lowest in Dundee and Aberdeen.

The included datazones had a combined population of 1.1 million in 2001, or 22% of the Scottish population. From this population a total of 45,444 individuals were hospitalised for alcohol-related conditions between 2000 and 2009, of whom 3970 (9%) were hospitalised for cirrhosis. Alcohol-related deaths numbered 7064, of which 3952 (56%) were attributable to cirrhosis. Nil or low counts restricted the age groups that could be included in the models for each health outcome: all ages for alcohol-related hospitalisations, 18+ for cirrhosis hospitalisations, and 25+ for all alcohol-related or cirrhosis deaths.

#### 3.2. Are alcohol-related health outcomes related to outlet densities?

Higher densities of on- and off-sales outlets were related to significantly higher incidence of all alcohol-related health outcomes

(Tables 2 and 3). Effect sizes were larger for off-sales than on-sales density, and AIC values indicated that the off-sales density models produced the best fit to the data. Effect sizes were also larger for mortality than for hospitalisation. An IQR increase in off-sales outlet density was associated with higher incidence of all alcohol-related conditions in general (8% higher hospitalisation, 19% higher mortality), and cirrhosis (11% higher hospitalisation, 15% higher mortality). Incidence of all outcomes was significantly lower for females than males, and at younger ages. Each percentage-point increase in income deprivation was associated with an average 4% increase in hospitalisation or mortality.

#### 3.3. Do relationships between outlet densities and health vary by age and sex?

Stratified models revealed clear variation in the relationships between outlet densities and health outcomes by age and sex (Table 4). On- and off-sales densities produced similarly-patterned associations, although effect sizes were higher for off-sales outlets and AIC values again indicated a better fit to the data for these models.

Underage (< 18 years) hospitalisations for all alcohol-related outcomes were significantly related to outlet densities, and the associations were strongest for females. An IQR increase in off-sales outlet density was associated with a 19% increase in alcohol-related hospitalisations for females (8% for males). For females the relationship with alcohol-related hospitalisation was strongest in this age group.

All alcohol-related hospitalisations among 18–24 year olds were lower in areas with higher outlet densities. The relationship was significant for males ( $p < 0.001$ ) such that an IQR increase in densities of off-sales outlets was associated with 7% fewer male alcohol-related hospitalisations. No significant associations with hospitalisation were found for 25–29 year old males or females, but rates of all alcohol-related mortality for 25–29 year old males were significantly higher in neighbourhoods with higher outlet densities.

Cirrhosis outcomes, particularly deaths, were most strongly related to outlet densities for the older age groups. Cirrhosis hospitalisation and death in under 30 year olds was rare – 70 and 31 cases respectively – hence the absence of a relationship with area-level outlet density is not surprising.

Clear patterning by sex was only observed for all alcohol-related hospitalisations; in groups 30 years old and over, hospitalisation rates were more strongly related to local outlet densities for males than for females.

**Table 1**

Descriptive statistics for the 1360 included datazones: combined and by city.

	All	Aberdeen	Dundee	Edinburgh	Glasgow
N included datazones	1360	235	136	527	462
Total included population (2001)	1,112,956	182,557	112,827	429,586	387,986
Datazone characteristics (mean(SD))					
Population (2001)	821 (166)	792 (155)	830 (141)	816 (180)	840 (158)
% income deprived (2006)	16.9 (13.6)	11.7 (9.9)	19.9 (11.4)	11.4 (11.0)	24.9 (14.2)
Proximity-weighted alcohol outlet density per km <sup>2</sup> at PWC:					
on-sales outlets mean (SD)	13.4 (23.0)	9.6 (21.6)	9.7 (12.9)	16.5 (27.4)	13.0 (20.0)
range	(0–187)	(0–125)	(0–78)	(0–187)	(0–151)
off-sales outlets mean (SD)	11.9 (15.0)	7.9 (10.6)	8.8 (8.7)	15.3 (19.5)	10.9 (11.0)
range	(0–127)	(0–59)	(1–47)	(0–127)	(0–83)
Health outcome counts per datazone (mean (SD)) (2000–2009 aggregated)					
Hospitalisation					
Cirrhosis	2.9 (2.9)	1.9 (1.9)	3.0 (2.2)	2.0 (2.2)	4.4 (3.5)
Other alcohol-related conditions	30.5 (23.1)	30.6 (20.6)	25.1 (14.0)	22.5 (16.9)	41.2 (27.8)
Death					
Cirrhosis	2.9 (3.2)	1.5 (1.7)	2.5 (2.2)	2.2 (2.3)	4.6 (4.0)
Other alcohol-related conditions	2.3 (2.7)	1.4 (1.7)	3.0 (2.6)	2.0 (2.4)	2.8 (3.2)

PWC=population-weighted centroid; SD=standard deviation.

**Table 2**  
The relationship between on-sales alcohol outlet density and incidence of alcohol-related hospitalisation or death<sup>a</sup>.

	All alcohol-related health outcomes		Cirrhosis	
	Hospitalisation	Death	Hospitalisation	Death
On-sales outlet density (IRR per IQR increase)	1.05 (1.04–1.06) <sup>***</sup>	1.12 (1.10–1.14) <sup>***</sup>	1.06 (1.04–1.09) <sup>***</sup>	1.09 (1.07–1.11) <sup>***</sup>
Sex				
Male	1.00	1.00	1.00	1.00
Female	0.40 (0.39–0.41) <sup>***</sup>	0.32 (0.31–0.34) <sup>***</sup>	0.41 (0.38–0.44) <sup>***</sup>	0.39 (0.36–0.41) <sup>***</sup>
Age group				
0–17	0.18 (0.17–0.19) <sup>***</sup>	–	–	–
18–24	0.81 (0.78–0.84) <sup>***</sup>	0.02 (0.01–0.03) <sup>***</sup>	0.03 (0.02–0.05) <sup>***</sup>	–
25–29	0.68 (0.65–0.71) <sup>***</sup>	0.11 (0.08–0.14) <sup>***</sup>	0.13 (0.10–0.18) <sup>***</sup>	0.09 (0.06–0.13) <sup>***</sup>
30–49	1.00	1.00	1.00	1.00
50–59	1.38 (1.33–1.42) <sup>***</sup>	2.91 (2.72–3.12) <sup>***</sup>	2.40 (2.22–2.60) <sup>***</sup>	2.87 (2.63–3.12) <sup>***</sup>
60–74	1.25 (1.21–1.28) <sup>***</sup>	3.05 (2.85–3.26) <sup>***</sup>	1.90 (1.75–2.06) <sup>***</sup>	2.80 (2.57–3.04) <sup>***</sup>
75 plus	0.86 (0.82–0.90) <sup>***</sup>	1.78 (1.62–1.96) <sup>***</sup>	0.79 (0.69–0.92) <sup>**</sup>	1.60 (1.42–1.81) <sup>***</sup>
Datazone deprivation				
% income deprived	1.05 (1.04–1.05) <sup>***</sup>	1.04 (1.04–1.05) <sup>***</sup>	1.04 (1.04–1.04) <sup>***</sup>	1.04 (1.04–1.05) <sup>***</sup>
City				
Glasgow	1.00	1.00	1.00	1.00
Aberdeen	1.40 (1.32–1.49) <sup>***</sup>	0.82 (0.73–0.93) <sup>**</sup>	0.81 (0.72–0.92) <sup>**</sup>	0.64 (0.55–0.73) <sup>***</sup>
Dundee	0.84 (0.78–0.90) <sup>***</sup>	0.98 (0.87–1.11)	0.83 (0.73–0.94) <sup>**</sup>	0.67 (0.58–0.77) <sup>***</sup>
Edinburgh	1.01 (0.96–1.06)	1.02 (0.93–1.12)	0.79 (0.72–0.87) <sup>**</sup>	0.83 (0.75–0.92) <sup>***</sup>

IRR, incidence rate ratio; IQR, interquartile range (11.9 proximity-weighted on-sales outlets per km<sup>2</sup>).

\*\* 0.001 < *p* ≤ 0.01.

\*\*\* *p* < 0.001.

<sup>a</sup> Models adjusted for age group, sex, datazone level income deprivation, and city.

**Table 3**  
The relationship between off-sales alcohol outlet density and incidence of alcohol-related hospitalisation or death<sup>a</sup>.

	All alcohol-related health outcomes		Cirrhosis	
	Hospitalisation	Death	Hospitalisation	Death
Off-sales outlet density (IRR per IQR increase)	1.08 (1.07–1.10) <sup>***</sup>	1.19 (1.16–1.22) <sup>***</sup>	1.11 (1.08–1.14) <sup>***</sup>	1.15 (1.11–1.18) <sup>***</sup>
Sex				
Male	1.00	1.00	1.00	1.00
Female	0.40 (0.39–0.41) <sup>***</sup>	0.32 (0.31–0.34) <sup>***</sup>	0.41 (0.38–0.44) <sup>***</sup>	0.39 (0.36–0.41) <sup>***</sup>
Age group				
0–17	0.18 (0.17–0.19) <sup>***</sup>	–	–	–
18–24	0.81 (0.78–0.84) <sup>***</sup>	–	0.03 (0.02–0.05) <sup>***</sup>	–
25–29	0.68 (0.65–0.71) <sup>***</sup>	0.11 (0.08–0.14) <sup>***</sup>	0.13 (0.10–0.17) <sup>***</sup>	0.09 (0.06–0.13) <sup>***</sup>
30–49	1.00	1.00	1.00	1.00
50–59	1.38 (1.34–1.42) <sup>***</sup>	2.93 (2.73–3.14) <sup>***</sup>	2.41 (2.22–2.61) <sup>***</sup>	2.88 (2.64–3.14) <sup>***</sup>
60–74	1.25 (1.21–1.29) <sup>***</sup>	3.06 (2.87–3.28) <sup>***</sup>	1.91 (1.76–2.07) <sup>***</sup>	2.80 (2.58–3.05) <sup>***</sup>
75 plus	0.86 (0.82–0.90) <sup>***</sup>	1.79 (1.62–1.97) <sup>***</sup>	0.80 (0.69–0.92) <sup>**</sup>	1.61 (1.42–1.82) <sup>***</sup>
Datazone deprivation				
% income deprived	1.04 (1.04–1.05) <sup>***</sup>	1.04 (1.04–1.05) <sup>***</sup>	1.04 (1.04–1.04) <sup>***</sup>	1.04 (1.04–1.04) <sup>***</sup>
City				
Glasgow	1.00	1.00	1.00	1.00
Aberdeen	1.41 (1.33–1.50) <sup>***</sup>	0.83 (0.74–0.93) <sup>**</sup>	0.82 (0.73–0.93) <sup>**</sup>	0.64 (0.56–0.74) <sup>***</sup>
Dundee	0.84 (0.78–0.90) <sup>***</sup>	0.98 (0.87–1.10)	0.83 (0.73–0.94) <sup>**</sup>	0.66 (0.58–0.77) <sup>***</sup>
Edinburgh	0.98 (0.94–1.04)	0.97 (0.89–1.06)	0.77 (0.70–0.84) <sup>***</sup>	0.79 (0.72–0.88) <sup>***</sup>

IRR, incidence rate ratio; IQR, interquartile range (10.6 proximity-weighted off-sales outlets per km<sup>2</sup>).

\*\* 0.001 < *p* ≤ 0.01.

\*\*\* *p* < 0.001.

<sup>a</sup> Models adjusted for age group, sex, datazone level income deprivation, and city.

### 3.4. Is outlet density related to socioeconomic gradients in alcohol-related health?

We used interaction models to investigate whether the socioeconomic gradients in alcohol-related health outcomes were affected by outlet densities. Continuous-by-continuous interaction models showed small but significant positive interactions for off-sales outlet densities in the relationship between income deprivation and mortality from all alcohol-related conditions combined (*p* = 0.024) or cirrhosis (*p* = 0.048), but neither for hospitalisations, nor for on-sales densities. Hence the socioeconomic gradients in alcohol-related and cirrhosis deaths were slightly steeper in

datazones with higher densities of off-sales premises. In datazones with below-average off-sales outlet densities, for example, a 1% increase in income deprivation rate was associated with a 4.2% increase in all alcohol-related deaths, whereas the equivalent figure was 4.6% for datazones with higher than average densities.

## 4. Discussion

There is growing recognition amongst researchers and policy-makers that geographical context is important for understanding health behaviours, including alcohol consumption. Understanding

**Table 4**

The increase in the health outcome rate associated with an interquartile range<sup>a</sup> increase in on-sales and off-sales outlet densities, stratified by sex and age group<sup>b</sup>. Incidence rate ratios and 95% confidence intervals are given.

Alcohol-related condition	Age group	On-sales outlet density		Off-sales outlet density				
		Male	Female	Male	Female			
All	Hospitalisation	0–17	1.05 (1.01–1.11)*	1.13 (1.09–1.18)***	1.08 (1.01–1.15)*	1.19 (1.12–1.26)***		
		18–24	0.95 (0.93–0.97)***	0.98 (0.96–1.01)	0.93 (0.90–0.96)***	0.97 (0.94–1.01)		
		25–29	0.99 (0.96–1.01)	1.00 (0.97–1.03)	0.97 (0.94–1.01)	1.00 (0.95–1.04)		
		30–49	1.09 (1.07–1.11)***	1.07 (1.05–1.09)***	1.14 (1.11–1.16)***	1.10 (1.07–1.13)***		
		50–59	1.13 (1.11–1.16)***	1.10 (1.07–1.13)***	1.22 (1.18–1.25)***	1.15 (1.11–1.19)***		
		60–74	1.12 (1.10–1.14)***	1.06 (1.03–1.09)***	1.19 (1.17–1.22)***	1.10 (1.06–1.14)***		
		75 plus	1.08 (1.06–1.11)***	1.03 (0.98–1.08)	1.14 (1.09–1.18)***	1.05 (0.98–1.12)		
	Death	25–29	1.16 (1.05–1.29)**	0.68 (0.39–1.19)	1.22 (1.04–1.42)*	0.65 (0.36–1.19)		
		30–49	1.10 (1.07–1.14)***	1.13 (1.08–1.18)***	1.16 (1.11–1.21)***	1.21 (1.14–1.28)***		
		50–59	1.16 (1.13–1.20)***	1.12 (1.07–1.18)***	1.27 (1.22–1.32)***	1.19 (1.12–1.27)***		
		60–74	1.15 (1.12–1.18)***	1.05 (0.99–1.11)	1.24 (1.19–1.29)***	1.08 (1.00–1.16)*		
		75 plus	1.06 (1.01–1.12)*	1.09 (1.01–1.18)*	1.11 (1.03–1.19)**	1.13 (1.02–1.26)*		
		Cirrhosis	Hospitalisation	18–24	0.74 (0.37–0.47)	0.99 (0.70–1.40)	0.72 (0.32–1.62)	0.96 (0.56–1.63)
				25–29	1.08 (0.94–1.24)	0.46 (0.19–1.14)	1.11 (0.91–1.36)	0.39 (0.15–1.01)
30–49	1.05 (1.01–1.09)*			1.11 (1.06–1.16)***	1.09 (1.03–1.16)**	1.16 (1.08–1.24)***		
50–59	1.10 (1.06–1.14)***			1.09 (1.03–1.15)**	1.18 (1.12–1.24)***	1.13 (1.05–1.22)**		
60–74	1.05 (1.01–1.09)*			1.08 (1.02–1.14)*	1.09 (1.03–1.16)**	1.13 (1.05–1.23)**		
75 plus	1.02 (0.93–1.13)			1.08 (0.96–1.22)	1.03 (0.89–1.19)	1.19 (1.02–1.39)*		
25–29	1.01 (0.79–1.28)			0.53 (0.22–1.27)	0.92 (0.61–1.39)	0.46 (0.18–1.20)		
Death	30–49		1.07 (1.03–1.11)**	1.13 (1.07–1.19)***	1.11 (1.04–1.18)**	1.21 (1.13–1.30)***		
	50–59		1.12 (1.08–1.17)***	1.11 (1.05–1.18)***	1.22 (1.16–1.28)***	1.18 (1.10–1.27)***		
	60–74		1.10 (1.07–1.14)***	1.05 (0.99–1.12)	1.17 (1.11–1.22)***	1.08 (0.99–1.17)		
	75 plus		1.04 (0.96–1.12)	1.07 (0.97–1.17)	1.06 (0.96–1.18)	1.10 (0.98–1.25)		

\* 0.01 < p ≤ 0.05.

\*\* 0.001 < p ≤ 0.01.

\*\*\* p < 0.001

<sup>a</sup> IQRs = 11.9 proximity-weighted outlets per km<sup>2</sup> for on-sales and 10.6 for off-sales outlets.

<sup>b</sup> Models adjusted for datazone level income deprivation, and city.

these processes is not only an academic concern but also offers options to policymakers tasked with reducing the societal burden of alcohol-related harm and related health inequalities. A multitude of place-based factors have been implicated in understanding patterns of alcohol consumption including the local availability of alcohol retailing. This study is the first in Scotland to examine the relationship between alcohol retailing and alcohol-related health outcomes amongst adults. We distinguished between off-sales and on-sales premises, responding to concerns that previous work has been biased towards public drinking spaces, while off-sales outlets have greater potential for producing harmful drinking behaviours, particularly in underage groups (Forsyth and Davidson, 2010; Holloway et al., 2008).

We found that alcohol outlet densities were associated with alcohol-related health outcomes in Scottish cities; rates of hospitalisation and mortality from all alcohol-related outcomes in general, and cirrhosis in particular, were significantly higher in populations of neighbourhoods with higher alcohol outlet densities. Strong relationships were also found for underage drinkers, particularly females. Income-related gradients in alcohol-related mortality were marginally larger in neighbourhoods with higher off-sales outlet densities.

Our indicator of chronic alcohol-related harm – cirrhosis – was more strongly related to off-sales than on-sales densities, as predicted, but this was also the case for all alcohol-related health outcomes (combining chronic and acute harms). The relative importance of on- and off-sales densities to the relationship could not be assessed, although model diagnostics suggested that on-sales densities were acting as a proxy for off-sales densities. This supports the claim of Forsyth and Davidson (2010) that off-sales outlets have the greatest potential for alcohol-related harm, due to their cheaper product, accessibility for under-age drinkers, large volumes obtainable, and absence of control over the final recipient. Other evidence shows the growing importance of off-premise

consumption of alcohol. While on-sales premises dominated the alcohol retail environment numerically in our study (73% of total outlets), off-sales outlets account for a more than 60% and rising share of alcohol sales in Scotland by volume (Information Services Division, 2010). Indeed, drinking at home has become more affordable and more socially accessible in recent years (Foster et al., 2010; Holloway et al., 2008). In addition, we suggest that local availability of off-sales outlets may have a stronger link to neighbourhood-level alcohol consumption and harms than on-sales outlets because of the convenience constraints of carrying the alcohol purchased to another location, often the home, for later consumption. Our findings, coupled with increased alcohol sales from off-sales outlets, give weight to claims of a misplaced policy focus on the night-time economy (Holloway et al., 2008), and challenge us to reconsider the spatial framing of drinking and related harms from public to private space.

Contrasting our findings for deaths and hospitalisations may shed light on the relative importance of the alcohol environment for chronic versus acute alcohol-related harms. Outlet densities were more strongly related to alcohol-related deaths than hospitalisations. Most alcohol-related deaths were due to chronic causes (56% were cirrhosis, and an unknown additional proportion were due to alcoholic gastritis, alcoholic cardiomyopathy, and other chronic disease) hence the finding suggests that the local alcohol environment – and most likely off-sales rather than on-sales outlets – is particularly important for the long-term excessive drinking that initiates the development of chronic alcohol-related illness. High densities of alcohol outlets may simultaneously increase the availability of alcohol and normalise alcohol consumption behaviours for local communities.

