The effects of extended public transport operating hours and venue lockout policies on drinking-related harms in Melbourne, Australia: Results from SimDrink, an agent-based simulation model

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Running head: Venue accessibility & drinking-related harms

*Word count (excluding abstract, reference, tables and figures):*3628

Conflict of interest statement: The authors declare no conflicts of interest.

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Abstract

Background: The late-night accessibility of entertainment precincts is a contributing factor to acute drinking-related harms. Using computer simulation we test the effects of improved public transport (PT) and venue lockouts on verbal aggression, consumption-related harms and transport-related harms among a population of young adults engaging in heavy drinking in Melbourne.

Methods: Using an agent-based model we implemented: a two-hour PT extension/24-hour PT; 1am/3am venue lockouts; and combinations of both. Outcomes determined for outer-urban (OU) and inner-city (IC) residents were: the number of incidents of verbal aggression inside public and private venues; the number of people ejected from public venues for being intoxicated; and the percentage of people experiencing verbal aggression, consumption-related harms and transport-related harms.

Results: All-night PT reduced verbal aggression in the model by 21% but displaced some incidents among OU residents from private to public settings. Comparatively, 1am lockouts reduced verbal aggression in the model by 19% but led to IC residents spending more time in private rather than public venues where their consumption-related harms increased. Extending PT by two hours had similar outcomes to 24-hour PT except with fewer incidents of verbal aggression displaced. Although 3am lockouts were inferior to 1am lockouts, when modelled in combination with any extension of PT both policies were similar.

Conclusions: A two-hour extension of PT is likely to be more effective in reducing verbal aggression and consumption-related harms than venue lockouts. Modelling a further extension of PT to 24 hours had minimal additional benefits but the potential to displace incidents of verbal aggression among OU residents from private to public venues.

Keywords: agent-based model; alcohol; drinking-related harms; public transport; SimDrink; venue lockouts; verbal aggression

Introduction

There is a complex relationship between the late-night accessibility of entertainment precincts and drinking-related harms. In particular, negotiating a journey home late at night is considered a concern for personal safety (Measham & Brain, 2005) and when public transport (PT) is not available regulated closing times for public venues create spikes in taxi demand that can lead to disputes or aggression in taxi queues. This is potentially exacerbated by policies such as mandatory venue lockouts (where venues and services remain open but entrance is not allowed) that leave many people simultaneously requiring transport. In Melbourne, Australia, creating a safe 24-hour city has been set as a goal of local planners, and limited late night transport has been flagged as a current barrier (City of Melbourne, 2010).

Melbourne's CBD is heavily populated with bars and nightclubs that are popular among 18-25 year olds. Travelling from outer-urban (OU) areas for a night out in inner-city (IC) entertainment precincts is common among this population (MacLean & Moore, 2014), yet despite many venue licences and individuals' nights out exceeding 1am there is limited PT available after this time. Beyond 1am, the only PT option is a 'nightrider' bus network that operates from the city centre (Public Transport Victoria, 2015b). However, due to poor coverage, lack of connectivity and security concerns, this is not considered to be an attractive or safe option for many young adults (Duff & Moore, 2015; MacLean & Moore, 2014). This inadequacy of PT is problematic, as not only can taxi fares be in excess of AUD80—leaving individuals who are unable to afford a taxi home waiting in the street for PT to start in the morning—but Melbourne's liquor licensing means that venues share common closing times, leading to long waits for taxis and the potential for the above-mentioned disputes and aggression. To reduce these harms it has been proposed that 24-hour PT should operate on Friday and Saturday nights and a 12-month trial has been commissioned to start in January 2016. However, the benefits and indirect effects of such a trial are yet to be quantified.

It is hypothesised that the provision of inexpensive PT throughout the night will ease taxi demand and minimise the amount of people who extend their nights out while waiting for the next morning's first train. Thus, extending PT could potentially reduce disputes and lower incidental alcohol consumption. However, it is also plausible that increasing the late-night accessibility of entertainment precincts could *increase* alcohol consumption, particularly if the flow of city-bound individuals were to increase after 1am, or if people who would typically catch the last train home were to extend their nights *because* of extra PT provisions. In both cases, the additional time spent in entertainment precincts would be after 1am, the time when individuals are most likely to be intoxicated (Miller, et al., 2013) and consequently at highest risk of experiencing consumption-related harms (i.e. drinking beyond their physiological limits, in contrast to other drinking-related harms such as experiencing verbal aggression) (Measham & Brain, 2005). These contrasting outlooks highlight the wide range of effects that could emerge from the implementation of PT-related alcohol policies.

Another policy option central to much debate within Australia is venue lockouts. In February 2014, following a rise in drinking-related violence in Sydney, a two year trial of 1.30am lockouts and 3am closing times were introduced in Kings Cross and the Sydney CBD. Preliminary findings suggest that this led to a 26-32% decrease in assaults (Menéndez, Weatherburn, Kypri, & Fitzgerald, 2015) with limited displacement effects (a simultaneous 9% decrease across the rest of NSW was also reported), although it is unclear whether these decreases were simply the result of reduced pedestrian traffic at night. In 2008, Melbourne's city council introduced a three month trial (March, April and May) of 2am lockouts for public venues across four local government areas (LGAs) (Department of Transport, 2015)—Melbourne's CBD (including Docklands), Port Phillip, Yarra and Stonington. However, the implementation of the policy was flawed, as although there were 487 venues within this area, 120 (25%) were granted exemptions by the Victorian Civil and Administrative Tribunal, many of which were nightclubs either in close proximity to venues with lockouts or located centrally within entertainment precincts (46 out of the 85 nightclubs obtained exemptions). The large number of exemptions created community confusion about the policy that limited its effectiveness, and an evaluation found mixed results (Department of Justice, 2008). Despite this, the Sydney data would indicate the potential for success in Melbourne, in particular in the context of improved PT, and modelling these benefits would be useful for informing policy discussion.

Changes to transport and venue lockout policies are likely to affect different people in different ways, depending on where they live, where they normally drink and other personal characteristics (Callinan, Room, Livingston, & Jiang, 2015; Hart, 2015; MacLean, Ferris, & Livingston, 2013; Meier, Purshouse, & Brennan, 2010). Often models used to test alcohol policy options inadequately capture these differences, and are therefore prone to error if results are extrapolated. Agent-based models (ABMs) are types of models that address this issue by using a set of autonomous 'agents' to represent a population (Gilbert, 2008). Each agent is given unique characteristics and follows simple behavioural rules to interact with others and their environment. When many agents are combined and simulated together, their individualised characteristics provide a representation of a real-world population, and large scale behavioural patterns can emerge from a multitude of local, stochastic interactions. This offers a powerful and complex method for describing human behaviour, which has been successfully applied to alcohol policy research previously (Giabbanelli & Crutzen, 2013; Gorman, Mezic, Mezic, & Gruenewald, 2006; Lamy, Perez, Ritter, & Livingston, 2011).