There is growing concern about increasing levels of alcohol consumption by young people which have led to increases in chronic alcohol-related illness at younger ages (Chief Medical Officer, 2001). Outlets selling alcohol for consumption off the

premises are likely to be important sources of alcohol for underage drinkers (Forsyth and Davidson, 2010). Our finding that alcohol-related hospitalisation of underage drinkers was related to off-sales densities supports this claim. Alcohol outlet densities have been linked with under 18 year olds' drinking (Chen et al., 2010, 2009; Young et al., 2013) and health outcomes inflicted on children by an adult (assault or other maltreatment) (Alaniz et al., 1998; Freisthler et al., 2008, 2004), but we are not aware of other work that has found links with health consequences of under 18 year olds' own drinking. Although underage drinkers more frequently source alcohol from social contacts rather than directly through retail outlets (Hearst et al., 2007; Information Services Division, 2010), both routes may be influenced by the physical availability of alcohol outlets. Moreover, alcohol purchases by underage customers are more successful if there are similar retail outlets nearby (Freisthler et al., 2003).

We expected the local alcohol environment to have least importance for alcohol-related health consequences of young legal drinkers because the riskiest drinking behaviours among this group may occur in out-of-neighbourhood entertainment districts (clusters of pubs and clubs) (Hayward and Hobbs, 2007). Accordingly, we found no relationship between outlet densities and alcohol-related hospitalisations for 25–29 year old males and females and 18–24 year old females, but found a surprising negative relationship for the youngest legal male drinkers (18–24). A possible explanation is that in residential neighbourhoods with higher densities of outlets, perhaps representing a sufficient choice of alcohol sources, young people may be less inclined to visit out-of-neighbourhood outlet aggregations, and may be less likely to engage in the risky drinking practices that such concentrations of young drinkers and alcohol sources can encourage. That alcohol-related deaths in 25–29 year old males were positively related to outlet densities complicates this story, but may be attributable to the heaviest drinkers being able to source large quantities of cheap alcohol most easily from local outlets (particularly off-sales outlets).

We also investigated whether the associations between neighbourhood outlet densities and the health outcomes varied by social group and hence might be a potential factor in explaining health inequalities. An Australian study attributed widening socioeconomic inequalities in cirrhosis mortality to increasing availability of alcohol over time (Najman et al., 2007). In our study, income-related gradients in deaths (but not hospitalisations) from cirrhosis and all alcohol-related outcomes in general were slightly wider in neighbourhoods with higher densities of off-sales outlets (but not on-sales). A possible mechanism is that consumption of alcohol at harmful levels is most prevalent among low income men and women (Information Services Division, 2010), and drinking among the heaviest drinkers is most sensitive to increases in alcohol availability (Makela, 2002). Our findings suggest that increased densities of off-sales alcohol outlets may result in wider socioeconomic inequalities in alcohol consumption and its health consequences.

Our study had limitations. First, whilst our outlet density measures indicate the neighbourhood availability of alcohol retailing, we were not able to include other attributes of retailing that may influence alcohol consumption. Future work could usefully include information on prices, trading hours, venue type and on-sales capacity. Second, our kernel density measures were necessarily based on 'as-the-crow-flies' radii, which could not account for barriers to movement. While this meant that not all outlets captured by the measure could be accessed on a 1 km journey on roadways or paths the proximity-weighting applied meant that the measure reflected the density of closer outlets more than those further away. Third, to ensure accurate representation of outlet density we excluded areas on the periphery of each licensing

board area – largely suburban areas with low outlet densities – which will have introduced some bias towards inner city locations. Fourth, exposure misclassification, a common issue for ecological studies, was inevitable because we considered only the outlet densities within the neighbourhood of residence at the time of hospitalisation or death. In reality individuals move between areas with different alcohol outlet densities (over daily and longer time periods). Future work could usefully incorporate a variety of geographical settings to which individuals are exposed over the course of their daily lives (e.g. residential neighbourhood, workplace and recreational settings). Work in the field of physical activity that tracks individual 'activity spaces', often using GPS technology, offers significant potential to research on alcohol environments. Longer term – and often longer distance – residential movements could also be studied using longitudinal datasets. Nonetheless, the fact that outlet densities in the place of residence at the time of hospitalisation or death were positively related to cirrhosis rates is noteworthy, given the long lag period of the disease. The alcohol retail environment in the individual's place of residence at the time of their hospitalisation or death might therefore be indicative of the alcohol environment they had experienced during the development of the disease. Fifth, causal inference is not possible because of the cross-sectional study design. Longitudinal analysis is required to ascertain the mechanisms underlying the relationships we found, recognising that supply and demand dynamics interact to shape alcohol outlet availability and alcohol consumption patterns (Grunewald, 2008).

Our findings have direct implications for alcohol policy in Scotland. In particular, the association between off-sales alcohol outlet density and alcohol-related hospitalisations and deaths highlights the potential for MUP (which primarily affects off-sales) to reduce alcohol-related harm at a population level. This potential is particularly relevant for efforts to reduce harmful alcohol consumption in more deprived neighbourhoods, where the impact of MUP on off-sales is likely to be most pronounced (Forsyth et al., 2014). The strength of the relationship between outlet density and alcohol-related hospitalisations of underage drinkers also highlights the need for greater efforts to reduce alcohol availability to this group.

Reducing alcohol outlet densities – particularly of off-sales outlets – could potentially help to reduce population-wide alcohol-related harm. Alcohol licensing regulations offer one possible mechanism for reducing outlet density, as recognised in WHO Europe's action plan on alcohol (World Health Organization, 2012). Scotland's 2005 Licensing Act includes provision for Licensing Boards to take account of "Protecting and improving public health" in making licensing decisions (Scottish Parliament, 2007, p9), although there is little evidence that this provision is often utilised.

## 5. Conclusions

Our study helps to further understanding of how social and spatial factors influence alcohol issues. Health problems attributable to alcohol were more prevalent in neighbourhoods with more alcohol outlets, which may indicate that outlet availability influences alcohol consumption. Availability of off-sales outlets appeared to drive these relationships, in line with the increasing dominance of off-premise drinking in UK. Alcohol-related hospitalisations of those under the legal minimum drinking age were also related to outlet densities, suggesting a need for greater enforcement of alcohol retail legislation. However, among the youngest legal drinkers alcohol-related health outcomes were somewhat decoupled from the residential alcohol environment. Tackling alcohol-related problems in this subgroup of the population is likely to require a wider focus, as

alcohol outlets outside the local neighbourhood may be more important. Efforts to reduce alcohol-related harm should consider the role of the alcohol retail environment.

## Acknowledgements

We would like to thank Glasgow, Edinburgh, Aberdeen and Dundee Licensing Boards for providing the alcohol outlet data, and NHS Scotland's Information Services Division for extracting and linking the health data. EAR was initially funded by a Wellcome Trust VIP award. The work was completed with support from the European Research Council [ERC-2010-StG Grant 263501].

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## Alcohol and Global Health 2

# Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol

Peter Anderson, Dan Chisholm, Daniela C Fuhr

Lancet 2009; 373: 2234-46

See Editorial page 2171

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This is the second in a Series of three papers about alcohol and global health

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This paper reviews the evidence for the effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol, in the areas of education and information, the health sector, community action, driving while under the influence of alcohol (drink-driving), availability, marketing, pricing, harm reduction, and illegally and informally produced alcohol. Systematic reviews and meta-analyses show that policies regulating the environment in which alcohol is marketed (particularly its price and availability) are effective in reducing alcohol-related harm. Enforced legislative measures to reduce drink-driving and individually directed interventions to already at-risk drinkers are also effective. However, school-based education does not reduce alcohol-related harm, although public information and education-type programmes have a role in providing information and in increasing attention and acceptance of alcohol on political and public agendas. Making alcohol more expensive and less available, and banning alcohol advertising, are highly cost-effective strategies to reduce harm. In settings with high amounts of unrecorded production and consumption, increasing the proportion of alcohol that is taxed could be a more effective pricing policy than a simple increase in tax.

### Introduction

The first paper in this Series<sup>1</sup> summarised the global burden of ill health and the economic cost attributable to alcohol use and alcohol-use disorders, noting that 4·6% of all ill health and premature death worldwide is due to alcohol, with poorer populations and lower-income countries having a greater disease burden per litre of alcohol than higher-income populations and countries. This second paper in the Series reviews the evidence for the effectiveness of policies and programmes to reduce the avoidable harm caused by alcohol, largely on the basis of an analysis of published systematic reviews and meta-analyses, which were identified through searches of the Cochrane library, Medline, Web of Science, and Web of Knowledge with specific search terms for each target policy area. Reference sections of identified papers were cross-checked to identify other relevant studies

contributing to this review. This paper briefly summarises the harm to be reduced, and reviews the evidence for effective policies and programmes and estimates their cost-effectiveness. It concludes with a short overview of the implications for policy development and implementation. Since most countries do not have adequate programmes in place, the third paper in the Series will describe how policies and programmes need to be scaled up, concluding with a global call to action.<sup>2</sup>

### Harm caused by alcohol

Alcohol is an intoxicant that affects a wide range of structures and processes in the CNS. By interacting with personality characteristics, associated behaviours, and sociocultural expectations, it is a causal factor for intentional and unintentional injuries and harm to people other than the drinker,<sup>3</sup> including reduced job performance<sup>4</sup> and absenteeism,<sup>5</sup> family deprivation,<sup>6</sup> interpersonal violence,<sup>7</sup> suicide,<sup>8</sup> homicide,<sup>9</sup> crime,<sup>10</sup> and fatalities caused by driving while under the influence of alcohol (drink-driving).<sup>11</sup> Furthermore, it is a contributory factor for risky sexual behaviour,<sup>12</sup> sexually transmitted diseases,<sup>13</sup> and HIV infection.<sup>14</sup> Alcohol is a potent teratogen with a range of negative outcomes to the fetus, including low birthweight, cognitive deficiencies, and fetal alcohol disorders.<sup>15</sup> Alcohol is neurotoxic to brain development, leading to structural hippocampal changes in adolescence,<sup>16</sup> and to reduced brain volume in middle age.<sup>17</sup> Alcohol is a dependence-producing drug, similar to other substances under international control, through its reinforcing properties and neuro-adaptation in the brain.<sup>18</sup> It is an immunosuppressant, increasing the risk of communicable diseases,<sup>19</sup> including tuberculosis.<sup>20</sup> Alcoholic beverages are classified as carcinogenic by the International Agency for Research on Cancer, increasing

### Key messages

- A substantive evidence base of systematic reviews and meta-analyses inform alcohol policy
- Making alcohol more expensive and less available are highly cost-effective strategies to reduce harm
- Banning of alcohol advertising, drink-driving countermeasures, and individually-directed interventions to drinkers already at risk are also cost-effective approaches
- School-based education does not reduce harm, but public information and education programmes can increase attention to alcohol on public and political agendas
- If more stringent alcohol policies are not put into place, global alcohol-related harm is likely to continue to increase

	Evidence of effect	Level of evidence
<b>Education and information</b>		
School-based education	Some positive effects on increased knowledge and improved attitudes but no sustained effect on behaviour. An SR of 14 SRs identified 59 high-quality programmes, of which only six were able to show any evidence for effectiveness <sup>42</sup>	1
Parenting programmes	An SR of 14 parenting programmes noted reductions in alcohol use in six parenting programmes <sup>43</sup>	2
Social marketing programmes	An SR of 15 programmes noted eight of 13 studies with some significant effects on alcohol use in the short term (up to 12 months), four of seven studies with some effect at 1–2 years, and two of four studies with some effect over 2 years. <sup>44</sup> (Some of the described programmes are not strictly social marketing programmes, and other reviews have concluded the same programmes as ineffective <sup>42</sup> )	2
Public information campaigns	Little scientific research; individual studies generally ineffective <sup>45</sup>	5
Counteradvertising	Little scientific research; inconclusive results <sup>45</sup>	5
Drinking guidelines	No scientifically published assessment <sup>45</sup>	6
Health warnings	SR of the experience in the USA noted some effect on intentions to change drinking behaviour, but no effect on actual behaviour change itself <sup>46</sup>	2
<b>Health-sector response</b>		
Brief advice	An MA of the effectiveness of brief interventions for hazardous and harmful alcohol consumption noted a positive effect of brief interventions on alcohol consumption, mortality, morbidity, alcohol-related injuries, alcohol-related social consequences, health-care resource use, and laboratory indicators of harmful alcohol use. <sup>47</sup> An SR of 12 studies noted that a combination of educational and office support programmes increased rates of screening and advice giving of primary health-care providers from 32% to 45% <sup>48</sup>	1 2
Cognitive-behavioural therapies for alcohol dependence	Effective—an SR of 17 studies of behavioural self-control training found a combined effect size of 0.33 (SE 0.08) for reduced alcohol consumption and alcohol-related difficulties <sup>49</sup>	1
Benzodiazepines for alcohol withdrawal	Effective—an SR of 57 trials recorded an RR of 0.16 (95% CI 0.04–0.69) for seizures compared with placebo <sup>50</sup>	1
Glutamate inhibitors for alcohol dependence	Effective—an SR of 17 RCTs reported an RR of point prevalence abstinence of 1.40 (95% CI 1.24–1.59) at 6 months and 1.62 (1.37–1.92) at 12 months <sup>51</sup>	1
Opiate antagonists for alcohol dependence	Effective—an SR of 29 RCTs reported a significant reduction in relapse, at least in the short term (3 months) (RR 0.64 [95% CI 0.51–0.82]) <sup>52</sup>	1
<b>Community programmes</b>		
Media advocacy	Little scientific research; but advocacy in media aimed at uptake of specific policies can lead to increased attention to alcohol on political and public agendas <sup>45</sup>	5
Community interventions	Evidence of effectiveness of systematic approaches to coordinate community resources to implement effective policies, when backed up by enforcement measures <sup>53</sup>	5
Workplace policies	An SR noted little evidence of effect in changing drinking norms and reducing harmful drinking <sup>54</sup>	2
<b>Drink-driving policies and countermeasures</b>		
Introduction and/or reduction of alcohol concentration in the blood	Effective in reducing drink-driving casualties—an MA of nine studies in the USA reported implementation of a legal concentration of 0.8 g/L alcohol in the blood resulted in 7% decrease in alcohol-related motor vehicle fatalities <sup>55</sup>	1
Sobriety checkpoints and unrestrictive (random) breath testing	Effective in reducing alcohol-related injuries and fatalities—an MA of 23 studies noted that alcohol-related fatal crashes reduced by 23% after introduction of sobriety checkpoints and by 22% after introduction of random breath testing <sup>56</sup>	1
Restrictions on young or inexperienced drivers (eg, lower concentrations of alcohol in blood for novice drivers)	Some evidence—an SR of three studies of lower alcohol concentrations in the blood detected reductions in fatal crashes of 9%, 17%, and 24% <sup>56</sup>	2
Mandatory treatment	Evidence for effectiveness—an MA of 215 assessments of remedial programmes noted that they reduced recurrence of alcohol-impaired driving offences and alcohol-related accidents by 8–9% <sup>57</sup>	2
Alcohol locks	Some evidence—an SR of one RCT and 13 controlled trials noted that interlock participants had lower recurrence of offences than did controls, an effect that did not extend once the interlock was removed <sup>58</sup>	2
Designated driver and safe-ride programmes	No evidence for effectiveness. An SR of nine studies was unable to draw any conclusions about effectiveness <sup>59</sup>	2
<b>Addressing the availability of alcohol</b>		
Government monopolies	Effective—privatisation followed by higher density of outlets, longer hours or more days of sale, changes in price, and an increase in consumption <sup>60</sup>	2
Minimum purchase age	Effective—a review of 132 studies published between 1960 and 1999 noted that changes in minimum drinking age laws can reduce youth drinking and alcohol-related harm, including road traffic accidents <sup>61</sup>	2
Outlet density	Effective—an SR reported consistent evidence for the effect of outlet density on violence, harm to others, and drink-driving fatalities <sup>62</sup>	2
Days and hours of sale	Effective—reviews noted consistent evidence that increases in days and hours of sale increase consumption and harm, and that reductions in days and hours of sale reduce consumption and harm <sup>45,63</sup>	3
<b>Addressing the marketing of alcohol beverages</b>		
Volume of advertising	Effective—an SR of 13 studies noted an effect of advertising on youth initiation and heavier drinking among current users. <sup>64</sup> An MA of 322 estimated advertising expenditure elasticities detected a positive effect of advertising on consumption (coefficient 0.029) <sup>65</sup>	1
Self-regulation of alcohol marketing	No evidence for effectiveness. Studies show that self-regulation does not prevent types of marketing that can affect young people <sup>66</sup>	5

(Continues on next page)

Evidence of effect		Level of evidence
(Continued from previous page)		
<b>Pricing policies</b>		
Alcohol taxes	Effective—an MA of 132 studies noted a median price elasticity for all beverage types of $-0.52$ in the short term and $-0.82$ in the long term, elasticities being lower for beer than for wine or spirits. <sup>65</sup> An MA of 112 studies noted mean price elasticities of $-0.46$ for beer, $-0.69$ for wine, and $-0.80$ for spirits. <sup>67</sup> Increasing taxes reduce acute and chronic alcohol-related harms. <sup>68</sup> Setting minimum prices can reduce acute and chronic harms <sup>69</sup>	1
<b>Harm reduction</b>		
Training of bar staff, responsible serving practices, security staff in bars, and safety-oriented design of the premise	Little effectiveness. An SR detected little effect unless backed up by police enforcement and licence inspectors <sup>70</sup>	2
<b>Reducing the public health effect of illegally and informally produced alcohol</b>		
Informal and surrogate alcohols	Some experience from reducing alcohol-related harm, by, for example, not allowing methanol to be used as denaturing agent <sup>29</sup>	5
Strict tax labelling	Some evidence of effectiveness drawn from other psychoactive substances (tobacco) <sup>21</sup>	5
Levels of evidence: 1=more than one systematic review; 2=one systematic review; 3=two or more randomised controlled trials; 4=one randomised controlled trial; 5=observational evidence; 6=not assessed. SR=systematic review. MA=meta-analysis. RR=risk ratio. RCT=randomised controlled trial.		
<b>Table 1: Summary of effect of policy measures, with level of evidence ranked according to availability of evidence</b>		

the risk of cancers of the oral cavity and pharynx, oesophagus, stomach, colon, rectum, and breast in a linear dose-response relation,<sup>21</sup> with acetaldehyde as a potential pathway.<sup>22</sup> Alcohol has a bifurcated relation with coronary heart disease. In low and apparently regular doses (as little as 10 g every other day), alcohol is cardioprotective,<sup>23</sup> although doubt remains about the effect of confounders.<sup>24</sup> At high doses, especially when consumed irregularly, it is cardiotoxic.<sup>25</sup>

The risk of a lifetime attributable death from a chronic alcohol-related disease increases linearly from zero consumption in a dose-response manner with the volume of alcohol consumed;<sup>26</sup> death from an acute alcohol-related disease increases from zero consumption in a dose-response manner with frequency of drinking, and rises exponentially with the amount drunk on an occasion.<sup>27</sup> Surrogate<sup>28</sup> and illegal<sup>29</sup> alcohols can bring an extra health risk from high ethanol concentrations and toxic contaminants, compounded by social marginalisation.<sup>30</sup>

Ecologically there is a very close link between a country's total alcohol per head consumption and its prevalence of alcohol-related harm<sup>31</sup> and alcohol dependence,<sup>32</sup> implying that when alcohol consumption increases, so does alcohol-related harm and the proportion of people with alcohol dependence and vice versa. Heavy episodic drinking patterns are more common in poorer than in richer drinking populations, and are largely responsible, for example, for alcohol's contribution to the differences in life expectancy between eastern and western Europe.<sup>33</sup>

As noted in the first paper in this Series, less than half the world's adult population drinks alcohol, with abstinence rates being highest in low-income countries and populations.<sup>1,34</sup> Much of the variation in per head alcohol consumption between countries and regions of the world indicates differences in abstinence rates; among drinkers there is less variation in alcohol

consumption. The effect of the present economic recession on alcohol-related harm is uncertain. On the one hand, if income falls,<sup>35</sup> particularly for the lower-middle class, then alcohol consumption and thus alcohol-related harm is likely to decrease; on the other hand, social dislocation<sup>36</sup> as a result of the economic recession is likely to increase alcohol-related harm, independent of changes in overall consumption. If, in the long term, affluence increases, especially in some of the most populous areas of the world in southeast Asia and the western Pacific, global alcohol-related harm will increase, compounded by the fact that, independently, the major diseases that are alcohol-related are rising.<sup>37</sup>

### Effectiveness of alcohol policies

Alcohol policies have been defined as sets of measures aimed at keeping the health and social harms from the use of alcohol to a minimum.<sup>38</sup> There are also a variety of other policies that can reduce or increase alcohol-related problems, but which are not normally described as alcohol policies, since they are not implemented specifically to reduce alcohol-related harm as a primary aim—eg, general road safety measures. Much of the published work to establish the effectiveness of alcohol policies has been done in high-income societies, although some policies have been assessed in low-income countries.<sup>39</sup>

The general principles on which particular strategies for alcohol policy work are fairly well understood, and these principles can often be applied across societies. For example, measures to counter drink-driving are premised on a general deterrence effect, and taxes on alcoholic beverages are premised on affecting consumer demand by increasing the cost relative to alternative spending choices. Thus, the fact that there is a conceptual framework and theory of action underlying alcohol policies, and that these principles generally operate

across societies, suggest that research findings from one society will have applicability in another.<sup>38</sup>

Although alcohol policy measures can substantially affect alcohol consumption and alcohol-related harm, several other contextual factors also have a role. For example, in the southern European Mediterranean countries there were large decreases in wine consumption that predated alcohol policies and prevention programmes. These decreases were largely consequent on urbanisation, shifts to factory and service work, and changes in family structure and de structuring of meals, supported in more recent years by increased health consciousness and alcohol policies.<sup>40</sup> Conversely, alcohol consumption has increased in several low-income countries in southeast Asia, where abstention rates have been traditionally high and where a rise in alcohol consumption has implied an increase in the proportion of the population that are drinkers. The rising consumption in these countries is probably an indicator of economic and social development and increases in consumers' purchasing power, as well as increases in the marketing of branded alcoholic beverages.<sup>38</sup>

This paper reviews the effect of alcohol policy for the nine policy target areas included in the report by WHO to the 2008 World Health Assembly,<sup>41</sup> which are summarised in table 1.

#### Target area 1: information and education

Provision of information and education is important to raise awareness and impart knowledge; however, in an environment in which many competing messages are received in the form of marketing and social norms supporting drinking, and in which alcohol is readily accessible, it does not lead to sustained changes in behaviour. Many systematic reviews have assessed school-based education and concluded that classroom-based education is not an effective intervention to reduce alcohol-related harm.<sup>42</sup> Although some evidence suggests a positive effect on increased knowledge about alcohol and on improved alcohol-related attitudes, evidence for a sustained effect on behaviour is scarce. Parenting<sup>43</sup> and social marketing<sup>44</sup> programmes have mixed effects. The little research that is available has shown that industry-funded educational programmes tend to lead to positive views about alcohol and the alcohol industry.<sup>72,73</sup>

Generally, public information campaigns are ineffective in reducing alcohol-related harm.<sup>45</sup> The effects of counter-advertising—a variant of public information campaigns that provides information about a product, its effects, and the industry that promotes it, to decrease its appeal and use—are inconclusive.<sup>45</sup> No rigorous assessments of whether or not publicising drinking guidelines have any effect on alcohol-related harm have been done.

Assessment of the effect of mandated health warnings on alcohol product containers does not show that exposure produces a change in drinking behaviour,

although some intervening variables are affected, such as intention to change drinking patterns.<sup>46</sup> These results contrast with those for tobacco, for which evidence does suggest an effect; however, this evidence could be an indicator of the nature of the warning labels, since the introduction of more graphic and larger warnings for cigarettes, with alternating messages, has affected behaviour.<sup>74</sup> Nevertheless, warning labels are important to help establish a social understanding that alcohol is a hazardous commodity.

#### Target area 2: health-sector response

Brief advice is the most effective evidence-based treatment method. Extensive evidence from systematic reviews and meta-analyses from a range of health-care settings in different countries has shown the effectiveness of early identification and brief advice for people with hazardous and harmful alcohol use but who are not severely dependent. Furthermore, evidence suggests that more intensive brief interventions are no more effective than are less intensive interventions.<sup>47</sup> Such evidence-based technologies are being implemented and assessed in demonstration programmes in both high-income and low-income countries, with an increasing evidence base for effective implementation strategies.<sup>48</sup>

For individuals with severe alcohol dependence and related problems, many specialised treatment approaches have been assessed, with evidence of an effect for reducing the harm of alcohol withdrawal,<sup>50</sup> behavioural therapies,<sup>49</sup> and pharmacological therapies including glutamate inhibitors<sup>51</sup> and opiate antagonists.<sup>52</sup> Babor and Del Boca<sup>75</sup> have shown that matching individuals with alcohol-use disorders to specified treatments does not improve outcomes.

#### Target area 3: community programmes

Community-based programmes include education and information campaigns, media advocacy, counter-advertising and health promotion, controls on selling and consumption venues, and other regulations reducing access to alcohol, enhanced law enforcement and surveillance, and community organisation and coalition development.<sup>76</sup> Evidence suggests that media advocacy can lead to reframing the solution to alcohol-related problems in terms of a coordinated approach by relevant sectors, such as health, enforcement, non-governmental organisations, and municipal authorities, resulting in increased attention to alcohol on political and public agendas.<sup>45</sup>

Interventions that have controlled access, which have included the environmental contexts of selling and distribution and which have involved enforcement, are effective in reducing alcohol-related traffic fatalities and assault injuries.<sup>53</sup> A community intervention project in the Northern Territory in Australia aimed to reduce higher levels of alcohol-related harm to national levels by use of a range of strategies, including a levy on alcoholic

beverages with more than 3% alcohol to fund education, increased controls on alcohol availability, and expanded treatment and rehabilitation services. The intervention led to a significant preferential reduction in acute alcohol-related deaths and to a non-significant reduction in chronic alcohol-related deaths in the Northern Territory compared with the control areas, largely due to the tax levy.<sup>77</sup> Some evidence also suggests that workplace programmes can change drinking norms and reduce harmful drinking.<sup>54</sup>

#### Target area 4: drink-driving policies

Many alcohol policy measures can reduce alcohol-related road traffic fatalities, including increased prices of alcohol, minimum purchase age laws, and outlet density, supported by mass media campaigns.<sup>78</sup> Implementation of effective drink-driving policies can lead to public and political commitment for such measures, emphasising lessons for the progressive implementation of other policy measures to reduce the harm done by alcohol, such that implementation often leads to increased public support for the implemented policy.<sup>79</sup>

Establishment of a legal concentration of alcohol in the blood and lowering it is effective in reducing drink-driving casualties.<sup>55</sup> Intensive random breath-testing, by which police regularly stop drivers at random to check the concentration of alcohol in their blood, and sobriety checkpoints, at which all vehicles are stopped and drivers suspected of drink-driving are breath tested, reduce alcohol-related injuries and fatalities.<sup>56</sup> There is evidence for some effectiveness of setting low concentrations of alcohol in the blood, including a zero level, for young or novice drivers;<sup>56</sup> of administrative suspension of the driver's licence for a driver caught over the limit,<sup>56</sup> mandatory treatment,<sup>57</sup> and the use of an ignition interlock (a mechanical device that does not allow a car to be driven by a driver who is over the limit) for repeat drink drivers;<sup>58</sup> and evidence for no effect of designated driver schemes.<sup>59</sup>

#### Target area 5: addressing the availability of alcohol

Although total bans on the sale of alcohol exist in several countries with large Muslim populations, and at the community level in several indigenous communities, there are also other widely dispersed bans for the use of alcohol in particular locations, circumstances, or statuses—eg, drinking in parks or streets, hospitals, or at the workplace. Government monopolies for the sale of alcohol can reduce alcohol-related harm;<sup>60</sup> such systems tend to have fewer stores, which are open for shorter hours than systems of private sellers. Without government monopolies, having a licensing system for the sale of alcohol allows for control, since infringement of laws can be met by licence revocation; however, an introduction of a licensing system, with fees generated from licences, can lead to a proliferation of licensed establishments as a mechanism to generate income for jurisdictions.

Implementation of laws that set a minimum age for the purchase of alcohol show clear reductions in drink-driving casualties and other alcohol-related harms;<sup>61</sup> the most effective means of enforcement is on sellers, who have a vested interest in retaining the right to sell alcohol.

Urban settings can also be risk factors for harmful alcohol use and harmful patterns of drinking, especially in areas of low social capital.<sup>80</sup> An increased density of alcohol outlets is associated with increased amounts of alcohol consumption among young people,<sup>81</sup> with increased numbers of assault, and with other harms such as homicide, child abuse and neglect, self-inflicted injury, and, with less consistent evidence, road traffic accidents.<sup>62,82</sup> Although extending times of sale can redistribute the times when many alcohol-related incidents occur, such extensions generally do not reduce rates of violent incidents and often lead to an overall increase in consumption and problems.<sup>63</sup> A reduction of the hours or days of sale of alcoholic beverages leads to fewer alcohol-related problems, including homicides and assaults (panel 1).<sup>83</sup>

Strict restrictions on availability can create an opportunity for an illicit market; but, in the absence of substantial home or illicit production, in most circumstances such restrictions can be managed with enforcement. Where a large illicit market exists, licence-enforced restrictions can increase the competitiveness of the alternative market, which needs to be considered during policy making.

#### Target area 6: addressing the marketing of alcoholic beverages

Alcohol is marketed through increasingly sophisticated advertising in mainstream media, and through linking alcohol brands to sports and cultural activities, through sponsorships and product placements, and through direct marketing such as the internet, podcasting, and mobile telephones. Econometric studies of the link between alcohol advertising and consumption have noted only weak interactions,<sup>65</sup> largely because of methodological difficulties.<sup>84</sup> The strongest evidence, however, comes from longitudinal studies that have shown an effect of various forms of alcohol marketing—including exposure to alcohol advertising in traditional media and promotion in the form of movie content and of alcohol-branded merchandise—on initiation of youth drinking, and on riskier patterns of youth drinking.<sup>64</sup> These findings are supported by those from experimental studies.<sup>85</sup> The effects of exposure seem cumulative and, in markets with greater availability of alcohol advertising, young people are likely to continue to increase their drinking as they move into their mid-20s, whereas drinking decreases at an earlier age in people who are less exposed to it. In some jurisdictions, alcohol marketing relies on self-regulation implemented by economic operators, including advertising, media, and alcohol producers. However, evidence from several studies shows that these voluntary systems do not prevent marketing content that affect young people.<sup>66</sup>

### Target area 7: pricing policies

Drinkers respond to changes in the price of alcohol as they do to changes in the price of other consumer products. When other factors are held constant, such as income and the price of other goods, a rise in alcohol prices leads to less alcohol consumption and less alcohol-related harm (and vice versa) in both high-income<sup>65,86</sup> and low-income countries.<sup>87,88</sup> Demand for alcohol is fairly inelastic to price, such that an increase in price results in a drop in consumption that is smaller than the price increase (elasticity measures how much alcohol consumption changes when the price changes: price elastic means that the percentage change in price, and inelastic that the percentage change in consumption, is less than the percentage change in price). Thus, increasing alcohol taxes not only reduces alcohol consumption and related harm, but also increases government revenue at the same time, noting that alcohol taxes are generally well below their maximum revenue-producing potential and that collected revenue is usually well below the social costs of alcohol.<sup>63</sup> The existence of a substantial illicit market for alcohol complicates policy considerations for alcohol taxes;<sup>88</sup> in such circumstances, tax changes are needed to bring the illicit market under effective government control—eg, taxation policies that increase the attractiveness of lower alcohol-content forms of culturally preferred beverages, such as decreased rates of taxation on low-strength beer. Additionally, enforcement needs to be much stronger, including the closure of illegal factories and after-hours production, and the use of tax stamps to record that duty has been paid on informal products. Beverage elasticities are generally lower for the preferred beverage (beer, spirits, or wine) in a particular market than for the less-preferred beverages,<sup>86</sup> and tend to decrease with increased levels of consumption.<sup>67</sup>

Controlling for overall consumption, beverage preferences, and time period, consumer responses to changes in the price of alcoholic beverages do not vary by country.<sup>67</sup> If prices are raised, consumers reduce overall consumption and tend to change to cheaper beverages, with heavier drinkers tending to buy the cheaper products within their preferred beverage category. The effect of an increase in alcohol price tends to be stronger in the long rather than the short term, which is important from a public health perspective.<sup>65</sup> Policies that increase alcohol prices delay the start of drinking, slow young people's progression towards drinking large amounts, and reduce young people's heavy drinking and the volume of alcohol consumed per occasion.<sup>68</sup> Price increases reduce the harms caused by alcohol<sup>89</sup> and alcohol dependence.<sup>90</sup> Setting a minimum price per unit gram of alcohol is modelled to reduce consumption and alcohol-related harm.<sup>69</sup> Price increases and a set minimum price are both estimated to have a much greater effect on heavier than on lighter drinkers, with modest or only small extra financial cost to lighter

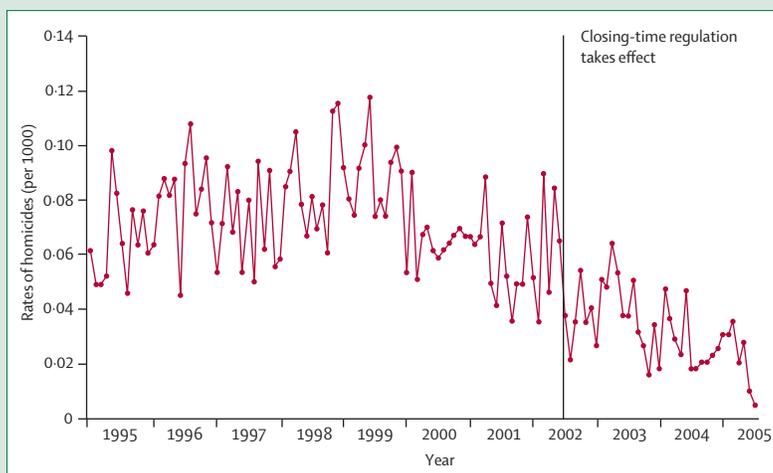
drinkers.<sup>69</sup> Natural experiments in Europe consequent to economic treaties have shown that as alcohol taxes and prices were lowered, so sales, alcohol consumption, and alcohol-related harm have usually increased (panel 2).<sup>35</sup>

### Target area 8: harm reduction

The relation between drinking and alcohol-related harm can be both affected and mediated by the physical and social context of drinking and by the succeeding contexts while the drinker is intoxicated.<sup>94</sup> Some evidence suggests that safety-oriented design of the premises<sup>95</sup> and the employment of security staff, partly to reduce potential violence, can reduce alcohol-related harm. Additionally, some evidence suggests that the use of drinking glasses with toughened glassware, which cannot be used as a weapon, does not reduce alcohol-related harm.<sup>70</sup> Although interventions modifying the behaviour of people serving alcohol and of door and security staff are ineffective on their own,<sup>70</sup> they can be effective with enforcement by police or liquor licence inspectors.<sup>96</sup> Interventions to reduce harm are important, since the problems potentially averted commonly harm people other than the drinker, including the consequences of drink-driving and violence.

#### Panel 1: Reduction of homicide rate in Diadema, Brazil

Homicide is one of the leading causes of death in Brazil, with one of the highest murder rates occurring in the Brazilian city of Diadema. To respond to this situation, local policy measures were introduced, including a new licensing law in 2002 prohibiting on-premises alcohol sales after 2300 h. To assess the effect on restricting alcohol availability through limiting opening hours on homicides and violence, data from the local police archives on homicides and assaults were analysed. Models were adjusted for contextual conditions, municipal efforts, and law enforcement interventions that took place before and after the closing-time law was adopted. The figure, taken from the study by Duailibi and colleagues,<sup>93</sup> shows the monthly rates of homicide per 1000 residents from 1995–2005 in Diadema. Introduction of a limit on opening hours substantially dropped homicide rates in Diadema and led to a 44% decrease in murders.



**Figure:** Rate of homicide in Diadema, Brazil, between 1995 and 2005

Homicide rate for July, 2005, is based on a half month of data. Reproduced with permission from the American Public Health Association.<sup>93</sup>

### Panel 2: Alcohol taxes and cross-border trade in Europe

The European Union (EU) introduced a single market for alcohol in 1993, resulting in substantial cross-border trade and tax competition between countries, and thus lower tax rates than would have occurred without a single market. Finland, which joined the EU in 1995, was given until 2003 to continue to restrict alcohol imports. After this time, alcohol imports were expected to increase heavily, not only because of the opening borders but also because neighbouring Estonia, well known for its low alcohol prices, was scheduled to join the EU in 2004. Therefore, the Finnish Government decided to lower the alcohol taxes; on March 1, 2004, the alcohol excise duty rate was lowered by an average of 33% to prevent excessive imports and thereby losses in alcohol tax revenues.<sup>91</sup> The tax decrease was the greatest on distilled spirits (-44%), and was more moderate on wines (-10%) and beer (-32%). In 2004, both importation of alcohol from Estonia and retail sales of alcohol in Finland increased. Retail monopoly sales of alcohol in March, 2004, were 50% higher than in March, 2003. The total consumption of alcohol per head increased by 10%, from 9.4 L in 2003 to 10.3 L in 2004, with recorded consumption increasing by 6.5%, from 7.7 L to 8.2 L per head, and unrecorded—and thus untaxed—consumption by an estimated 25%, from 1.7 L to 2.1 L per head. The recorded consumption of spirits increased by 18%, but the increase in sales did not cancel out the effects of the tax cuts on tax revenues. The health effect associated with Estonia joining the EU was not statistically significant, but the effect of alcohol tax cuts in March, 2004, was significant, resulting in an estimated eight additional alcohol-positive deaths per week—a 17% increase compared with the weekly average of 2003,<sup>92</sup> with the largest number of deaths occurring in people who were underprivileged.<sup>93</sup> In response to the worsening situation, alcohol taxes were raised in Finland at the beginning of 2008 by an average of 11.5%. This case study shows, as was the experience with tobacco, that cross-border issues are not solved by decreasing taxes.