In this paper we use an ABM SimDrink, developed in Scott et al. (Scott, et al., 2015), to virtually implement combinations of 24-hour PT and venue lockout policies in Melbourne. The model is designed to capture the net effects of alcohol policies on a population of 18-25 year old heavy drinkers, measuring the resulting prevalence of experiencing verbal aggression, consumption-related harms and difficulty getting home. The approach taken is novel because it involves simulating and tracking a population on an hourly time scale throughout the course of a night. This is consistent with the shift in contemporary alcohol and other drug research towards considering the consumption event as the unit of analysis (Bøhling, 2014; Callinan, Livingston, Dietze, & Room, 2014; Dilkes-Frayne, 2014; Kuntsche, Dietze, & Jenkinson, 2014); researchers are attempting to understanding individuals' decisions and their consequences within a single drinking event (a 'big night out'). By using this type of simulation model to compare hypothetical time-specific (i.e. hour of day specific) policies, this study is an example of how modelling can provide insight into the mechanisms by which interventions can affect outcomes. Further, although the model has been applied to Melbourne, these results are applicable to other settings that have similar characteristics—namely locations with a central entertainment precinct that attracts both local residents and residents from surrounding suburbs.

Methods

<u>*The model*</u>

SimDrink is an existing ABM (Scott, et al., 2015), which simulates a population of young (18-25 year olds) people from Melbourne (either residing in IC or OU areas) meeting up with friends, who then move between private, public-niche (e.g. pubs, bars) and public-commercial (e.g. nightclubs) venues over the course of a night (Barton & Husk, 2012). The model tracks individuals' alcohol consumption, spending and whether or not they experience verbal aggression, drink more than their physiological limits (experience ‘consumption-related harms’) or have difficulty getting home (experience ‘transport-related harms’). A detailed model description is provided in Appendix A, parameters used for the model are in provided in Appendix B, and further information including model sensitivities can be found in (Scott, et al., 2015).

Model assumptions and the psychosocial characteristics of drinking in Australia

The model makes several underlying assumptions about the single-occasion drinking sessions of young Australians. In particular, the model assumes:

- Public locations attended by young drinkers from both OU and IC areas are typically in the IC (MacLean & Moore, 2014);
- It is common for people to move between venues (including between public and private settings) throughout the course of a single night (Dietze, Livingston, Callinan, & Room, 2014; Miller, et al., 2013)
- Individuals drink at different rates in different settings (i.e. in public-niche versus public-commercial) and when intoxicated (Lindsay, 2005);
- Friendship groups don’t split up when changing venues, with the exception of some members going home (Miller, et al., 2013—the most common reasons for young people to attend drinking environments is either to socialise with friends or for special events/celebrations);
- Due to both peer-pressure and safety concerns (in particular among OU residents), after exceeding their planned length of night people will only go home if at least one friend has also exceeded their planned length of night (Duff & Moore, 2015—also based on extensive fieldwork from AH and JW); and

- Given the high cost of taxis in Melbourne, most people will be aware of the last train departure time and many people are likely to make specific efforts to catch the last train home (Duff & Moore, 2015—also based on extensive fieldwork from AH and JW).

The extent to which these features are unique to Australia may limit the generalisability of this model to other international settings. For the model to be applied elsewhere, the relevance of these features (along with parameter estimates in Appendix B) would need to be considered.

Measures

For this analysis, the model outputs that have been used to compare different scenarios are: the number of incidents of verbal aggression among OU and IC residents inside public and private venues; the number of OU and IC residents ejected from public venues for being intoxicated; the percentage of OU and IC residents experiencing verbal aggression (noting that these can also occur outside of venues) and consumption-related harms; and the percentage of OU and IC residents experiencing transport-related harms. For each policy scenario being tested, 1000 simulations were run and average outputs were used to account for stochastic model variation. The modelled population for this analysis was 50% male, 50% IC residents (versus 50% OU residents) and 50% 18-21 year olds (versus 50% 22-25 year olds).

Scenarios

To implement a policy of 24-hour PT it was assumed that the model parameter determining PT cut-off time was greater than the model run time. To implement a policy of 1am venue lockouts, agents moving between venues after this time no longer had the option to go to IC public venues. In a separate scenario, both 24-hour PT and 1am lockouts were implemented together.

Sensitivity analysis

Alternate scenarios were run to compare outcomes when: PT was extended by only two hours instead of operating all night; venue lockouts occurred at 3am rather than 1am; and the combinations of a two-hour PT extension with 3am venue lockouts, and 24-hour PT with 3am venue lockouts.

Results

Using baseline parameters, IC residents in the model were more likely to be involved in verbal aggression or ejected from public venues than OU residents, and less likely to be involved in verbal aggression in private venues (Table 1 and Figure 1); however, this is a reflection of IC residents spending more time in public venues (Scott, et al., 2015) rather than IC residents having a higher propensity for harm overall. When weighted by the numbers attending each venue type, the overall modelled prevalence of experiencing verbal aggression was very similar among IC and OU residents (6.36% versus 6.09% for IC and OU residents respectively). IC residents had a slightly lower prevalence of consumption-related harms than OU residents (13.25% versus 13.43%) and a slightly lower prevalence of transport-related harms than OU residents (5.41% versus 5.72%).

When implemented in the model, a policy of 24-hour PT had much more significant effects on OU residents in public venues than IC residents in public venues, as might be expected. Overall, the prevalence of experiencing verbal aggression decreased by 21% when 24-hour PT was available, owing largely to people no longer spending time on the street or in taxi ranks waiting to get home. However, the increased accessibility of public venues in the model resulted in OU residents spending more time in the IC, leading to the displacement of some incidents of verbal aggression from OU private to IC public venues: the number of verbal aggression incidents among OU residents inside public venues increased by 34%, and decreased in private venues by 25%. Further, this coincided with a 70% increase in the number of OU residents being ejected from public venues for being intoxicated (the model does not include being ejected for other reasons (Brands, van Aalst, & Schwanen, 2015)).