#### Target area 9: reducing the public health effect of illegally and informally produced alcohol

Unrecorded alcohol—defined as informally produced alcohols, illegally produced or smuggled alcohol products, and surrogate alcohol that is not officially intended for human consumption (mouthwash, perfumes, and eau-de-cognes)—could have health consequences because they have a high ethanol content and could be contaminated with methanol and lead, for which many poisoning outbreaks and fatalities have been recorded internationally, and possibly contaminated with some higher alcohols, which have been attributed to higher rates of alcoholic liver disease.<sup>28,29</sup> The complete removal of methanol from denatured spirits is probably the greatest measure to reduce morbidity and mortality attributable to methanol. Some countries, including Australia, have abolished the use of methanol to denature alcohol, with a subsequent substantial reduction in toxic effects.<sup>29</sup> Many European countries do not allow methanol (or methanol-containing wood alcohol) to be used as a denaturing agent.<sup>29</sup> For cosmetics, perfume oils that are part of the formula can be used as a denaturing agent. Other surrogate alcohols—eg, those for automobile products—could be treated with bittering agents to avoid consumption. Rigorous control of selling of medicinal alcohol and the selling of only small container sizes has reduced potential harm from medicinal alcohols in Nordic countries.<sup>29</sup> Illegally traded

alcohol can be a health risk either from contamination during the trading process or because it is cheaper than legal alcohol, thus leading to higher consumption. The experience with tobacco smuggling<sup>71</sup> would suggest that the widespread introduction of tax stamps recording that duty has been paid, which have been previously used and which are now being re-introduced in several countries, together with electronic movement and surveillance systems to track the trade of alcohol, could reduce illegal trade.

#### Cost and cost-effectiveness of alcohol policies

The effect of harmful use of alcohol extends beyond the direct health-related consequences to drinkers (mortality and morbidity effects) to a broader set of social costs, including criminal damage, violence, and lost productivity in the workplace. Documentation of these social costs is important in itself, because the negative spill over effects (or so-called externalities) imposed on society as a result of the private consumption of alcohol represent instances of market failure, which is a central justification for government intervention and action. Studies of social costs have been done in many countries,<sup>1</sup> and the proportion of these costs that are avoidable via the implementation of cost-effective and effective policy measures has been estimated for a small subset.<sup>97</sup> Improved understanding of which measures or strategies represent best use of society's resources—and by how much they can reduce the harmful consequences of alcohol use—is directly relevant to an evidence-based approach to alcohol policy, planning, and assessment.

Building on the review of alcohol policy measures discussed previously, in this section we match international evidence for the cost-effectiveness of specific interventions against the various target areas for action. The primary data source is an earlier WHO analysis of the health costs and effects of population as well as individual-based measures for countering hazardous alcohol use in WHO regions,<sup>98</sup> which have been updated for this review. Specifically, population-level costs associated with the implementation of interventions, including legislation, enforcement, administration, and training costs, plus inpatient and outpatient services, have been updated from 2000 to 2005 international dollar prices, and now include estimates for school-based education and mass media awareness campaigns. (An international dollar [I\$] has the same purchasing power as the US dollar has in the USA and is used as a means of translating and comparing costs from one country to the other with a common reference point, the US\$.) Intervention health effects—expressed in disability-adjusted life-years (DALYs) saved, relative to an epidemiological situation of no alcohol control measures in the population—were also updated to reflect demographic change in regional populations since 2000, and have been extended to include the effect of a sustained campaign of tax enforcement on reducing amounts of unrecorded production and consumption. Despite these

updates, the analysis continues to rely on many sources of epidemiological and economic data, and assumes that estimates of effect size reported in international published work—eg, with respect to comprehensive advertising bans or roadside breath-testing of drivers—have applicability beyond their original context. Therefore results need to be interpreted with these caveats in mind. Furthermore, non-health effects of alcohol policy measures, such as reduced damage to property or enhanced work productivity, are not included in the analysis.

The results shown in table 2 are provided for three culturally and geographically distinct WHO reporting subregions in which alcohol use poses a substantial public health problem: countries of the Americas region with low child and adult mortality (eg, Brazil, Mexico); countries of the European region with low child mortality but high adult mortality (eg, Russia, Ukraine); and countries of the western Pacific region with low child and adult mortality (eg, China, Vietnam). Because evidence on which to undertake modelling is scarce, no quantitative estimates of cost or effectiveness were made for specific interventions relating to target areas 8 and 9 (harm reduction and reduction of illegal production).

For target areas 1 and 3 (information and education, and community action), we estimated the costs of school-based education and mass-media awareness campaigns, respectively. Although these interventions are not expensive (I\$0·20–0·80 per year per person in the population across the three geographical settings considered here), they do not notably affect consumption levels or health outcomes. Such interventions are therefore not effective or cost-effective strategies to pursue to reduce health-related harm due to alcohol use (especially since other actionable strategies exist that are very cost effective).

For target area 2, the health-sector response, brief interventions for hazardous alcohol use have been greatly studied. Compared with the situation of no alcohol control policies, the cost-effectiveness of such interventions (in the range of I\$2000–4000 per DALY saved in the three subregions) is not as favourable as is the population-level policy instruments because they involve direct contact with health-care professionals and services. For alcohol dependence—a disease entity in its own right—the relative cost-effectiveness of pharmacological agents (such as acamprosate and

	Coverage	WHO subregion					
		Americas (eg, Brazil, Mexico)		Europe (eg, Russia, Ukraine)		Western Pacific (eg, China, Vietnam)	
		Yearly cost per head (I\$)*	Cost per DALY saved (I\$)†	Yearly cost per head (I\$)*	Cost per DALY saved (I\$)†	Yearly cost per head (I\$)*	Cost per DALY saved (I\$)†
<b>Target area 1: raising awareness and political commitment</b>							
School-based education	80%	0·29	NA‡	0·34	NA‡	0·53	NA‡
<b>Target area 2: health-sector response</b>							
Brief interventions for heavy drinkers	30%	1·04	3870	1·78	2671	0·42	2016
<b>Target area 3: community action</b>							
Mass media campaign	80%	0·31	NA‡	0·79	NA‡	0·19	NA‡
<b>Target area 4: drink-driving policies and countermeasures</b>							
Drink-driving legislation and enforcement (via random breath-testing campaigns)	80%	0·44	924	0·72	781	0·24	1262
<b>Target area 5: addressing the availability of alcohol</b>							
Reduced access to retail outlets	80%	0·24	515	0·47	567	0·16	1307
<b>Target area 6: addressing marketing of alcohol beverages</b>							
Comprehensive advertising ban	95%	0·24	931	0·47	961	0·16	955
<b>Target area 7: pricing policies</b>							
Increased excise taxation (by 20%)	95%	0·34	277	0·67	380	0·20	1358
Increased excise taxation (by 50%)	95%	0·34	241	0·67	335	0·20	1150
Tax enforcement (20% less unrecorded)	95%	0·56	468	0·87	498	0·37	2603
Tax enforcement (50% less unrecorded)	95%	0·63	476	0·93	480	0·43	2733
<b>Combination strategy</b>							
Brief advice, random breath-testing, reduced access, advertising ban, plus increased tax (by 50%) and its enforcement (50% less unrecorded consumption)	..	2·35	691	4·10	754	1·31	1704

\*Implementation cost in 2005 international dollars (I\$). †Cost-effectiveness ratio, expressed in international dollars per disability-adjusted life-year (DALY) saved for the year 2005. ‡Not applicable (NA) because effect size not significantly different from zero (cost-effectiveness ratio would therefore approach infinity).

**Table 2: Cost and cost-effectiveness of interventions relating to different target areas for alcohol public health policy**

**Panel 3: Six key policy approaches for countries in which alcohol is normally available**

- 1 Minimum tax rates for all alcoholic beverages, at least proportional to alcoholic content, should be introduced and increased regularly in line with inflation. In countries with high levels of unrecorded production and consumption, initial focus should be to increase the proportion of unrecorded alcohol that is taxed, rather than to increase overall alcohol taxes.
- 2 Government monopolies for the retail sale of alcohol should be introduced or maintained with a minimum age of purchase of 18–21 years. When government monopolies are not feasible, a licensing system should be introduced with restrictions on outlet density and days and hours of sale to manage the level of alcohol-related harm.
- 3 A ban on direct and indirect alcohol advertising.
- 4 Legal concentrations of alcohol in the blood for drivers should be introduced, with a phased reduction to 0.5 g/L and eventually to 0.2 g/L, with visible enforcement through random and systematic checks.
- 5 Widespread simple help for hazardous and harmful alcohol consumption should be made available through primary-care facilities, supported by more intensive help for alcohol dependence.
- 6 Educational programmes should not be implemented in isolation as an alcohol policy measure, or with the sole purpose of reducing the harm caused by alcohol, but rather as a measure to reinforce awareness of the problems created by alcohol and to prepare the ground for specific interventions and policy changes.

naltrexone) has yet to be assessed in these regions of the world.

For drink-driving policies and countermeasures (target area 4), there is good evidence from high-income countries for the effectiveness of drink-driving laws and their enforcement via roadside breath-testing and checkpoints. With the assumption that reported effect sizes from high-income study settings could be realised elsewhere, the estimated cost per DALY saved of such countermeasures across the three WHO subregions assessed here ranged from I\$762 in eastern Europe to I\$1264 in the western Pacific.

The effect of reducing access to retail outlets for specified periods of the week and implementation of a comprehensive advertising ban (which are specific interventions relating to target areas 5 and 6, addressing the availability and marketing of alcoholic beverages, respectively) have the potential to be very cost-effective countermeasures, but only if they are fully enforced (every healthy year of life restored costs between I\$500 and I\$1000).

Within the category of pricing policies (target area 7), consistent evidence shows that the consumption of alcohol is responsive to an increase in final price, which can be effectuated via higher excise taxes on alcoholic beverages. Tax increases (of 20% or even 50%) represent a highly cost-effective response in countries with a high prevalence of heavy drinking (eg, every DALY saved costs less than I\$500 in both Latin American and eastern European settings). In lower-prevalence contexts—including the western Pacific subregion, where alcohol use in girls and women is relatively infrequent—population-level effects fall and cost-effectiveness ratios

rise accordingly. The effect of increases in alcohol tax stands to be mitigated by illegal production, tax evasion, and illegal trading, which accounts for roughly a third of all consumption in the three subregions considered here (and up to 80% in some subregions of Africa and southeast Asia). Reduction of this unrecorded consumption (by 20–50%) via concerted tax-enforcement strategies is estimated to cost 50–100% more than a tax increase but produces similar levels of effect, at least in the three subregions examined in this paper. In settings with high levels of unrecorded production and consumption such as India, increasing the proportion of consumption that is taxed (and therefore more costly to the price-sensitive consumer) could be a more effective pricing policy than a simple increase in excise tax (which might only encourage further illegal production, smuggling, and cross-border purchases).

Specific intervention strategies are not implemented in isolation, but should be combined to maximise possible health gains up to the point at which it remains affordable to do so. The best possible mix of interventions at different spending limits will depend on the relative cost and cost-effectiveness of the individual components, and on the interactions that exist between them. Table 2 includes an example of a wide-ranging combination strategy, showing that although cost-effectiveness is maintained, implementation costs naturally rise.

**Implications for policy development**

A main goal of alcohol policy is to promote public health and social wellbeing. Additionally, policy can address market failures by deterring children from using alcohol, protecting people other than drinkers from the harm caused by alcohol, and providing all consumers with information about the effects of alcohol. Further, the notion of stewardship implies that liberal states have a duty to look after important needs of people individually and collectively.<sup>99</sup> It emphasises the obligation of states to provide conditions that allow people to be healthy and, in particular, to take measures to reduce health inequalities. The stewardship-guided state recognises that a primary asset of a nation is its health: higher levels of health are associated with greater overall wellbeing and productivity.<sup>100</sup> Panel 3 summarises six key policy approaches for countries in which alcohol is normally available.

Most of the evidence for effective alcohol policy comes from either Anglophone or Scandinavian countries, in which alcohol use is commonly characterised by low rates of abstinence and fairly high rates of heavy episodic drinking. Many of these societies have had a tradition of government regulation of the sale of alcohol,<sup>101</sup> and adoption of evidence-based alcohol policies is often a matter of recovering a lost policy tradition that has been abandoned in the face of the deregulatory phase of the past three or so decades.

The situation is very different in many low-income countries, where there is often little or no tradition of alcohol regulation by government, where the alcohol industry is attempting to expand its markets, and where few civil society organisations are attempting to reduce alcohol-related harm.<sup>2,39</sup> In such countries, there is a need to build public health infrastructures for alcohol policy, appoint governmental officials responsible for prevention of and management of alcohol-use disorders, provide capacity building in alcohol policy and research, and ensure that knowledge of evidence is introduced into policy and programme practice. Developed policies need to be comprehensive, keeping any negative consequences due to perverse incentives to a minimum.<sup>102</sup> Insufficient transparency and information, poor organisation and preparation for the introduction of new policies and laws, vertically as opposed to horizontally organised government, little financing, the presence of corruption, and public distrust of authority are all impediments to the acceptance, implementation, and enforcement of effective policy.<sup>103,104</sup>

Since there are substantial commercial interests involved in promotion of alcohol's manufacture, distribution, pricing, and sale,<sup>2</sup> the alcohol industry has become increasingly involved in the policy arena to protect its commercial interests, leading to a common claim among public health professionals that the industry is influential in setting the policy agenda, shaping the perspectives of legislators on policy issues, and determining the outcome of policy debates towards self-regulation.<sup>2</sup> Caution has been expressed against the role of industries in trying to do the work of governments, which are the proper guardians of the public interest, and are accountable to all citizens to set goals for regulators, deal with external factors, mediate among different interests, attend to the demands of social justice, and provide public goods and collect the taxes to pay for them.<sup>105</sup> Thus, the responsibilities of the alcohol industry in reduction of the harm caused by alcohol should be related to its product—eg, through commitments to a minimum pricing structure, and commitments to support reductions in illegally traded alcohol.

As will be discussed in more detail in the third paper in this Series,<sup>2</sup> to be effective, alcohol policy must also allow an expression of voice (the capacity of individuals to influence the decisions that shape their lives) from civil society to counteract the vested trade interests, which often dominate political decision making.<sup>106</sup> Non-governmental organisations are important partners for all elements of alcohol policy; they are an essential component of a modern civil society, raise people's awareness of issues and their concerns, advocate change, and create a dialogue on policy.<sup>107</sup>

Finally, effective alcohol policies can be eroded by international trade, trade agreements, and cross-border issues.<sup>108,109</sup> For example, substantive evidence suggests

that the introduction of a single market for alcohol in the European Union in 2003 resulted in substantial tax competition between countries, and thus lower tax rates than would have occurred without a single market (panel 2).<sup>110</sup>

## Conclusions

A substantial evidence base exists for the effectiveness of different policies in reducing the harm caused by alcohol. Essentially, policies that regulate the environment in which alcohol is marketed (economic and physical availability and commercial communications) are effective in reducing alcohol-related harm. Enforced legislative measures to reduce drink-driving are effective, as are individually-directed interventions to drinkers already at risk. However, the evidence shows that information and education type programmes do not reduce alcohol-related harm; nevertheless, they have an important role in providing information, and in increasing attention and acceptance to alcohol on the political and public agendas.

Addition of a cost component to health impact assessment allows the opportunity to identify alcohol prevention and control strategies that offer greatest (or worst) value for money. For example, devotion of scarce resources to interventions that do not discernibly reduce the harm caused by alcohol, as seen for information and education, is not economically rational and serves only to divert resources away from efficient prevention or control strategies. Conversely, taxation policies cost fairly little to implement but reap substantial health returns. In the three WHO subregions represented in this paper, all the population-based interventions represent a cost-effective use of resources (against the international benchmark of per head income), and compare favourably with treatment strategies for disease and injury that could in fact result from harmful alcohol use (eg, cirrhosis of the liver, depression, trauma care for people injured by alcohol-impaired drivers). Brief interventions for the treatment of individual high-risk drinkers also compare favourably with such treatment strategies, but are evidently harder to scale-up because of their associated training and manpower needs.

The presence of an evidenced-based alcohol policy, although important, is not enough. Policy needs to be implemented, assessed, and refined. Furthermore, alcohol is the only major dependence-producing psychoactive substance causing substantial harm to health, and globally it is the most often used psychoactive substance. However, at present alcohol is not covered by an international treaty. The extent to which this omission should be rectified will be discussed in the third paper in the Series.<sup>2</sup>

## Contributors

All authors have participated in the preparation of this paper, and have seen and approved the final version.

**Conflicts of interest**

We declare that we have no conflicts of interest.

**Acknowledgments**

We thank Robert Beaglehole for his sustained support and contribution throughout the whole process of preparing the paper; Sally Casswell, Jürgen Rehm, and Robin Room for their inputs during various stages of the preparation of the paper; and four anonymous reviewers for their very helpful and constructive comments. The views expressed in this paper are solely the responsibility of the named authors and do not necessarily reflect the decisions or stated policy of the WHO or its member states.

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# Reducing and preventing alcohol misuse and its consequences: A Grand Challenge for social work

Article in *The International Journal of Alcohol and Drug Research* · July 2016

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## Reducing and preventing alcohol misuse and its consequences: A Grand Challenge for social work

Audrey L. Begun<sup>1</sup>, John D. Clapp<sup>1</sup>, and The Alcohol Misuse Grand Challenge Collective<sup>2</sup>

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<sup>2</sup> Listed in Appendix A

*The paper, **Reducing and Preventing Alcohol Misuse and Its Consequences: A Grand Challenge for Social Work**, was originally published online (<http://aaswsw.org/wp-content/uploads/2015/12/WP14-with-cover.pdf>) as a Working Paper developed for the American Academy of Social Work and Social Welfare (AASWSW). The paper was written in response AASWSW's call for papers on Grand Challenges for Social Work. The goal of AASWSW's Grand Challenge initiative was to identify pressing social problems that had the potential to be greatly reduced over the next decade. The hope was to begin a dialogue that would transcend professional and national boundaries. The paper was written to stimulate development of a critical mass among those familiar with the alcohol arena, as well as to introduce the issues and possibilities to leaders and scholars in social work, from other professions/disciplines, and policy makers who do not work in the "alcohol field" per se.*

*As the readers of IJADR recognize, alcohol research and solutions to alcohol misuse are inherently multi-disciplinary. Although we often collaborate across disciplinary lines, individual scholars and our professional organizations are often isolated. The hope of re-printing this invited paper here is to facilitate its distribution and stimulate conversation between alcohol researchers and their peers studying other issues. We encourage you to share it with others. If you or your professional organization is interested in becoming involved in this Grand Challenge please contact, John D. Clapp at [clapp.5@osu.edu](mailto:clapp.5@osu.edu).*

### Abstract

In both the United States and throughout the world, alcohol misuse is associated with high rates of morbidity, mortality, and co-occurring physical and mental health problems. It causes an array of acute and chronic problems and contributes to extensive costs in every sector of society (e.g., health, mental health, education, legal, economic productivity). The scientific discovery, development, and implementation of evidence-informed solutions for alleviating alcohol-related problems are inherently multisectoral, as they affect individuals, families, communities, and larger social systems. The advent of new technologies, research approaches, and intervention strategies has dramatically accelerated positive results in addressing such problems over the past 40 years. Still, alcohol misuse remains a significant global problem, and reducing and preventing its consequences is a Grand Challenge for Social Work. This paper addresses the following points about the challenge: (1) it is large, important, and compelling; (2) it can be analyzed and assessed; (3) demonstrable progress can be made in a decade; (4) multisectoral collaboration is required to meet this challenge; and (5) sustainable solutions to the challenge require significant, transformative, and groundbreaking innovations.

### Background

Alcohol use is tightly woven into the fabric of human history and social life. Early historical references to alcohol-related problems date to 4000 BCE (Hanson, Venturelli, & Fleckenstein, 2015; Howard, Garland, & Whitt, 2013; McGovern, 2009; Singer, 2012). Alcohol use is integrated into celebrations, leisure, sport activities, entertainment, popular culture, and the global economy. Furthermore, alcohol can be beneficial to health and social situations when consumed in moderation. In appropriate contexts, it can reduce stress, enhance social connectedness, and reduce risk of certain medical conditions (e.g., cardiovascular disease, ischemic stroke, diabetes, disability, dementia, osteoporosis) (Gill, Shipley, Hornby, Gill, & Beevers, 1988; Holbrook & Barrett, 1993;

Karlmanngla et al., 2009; Klatsky, 1999; Koppes et al., 2005; Neafsey & Collins, 2011; Sampson, 2003).

*Alcohol misuse* involves drinking in greater quantities or more frequently than is advisable, and may involve drinking in risky situations or circumstances. Alcohol misuse is associated with high rates of morbidity, mortality, and co-occurring physical and mental health problems in the United States and globally. This paper addresses the consequences of alcohol misuse (i.e., deleterious effects on health and safety of individuals, families, and communities) and strategies for reducing and prevention them, making the following points about the challenge: (1) it is large, important, and compelling; (2) it can be analyzed and assessed; (3) demonstrable progress can be made in a decade; (4) multisectoral collaboration is required to meet

this challenge; and (5) sustainable solutions to the challenge require significant, transformative, and groundbreaking innovations.

### **The Challenge Is Large, Important, and Compelling**

Alcoholic beverages are by far the most commonly used and abused of psychoactive substances, and alcohol use has increased over the past decade (Dawson, Goldstein, Saha, & Grant, 2015). According to the 2013 National Survey on Drug Use and Health (SAMHSA, 2014), more than 60 million individuals aged 12 years and older in the United States are estimated to have engaged in past-month binge drinking, and an estimated 16.5 million Americans have engaged in heavy drinking. By comparison, an estimated 24.6 million used illicit drugs or engaged in prescription drug abuse during the past month (SAMHSA, 2014). An estimated 21.6 million (8.2%) of Americans aged 12 years and older experienced a diagnosable substance use disorder during the past year, and alcohol was involved for more than three-quarters of such individuals, either alone or in combination with other substances (SAMHSA, 2014). Considerable gaps exist between the 20.1 million individuals in the United States who need treatment for a substance use disorder and the estimated 2.5 million individuals who received care in a facility specializing in alcohol or other drug treatment (SAMHSA, 2014). Among those who did not receive the care for which they perceived a need, a lack of health coverage for specialized treatment was the most commonly cited barrier (SAMHSA, 2014). In the United States, nationwide cost estimates for 60 major illnesses places alcohol use disorders as the second and drug use disorders as the seventh most costly (Kirschstein, 2000); the cost of untreated alcohol misuse is estimated at \$223.5 billion annually (Research Society on Alcoholism, 2015).

### **Health concerns associated with alcohol misuse**

Alcohol misuse contributes to a wide array of physical and mental health concerns. According to 2012 data from the World Health Organization (WHO), alcohol misuse is attributable to 5.1% of the global burden of disease and injury and about 5.9% of deaths globally (about 3.3 million): “The harmful use of alcohol ranks among the top five risk factors for disease, disability and death throughout the world” (p. 2). Mental and substance abuse disorders are the leading cause of “years lived with a disability” (YDLs) world-wide, with alcohol use disorders accounting for 9.6% of YDLs (Whiteford et al., 2013). Specifically, alcohol misuse is related to the prevalence and incidence of accidental injury, infectious disease exposure (e.g., HIV risk behaviors), and other diseases (e.g., diabetes, hypertension, stomach ulcers, heart attack/failure, liver disease, various forms of cancer) (Nolen-Hoeksema, 2004; Rehm & Hingson, 2013). In the United States, alcohol is among the leading risk factors for mortality and is a recognized contributor to the top 10 causes of death, including heart disease, cancer, stroke, fatal injuries, and suicide (Centers for Disease Control and Prevention, 2014). Alcohol misuse is often found in adults to be comorbid with memory/cognitive impairment and major depressive,

bipolar, and other cognitive and emotional impairments. And, fetal alcohol exposure is associated with an increased risk of neurodevelopmental disorders and birth defects on a spectrum, the most extreme of which may be diagnosed as fetal alcohol syndrome.<sup>1</sup>

### **Social problems associated with alcohol misuse**

Alcohol misuse also is a recognized risk factor for numerous large-scale social problems for which social workers provide assessment, prevention and treatment intervention, programs, and policy recommendations. Examples include the perpetration of intimate partner violence (Maldonado, Watkins, DeLillo, 2015; Peralta, Tuttle, & Steele, 2010), parental child maltreatment (Freisthler & Holmes, 2012), human trafficking (Bhunu & Mushayabasa, 2012; Wiechelt & Shdaimah, 2011), intentional and nonintentional injury (Cunningham et al., 2011), problem gambling (Griffiths, Wardle, Orford, Sproston, & Erens, 2011), school failure (Kelly, 2015), community-level distress (Flynn & Wells, 2013), housing insecurity/homelessness (Kirst, Zerger, Misir, Hwang, & Stergiopoulos, 2015), criminal justice system involvement (Begun, Rose, LeBel, & Teske-Young, 2009), sexual risk taking and unintended pregnancy (Walton et al., 2011; Xaverius, Tenkku, & Salas, 2009), sexual assault (Busch-Armendariz, DiNitto, Bell, & Bohman, 2010), and suicidality (Cherpitel, Borges, & Wilcox, 2004; Kennedy et al., 2015).

### **Alcohol misuse among youth**

Alcohol misuse has proven particularly problematic for youth. Fetal alcohol exposure contributes to a spectrum of preventable birth defects and neurodevelopmental challenges with lifelong implications (Sokol, Delaney-Black, & Nordstrom, 2003; Velasquez, von Sternberg, & Parrish, 2013; Waterman, Pruett, & Caughey, 2013). From a neurobiological perspective, the developing adolescent brain places teenagers at risk for substance misuse given youths’ proclivities towards impulsivity, sensation seeking, and disregard of future outcomes; they also respond more to alcohol’s reward stimuli compared to adults (McLoughlin, Gould, & Malone, 2015). Adolescent alcohol use, especially among preteens, is a serious risk factor for suicidal ideation and suicide attempts in girls and boys; for example, youth who reported an episode of heavy episodic drinking during the past year were significantly more likely to report a suicide attempt than peers who did not (McLoughlin, Gould, & Malone, 2015). In addition, the use of alcohol while feeling depressed is correlated with suicidal behavior among adolescents (McLoughlin, Gould, & Malone, 2015). In terms of health trajectories, early onset of first use of alcohol (for youth aged between 11 and 14 years) significantly increases the risk of an alcohol use disorder later in life; therefore, preventing adolescent alcohol use is a reasonable target for intervention strategies (DeWit, Adlaf, Offord, & Ogborne, 2000). College students and young adults also experience high rates of alcohol-related problems stemming from heavy use patterns and drinking in high-risk contexts (Clapp et al., 2009; Johnston et al., 2010; Reed et al., 2013). Alcohol

<sup>1</sup> See <http://www.cdc.gov/ncbddd/fasd/facts.html>.

poisonings among individuals aged 18 to 24 years, for instance, have increased over 190% over the past two decades (R. Hingson, personal communication, May, 2012).

### The role of social work

- Alcohol misuse is a compelling and critical problem for social work because social workers encounter alcohol misuse in a broad range of practice settings. It directly or indirectly relates to every domain of well-being about which the profession is concerned: achieving basic needs for individuals and families (e.g., housing security), health and safety, social relationships, personal fulfillment/self-actualization, healthy communities and social institutions, social policy, public health, and global relations. This concept paper is focused primarily on the safety and health domains, and emphasizes the complexity of the problems associated with alcohol misuse: Alcohol problems are truly biopsychosocial in nature, which is a core tenet of the social work profession.
- Alcohol misuse is a lifespan issue related to negative developmental consequences of prenatal exposure; abnormal brain development in childhood; family disorganization and child maltreatment; negative physical and social consequences of binge drinking during adolescence and emerging adulthood; and problems that occur during early, middle, and late adulthood involving addiction, alcohol attributable diseases, injury, and medication interactions.
- Alcohol misuse is a problem with multiple political and economic dimensions. It ranges from individuals' internal biological, genetic, physiological, and psychological systems to the interpersonal, group, neighborhood, institutional, regional, national, and global levels.
- It requires multisectoral collaboration to study and develop effective solutions.
- Distinct addressable disparities exist in terms population vulnerabilities, the distribution of the problems associated with alcohol misuse, and access to evidence-informed prevention and treatment services.

For these reasons, social work has a prominent role to play in resolving the Grand Challenge of reducing and preventing negative consequences associated with alcohol misuse.

### The Challenge Can Be Analyzed, Assessed, and Alleviated

Alcohol research includes measures ranging from individual treatment responses at the micro- level (e.g., neuroscience, genomics, epigenetics, proteomics, metabolomics) to macro-level studies (e.g., population-based epidemiology, econometrics, health/human services, policy-level interventions). Contemporary research methodologies for studying alcohol misuse include community-based participatory research studies (CBPR) and rich descriptive approaches (e.g., qualitative, phenomenological, narrative, ethnographic); experimental

(e.g., single system to randomized controlled and comparative effectiveness trials); cost-effectiveness; systematic review; meta-analysis; network analysis; and studies of policy effects at local, state, regional, national, and global levels. Researchers increasingly use systems science (e.g., big data, “big data, small *n*” studies), data analytics, agent-based modeling, and dynamical/computational simulation to study alcohol-related behaviors (Gorman, Mezic, Mezic, & Gruenewald, 2006; Scribner et al., 2009). Investigators leverage emerging technologies to capture real-time data (e.g., ecological momentary assessments, geo-spatial tracking) and microunit data points that can be used to create complex pictures of alcohol-related behaviors and events, as well as other environmental influences (Cohn, Hunter-Reel, Hagman, & Mitchell, 2011). And, intervention science addresses translational science aspects including dissemination and implementation science, in addition to answering “what works” and mechanisms of change questions.

### Applying research to affect change

Despite variations in methods across such approaches the Grand Challenge of reducing alcohol misuse and its associated consequences can be analyzed, assessed, and alleviated. The challenge can be met by drawing on varied methods and scientific traditions, and facilitating multisectoral triangulation of findings.

With this rich diversity of conceptual, methodological, and analytical approaches comes great opportunity. Problems related to alcohol misuse are proving to be changeable. For example, youthful drivers were involved in fewer alcohol-related crashes with the advent and enforcement of minimum drinking-age legislation (Wagenaar & Toomey, 2002) and driving under the influence across the whole population of individuals aged 12 years and older declined by 3% between 2002 and 2012 (National Institute on Drug Abuse, 2014). Among parents involved with the child welfare system who experience substance abuse problems, completing substance abuse treatment significantly contributes to greater likelihood of child reunification and less time that children spend in foster care (Marlowe & Carey, 2012). Heavy alcohol use and binge drinking during pregnancy declined between the 2008 through 2011 periods, although the number of pregnant women drinking alcohol at all did not appear to decline (SAMHSA, 2011). Rates of alcoholic liver disease showed a marked decline from 1970 to 2000; however, liver cirrhosis deaths (often caused by alcohol misuse) remained disproportionately high among both black non-Hispanic and white Hispanic individuals (Mann, Smart, & Govoni, 2004; NIAAA, 2001). To reduce the burden of disease related to alcohol use and alcohol use disorders, “implementation of prevention interventions and expansion of treatment are necessary” (Rehm et al., 2014, p. 1068).

### Innovative organization of research

Research and interventions related to alcohol misuse are increasingly being linked in innovative ways by employing an array of methodologies, involving numerous disciplines, and applying a variety of technologies to achieve national

and international reach. For example, the Higher Education Center for Alcohol and Drug Misuse Prevention and Recovery (HEC) at The Ohio State University is being built to move prevention and recovery research into colleges and universities nationally as a means of preventing alcohol misuse, consequences associated with alcohol misuse, and alcohol use disorders. By developing smart technologies, using systems dynamic modeling to develop simulation tools, and harnessing social media to generate “big data,” HEC is systematically employing novel strategies for the rapid translation of science models. A partnership of professionals working in prevention and recovery, HEC engages researchers from multiple disciplines (e.g., social work, engineering, geography, pharmacy, social psychology). This model is one example that illustrates how “bringing the pieces together” is not only possible but also likely the key to meeting this Grand Challenge.

Disseminating emerging knowledge to practitioners at individual, family, community, and larger systems levels is another opportunity to further alleviate alcohol misuse in innovative ways. Professional development curricula that tap into the evidence base related to alcohol misuse integrate knowledge into professional education systems to improve the well-being of individuals at risk for developing alcohol or other substance use disorders. These opportunities prepare individuals in several professions (e.g., social work, nursing, medicine, clergy) to work with individuals and families affected by alcohol problems to implement prevention strategies. Interdisciplinary curricula are also available for practitioners who deliver screening, brief intervention, and referral to treatment (SBIRT), and to prepare substance abuse clinical researchers in the health professions (e.g., Substance Abuse Research Education and Training [SARET]). The advent of open source online training mechanisms (e.g., iTunes U, Coursera, Udacity, edX) and University-based online courses, present additional opportunities for both preservice and in-service/continuing education related to this Grand Challenge.

### **Demonstrable Progress toward the Challenge Can Be Made in a Decade**

In 2010, the National Institute on Alcohol Abuse and Alcoholism produced a review of progress in alcohol research over the first 40 years since it became the lead Federal agency for conducting and funding research on alcohol-related problems in the United States (Warren & Hewitt, 2010). The report documents accomplishments related to a better understanding of the epidemiology and etiology of alcohol use disorders, strategies for treating and preventing alcohol use disorders, and the effects of alcohol on various aspects of health and human functioning.

The rate of new knowledge and innovation being generated continues to accelerate. Large-scale, national epidemiological surveys—the National Epidemiologic Survey on Alcohol and Related Conditions, National Survey on Drug Use and Health, and Monitoring the Future—shed light on population trends in alcohol misuse and alcohol use disorders over time and across population

subgroups. Enormous strides have been made in understanding the complex genetics and epigenetic mechanisms in developing alcohol use disorders, in large part due to the multidisciplinary, multisite Collaborative Study on Genetics of Alcoholism (Edenberg, 2003). Study of the problem’s etiology has also been stimulated by the use of ecological momentary assessment methodologies whereby investigators gain insight about craving, use, and environmental influences on behavior “in the moment” rather than relying on retrospective reporting (Moskowitz & Young, 2006). Intervention research efforts have resulted in a strong evidence base and numerous collaborative efforts among social work and allied health programs supporting the application of approaches for early identification and screening for possible alcohol use disorders, and for using SBIRT (Barbosa, Cowell, Bray, & Aldridge, 2015; Mitchell, Gryczynski, O’Grady, & Schwartz, 2013). New promising treatment approaches that combine pharmacotherapies and behavioral therapies have emerged (Jonas et al., 2014; Miller, Locastro, Longabaugh, O’Malley, & Zweben, 2005). Evidence supports the use of drug courts as systems for coordinating and judicially supervising treatment for individuals involved with the criminal justice system as a result of problems with alcohol or other drugs (Brown, Allison, & Nieto, 2011) and for families involved in the child welfare system (Green, Furrer, Worcel, Burrus, & Finigan, 2007; Smith, 2003). Increasing evidence supports alcohol treatment protocols delivered via computer or mobile devices, or traditional face-to-face approaches being supported by smartphone technology, in addition to treatments that integrate data from ecological momentary assessment (Cohn et al., 2011; Hasin, Aharanovich, & Greenstein, 2014; White et al., 2010). Finally, there are numerous macro-level examples of alcohol control interventions including drunk-driving prevention, responsible beverage service, and controlling alcohol outlet density (Clapp et al., 2005; Community Preventive Services Task Force, 2015; Gruenewald, 2007; Gruenewald, Freisthler, Remer, LaScala, & Treno, 2006; Holder, Saltz, Gruber, Treno et al., 1997; Holder, Saltz, Gruber, Voas et al., 1997).

Efforts in these areas have led to development of a mature knowledge base regarding alcohol misuse and alcohol use disorders. However, tremendous disparities exist among and between demographic groups, communities, and nations in terms of rates for incidence and prevalence of alcohol problems, diagnosis and treatment, and prevention outcomes. Applying a “social determinants of health” lens contributed from the field of public health is an important way to move from theory to action in integration across multiple levels of science, policy, and intervention—particularly with regard to vulnerable and underserved populations (International Center for Alcohol Policies, 2009).

### **Directions for current and future research**

Four important directions of current and future research can help resolve this Grand Challenge in the next decade.

***Mechanisms of behavior change***

Alcohol treatment studies have begun to move beyond “what works” to developing an understanding of how and why treatment works, and how self-change occurs outside of treatment. This includes identifying the common elements in evidence-based approaches and common factors in successful behavior-change efforts for individuals who have the consequences of alcohol misuse. Mechanisms of behavior-change research can capitalize on emerging research methodologies and analytic techniques, as well as the wealth of evidence from previous studies about necessary components in effective prevention and treatment interventions.

***Effectiveness studies***

In this domain, researchers assess strategies known to work under controlled circumstances with diverse populations that are heterogeneous in terms of gender, ethnicity/race, nation/national origin, incarceration history, sexual orientation, cognitive and physical condition, and other forms of human diversity. Effectiveness studies also include real-world treatment contexts that include diverse types of settings beyond the specialized addiction treatment program and intervention delivery by a diverse range of providers (i.e., professionals from varied disciplines and individuals with differing levels of education/training, including paraprofessionals and natural helpers). Multisite study networks (e.g., the National Institute on Drug Abuse and Canadian clinical trials networks, the National Institutes of Health) support centers for clinical and translational science and provide new opportunities to conduct these studies with greater scientific integrity and generalizability of study results.

***Interdisciplinary and multilevel approaches***

Researchers and practitioners are increasingly working across traditional disciplinary and systemic boundaries to advance scientific inquiry and develop multilevel intervention strategies to address alcohol misuse. Integration is also taking place across subdisciplines in fields such as psychology (e.g., developmental, social, experimental, clinical), engineering (e.g., human, bio, systems science), public health (e.g., health behavior, biostatistics, epidemiology), and mathematics (e.g., agent-based modeling, computational science, big data, statistics). These endeavors are contributing to ever-greater understanding of biopsychosocial and transdisciplinary features related to alcohol misuse and its consequences. Concurrently, this type of work contributes to expanding knowledge concerning the ways in which novel interventions respond to the multiple levels at which “person in environment” systems operate (i.e., internal/individual, micro, meso, and macro systems).

***Translational and implementation science***

Major initiatives are being launched to develop the science around strategies that are most effective and efficient for treatment, prevention, policy, practitioner development, and service delivery systems. At one end of the translational science knowledge building continuum are epidemiology, etiology, and theory building/testing studies that can inform the development of prevention, treatment,

and policy intervention strategies. At the other end are implementation science efforts that can help inform efforts to get evidence-informed interventions into mainstream practice (Proctor et al., 2009).

Access to appropriate prevention, early intervention, and treatment across diverse, vulnerable populations continues to be a challenge despite advances in science and policy. Moving these streams of work forward in a unified way and in the context of a challenging funding environment will require leadership, innovation, and the involvement and coordination of multiple stakeholders. Currently, many of the parts necessary for making this progress are accessible or emerging, making demonstrable progress possible over the next decade.