A policy of 1am venue lockouts had much more significant effects on IC residents than OU residents in the model. This policy caused IC residents, who, unlike OU residents, were previously able to move from private to public venues late at night (OU residents did not do this once PT had stopped), to spend more time in private venues where the risk of experiencing verbal aggression was lower. With 1am lockouts in place there was a 49% reduction in the number of IC residents being ejected from public venues and a 25% reduction in the number of verbal aggression incidents involving IC residents inside public venues, with no apparent displacement. As drinking rates were modelled to be faster in private venues—which studies suggest occurs due to convenience and lower costs (Foster, Read, Karunanithi, & Woodward, 2010) —the additional time spent in private venues also explains the increased prevalence of consumption-related harms observed among IC residents. For both IC and OU residents, this policy reduced the overall prevalence of experiencing verbal aggression, led to increases in the prevalence of consumption-related harms and reduced transport-related harms by more than a third (35%).

The combination of 24-hour PT and 1am lockouts in the model reduced the prevalence of experiencing verbal aggression by 25%—more than either policy alone—but led to increased consumption-related harms among both OU and IC residents. For OU residents, these changes were largely driven by the 24-hour PT policy on its own, but with a much smaller displacement of verbal aggression from private to public venues due to the restricted flow of people from OU areas to the IC late at night. For IC residents, these changes were largely driven by, and very similar to, the 1am lockout policy alone.

<Table 1>

Sensitivity analysis

Similar results were found when a two-hour extension of PT was modelled instead of 24-hour PT (Table 2 and Figure 1). In particular, the overall reduction in the prevalence of experiencing verbal aggression was the same (22%), there were substantial reductions in the prevalence of experiencing transport-related harms (a decrease of 82%), and fewer incidents of verbal aggression among OU residents were displaced from private to public venues was smaller.

The model showed a policy of 3am lockouts to be less than half as effective as 1am venue lockouts in reducing the overall prevalence of experiencing verbal aggression (a decrease of 8% versus a decrease of 19% for 1am lockouts), but when implemented in combination with either 24-hour PT or a two-hour extension of PT produced similar results to a 1am lockout with 24-hour PT.

<Table 2>

<Figure 1>

Discussion

This study takes the novel approach of using a simulation model of a single drinking occasion to implement and compare time-specific alcohol policies. Using an existing ABM we simulate a population of young heavy drinkers in Melbourne in order to virtually implement and compare the effects of PT extensions and venue lockout policies on verbal aggression, consumption-related harms and transport-related harms. Further, although the setting was specified as Melbourne, the results apply more broadly to places with centralised entertainment precincts that are popular among young adults.

The model predicts that a policy of 24-hour PT would be effective in reducing the prevalence of experiencing verbal aggression, with small concurrent reductions in consumption-related harms, but may lead to the displacement of some verbal aggression incidents among OU residents from private to public venues. However, an extension of PT operations by two hours had similar overall effects with fewer incidents of verbal aggression displaced, and was able to reduce 82% of transport-related harms. Given the high cost of operating 24-hour PT, the model suggests that this option would be worth exploring further.

A policy of 1am lockouts reduced the overall prevalence of experiencing verbal aggression in the simulation by 19%, slightly less than the 21% reduction under a policy of 24-hour PT, but also resulted in some increased consumption-related harms due to many IC residents being displaced from public venues to private venues where they drank faster and consumed a greater amount of alcohol. This modelled decrease in verbal aggression is roughly consistent with recent observations from Sydney, where the introduction of a 1.30am lockout in Kings Cross and the CBD resulted in a

26-32% decrease in assaults (Menéndez, et al., 2015), and an evaluation of the 2am venue lockouts in Melbourne, which suggested that assaults were down by 5-36% (Department of Justice, 2008); although the lack of data informing both evaluations makes this comparison tenuous. Nevertheless, this policy was also effective in decreasing transport-related harms among both IC and OU residents, with a reduction across the overall sample of 32%. When the lockout time was changed from 1am to 3am the policy was only approximately half as effective in reducing verbal aggression and transport-related harms.

The comparison of the modelled effects of the PT and venue lockout policies on their own support the suggestion that enabling policies can be similarly effective to restrictive ones, but without the economic and cultural downsides of restrictions (Department of Justice, 2008). For Melbourne, the model suggested that an enabling policy such as 24-hour PT—or even a two-hour extension in PT operations—may be more beneficial than a restrictive policy such as 1am venue lockouts, and even more beneficial than a policy of 3am lockouts. Such policies have a far greater chance of success, and face fewer cultural and political barriers in their implementation (Brands, et al., 2015; Lam, et al., 2015; Waitt, Jessop, & Gorman-Murray, 2011). The model has thus provided a demonstration that alternatives to tried policies, which might be more in line with the preferences and understandings of safety held by night-time economy patrons themselves, can be equally successful.

When implemented in combination, the modelled effects of 24 hour PT and 1am lockouts were roughly cumulative, since the individual policies disproportionally affected OU and IC residents respectively. However, when the venue lockout time was changed from 1am to 3am in the combined scenario, or when 24-hour PT was changed to a two-hour extension of PT, similar effects were observed. This is important, as implementing a 3am lockout policy is likely to have less cultural opposition (Lam, et al., 2015) and extending PT by only two hours is considerably less expensive than implementing 24-hour operations. Our model suggests that similar overall outcomes could be achieved in terms of reductions in verbal aggression, consumption-related harms and transport-related harms.

This study has several limitations. First, these estimates are based on a theoretical model and there is uncertainty in the model parameters. In particular, limited studies were available that could be used to estimate many of the parameters (see Appendix B for a list of parameters and their sources), including the gender and socio-demographic distributions of harms (Brands, et al., 2015; Waitt, et al., 2011). Importantly, the key parameters governing agents' decisions to change venues or settings or to stop drinking were derived from relatively crude survey data, and further research into how policy affects these decisions is necessary. However, one-way sensitivity analyses and Latin Hypercube uncertainty experiments indicated that the model outcomes were robust when one or more of these parameters varied within their plausible ranges (Scott, et al., 2015). Second, baseline outcomes for the prevalence of consumption-related harms and transport-related harms have not been calibrated to data, since we could not identify any suitable studies. As a result, we emphasize that modelled outcomes should not be used to directly estimate the prevalence of these harms under individual policies, rather to compare multiple policy options as we have done. Third, as the model simulates a single drinking occasion, it only captures the immediate response to changes in alcohol policy and is unable to evaluate longer term behavioural changes as the population adapts to policies. This could potentially be addressed with further work, allowing agents to modify their behaviour and characteristics according to past experiences. Finally, several important lines of inquiry were beyond the scope of the model and the available data. For example, we were unable to investigate the perpetrators of verbal aggression (only the incidents experienced), or the implications of displacing incidents among OU residents from private to public venues. Further ethnographic research should be undertaken to determine how interactions with security staff or an altered environment of social interactions affects this sub-population. We were also unable to investigate the possible effects of increased time spent in private venues on other forms of harm such as sexual assault. Future research and policy debate on reducing harm in the night-time economy should include careful consideration of such displacement effects.