**Multisectoral Collaboration Is Required to Meet the Challenge**

Alcohol misuse and its consequences make up a complex systems problem. Numerous disciplines have examined the etiology of alcohol-related problems from multiple perspectives ranging from microbiology and genomics to macroeconomics and public policy. Similarly, solutions to alcohol-related problems have emerged from various subfields of biology, pharmacology, psychology, medicine and psychiatry, engineering, social work, public health, anthropology, nursing, occupational therapy, sociology, criminal justice, education, mathematics, public policy, economics, business, and law. Given the number of disciplines studying alcohol misuse, solutions to alcohol-related problems are inherently multisectoral. The social work profession is a natural fit to lead the reduction of alcohol misuse and its consequences because it intersects and interfaces with the populations most likely to be affected by alcohol misuse. Social workers provide prevention, treatment, and intervention activities in multisectoral settings (e.g., hospitals, jails, schools, shelters, communities).

**Collaboration between researchers and practitioners**

As multisectoral collaboration among alcohol researchers and practitioners expands, there are significant opportunities to promote theory, measures, design, analytic approaches, technologies, and implementation strategies that transcend traditional disciplinary boundaries. Many organizations<sup>2</sup> include members from numerous academic fields and traditions (including social work), but have yet to launch a coordinated offense directed toward the Grand Challenge of significantly reducing alcohol misuse and its consequences.

<sup>2</sup> Examples include The Research Society on Alcoholism, Mechanisms of Behavioral Change Study Group, Society for Prevention Research, Association for Medical Education and Research in Substance Abuse, International Society for Biomedical Research on Alcoholism, Asia-Pacific Society for Alcohol and Addiction Research, European Society for Biomedical Research on Alcoholism, Latin American Society for Biomedical Research on Alcoholism, and the Fetal Alcohol Spectrum Disorders Study Group.

### **Collaboration between governmental and nongovernmental organizations**

On a global level, governments and nongovernmental organizations play a critical role in meeting this challenge. The National Institute on Alcohol Abuse and Alcoholism has dedicated resources to helping nations around the world develop evidence-informed responses to alcohol misuse and its consequences, and the World Health Organization monitors the scope of the problem. Though member countries voted on the Global Strategies to Reduce Alcohol-Related Harms at the 2010 World Health Assembly, the global response to alcohol-related problems has much room to improve. In many parts of the developing world, there is inadequate funding for alcohol research, alcohol policies of varied effectiveness, and sustainable implementation of evidence-based alcohol prevention and treatment programs. More can be done in developed countries as well. Increased funding and coordination across multiple sectors including industry and government will likely be required to build the infrastructure to fund, develop, and test solutions to this challenge.

### **Targeted collaboration with the alcohol industry**

The alcohol beverage and hospitality industries have long been viewed as adversaries to public health efforts aimed at reducing alcohol misuse. This has given rise to concerns regarding the influence of the beverage industry, including suggestions that the implementation of policies with a strong evidence base, such as minimum pricing and regulation of advertising, have been delayed or inhibited (Gilmore & Daube 2014; Hill & Casswell, 2004). Although the examples of irresponsible product development and advertising are plentiful, prevention approaches grounded in prohibition seldom work. A thoughtful, selective and more open approach to working with these stakeholders, including the National Alcohol Beverage Control Association and state licensure boards, will be vital for meeting this Grand Challenge. Many of the world's largest producers of alcohol are developing evidence-based programs to reduce the harms associated with alcohol misuse and have formed alliances such as the International Alliance for Responsible Drinking. Working with industries such as insurance companies, healthcare organizations, and casinos as potentially strong tactical partners is another strategy to consider for meeting the Grand Challenge. Advocates must think broadly and without ideological constraints.

### **Sustainable Solutions to the Challenge Require Significant, Transformative, and Groundbreaking Innovations**

Rapid advances in technology and science, coupled with a growing comprehensive body of knowledge and professional practice, provide the basis for other areas of innovation. For this particular Grand Challenge, four interrelated areas of potential innovation can transform the current situation: structural innovations; scientific innovations; technological innovations; and prevention, treatment, and policy innovations.

### **Structural innovations**

Structural innovations include developing mechanisms to bring the various academic, scientific, professional, governmental, and nongovernmental streams of together in a more unified, systematic manner to work on the alcohol misuse challenge. Developing systematic and coordinated roadmaps for action will require leadership, a substantial organizing effort, the development of common concepts and nomenclature, and summarizing the “state of the field” in an accessible way. Additionally, identifying and developing new models for the sale and taxation of alcohol, and the funding of research and solutions to alcohol-related problems at the individual, family, community, and larger system levels must occur. On the academic side, tenure and promotion systems will need to embrace team science, university-community collaborations, and multisectoral endeavors, a change that is slowly taking place nationally (Basken, 2015).

### **Scientific innovations**

Innovations in science will likely occur naturally within the various subfields of alcohol research and other areas from which alcohol science can draw. Advances in numerous areas have occurred in recent years. The expansion of systems science and the study of complex systems will provide critical contributions and opportunities, as will the design of multilevel studies (e.g., Clapp et al., 2006; Galea, Hall, & Kaplan, 2009). Major opportunities for exponential advances will occur by developing mechanisms for the various alcohol research subfields to integrate more complexity into theory and methods. Adoption of new clinical substance use disorder definitions (i.e., the Diagnostic and Statistical Manual of Mental Disorders fifth edition [DSM-5], the International Classification of Diseases version 10 [ICD-10]) necessitate innovations in measurement science as the entire field of applied addiction study moves forward. Emerging biomarker and behavioral genetic science arenas are also becoming ideally positioned to inform innovations in assessment, diagnosis, treatment, and prevention.

### **Technological innovations**

Health behavior models have failed to keep pace with rapid mobile technological innovations (Riley et al., 2011). For example, portable tools for self-monitoring one's blood alcohol levels, the effect of alcohol levels on other biological/physiological functions, and personal spending on alcohol are emerging on the market (e.g., the Breeze Breathometer, credit and debit card purchases paired with smartphone health tracking apps). As technological innovations progress, researchers and practitioners will be challenged with the need to balance and more fully understand the ecological factors important to target when intervening (e.g., when/where to intervene in time and space). Though these innovations might provide opportunities for research and intervention, they also will likely introduce new challenges that need to be addressed. For example, the potential sale of alcohol via the Internet complicates efforts to limit access by underage populations. Furthermore, when layered with geopolitical changes and economic disparities, technological innovations related to alcohol problems will likely raise distributive justice issues.

For instance, on one hand, as automotive technology evolves toward less and less driver control, and driverless vehicles become common in wealthier nations, drunk driving crashes will likely decrease drastically. The Ford Motor Company's chief executive officer estimates that all new vehicles in the U.S. will be equipped with driverless technology in the next 15 years (Rosenbush, 2015). On the other hand, this change could flood poorer nations with older, driver-operated vehicles exported from the United States and affect drunk driving patterns in nations where vehicles were not previously as commonly available. Global leadership on this and similar issues is critical.

### Prevention and treatment innovations

As noted above, the science around the etiology, prevention, and treatment of alcohol problems has advanced in recent years. Social work scholars are well represented among authors and editors of important textbooks on these topics (e.g., McNeece & DiNitto, 2012; Miller, Forchimes, & Zweben, 2011; Straussner, 2014; Straussner & Fewell, 2011; van Wormer & Davis, 2013; van Wormer & Thyer, 2010; Vaughn & Perron, 2013). True innovations in the prevention and treatment sectors are possible through multisectoral collaboration. For instance, models that integrate pharmacological, motivational, or cognitive/behavioral therapies with biometric monitoring and "smart" technology might prove effective, but they will require new training for professionals, reimbursement models, and case management systems. Additionally, environmental policies and partnerships between behavioral and computer scientists will need to support innovations that include ecological approaches that attempt to interrupt problem behaviors *in situ* using smart technologies based on situational dynamics.

Continued advances in the translation of science to practice remain an essential priority to solve the challenge of alcohol misuse. Evidence-based community intervention and prevention efforts are necessary because effective integration of alcohol prevention and treatment strategies into routine practice requires significant "cultural" adaptations, particularly in community settings where social norms run counter to the aim of reducing alcohol misuse (Holleran Steiker, 2008; Holleran Steiker, Grahovac, & White, 2014). Large-scale data mining efforts with human services data, development of culturally sensitive measurement and intervention, and applying epigenetic research to risk assessment are important innovative steps in moving alcohol misuse prevention and treatment forward.

### Conclusion

Given the current fragmentation of responses to alcohol-related problems at the academic and governmental levels, it is not surprising that findings from scientific studies often fail to fully inform practice in prevention, treatment, and recovery for alcohol-related practice and policy. The study of and practice surrounding alcohol misuse and its consequences are at a critical precipice. There is a great

opportunity and need to rapidly move science from "bench to bedside;" however, doing so effectively and efficiently requires social work to assume a leading role in augmenting and orchestrating a cohesive community of interdisciplinary scientists, prevention and treatment providers, business, policy makers, and citizens across the United States and the world. Alcohol misuse has an impact on every population and domain of well-being around which social workers assess, intervene, evaluate, advocate, conduct research, or inform policy. The case has been made: Though the Grand Challenge to reduce and prevent alcohol misuse and its consequences is monumental, progress is achievable with a commitment to a collaborative and sustainable spirit and an appreciation for groundbreaking innovation.

### Acknowledgments

The authors would like to acknowledge John Gabbert at the Center for Social Development who provided editorial support.

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## Appendix A

### *The Alcohol Misuse Grand Challenge Collective*

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## EPIDEMIOLOGY AND POLICY

### The Neighborhood Alcohol Environment and Alcohol-Related Morbidity

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(Received 4 March 2009; first review notified 23 April 2009; in revised form 15 July 2009; accepted 17 July 2009; advance access publication 10 August 2009)

**Abstract — Aims:** The aims of this study were (1) to examine the association between neighborhood alcohol outlet density and individual self-reported alcohol-related health outcomes in the last year—sexually transmitted infections (STI), motor vehicle accidents, injury, liver problems, hypertension and experienced violence; (2) to determine whether the relationship between morbidity and alcohol outlet density is mediated by individual alcohol consumption; and (3) to explore the role of alcohol outlet density in explaining any observed racial and ethnic differences in morbidity. **Method:** Hierarchical models from a random sample of Los Angeles, CA, and Louisiana residents ( $N = 2881$ ) from 217 census tracts were utilized. The clustering of health and social outcomes according to neighborhood varied by health problem examined. **Results:** There was substantial clustering of STI (intraclass correlation coefficient, ICC = 12.8%) and experienced violence (ICC = 13.0%); moderate clustering of liver problems (ICC = 3.5%) and hypertension (ICC = 3.9%); and low clustering of motor vehicle accident (ICC = 1.2%) and injury (ICC = 1.4%). Alcohol outlet density was significantly and positively associated with STI (crude OR = 1.80, 95% CI = 1.10–3.00), liver problems (crude OR = 1.33, 95% CI = 1.02–1.75) and experienced violence (crude OR = 1.31, 95% CI = 1.13–1.51) although not with other morbidity outcomes. Mediation analyses of morbidity outcomes revealed partial mediation of individual alcohol consumption in the relationship between alcohol density and STI and violence, and full mediation for liver problems. **Conclusions:** Findings support the concept that off-premise alcohol outlets in the neighborhood environment may impact health and social outcomes, either directly or indirectly, through individual alcohol consumption and these associations may be heterogeneous with respect to race and ethnicity.

## INTRODUCTION

In ecologic studies at the neighborhood level, alcohol outlet density has been shown to be strongly associated with both alcohol consumption (Gruenewald *et al.*, 1993; Scribner *et al.*, 2000; Gruenewald *et al.*, 2002) and numerous alcohol-related outcomes including fatal and injury traffic crashes (Scribner *et al.*, 1994), drunk driving offenses (Mackinnon *et al.*, 1995; Treno *et al.*, 1996; Gruenewald *et al.*, 2000), cirrhosis mortality (Gruenewald and Ponicki, 1995, Mackinnon *et al.*, 1995), assaultive violence (Scribner *et al.*, 1995, 1999; Gorman *et al.*, 2001), sexually transmitted diseases (Scribner *et al.*, 1998; Cohen *et al.*, 2006) and liquor law violations (Mackinnon *et al.*, 1995). Over the past decade there has been a recognition that the strongest effects emerge at the smaller units of aggregation, i.e. census tracts and blocks groups, often used as units that approximate neighborhoods (Scribner *et al.*, 1999; Gorman *et al.*, 2001).

Multilevel studies have confirmed that the effect of alcohol outlets on health outcomes is independent of individual-level risk factors (Scribner *et al.*, 2000). Despite evidence for a contextual effect at the neighborhood level, the mechanisms of the association between alcohol outlets and health outcomes have not been carefully studied. Various theoretical explanations have been offered, however, including social contextual models, niche theory and assortative drinking (Gruenewald, 2007), the impact of outlets on neighborhood social networks and social capital (Scribner *et al.*, 2007, Theall *et al.*, in press), as well as the role of increased alcohol consumption and its effect on liberalizing social norms (Scribner *et al.*, 2000). Neighborhood alcohol outlet density may be associated with individual alcohol consumption through the frequency of

exposure to cues relating to alcohol, including increased availability (Laibson, 2001). In addition to serving as a reminder to drink and supplying alcohol, outlets pose a situational risk in the neighborhood environment. Outlets are often sites where people who engage in high-risk behaviors gather, not just for drinking but sometimes to use and exchange other drugs. Alcohol outlets are also associated with more social disorder, which may be linked to various poor health outcomes.

The objectives of this study were (1) to examine whether neighborhood alcohol outlet density is positively associated with individual self-reported alcohol-related health outcomes in the last year—sexually transmitted infections (STI), motor vehicle accidents, injury, liver problems, hypertension and experienced violence; (2) to determine whether the relationship between morbidity and alcohol outlet density is mediated by individual alcohol consumption; and (3) to explore the role of alcohol outlet density in explaining any observed racial and ethnic differences in morbidity. Given the observed racial and ethnic differences in many of the outcomes examined (Centers for Disease Control and Prevention, 2000; Williams, 2001; Krieger *et al.*, 2003) and the potential impact of alcohol density on certain population subgroups (Parker, 2004; Livingston *et al.*, 2007), we sought to determine whether the impact of alcohol outlets on morbidity may also vary by race and/or ethnicity.

## METHODS

### *Study sites and selection of census tracts*

This cross-sectional study was conducted in Louisiana and California, which have different demographics, different retail sales patterns and different cultural attitudes toward alcohol.

In Louisiana, there are areas (such as New Orleans) that are very permissive with alcohol, allowing purchases 24 h a day, 7 days per week, and other areas that are 'dry' (alcohol sale prohibited) or where the sale of alcohol is limited to certain hours. Los Angeles has more uniform retail sales patterns but a highly diverse population, allowing us to study the impact of alcohol marketing practices on different racial and ethnic groups. The study took place between 4 October 2004 and 28 August 2005 in Louisiana and 19 October 2005 in Los Angeles County. Sampling was limited to urban residential census tracts, with urban defined as having more than 2000 residents per square mile in the 2000 US census. We randomly selected 114 of these census tracts in southeastern Louisiana and 114 census tracts in Los Angeles County, for a total of 228 census tracts. In Louisiana, data collection was suspended when Hurricane Katrina struck, after measurements were collected in 103 census tracts. Those 11 census tracts differed only in population size (they included on average 2000 fewer people per tract) from the other census tracts selected in Louisiana. Furthermore, the sampling procedure was stratified by the region; therefore, the lost neighborhoods were representative of the New Orleans region in terms of SES and racial/ethnic content. Therefore, the representativeness of the remainder of the Louisiana sample was unaffected.

For the purpose of the present study, a census tract was used as a proxy for neighborhood. The resulting sample included 2881 individuals—1578 from Los Angeles County and 1303 from Louisiana. The research was approved by RAND Corporation, Charles R. Drew University of Medicine and Science, the Louisiana State University and Tulane University Institutional Review Boards.

#### *Survey procedures*

Sampling employed a two-stage procedure that involved selecting census tracts stratified by location (Los Angeles versus Southern Louisiana) in the first stage and sampling approximately 10 households per census tract in Los Angeles and in Louisiana using a list-based systematic sample in the second stage. A list-based sample was chosen because in addition to the phone numbers, we also required the corresponding addresses for geocoding. Up to 25 contact attempts were made.

Several steps were taken to improve response rates including sending advance letters, providing incentives (a \$15 check upon completion), toll-free numbers, and answering machine messages. These channels supplemented and reinforced the work of interviewers, who provided information tailored to respondents' questions. Advance letters were sent to all unique addresses in the household sample. In the event that multiple phone numbers were matched to the same address, only one letter was sent to that address. The advance letter explained the data collection project and encouraged respondents to participate. It also provided the toll-free telephone number for the participant to call and complete the survey and the number for the Principal Investigator at RAND for the participant to call to get more information about the study. The cooperation rate, the proportion of all cases interviewed of all eligible respondents ever contacted, was 76.2% in Los Angeles and 79.8% in Louisiana for the phone survey. The response rates for Los Angeles County and the state of Louisiana were 34.4% and 37.9%, respectively, based on the method codified by the Council of American Survey Research Organizations (CASRO), which

reflects the percentage of completed interviews achieved after fully processing all attempted sample records according to the prescribed sample management rules.

#### *Data sources*

Individual-level data were obtained from the phone survey. Counts of alcohol licenses for all years came from the California Department of Alcohol Beverage Control (ABC) and the Louisiana Department Alcohol and Tobacco Control (ATC). Alcohol outlets were classified based on their license to sell alcohol off-premise (liquor stores, grocery stores and convenience stores) using license codes provided by the ABC or ATC (depending on state). Neighborhood-level socio-demographic characteristics were obtained from the 2000 US Census.

All unique address listings for survey respondents and alcohol outlets were geo-coded and mapped to the 2000 Census tract areas, and individual data sources were matched by the census tract. Over 98% of addresses were matched using Arcview GIS software (ESRI Inc, Redlands, CA, USA) along with Los Angeles County and Louisiana TIGER street files from the 2000 Census. Addresses that the computer were unable to match were hand placed with the help of an Internet mapping site (Mapquest) and a Thomas Guide map book.

#### *Measures*

The primary outcomes of interest included self-reported STI in the past year, motor vehicle accident in the past year, injury that required an emergency room visit in the last year, history of liver problems, history of hypertension, and heard, witnessed or experienced violence in their neighborhood in the past 6 months. All variables were dichotomous (yes versus no). Outcomes were chosen given their association with alcohol availability and alcohol consumption. Time frames for each morbidity survey items differed to reflect the average frequency of occurrence.

The primary exposure of interest was a contextual neighborhood factor—off-premise alcohol outlet density. Outlet density was measured as (1) the ratio of the number of off-premise outlets to the square mile area in each tract based on 2000 geographic census data; (2) the number of outlets per square mile in a 1.0 mile radius of each respondent's residence; and (3) individual geographic distance to the nearest off-premise outlet. The number of outlets per roadway mile was also calculated and compared for consistency with outlets per square mile. The number of outlets per square mile in distances of 0.1, 0.25 and 0.50 radii was also examined. Results were consistent and therefore we only present data using outlets per square mile and outlets within a 1.0 mile buffer.

Individual alcohol consumption was examined as the primary mediator in the relationship between off-premise neighborhood alcohol outlet density and self-reported morbidity outcomes. Consumption patterns included the number of drinking days per year (measured on a scale from 1–8 or never to daily and recoded to 0, 12, 30, 78, 182, 273 and 365), the number of drinks per day on days when alcohol is consumed, the average estimated daily ethanol consumption in the last 90 days, the average daily ethanol consumption in the last 12 months and heavy episodic drinking (HED) or having at least five or more drinks for men or four or more drinks for women per sitting at least 1 day in the last month (yes/no). The average daily ethanol

consumption based on the previous 90 days was computed as follows:

$$\text{ethanol}_{90\text{days}} = \text{ethanol} * \text{ounces} * \text{drinks} * \text{drinkdays}90/90,$$

where ‘ethanol’ is the alcohol content of the respondent’s most common drink in the last 90 days, ‘ounces’ the size of that drink in ounces, ‘drinks’ the number of drinks per occasion and ‘drinkdays90’ the number of days drinking within the last 90 days.

Race was assessed in the survey as White, Black, Asian, American Indian, Pacific Islander and multi-racial. Due to the limited number of Asian, American Indian, Pacific Islander and multi-racial respondents, these racial categories were combined into one group for primary analyses. Ethnicity was measured as in the survey—Hispanic or non-Hispanic ethnicity.

Additional factors examined as potential predictors of self-reported morbidity or as potential confounding factors in the alcohol density–morbidity relationship included individual- and neighborhood-level socio-demographic characteristics, individual perception of neighborhood characteristics and aggregated neighborhood characteristics, and sexual behavior (primarily for STI outcome). Individual-level socio-demographic characteristics included sex, age, marital status (married versus not married), education (0–5, never attended school to college graduate), employment (employed full-time, legally, versus other) and annual income (0–3, <\$20,000, \$20,000 to \$34,999, \$35,000–\$74,999 and ≥\$75,000). Neighborhood-level socio-demographic characteristics included percentage White, Black and Hispanic, percentage with less than a high school education, percentage below the Federal poverty level (for US 2000 Census) and economic deprivation. Economic deprivation or concentrated disadvantage was measured using a Z-score standardized index of concentrated disadvantage (Sampson and Morenoff, 2004) measuring economic disadvantage in urban neighborhoods and defined by the percent of families below the poverty line, percent of families receiving public assistance, percent of unemployed individuals in the civilian labor force and percent of female-headed families with children (Cronbach’s alpha = 0.86).

Sexual behavior included an index of sexual risk, calculated based on the number of sexual partners in the last 12 months and whether a condom was used during the last sexual encounter (yes/no), and ranging from 0 to 4 where 0 = lowest risk (no sex partners), 1 = one sex partner and condom use at last sex, 2 = one sex partner and no condom use, 3 = two or more sex partners and condom use and 4 = two or more sex partners and no condom use.

### Statistical analyses

Second-level hierarchical logistic regression models, with individuals (first level,  $n = 2881$ ) nested within neighborhoods or census tracts (second level,  $n = 217$ ) were used to examine the contextual effect of alcohol outlet density on self-reported morbidity outcomes. SAS version 9 was used for all analyses, including PROC GLIMMIX for hierarchical models. Such models allow for estimates of variance components at both the individual level and neighborhood level (Bryk and Raudenbush, 1992, Snijders and Boskers, 1999). Partitioning variance in this way accounts for the variance in individual-level outcomes that can be attributed to differences between neighborhoods, ex-

pressed as the intraclass correlation coefficient (ICC). The ICC was calculated as follows:

$$\frac{V_{\text{neighborhood}}}{V_{\text{neighborhood}} + V_{\text{individual}}},$$

where  $V_{\text{neighborhood}}$  = variance between neighborhoods and  $V_{\text{individual}}$  = variance within neighborhoods or between individuals. For all outcomes, which are dichotomous or binary in nature, the ICC was calculated by following the formula of Snijders based on an underlying continuous variable with  $V_{\text{student}} = \Pi^2/3$  (Snijders and Boskers, 1999).

For each outcome variable, the following models were examined: (1) an empty or unconditional means model that is a function of the neighborhood-level random intercept (used to obtain the amount of clustering in morbidity within neighborhood); (2) crude bivariate multi-level models including all individual- and neighborhood-level measures to examine their crude association with morbidity—paying particular attention to the relationship between alcohol outlet density and each outcome; (3) for models with a significant association between density and morbidity, alcohol consumption patterns were added to the crude and adjusted (adjusted for known predictors of morbidity outcomes) models (separately) to examine potential mediation by consumption; and (4) multivariate models were examined to determine the impact of alcohol outlet density on any observed racial or ethnic differences in morbidity, including according to study location.

Mediation by alcohol consumption was assessed by including, separately, each consumption pattern (i.e. drinking days or frequency, drinks per day or quantity, average daily ethanol consumption in last 90 days and year, and HED) in a multivariate model with off-premise outlet density—for morbidity outcomes with a significant relationship between density and morbidity. Removal of the effect of density after inclusion of alcohol consumption patterns, and a significant relationship between consumption and morbidity outcomes, was deemed indicative of mediation.

All of the individual-level variables were centered at their respective means. The effects of any spatial autocorrelation in the data were taken into account in PROC GLIMMIX with repeated measures of spherical clustering, based on the tract centroids and state plane coordinate system in miles, using a 2.5 mile lag distance.

## RESULTS

Among the 2881 survey respondents, the prevalence of select morbidities—STI (1.0%), motor vehicle accident (8.1%), injury (11.5%), liver problems (4.9%), hypertension (20.7%) and experienced violence (20.0%)—was within local and national prevalence estimates for these outcomes. For example, with respect to STI, national HIV prevalence is 1.0% (CDC, 2008a) and rates of Chlamydia range from 1.2% to 13.8% and gonorrhea from 0.1% to 3.8% (CDC, 2008b). In the United States, 7% of deaths are injury related and the prevalence of initial physician office and outpatient department visits for injury is 12% (Bergen *et al.*, 2008). The prevalence of hypertension in the United States is 32% (CDC, 2009).

There were no significant differences by study region in morbidity outcomes except for hypertension, which was higher among Louisiana than California respondents (23.8% versus

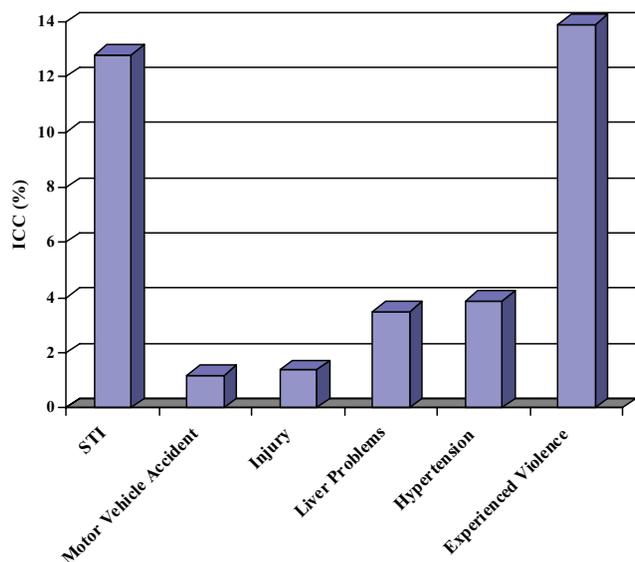


Fig. 1. Clustering of self-reported morbidity outcomes.

17.4%, likelihood ratio chi-square = 16.9,  $P < 0.001$ ). The clustering of morbidity by neighborhood varied by outcome, as shown in Fig. 1. There was strong clustering of STI (ICC = 12.8%) and experienced violence (ICC = 13.0%), moderate clustering of liver problems (ICC = 3.5%) and hypertension (ICC = 3.9%), and low clustering of motor vehicle accident (ICC = 1.2%) and injury (ICC = 1.4%).

Table 1 presents characteristics of survey participants. The majority of respondents were female (63.9%) and substantial proportions were White (46.2%) or Black (25.3%). Approximately one-fifth was Hispanic. Respondents ranged in age from 18 to 65 (mean = 42.9 years). Nearly half (46.9%) indicated they were married and 62.2% were employed full-time. Half of the respondents reported an annual income of \$34,999 or less. The average number of years lived in their neighborhood was 11.9 (range = 1–64).

The average distance to the nearest off-premise outlet was 0.5 mile and the average individual off-premise outlet density in a 1.0 mile radius was 1.1. Respondents drank, on average, 51.7 days out of the year, with an average of 1.3 drinks per day. Approximately 20% were classified as heavy episodic drinkers (HED). The average level of visible alcohol consumption in the neighborhood was between at least once a year and once a month.

Individual-level characteristics associated with morbidity outcomes varied, as shown in Table 2, and included both protective and risk factors for self-reported morbidity. Compared to White respondents, Black respondents were significantly more likely to indicate that they had been injured (crude OR = 1.56, 95% CI = 1.10, 2.20) or had hypertension (crude OR = 2.56, 95% CI = 1.94, 3.38). Respondents of other racial backgrounds were also significantly more likely to report hypertension than White respondents (crude OR = 1.37, 95% CI = 1.05, 1.80). Respondents of Hispanic ethnicity were significantly less likely to report injury and hypertension than were non-Hispanics.

Similar to neighborhood off-premise outlet density, individual-level outlet density in a 1.0 mile radius was posi-

Table 1. Characteristics of participants

	Number (%) or mean (SD)
Study location	
LA county	1578 (54.8%)
State of LA	1303 (45.2%)
Sex	
Male	1039 (36.1%)
Female	1842 (63.9%)
Age (years)	42.9 (13.2)
Race	
White	1330 (46.2%)
Black	731 (25.3%)
Other	820 (28.5%)
Hispanic ethnicity (yes)	663 (23.0%)
Married (yes)	1352 (46.9%)
Employed full-time, legally (yes)	1791 (62.2%)
Annual income	
< \$20,000	847 (31.8%)
\$20,000–\$34,999	500 (18.8%)
\$35,000–\$74,999	704 (26.4%)
≥\$75,000	612 (23.0%)
Years lived in neighborhood	11.9 (11.1)
Distance to nearest off-premise alcohol outlet (miles)	0.5 (±1.1)
Individual off-premise outlet density in 1.0 mile radius	1.1 (±0.9)
Drinking days per year (0–365)	51.7 (±88.2)
Drinks per day on days drink	1.3 (±1.4)
Average daily consumption in last 90 days	0.10 (±0.5)
Average daily consumption in last year	0.02 (±0.1)
Heavy episodic drinking (HED) in the last month (yes)	512 (17.8%)
Level of visible alcohol use in neighborhood	2.4 (±1.5)
Sexual risk behavior (range = 0–4)	1.6 (±1.1)

Note. Number and percentages reflect that of non-missing responses.

tively and significantly associated with STI (crude OR = 1.08, 95% CI = 1.01–1.20), liver problems (crude OR = 1.30, 95% CI = 1.10–1.50) and experienced violence (crude OR = 1.44, 95% CI = 1.25–1.65). The frequency of alcohol consumption (drinking days) was associated significantly and positively with having a motor vehicle accident and witnessing violence and inversely with liver problems and hypertension. The number of drinks per day and bingeing were both positively and significantly associated with injury and violence and inversely associated with hypertension.

Neighborhood-level characteristics and their association with morbidity are presented in Table 3. The average proportion of White, Black and Hispanic residents was ~30%. The average percentage of residents below poverty was 21.0% and the average concentrated disadvantage was 2.2 (range = –4.6 to 20). The average off-premise alcohol outlet density per square mile was 10.2 (range = 0–100, 25th percentile = 3.0, 75th percentile = 14.0).

The off-premise outlet density was significantly and positively associated with STI (crude OR = 1.80, 95% CI = 1.10–3.00), liver problems (crude OR = 1.33, 95% CI = 1.02–1.75) and experienced violence (crude OR = 1.31, 95% CI = 1.13–1.51) but not with other morbidity outcomes. Additional neighborhood-level factors associated with morbidity varied, as shown in Table 3.

Table 4 presents the result of the hypothesized mediation models for STI, liver problems and experienced violence (i.e. factors that were significantly associated with neighborhood off-premise outlet density). Model 1 presents the adjusted

Table 2. Characteristics of participants and crude association between participant characteristics and self-reported morbidity ( $N = 2881$ )

	Crude odds ratio (95% CI)					
	STI	Motor vehicle accident <sup>c</sup>	Injury	Liver problems	Hypertension	Experienced violence
Study location <sup>a</sup>						
State of LA	1.29 (0.6–2.9)	1.09(0.8–1.4)	1.11 (0.9–1.4)	0.83 (0.6–1.2)	<b>1.54 (1.26–1.88)</b> ‡	1.02 (0.8–1.3)
LA county	1.00	1.00	1.00	1.00	1.00	1.00
Sex <sup>a</sup>						
Male	0.99 (0.4–2.3)	0.95 (0.7–1.3)	1.25 (0.99–1.6)	1.35 (0.96–1.9)	0.84 (0.7–1.02)	1.02 (0.8–1.3)
Female	1.00	1.00	1.00	1.00	1.00	1.00
Age (years)	0.98 (0.9–1.0)	<b>0.98 (0.97–0.99)</b> ‡	<b>0.99 (0.98–0.99)</b> ‡	<b>1.03 (1.02–1.05)</b> †	<b>1.07 (1.06–1.08)</b> ‡	<b>0.98 (0.97–0.99)</b> ‡
Race <sup>a</sup>						
White	1.00	1.00	1.00	1.00	1.00	1.00
Black	1.18 (0.41, 3.43)	1.14 (0.77, 1.71)	1.56 (1.1, 2.2)‡	1.06 (0.62, 1.79)	<b>2.56 (1.94, 3.38)</b> ‡	1.19 (0.89, 1.59)
Other	0.81 (0.29, 2.23)	1.15 (0.80, 1.63)	1.22 (0.89, 1.68)	1.33 (0.84, 2.09)	<b>1.37 (1.05, 1.8)</b> ‡	0.81 (0.62, 1.06)
Hispanic ethnicity (yes)	1.31 (0.5–3.2)	0.83 (0.6–1.2)	<b>0.68 (0.5–0.9)</b> ‡	1.27 (0.86–1.9)	<b>0.54 (0.42–0.69)</b> ‡	1.15 (0.9–1.5)
Married (yes)	0.53 (0.2–1.2)	<b>0.68 (0.50–0.90)</b> ‡	<b>0.64 (0.5–0.8)</b> ‡	0.77 (0.55–1.1)	<b>0.83 (0.77–0.99)</b> †	<b>0.66 (0.54–0.81)</b> ‡
Education, 0 = never attended school to 5 = college graduate <sup>a</sup>	<b>0.76 (0.60–0.90)</b> ‡	1.11 (0.98–1.3)	0.95 (0.87–1.05)	<b>0.74 (0.65–0.85)</b> ‡	0.94 (0.9–1.02)	0.97 (0.9–1.05)
Employed full-time, legally (yes)	0.56 (0.3–1.2)	1.24 (0.9–1.7)	<b>0.73 (0.58–0.92)</b> ‡	<b>0.41 (0.29–0.59)</b> ‡	<b>0.57 (0.48–0.69)</b> ‡	0.93 (0.8–1.13)
Annual income						
<\$20 000	12.71 (0.83, 94.04) <sup>b</sup>	0.82 (0.56, 1.22)	1.33 (0.95, 1.85)	<b>2.04 (1.24, 3.34)</b> ‡	<b>1.37 (1.04, 1.80)</b> ‡	<b>1.77 (1.31, 2.41)</b> ‡
\$20 000–\$34 999	5.52 (0.39, 76.63) <sup>b</sup>	0.90 (0.58, 1.40)	0.93 (0.62, 1.38)	1.06 (0.57, 1.96)	1.29 (0.95, 1.75)	1.36 (0.97, 1.91)
\$35 000–\$74 999	5.60 (0.40, 79.64) <sup>b</sup>	1.04 (0.71, 1.54)	1.05 (0.74, 1.50)	0.90 (0.50, 1.61)	1.06 (0.80, 1.42)	1.17 (0.85, 1.61)
≥\$75 000	1.00	1.00	1.00	1.00	1.00	1.00
Years lived in neighborhood	0.96 (0.9–1.0)	1.00 (0.98–1.0)	<b>0.98 (0.97–0.99)</b> †	1.00 (0.99–1.02)	<b>1.03 (1.02–1.04)</b> ‡	0.99 (0.98–1.00)
Distance to nearest off-premise alcohol outlet (miles)	0.81 (0.3–1.8)	1.05 (0.96–1.1)	1.05 (0.97–1.1)	0.89 (0.7–1.2)	1.05 (0.97–1.1)	0.88 (0.8–1.02)
Individual off-premise outlet density in 1.0 mile radius	<b>1.08 (1.01–1.2)</b> †	0.86 (0.7–1.0)	1.04 (0.9–1.2)	<b>1.30 (1.1–1.5)</b> †	0.92 (0.8–1.04)	<b>1.44 (1.25–1.65)</b> ‡
Drinking days per year (0–365)	1.05 (0.9–1.3)	1.07 (1.01–1.1)†	1.02 (0.97–1.1)	0.86 (0.8–0.94)‡	0.89 (0.85–0.94)‡	1.05 (1.01–1.10)†
Drinks per day on days drink	1.19 (0.9–1.5)	1.06 (0.97–1.2)	<b>1.09 (1.01–1.2)</b> †	0.91 (0.8–1.04)	<b>0.83 (0.77–0.89)</b> ‡	<b>1.15 (1.07–1.22)</b> ‡
Average daily consumption in the last 90 days	0.93 (0.3–2.5)	1.0 (0.9–1.7)	<b>4.26 (1.4–13.3)</b> ‡	0.6 (0.2–1.5)	<b>0.85 (0.7, 0.98)</b> †	<b>3.39 (1.2–9.8)</b> ‡
Average daily consumption in the last year	1.70 (0.1–3.2)	1.6 (0.7–2.1)	1.05 (0.9–1.3)	1.9 (0.6–6.9)	0.26 (0.04–1.6)	0.96 (0.8–1.2)
Heavy episodic drinking (HED) in the last month (yes)	1.15 (0.4–3.1)	1.31 (0.94–1.8)	<b>1.50 (1.14–1.98)</b> ‡	0.93 (0.6–1.5)	<b>0.55 (0.42–0.72)</b> ‡	<b>1.43 (1.13–1.81)</b> ‡
Level of visible alcohol use in the neighborhood	<b>1.45 (1.1–1.9)</b> ‡	<b>1.11 (1.01–1.2)</b> †	<b>1.15 (1.07–1.24)</b> ‡	<b>1.20 (1.07–1.34)</b> ‡	0.97 (0.9–1.03)	<b>1.62 (1.52–1.73)</b> ‡
Sexual risk behavior (range = 0–4)	<b>1.62 (1.1–1.4)</b> ‡	1.09 (0.9, 1.2)	<b>1.10 (0.98, 1.24)</b> †	0.99 (0.84, 1.17)	<b>0.70 (0.64, 0.77)</b> ‡	<b>1.15 (1.05, 1.26)</b> ‡

$P$ -value: ‡ < 0.01; † < 0.05 based on crude multi-level logistic regression models accounting for spatial autocorrelation.

<sup>a</sup>Comparisons made for: state of LA versus LA county; males versus females; race listed versus White race; lowest versus highest education level.

<sup>b</sup>Exact logistic regression used for STI–income association given the extremely small cell sizes.

<sup>c</sup>Controlling for car ownership.

relationship between off-premise outlet density and each morbidity outcome, controlling for study location, age, sex, race, ethnicity, education and income. Models 2–6 add individual alcohol consumption patterns—drinking days, drinks per day, average daily consumption in last 90 days and year, and HED drinking—to Model 1 to examine mediation by consumption.