Conclusion

Our model suggests that a two-hour extension of PT is likely to be more effective in reducing verbal aggression and consumption-related harms than venue lockouts. Modelling a further extension of PT to 24 hours had minimal additional benefits and the potential to displace incidents of verbal aggression among OU residents from private to public venues. When implemented in conjunction with any extension of PT, 3am lockouts were equally as effective as 1am lockouts in reducing verbal aggression.

Acknowledgements

The research reported here was funded by an Australian Research Council Discovery Project (DP110101720). The authors gratefully acknowledge the contribution to this work of the Victorian Operational Infrastructure Support Program. The National Drug Research Institute is supported by funding from the Australian Government under the Substance Misuse Prevention and Service Improvement Grants Fund. NS is the recipient of a Burnet Institute Jim and Margaret Beever Fellowship, PD is the recipient of a National Health and Medical Research Council (NHMRC) Senior Research Fellowship and ML is the recipient of an NHMRC Early Career Fellowship.

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Tables

Table 1, policies of 24 hour public transport (PT), 1am venue lockouts, and both. Changes in the number of verbal aggression incidents in public and private venues; the number of people ejected from public venues; and the prevalence of experiencing verbal aggression, consumption-related harms and transport-related harms. Disaggregated for Inner City (IC) residents, Outer Urban (OU) residents and the entire model population.

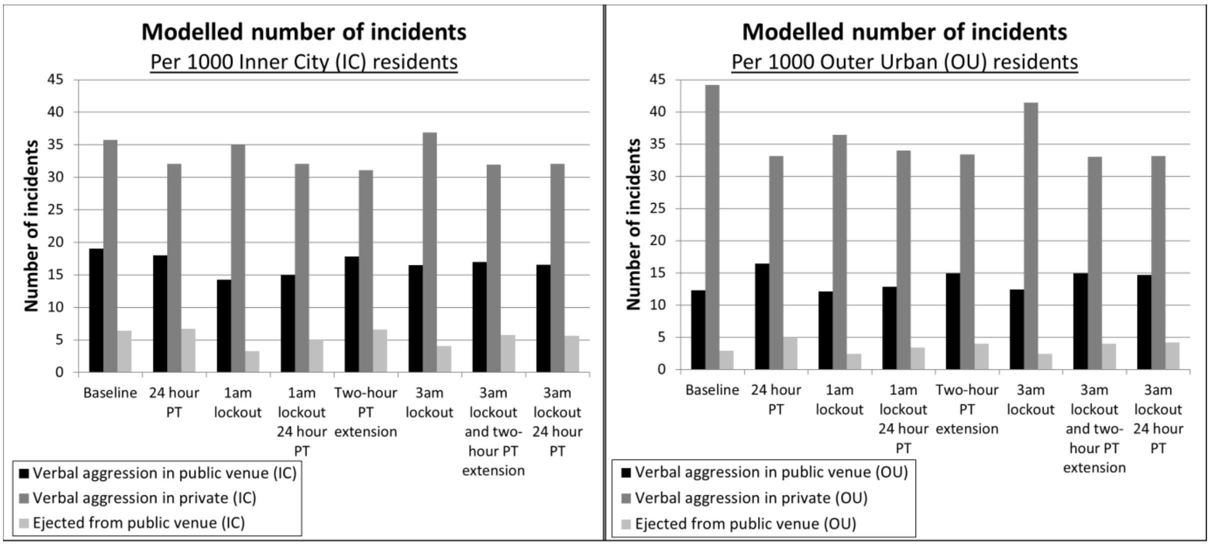
	Baseline (average number of incidents per 1000 population)	**24 hour PT (% change from baseline)**	**1am lockout (% change from baseline)**	**1am lockout 24 hour PT (% change from baseline)**
Verbal aggression in public venue	*15.67*	+10%	-16%	-11%
Verbal aggression in public venue (OU)	*12.32*	+34%	-2%	+5%
Verbal aggression in public venue (IC)	*19.03*	-5%	-25%	-21%
Verbal aggression in private venue	*39.96*	-18%	-11%	-17%
Verbal aggression in private venue (OU)	*44.15*	-25%	-18%	-23%
Verbal aggression in private venue (IC)	*35.75*	-10%	-2%	-10%
Ejected from public venue	*4.68*	+25%	-39%	-9%
Ejected from public venue (OU)	*2.93*	+70%	-17%	+16%
Ejected from public venue (IC)	*6.43*	+4%	-49%	-21%
	Baseline (average prevalence)	**24 hour PT (% change from baseline)**	**1am lockout (% change from baseline)**	**1am lockout 24 hour PT (% change from baseline)**
Verbal aggression	*6.23*	-21%	-19%	-25%
Verbal aggression (OU)	*6.09*	-20%	-18%	-24%
Verbal aggression (IC)	*6.36*	-22%	-21%	-27%
Consumption-related harms (all)	*13.33*	-2%	5%	7%
Consumption-related harms (OU)	*13.43*	-6%	2%	4%
Consumption-related harms (IC)	*13.25*	2%	8%	10%
Transport-related harms (all)	*5.56*	N/A	-35%	N/A
Transport-related harms (OU)	*5.72*	N/A	-18%	N/A
Transport-related harms (IC)	*5.41*	N/A	-52%	N/A