Contrary to the conceptualized mediating relationship between individual alcohol consumption on the relationship between neighborhood off-premise density and STI, the addition of alcohol consumption patterns did not reveal any full

mediation—density remained significantly and positively associated with STI for each consumption pattern and individual consumption was not associated with STI. The effect estimate was reduced by including any one of the individual consumption items, especially estimated daily ethanol consumption (adjusted OR = 1.80–1.02) which may indicate some partial mediation although none of the consumption items were significantly associated with STI. Results for STI were more consistent with a confounding relationship, i.e. the addition of consumption patterns (separately, Models 2–6) to a model

Table 3. Neighborhood-level characteristics<sup>a</sup> and crude association between neighborhood characteristics and self-reported morbidity (*N* = 2881)

	Crude odds ratio (95% CI)					
	STI	Motor vehicle accident <sup>b</sup>	Injury	Liver problems	Hypertension	Experienced violence
Mean off-premise outlet density per square mile	<b>1.80 (1.1–3.0)</b> <sup>§</sup>	0.99 (0.9–1.0)	1.02 (0.89–1.16)	<b>1.33 (1.02–1.75)</b> <sup>†</sup>	0.98 (0.9–1.1)	<b>1.31 (1.13–1.51)</b> <sup>‡</sup>
Mean distance to nearest off-premise outlet	0.85 (0.4–1.8)	0.97 (0.8–1.1)	0.95 (0.82–1.10)	0.63 (0.38–1.03)	1.00 (0.9–1.1)	0.89 (0.8–1.04)
Mean visible alcohol use in neighborhood	1.55 (0.9–2.6)	0.97 (0.8–1.2)	<b>1.24 (1.06–1.45)</b> <sup>†</sup>	<b>1.60 (1.28–1.99)</b> <sup>‡</sup>	1.09 (0.94–1.3)	<b>2.09 (1.79–2.44)</b> <sup>‡</sup>
Mean % White	0.73 (0.2–3.1)	1.00 (1.00–1.01)	1.00 (0.99–1.00)	0.98 (0.95–1.00)	0.99 (0.98–1.00)	0.97 (0.98–0.99) <sup>†</sup>
Mean % Black	1.01 (0.99–1.02)	0.97 (0.6–1.5)	<b>1.50 (1.02–2.22)</b> <sup>†</sup>	0.87 (0.47–1.60)	<b>2.76 (2.02–3.76)</b> <sup>‡</sup>	<b>2.82 (2.10–3.80)</b> <sup>‡</sup>
Mean % Hispanic	1.47 (0.4–5.3)	0.62 (0.4–1.02)	0.80 (0.5–1.2)	<b>1.90 (1.10–3.27)</b> <sup>†</sup>	<b>0.44 (0.31–0.63)</b> <sup>‡</sup>	1.30 (0.96–1.76)
% Neighborhood with < high school education	1.57 (0.6–4.4)	0.56 (0.1–2.2)	1.76 (0.58–5.4)	0.94 (0.15–5.9)	<b>9.09 (3.8–21.8)</b> <sup>‡</sup>	<b>14.09 (4.1–8.1)</b> <sup>‡</sup>
Mean % below poverty	10.10 (0.6–18.3)	<b>0.33 (0.1–0.9)</b> <sup>†</sup>	<b>2.72 (1.14–6.5)</b> <sup>‡</sup>	<b>8.48 (2.56–28.1)</b> <sup>‡</sup>	1.58 (0.7–3.5)	<b>37.8 (15.5–91.8)</b> <sup>‡</sup>
Mean concentrated disadvantage	1.02 (0.9–1.1)	0.97 (0.9–1.0)	<b>1.04 (1.01–1.06)</b> <sup>†</sup>	<b>1.04 (1.01–1.08)</b> <sup>†</sup>	<b>1.05 (1.02–1.07)</b> <sup>†</sup>	<b>1.11 (1.08–1.14)</b> <sup>‡</sup>

*P*-value: <sup>‡</sup> <0.0001; <sup>†</sup> <0.01; <sup>§</sup> <0.05 based on crude multi-level logistic regression models accounting for spatial autocorrelation.

<sup>a</sup>Aggregated individual-level items for all characteristics except outlet density, racial distribution, education, poverty and concentrated disadvantage.

<sup>b</sup>Controlling for car ownership.

Table 4. Mediation by alcohol consumption on neighborhood alcohol outlet density and self-reported morbidity (*N* = 2881)

	Adjusted odds ratio (95% CI)		
	STI	Liver problems	Experienced violence
Model 1			
Off-premise outlet density in 1.0 mile radius from home	<b>1.80 (1.1–3.0)</b> <sup>†</sup>	<b>1.33 (1.02–1.75)</b> <sup>†</sup>	<b>1.31 (1.13–1.51)</b> <sup>‡</sup>
Model 2			
Off-premise outlet density in 1.0 mile radius from home	<b>1.78 (1.06–2.97)</b> <sup>†</sup>	1.27 (0.96–1.67)	<b>1.03 (1.02–1.04)</b> <sup>†</sup>
Drinking days per year (0–365)	0.99 (0.80–1.22)	<b>0.86 (0.79–0.95)</b> <sup>‡</sup>	<b>1.06 (1.01–1.11)</b> <sup>†</sup>
Model 3			
Off-premise outlet density in 1.0 mile radius from home	<b>1.78 (1.07–2.96)</b> <sup>†</sup>	<b>1.33 (1.01–1.75)</b> <sup>†</sup>	<b>1.03 (1.01–1.04)</b> <sup>†</sup>
Drinks per day on days drink	1.09 (0.82–1.44)	0.91 (0.80–1.04)	<b>1.15 (1.07–1.22)</b> <sup>‡</sup>
Model 4			
Off-premise outlet density in 1.0 mile radius from home	<b>1.02 (1.00, 1.04)</b> <sup>§</sup>	<b>1.01 (1.00, 1.03)</b> <sup>§</sup>	<b>1.02 (1.01, 1.04)</b> <sup>‡</sup>
Estimated daily consumption, last 90 days	0.94 (0.34, 2.56)	0.59 (0.23, 1.53)	0.99 (0.81, 1.20)
Model 5			
Off-premise outlet density in 1.0 mile radius from home	<b>1.02 (1.01, 1.04)</b> <sup>§</sup>	<b>1.02 (1.00, 1.03)</b> <sup>§</sup>	<b>1.02 (1.01, 1.03)</b> <sup>‡</sup>
Estimated daily consumption, last year	0.99 (0.81, 1.20)	1.85 (0.52, 6.59)	<b>4.23 (1.26, 14.22)</b> <sup>§</sup>
Model 6			
Off-premise outlet density in 1.0 mile radius from home	<b>1.78 (1.07–2.97)</b> <sup>†</sup>	<b>1.33 (1.02–1.75)</b> <sup>†</sup>	<b>1.03 (1.01–1.04)</b> <sup>‡</sup>
HED at least one day in the last month	1.02 (0.34–3.06)	0.93 (0.59–1.46)	<b>1.42 (1.12–1.80)</b> <sup>‡</sup>

*P*-value: <sup>‡</sup> <0.0001; <sup>†</sup> <0.01; <sup>§</sup> <0.05 based on adjusted multi-level logistic regression models, adjusted for study location, age, sex, race, ethnicity, education and income.

with density did not remove but weakened the effect of density on STI, so that controlling for the amount of individual consumption provides a more valid estimate of the role that neighborhood alcohol outlet density plays on STI.

For liver problems, the number of drinking days per year did appear to mediate the relationship between neighborhood density and consumption (rendering density insignificant and consumption being significantly associated with liver problems); however, this relationship is difficult to determine given the study design and nature of the outcome and its impact on consumption (i.e. liver problems could lead to a decrease in consumption, yet alcohol consumption does lead to liver problems).

The results for experienced violence suggest potential partial mediation and/or confounding of individual alcohol consumption in the relationship between neighborhood outlet density and violence.

Table 5 presents the results of multivariate hierarchical models for the association between outlet density per square mile and density within a 1.0 mile radius of the respondent's home, for each morbidity outcome, stratified by race and ethnicity. The impact of outlet density on morbidity outcomes did differ by race and ethnicity, although in some instances this may have been a result of decreased sample size. Nonetheless, differences were observed and for the majority of outcomes, the magnitude of effect was greater when outlet density in a

Table 5. Morbidity and the neighborhood alcohol environment—potential modification by race and ethnicity

	Adjusted odds ratio (95% CI)					
	STI	Motor vehicle accident	Injury	Liver problems	Hypertension	Experienced violence
Impact of off-premise outlet density per square mile						
Among Whites ( <i>n</i> = 1330)	<b>1.04 (1.01, 1.08)<sup>†</sup></b>	0.99 (0.96, 1.01)	1.01 (0.99, 1.04)	1.01 (0.99, 1.04)	1.00 (0.99, 1.02)	<b>1.05 (1.03, 1.07)<sup>‡</sup></b>
Among Blacks ( <i>n</i> = 731)	1.02 (0.99, 1.05)	0.99 (0.97, 1.02)	<b>1.12 (1.02, 1.13)<sup>†</sup></b>	<b>1.02 (1.01, 1.03)<sup>†</sup></b>	1.00 (0.99, 1.01)	1.01 (0.99, 1.02)
Among other racial groups ( <i>n</i> = 820)	0.95 (0.85, 1.05)	<b>0.97 (0.94, 1.01)<sup>§</sup></b>	1.02 (1.00, 1.05)	1.02 (1.00, 1.05)	0.99 (0.97, 1.01)	<b>1.02 (1.00, 1.04)<sup>‡</sup></b>
Among Hispanics ( <i>n</i> = 657)	<b>1.03 (1.01, 1.05)<sup>†</sup></b>	<b>0.97 (0.93, 1.00)<sup>§</sup></b>	1.00 (0.97, 1.02)	1.01 (0.99, 1.04)	1.01 (0.99, 1.03)	1.01 (0.89, 1.03)
Among non-Hispanics ( <i>n</i> = 2049)	0.99 (0.93, 1.06)	0.99 (0.98, 1.01)	1.01 (1.00, 1.02)	<b>1.02 (1.01, 1.03)<sup>†</sup></b>	1.00 (0.99, 1.01)	<b>1.03 (1.01, 1.04)<sup>‡</sup></b>
Impact of individual off-premise outlet density in 1.0 mile radius from home						
Among Whites ( <i>n</i> = 1330)	<b>1.65 (1.05, 2.90)<sup>†</sup></b>	0.86 (0.67, 1.11)	<b>1.26 (0.96, 1.64)<sup>§</sup></b>	1.07 (0.87, 1.32)	0.99 (0.83, 1.18)	<b>1.63 (1.34, 1.99)<sup>‡</sup></b>
Among Blacks ( <i>n</i> = 731)	1.25 (0.74, 2.13)	0.84 (0.61, 1.14)	<b>1.43 (1.12, 1.83)<sup>‡</sup></b>	1.12 (0.93, 1.36)	0.87 (0.73, 1.04)	1.02 (0.83, 1.25)
Among other racial groups ( <i>n</i> = 820)	1.41 (0.64, 3.14)	<b>0.73 (0.50, 1.06)<sup>§</sup></b>	1.29 (0.85, 1.96)	0.95 (0.70, 1.28)	0.84 (0.65, 1.08)	<b>1.50 (1.20, 1.86)<sup>‡</sup></b>
Among Hispanics ( <i>n</i> = 657)	<b>2.08 (1.03, 4.23)<sup>‡</sup></b>	<b>0.51 (0.33, 0.77)<sup>‡</sup></b>	1.09 (0.67, 1.21)	1.19 (0.83, 1.70)	1.12 (0.88, 1.41)	<b>1.28 (1.03, 1.59)<sup>‡</sup></b>
Among non-Hispanics ( <i>n</i> = 2049)	1.24 (0.80, 1.94)	0.95 (0.78, 1.14)	<b>1.16 (1.01, 1.35)<sup>†</sup></b>	<b>1.30 (1.08, 1.57)<sup>‡</sup></b>	0.93 (0.81, 1.06)	<b>1.40 (1.18, 1.66)<sup>‡</sup></b>

*P*-value: <sup>‡</sup> < 0.01; <sup>†</sup> < 0.05; <sup>§</sup> < 0.10 based on adjusted multi-level logistic regression models, adjusted for study location, age, sex, race, ethnicity, education and income.

1.0 mile radius was considered (versus density per square mile of tract or neighborhood).

The association between outlet density and STI was stronger among Whites compared to Blacks or other respondents and stronger among Hispanics compared to non-Hispanic respondents. Greater outlet density was associated with decreased likelihood of motor vehicle accidents among other racial groups and Hispanics. Outlet density was positively associated with injury for all racial and ethnic groups, and significantly so for Whites, Blacks and non-Hispanics when density in a 1.0 mile buffer was considered. Greater density was also associated with a greater likelihood of liver problems among non-Hispanics and a greater likelihood of experienced violence for all racial and ethnic groups, although not significantly so for Black respondents. There were no observed associations between density and hypertension once the data were stratified by race and ethnicity.

While not examined in a mediation model, reported visible alcohol use in the respondent's neighborhood was positively and significantly associated with all morbidity outcomes except hypertension. Such visible alcohol use may be a marker for social disorder. Because drug markets, violence and alcohol availability may overlap (Zhu *et al.*, 2004, 2006), social and health problems in areas with increased alcohol availability may be driven more by the overlapping social issues and resulting social disorder than by alcohol availability alone. In this sample, measures of neighborhood alcohol outlet density were significantly ( $P < 0.001$ ) correlated with visible alcohol use at a magnitude of 0.20–0.30.

## DISCUSSION

The neighborhood environment increasingly is being recognized as a key component of individual health. Key findings of our study are that morbidity clusters by neighborhood, al-

cohol outlet density is associated with several alcohol-related outcomes, (STI, liver problems and experienced violence) and the associations are heterogeneous with respect to race and ethnicity.

With increased clustering indicative of a stronger area-based (in this case, census tract) influence, results suggest that, in the present sample, the neighborhood influence is strongest for STI and experienced violence, and lowest for motor vehicle accident and injury. STIs were mainly reported in females who typically are infected from sexual relations with males. The reason why the association with alcohol outlet density may not be mediated by individual drinking is because the male partner may be the one who drinks, while the female recipient of the STI may be abstinent from alcohol. Similarly, an abstinent resident in a neighborhood with high alcohol outlet density will be just as likely to experience violence as the residents who drink. Contextually determined outcomes may not be mediated by individuals' drinking behaviors. In contrast, liver problems only occur as a consequence of individual drinking, so mediation would be expected. Motor vehicle accidents, on the other hand, are very individually isolated outcomes that typically occur when traveling outside of the neighborhood, for which a car is needed. While the environment is expected to have a greater impact on injury, the question did not limit responses to injuries occurring in or near home, but could have occurred at work or elsewhere.

Furthermore, only density in a radius (e.g. 1.0 mile) from the respondent's home and density per square mile of the census tract (rather than distance to travel to nearest outlet) were associated with STI, liver problems and experienced violence. We have shown in these data that alcohol density impacts on alcohol consumption rather than nearness of the closest outlet (Schonlau *et al.*, 2008) and we showed the same in a previous study (Scribner *et al.*, 2000).

In addition to variation in the associations between alcohol outlet density measures and morbidity outcomes, there were

inconsistencies in the association between individual consumption patterns and morbidity outcomes. Individual consumption was positively associated with experienced violence. The inverse relationship between individual ethanol consumption and hypertension may reflect that patients with some medical conditions or taking medication avoid alcohol.

Despite few observed racial and ethnic differences in self-reported morbidity outcomes, we examined the contribution of alcohol outlet density to all outcomes within each racial and ethnic group. Although the decreased sample size and therefore power may have influenced some of the results of the stratified analysis, significant associations with outlet density were observed and for the majority of outcomes, the magnitude of effect was greater when outlet density in a 1.0 mile radius was considered (versus density per square mile of tract or neighborhood). Outlet density appears, in our sample, to have had a stronger impact on STI among White and Hispanic respondents, and on injury among Black respondents. Furthermore, Black respondents were the only group within whom outlet density did not impact their likelihood of experienced violence. This may also be a result of limited variation in alcohol outlet density among Black respondents, with more clustering of Black respondents in neighborhoods that also have high rates of alcohol availability.

Limitations of this study include a cross-sectional design, survey sampling methodology, self-reported alcohol consumption and morbidity outcomes, and inclusion of only off-premise outlets. Because the sampling was based on listed landline numbers, the response rate was likely impacted. Furthermore, the self-reported nature of the study's surveys and the resulting data on alcohol use and alcohol-related health incidence may have resulted in under-reporting by respondents. Therefore, one of this study's strengths of utilizing respondent information may also have been a limitation; however, the use of self-reporting surveys among the general public is a vital tool that may be the only way to obtain data from individuals who are not currently seeking treatment for their alcohol-related health conditions.

The computing of alcohol-outlet density was based only on off-premise locations. Many of the examined outcomes may also be greatly influenced by on-premise environments (e.g. violence, STI). As mentioned, respondents' reporting of alcohol consumption was not restricted to what they consumed from off-premise purchases, while on-premise locations may clearly play a large role in alcohol consumption. Furthermore, there may be substantial variations within the two geographic locations in the number of on-premise outlets and their impact on alcohol access, consumption and alcohol-related morbidity. However, study location was controlled for in all analyses to minimize this effect. Analyses were limited to off-premise outlets due to data availability but also because we wished to examine the unique impact of off-premise outlets.

Another limitation is that we examined variations in the density and morbidity relationships only by race and ethnicity, but such differences by class, income, age and other demographics are also important and may be examined in future studies.

Furthermore, the only off-premise parameter examined was density measures and therefore we did not account for differences in the availability by outlet type (e.g. liquor stores versus grocery stores), the impact of alcohol advertising and promotion within or near outlets, or alcohol pricing (Bluthenthal *et al.*, 2008). Additionally, while density per square mile is a widely

used measure of alcohol density, density per capita is also commonly used and has the advantage of accounting for population density. As an additional sensitivity analysis, we calculated a per capita (per 1000 population) measure and compared it with the per square mile measure. Results were similar, which was expected given the more urban nature of the sampled tracts (Scribner *et al.*, 1999).

In conclusion, our findings support the notion that alcohol outlets are likely to play a significant role in health outcomes at the neighborhood level, irrespective of individual consumption patterns. Alcohol availability may have a different influence on individuals according to race or ethnicity, although additional research is needed to confirm and further understand this possibility. To address the impact of alcohol availability and other contextual factor on health outcomes, knowledge not only of its association with health outcomes but also on why and how these environments may influence health is required (Morenoff, 2003). Observed results presented here suggest that, with respect to neighborhood alcohol availability, changing this environment may prove effective at reducing certain alcohol-related morbidity outcomes.

*Acknowledgements* — This research was supported by grants from the Centers for Disease Control and Prevention, CDC (1K01SH000002-01 to K.P.T.); the National Cancer Institute, NCI (1 R03 CA103484-01 to D.C.); and the National Institute on Alcohol Abuse and Alcoholism, NIAAA (R01AA013749 to R.S.). The authors wish to thank Paul Robinson, Adrian Overton, Diane Schoeff, Heather Guentzel, Kamua Williams, Michael Murrley, Erica Alacron, Catherine Haywood, Kellie Trombacco and all of the study participants. The views presented in this paper are those of the authors and do not represent those of the funding agencies.

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