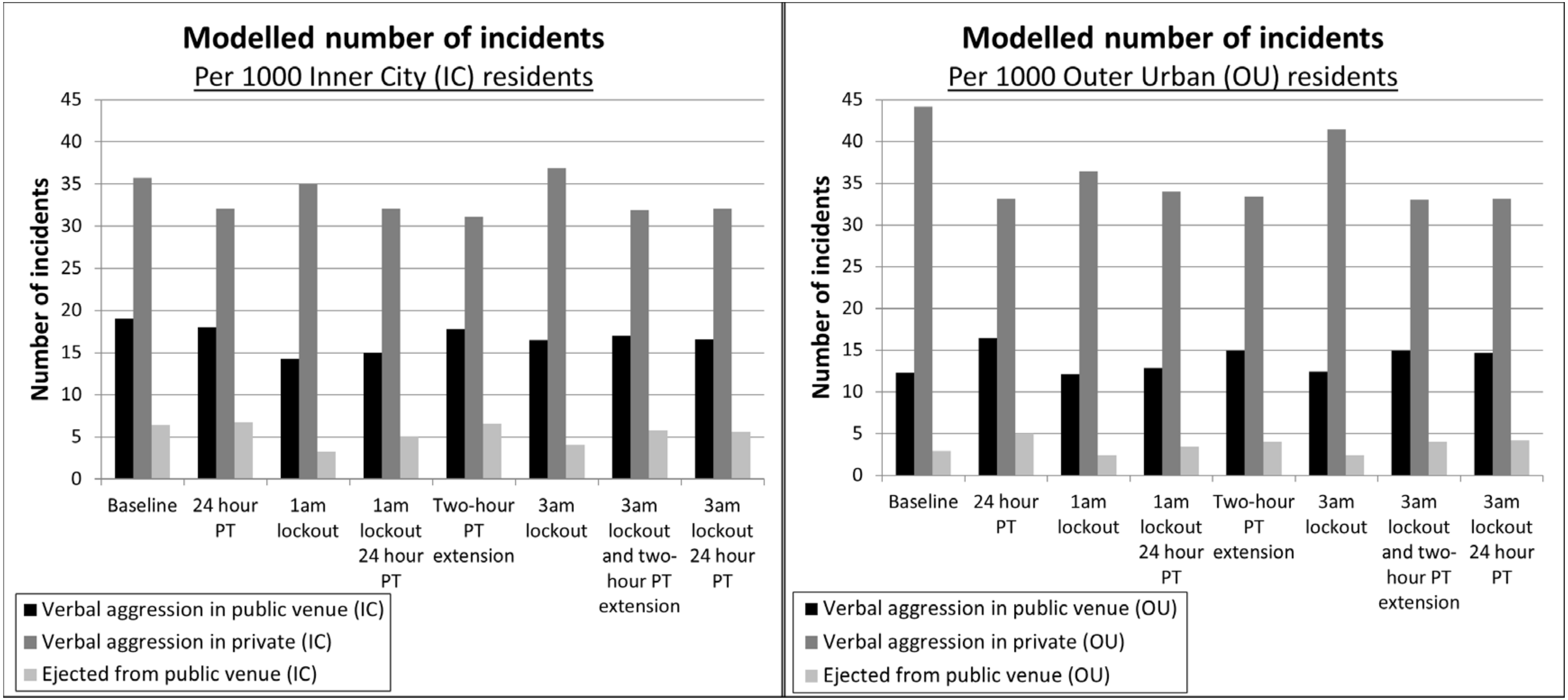
Table 2, policies of a two-hour public transport (PT) extension, 3am venue lockouts, both, and 3am venue lockouts with 24 hour PT. Changes in the number of verbal aggression incidents in public and private venues; the number of people ejected from public venues; and the prevalence of experiencing verbal aggression, consumption-related harms and transport-related harms. Disaggregated for Inner City (IC) residents, Outer Urban (OU) residents and the entire model population.

	Baseline (average number of incidents per 1000 population)	**Two-hour PT extension (% change from baseline)**	**3am lockout (% change from baseline)**	**3am lockout two-hour PT extension (% change from baseline)**	**3am lockout 24 hour PT (% change from baseline)**
Verbal aggression in public venue	*15.67*	+5%	-8%	+2%	0%
Verbal aggression in public venue (OU)	*12.32*	+21%	+1%	+21%	+20%
Verbal aggression in public venue (IC)	*19.03*	-6%	-13%	-11%	-13%
Verbal aggression in private venue	*39.96*	-19%	-2%	-19%	-18%
Verbal aggression in private venue (OU)	*44.15*	-24%	-6%	-25%	-25%
Verbal aggression in private venue (IC)	*35.75*	-13%	3%	-11%	-10%
Ejected from public venue	*4.68*	+14%	-31%	+5%	+5%
Ejected from public venue (OU)	*2.93*	+37%	-17%	+39%	+43%
Ejected from public venue (IC)	*6.43*	+3%	-37%	-10%	-12%
	Baseline (average prevalence)	**Two-hour PT extension (% change from baseline)**	**3am lockout (% change from baseline)**	**3am lockout two-hour PT extension (% change from baseline)**	**3am lockout 24 hour PT (% change from baseline)**
Verbal aggression	*6.23*	-22%	-8%	-23%	-23%
Verbal aggression (OU)	*6.09*	-21%	-6%	-22%	-22%
Verbal aggression (IC)	*6.36*	-24%	-10%	-24%	-25%
Consumption-related harms (all)	*13.33*	-1%	+1%	0%	+1%
Consumption-related harms (OU)	*13.43*	-3%	0%	-4%	-2%
Consumption-related harms (IC)	*13.25*	+1%	+2%	+4%	+5%
Transport-related harms (all)	*5.56*	-82%	-16%	-85%	N/A
Transport-related harms (OU)	*5.72*	-79%	-6%	-79%	N/A
Transport-related harms (IC)	*5.41*	-86%	-26%	-92%	N/A

Figures

Figure 1: Results of simulating various public transport (PT) and venue lockout policies. The modelled number of incidents of verbal aggression in public venues, verbal aggression in private venues, and people being ejected from public venues among Inner City (IC) residents (left), Outer Urban (OU) residents (right).





Modelled number of incidents
Per 1000 Inner City (IC) residents
Number of incidents
45
40
35
30
25
20
15
10
5
0
Baseline
24 hour PT
1am lockout
1am lockout 24 hour PT
Two-hour PT extension
3am lockout
3am lockout and two-hour PT extension
3am lockout 24 hour PT
Verbal aggression in public venue (IC)
Verbal aggression in private (IC)
Ejected from public venue (IC)
Modelled number of incidents
Per 1000 Outer Urban (OU) residents
Number of incidents
45
40
35
30
25
20
15
10
5
0
Baseline
24 hour PT
1am lockout
1am lockout 24 hour PT
Two-hour PT extension
3am lockout
3am lockout and two-hour PT extension
3am lockout 24 hour PT
Verbal aggression in public venue (OU)
Verbal aggression in private (OU)
Ejected from public venue (OU)

Supplementary material

The effects of extended public transport operating hours and venue lockout policies on drinking-related harms: Results from SimDrink, an agent-based simulation model

Nick Scott, Aaron Hart, James Wilson, Michael Livingston, David Moore, Paul Dietze

Appendix A: Detailed model description from Scott et al. (2015)

Model environment

The model environment consists of a circular Inner City (IC) area of radius 5km and an Outer Urban (OU) area extending radially between 5km and 25km from the centre. The IC area contains a mixture of venue types where people can consume alcohol: public venues that are classified as either niche (e.g. bars, pubs) or commercial (e.g. nightclubs); and private venues (e.g. house parties). The OU area contains only private venues since OU public venues in Melbourne are less popular among the young population being modelled, who would typically commute to the IC to attend public venues instead (MacLean & Moore, 2014). All venues are distributed randomly throughout their respective regions (IC or OU). There is a taxi rank in the centre of the model that acts as a gateway for people leaving public venues after public transport stops running. Although travel time is calculated for all movements, transport issues occurring at other times or locations are not considered in this model (i.e. public transport is assumed to be adequate when it is operating, and all travel departing from private venues is assumed to be non-problematic). Finally, there is a node near the centre of the city where individuals who leave public venues unable to afford transport home wait for the first train.

Agent properties

At the start of the night each agent is allocated some fixed properties and some counters to track their night. Their fixed properties are gender, age (18-21 years or 22-25 years), residence (IC or OU), drinking rate, personal drinking limit, initial spending money, size of initial friendship group and planned length of night, and their counters track remaining spending money, total drinks consumed, total hours spent drinking and whether harms have been experienced (verbal, drinking too much or difficulty getting home). The distributions used to allocate fixed properties are listed in Appendix B.

Each agent forms fixed links to all of their friends (friendship groups remain linked throughout the night) and each friendship group is allocated a starting time. There is also a single temporarily link connecting agents to their current venue. Friendship groups enter the model together at their start time and once an individuals' night is over they are able to leave the model, disconnecting links to their friends and final venue.

Venue properties

Venues are also allocated fixed properties and counters. Their fixed properties are location (IC or OU), setting (private, public-niche or public-commercial), closing time (11pm, 12am, 1am, 3am or 5am for public venues or infinite for private venues), drink limit (the maximum number of drinks people in the venue can have before being thrown out—different values for 18-21 year olds and 22-25 year olds in public venues; infinite for private venues) and drink price, and their counters are number of drinks sold, number of verbal fights in the venue and number of patrons ejected for having total alcohol consumption over their drink limit. The distributions used to allocate fixed properties are listed in Appendix B.

Time frame of model

Each time step in the model represents an hour. A complete simulation commences at t=0 corresponding to 5pm and the model runs until all agents have finished their night out. This occurs when they either go home or become stuck in the city waiting for public transport to start the morning.

Model assumptions and the psychosocial characteristics of drinking in Australia

The model makes several underlying assumptions about the single-occasion drinking sessions of young Australians. In particular, the model assumes:

- Public locations attended by young drinkers from both OU and IC areas are typically in the IC (MacLean & Moore, 2014);
- It is common for people to move between venues (including between public and private settings) throughout the course of a single night (Dietze, et al., 2014; Miller et al., 2013);
- Individuals drink at different rates in different settings (i.e. in public-niche versus public-commercial) and when intoxicated (Lindsay, 2005);
- Friendship groups don't split up when changing venues, with the exception of some members going home (Miller et al., 2013—the most common reasons for young people to attend drinking environments is either to socialise with friends or for special events/celebrations);
- Due to both peer-pressure and safety concerns (in particular among OU residents), after exceeding their planned length of night people will only go home if at least one friend has

also exceeded their planned length of night (Duff & Moore, 2015—also based on extensive fieldwork from AH and JW); and

- Given the high cost of taxis in Melbourne, most people will be aware of the last train departure time and many people are likely to make specific efforts to catch the last train home (Duff & Moore, 2015—also based on extensive fieldwork from AH and JW).

The extent to which these features are unique to Australia may limit the generalisability of this model to other international settings. For the model to be applied elsewhere, the relevance of these features (along with parameter estimates) would need to be considered.

Setting up a simulation

The model is initially populated according to the six steps below. Parameters can be found in Appendix B, and further details are represented schematically by the flow diagrams in (Scott et al., 2015).

Each simulation is set up by: 1) generating and distributing venues throughout the model and allocating them their fixed properties; 2) generating a seed population of OU and IC residents and assigning them each a friendship group size; 3) assigning the seed population to start locations for their night; 4) creating additional agents ('friends') in the same location who are linked to the seed agents; 5) allocating fixed properties (age, sex, drinking behaviours and spending money) to all agents; and 6) making agents who do not commence their drinking at t=0 inactive at their current location (where they will not interact with anything until their starting time). Each of these steps is done according to the parameters in Appendix B.

Agent behaviour

Once the model is started seven main operations are performed each time step. Each of these steps is schematically represented in the flow diagrams in (Scott et al., 2015), and the corresponding parameters for each decision are provided in Appendix B.

1) *Offer public venues a chance to eject intoxicated patrons or close*
   Public venues identify patrons who have consumed more than the venue's drink limit and force them to go home. If these agents have at least one friend who has consumed more than a harms threshold, they may experience harms as they leave (see step 4). If a public

venue has reached closing time, all current patrons are offered a choice of whether to go home or move on to another venue—those choosing to move to another venue do so with their remaining friends.

2) *Offer agents a chance to move between venues*

   Agents who have been at a venue for an hour or more choose to either stay at the venue or move to another (Dietze et al., 2014; Miller et al., 2013). Those choosing to move take their entire friendship group with them (Miller et al., 2013), and their new location depends on their current setting type, their residence and the types of venues still open. The model assumes: agents only visit private locations near their residence (i.e. IC agents only go to private venues in the IC); agents don't move from OU private venues to the city once public transport has stopped; there is no gender differences in places visited; IC to IC travel is not done by taxi unless an IC resident is going home (when they choose whether to get a taxi or not); travel time between venues depends on mode of transport and is a maximum of one hour; and the cost of travel by public transport is negligible.

3) *Offer agents a chance to consume drinks*

   Agents calculate their actual drinking rates: that is, they scale their fixed drinking rates depending to their current setting (private, public-niche, public-commercial) and whether they are intoxicated (agents decrease their drinking rate when they have consumed more than half their drinking limits). Agents then attempt to buy an hours' worth of drinks; however those who have just arrived at a venue must deduct travel and queueing time, and those who do not have enough money will buy only as many as they can afford.

4) *Determine harms experienced by agents*

   Agents who have consumed more than their personal drinking limit are considered to have drunk too much and will go home. Agents can also experience verbal violence—this depends on their current location type and whether they have consumed more than a harms drink threshold (agents who have consumed more than 12 (men) or 6 (women) drinks are at increased risk of verbal violence—Appendix B). Agents are considered to have had difficulty getting home if they have spent two or more hours waiting for a taxi.

5) *Get agents to consider going home*

Agents are forced to go home if either: they have consumed more than their personal drink threshold; they are out of money; they and one or more of their friends have exceeded their planned length of night (Duff & Moore, 2015); or if more than half of their initial friendship group has gone home. Agents may decide to go home if: they are in a public venue and the last train is about to leave (Duff & Moore, 2015—this choice depends on their remaining money, the planned length of their night and where they live); they are in a public venue, public transport has stopped and they have only enough money for a taxi left; or if they or a friend have experienced some verbal violence.

6) *Distribute some agents from the taxi rank to their new locations*
   Each time step agents waiting at the taxi rank have some chance of going to their new venue (either home or a private venue). This depends on the number of taxis (per 100 people) in the model and the current size of the queue. Agents who have been waiting for 2 or more hours for a taxi and have consumed more than a harms drinking threshold will loop through step 4 again.

7) *Activate friendship groups*
   Friendship groups who have a start time corresponding to the current model time are activated and begin to interact with the rest of the model, ‘starting’ their night out.

Appendix B: Model parameters and references

Variable	Description	Value	Source	Comments
Setup				
N_seeds	Number of seeds to start the model.	300	Sensitivity analysis (Scott et al., 2015)	Combine with friend distribution for total population size.
p_male	Proportion of men.	0.5	Sensitivity analysis (Scott et al., 2015)	
p_young	Proportion of 18-21 year olds (versus 21-25 year olds).	0.5	Sensitivity analysis (Scott et al., 2015)	
p_inner	Proportion from the Inner City.	0.5	Sensitivity analysis (Scott et al., 2015)	
N_public	Number of public (Inner City) venues.	100	Sensitivity analysis (Scott et al., 2015)	
N_privateOU N_privateIC	Number of private Outer Urban venues. Number of private Inner City venues.	500 500	Sensitivity analysis (Scott et al., 2015)	No impact, not shown.
p_ICpub0	Proportion of Inner City residents starting in public venue.	0.31	Young Adults Alcohol Study [YAAS] (Dietze et al., 2014)	Proportion of Yarra residents starting in public venues.
p_OUpub0	Proportion of Outer Urban residents starting in public venue.	0.27	YAAS (Dietze et al., 2014)	Proportion of Hume residents starting in public venues.
Agent properties				

dist(friend)	Distribution of number of friends.	Poisson(5.69)	Patron Offending and Intoxication in Night-Time Entertainment Districts study (Miller et al., 2013)	Fit to survey results.
dist(length)	Distribution of the planned length of nights.	Poisson(8)	YAAS (Dietze et al., 2014)	Poisson curve fitted to Hume and Yarra residents' total time out.
dist(start)	Distribution of starting times for night out.	Gamma(78.313,4.094)	YAAS (Dietze et al., 2014)	Fit to the time of first drink for Hume and Yarra residents, truncated to be between 5pm and 11pm.
dist(dlim18M) dist(dlim22M) dist(dlim18F) dist(dlim22F)	Distribution of 18-21 year old drinking limits, men. Distribution of 22-25 year old drinking limits, men. Distribution of 18-21 year old drinking limits, women. Distribution of 22-25 year old drinking limits, women.	Poisson(20) Poisson(20) Poisson(15) Poisson(15)	Sensitivity analysis (Scott et al., 2015)	Authors' estimate. Consumption limits for young and old assumed to be the same (however they behave differently).
dist(spend18) dist(spend22)	Distribution of 18-21 year old spending money. Distribution of 22-25 year old spending money.	Gamma(3.456,0.026) Gamma(3.279,0.024)	YAAS (Dietze et al., 2014)	Fit to total spent on night out, by 18-21 year old participants from Hume and Yarra who spent >=$50. Similarly for 22-25 year olds.
dist(drate18M) dist(drate22M) dist(drate18F) dist(drate22F)	Distribution of 18-21 year old drinking rates, men. Distribution of 22-25 year old drinking rates, men. Distribution of 18-21 year old drinking rates, women. Distribution of 22-25 year old drinking rates, women.	Gamma(2.634,1.006) Gamma(2.643,1.238) Gamma(1.744,0.970) Gamma(4.451,2.707)	YAAS (Dietze et al., 2014)	For male 18-21 year old Hume and Yarra residents who attended a private venue first. Fit to distribution of: Total drinks/time in in first venue. Similarly for other age/sex categories.

s_pri_rate	Drink rate scaling factor in private venues.	1	YAAS (Dietze et al., 2014)	Definition.
s_com_rate s_nic_rate	Drink rate scaling factor in commercial venues. Drink rate scaling factor in niche venues.	1.46 1.00	YAAS (Dietze et al., 2014)	For Hume and Yarra residents, at first venue attended, determine: mean drinking rate of (18-21 year old male) participants in commercial venues / mean drinking rate of (18-21 year old male) participants in private venues. Average across age and sex categories. Similarly for niche venues.
s_pri_rate_drunk s_com_rate_drunk s_nic_rate_drunk	Drink rate scaling factor in private venues after drinking more than half personal drink limit. Drink rate scaling factor in commercial venues after drinking more than half personal drink limit. Drink rate scaling factor in niche venues after drinking more than half personal drink limit.	0.76 0.63 0.89	YAAS (Dietze et al., 2014)	Average for Hume and Yarra residents of: drinking rate in last venue of evening (for people ending in a private venue, having attended two or more venues) / average drink rate in first venue (if it was private). Similarly for nightclubs and pub/bar venues.
Setting properties				
dist(CT_com)	Distribution of commercial venue closing times.	(2am, 3am, 4am, 5am, 6am, 7am)= (6, 167, 7, 32, 1, 77)/290	Victorian Commission for Gambling and Liquor Regulation (Victorian Commission for Gambling and Liquor Regulation, 30 April 2015)	Melbourne liquor licensing reports. Commercial venues considered to be venues with “Late night (general) Licence”; Niche bars considered to be venues with “General Licence – Trading to 12am/1am”, “On-Premises Licence – Trading to 12am/1am” or “Late night (on-premises) Licence”.
dist(CT_nic)	Distribution of niche venue closing times.	(12am, 1am, 2am, 3am, 4am, 5am,6am,7am)= (120, 862, 16, 197, 13, 38, 2, 35)/1283		
p_commercial	Proportion of public venues that are commercial (vs niche).	0.18		
dist(QT_com) dist(QT_com_late)	Distribution of commercial venue queueing times (early). Distribution of commercial venue queueing times (late).	0 0.5 hour	Sensitivity analysis (Scott et al., 2015)	Authors’ estimate. No queues for niche venues that close before 1am.

dist(QT_nic) dist(QT_nic_late)	Distribution of niche venue queueing times (early). Distribution of niche venue queueing times (late).	0 hour 0.333 hour		
queue_time	Time of night that queues become longer.	10pm	Sensitivity analysis (Scott et al., 2015)	Based on cover charges, drink deals.
dist(DL_com_young) dist(DL_com_old) dist(DL_nic_young) dist(DL_nic_old)	Distribution of commercial venue drink limits (18-21). Distribution of commercial venue drink limits (22-25). Distribution of niche venue drink limits (18-21). Distribution of niche venue drink limits (22-25).	18 20 18 20	Sensitivity analysis (Scott et al., 2015)	Authors' estimate. Older people are thought to be more in control when intoxicated (Demant & Järvinen, 2010).
p_freedrink	Proportion of private venues where drinks are free.	0.15	YAAS (Dietze et al., 2014)	Proportion of private venues visited by Hume and Yarra residents where drinks were consumed and no money was spent (including money spent on them by others).
$_com $_nic $_pri	Drink price in commercial venues. Drink price in niche venues. Drink price in private venues.	$9.72 $8.56 $5.08	YAAS (Dietze et al., 2014)	Total amount spent by Hume and Yarra residents on drinks in commercial venues (including what others spent on them)/total drinks they consumed there. Only includes venues where spending >0. Similarly for niche and private venues.
Movements				
money2goout	Average spending money of friends required for group to go to public venue.	$30	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.
p_taxi	Probability of getting a taxi (per hour): number of taxis per 100 people in the model, assuming they are all available for one trip per hour. I.e. pr(getting taxi each	1/100 people	Calibration	Parameter can be used to calibrate the percentage of people experiencing transport harms. Increases / decreases the number of

	hour)=(#people/100) * p_taxi * (1/taxiqueue).			taxis in the model.
v_pt v_nopt v_taxi taxi$_OU taxi$_IC d_OUpri2OUpri d_OUpri2OUpri_noPT	Public transport travel speed. Travel speed with no public transport. Taxi speed. Cost of a taxi to Outer Urban private / home. Cost of a taxi to Inner City private / home. Agents travelling Outer Urban private-Outer Urban private will preference venues in this radius when public transport is available. Agents travelling Outer Urban private-Outer Urban private will preference venues in this radius when public transport is not available.	25km/h 10km/h 60 km/h $50 $25 15km 5km	Sensitivity analysis (Scott et al., 2015)	Used to define movement times in model.
p_move	Probability of a group of friends moving each hour.	0.12	YAAS (Dietze et al., 2014)	Total venue changes / total time out of Hume and Yarra residents.
p_ICyoung_com P_ICold_com p_OUyoung_com p_OUold_com	Probability that a public venue visited by an 18-21 year old Inner City resident is commercial. Probability that a public venue visited by a 22-25 year old Inner City resident is commercial. Probability that a public venue visited by an 18-21 year old Outer Urban resident is commercial. Probability that a public venue visited by a 22-25 year old Outer Urban resident is commercial.	0.38 0.34 0.47 0.38	YAAS (Dietze et al., 2014)	Number of commercial venues visited by 18-21 year old Yarra residents / number public venues visited by 18-21 year old Yarra residents. Similarly for 22-25 year olds and Hume residents.
p_bar2bar	Probability of moving public to public (vs public to private).	0.78	YAAS (Dietze et al., 2014)	Total public-public movements of Hume and Yarra residents/total public-public + public-private movements.

p_house2house	Probability of moving private to private (vs private to public).	0.26	YAAS (Dietze et al., 2014)	Total private-private movements of Hume and Yarra residents/total private-private + private-public movements.
t_transport	Time when public transport turns off.	1am	Public Transport Victoria (Public Transport Victoria, 2015a)	Last outbound train from the city.
p_PTrush_OU_plan_$	Pr of rushing for last train, Outer Urban resident, within hour of planned length, not enough left for taxi.	0.6	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.
p_PTrush_OU_plan	Pr of rushing for last train, Outer Urban resident, within hour of planned length.	0.4		
p_PTrush_OU_$	Pr of rushing for last train, Outer Urban resident, not enough left for taxi.	0.2		
p_PTrush_OU	Pr of rushing for last train, Outer Urban resident.	0.1		
p_PTrush_IC_plan_$	Pr of rushing for last train, Inner City resident, within hour of planned length, not enough left for taxi.	0.4		
p_PTrushIC_plan	Pr of rushing for last train, Inner City resident, within hour of planned length.	0.2		
p_PTrush_IC_$	Pr of rushing for last train, Inner City resident, not enough left for taxi.	0.1		
p_PTrush_IC	Pr of rushing for last train, Inner City resident.	0		
p_ICtaxi	Probability of an Inner City resident trying to get a taxi home after public transport stops (compared to walking).	0.5		
p_lastchancetaxi_OU	Probability Outer Urban resident using the last of their money to get home.	0.5		
p_lastchancetaxi_IC	Probability Inner City resident using the last of their money to get home.	0.2		

p_close2home	Probability of going home after a venue closes.	0.5	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.
Harms				
harms_drinkthreshold	Above this many drinks consumed people are at greater risks of verbal fights.	12 (M) / 6 (F)	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.
s_pri_vfm s_com_vfm s_drunk_vfm	Verbal fight, scaling factor for private venue (relative to niche venue), men. Verbal fight, scaling factor for commercial venue (relative to niche venue), men. Verbal fight, scaling factor when consumed more than harms_drinkthreshold drinks, men.	2.5 5 5	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.
p_vfm	Verbal fight per person-hour, niche venue, men.	0.00127	YAAS (Dietze et al., 2014)	Dependent on scaling factors and harms_drinkthreshold. Let time_nic_m and time_nic_m_drunk be the total person hours in YAAS spent by men in niche venues before and after harms_drinkthreshold drinks were consumed respectively. For venues where the drink threshold is crossed, all time is counted towards time_nic_m_drunk. Then p_vfm = total verbal fights for men / [time_nic_m + time_pri_m*s_pri_vfm + time_com_m*s_com_vfm + s_drunk_vfm*(time_nic_m_drunk + time_pri_m_drunk*s_pri_vfm + time_com_m_drunk*s_com_vfm)]. Uses participants from all LGAs.
s_pri_vff	Verbal fight, scaling factor for private venue (relative to niche venue), women.	2.5	Sensitivity analysis (Scott	Authors' estimate.

s_com_vff s_drunk_vff	Verbal fight, scaling factor for commercial venue (relative to niche venue), women. Verbal fight, scaling factor when consumed more than harms_drinkthreshold drinks, women.	5 5	et al., 2015)	
p_vff	Verbal fight per person-hour, niche venue, women.	0.00088	YAAS (Dietze et al., 2014)	Analogous to p_vfm. Uses participants from all LGAs.
p_verbalhome	Probability of going home after a friend has a verbal argument.	0.7	Sensitivity analysis (Scott et al., 2015)	Authors' estimate.