

Using simulation modelling to examine the impact of venue lockout and last-drink policies on drinking-related harms and costs to licensees

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Many variations of venue lockout policies have been introduced in an attempt to reducing drinking-related harms. However, there is limited evidence to support their effectiveness¹ or to differentiate between variations of the same policy, such as the lockout times that are used. Over the last decade or so, *ad hoc* versions of these policies have been introduced in Australia as a result of the politicisation (or 'problematisation') of drinking-related violence,² where late-night trading has been presented as the sole or primary cause of aggression in the night-time economy. As a result, several of Australia's major cities have a varied and inconsistent history of venue lockout and last-drink policies.

In 2008, Melbourne's city council introduced a three month trial (March, April and May) of 2 am lockouts for public venues (meaning that they can remain open but patrons cannot enter or re-enter after 2 am) across four local government areas (LGAs)³—Melbourne's CBD (including Docklands), Port Phillip, Yarra and Stonnington. 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 close to venues with lockouts or located centrally within entertainment precincts (46 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

Abstract

Objective: Many variations of venue lockout and last-drink policies have been introduced in attempts to reduce drinking-related harms. We estimate the public health gains and licensee costs of these policies using a computer simulated population of young adults engaging in heavy drinking.

Method: Using an agent-based model we implemented 1 am/2 am/3 am venue lockouts in conjunction with last drinks zero/one/two hours later, or at current closing times. Outcomes included: the number of incidents of verbal aggression in public drinking venues, private venues or on the street; and changed revenue to public venues.

Results: The most effective policy in reducing verbal aggression among agents was 1 am lockouts with current closing times. All policies produced substantial reductions in street-based incidents of verbal aggression among agents (33-81%) due to the smoothing of transport demand. Direct revenue losses were 1-9% for simulated licensees, with later lockout times and longer periods between lockout and last drinks producing smaller revenue losses.

Conclusion: Simulation models are useful for exploring consequences of policy change. Our simulation suggests that additional hours between lockout and last drinks could reduce aggression by easing transport demand, while minimising revenue loss to venue owners.

Implications for public health: Direct policies to reduce late-night transport-related disputes should be considered.

Key words: alcohol, agent-based model, last drinks, venue lockouts, verbal aggression

results.⁴ These lockouts were subsequently revoked, and Melbourne currently has no venue lockout policies and varied closing times for venues, with a large number of current licenses (185 or 11%) allowing venues to serve alcohol until 5 am or later.⁵

At about the same time in 2008, 3:30 am public venue closing times and 1:30 am lockouts were introduced in Newcastle, with no exceptions, which resulted in a sustained 37% reduction in assaults in comparison to a local control city Hamilton.⁶ However a change of policy in 2010 that required Hamilton to enforce 1 am venue lockouts, but

without any changes to venue closing times (which could be as late as 5 am), resulted in no significant changes to drinking-related assaults in Hamilton.¹ This suggests that the reductions observed in Newcastle may have been caused by the restriction in operating hours rather than the lockout policy itself.

In February 2014, following a rise in drinking-related violence in Sydney, a two-year trial of 1.30 am lockouts and 3 am closing times was introduced in Kings Cross and the Sydney CBD. Preliminary findings suggest that this led to a 26-32% decrease in assaults⁷ with limited displacement effects (a simultaneous

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9% decrease across the rest of NSW was also reported), and a reduction in the number of drinking-related serious injury presentation in the emergency department of a major nearby hospital.⁹ However, it is unclear whether these decreases were simply the result of reduced participation in the night-time economy, with business revenue allegedly falling 20–50%,⁹ as supported by a 33% fall in foot traffic (from a Saturday night peak of about 6,000 in 2011 to about 4,000 in 2015),¹⁰ lower passenger crossings at Kings Cross station and reduced taxi patronage.⁷ At the time of writing a review of these laws was under way. Other evaluations of lock-out laws in Queensland^{11,12} and in regional Victorian cities¹³ have produced mixed findings, with the weight of evidence suggesting that trading hours (or hours of service) are more likely to reduce harm than lockout provisions. Recent legislation in Queensland means that from July 2016, state-wide laws of 2 am last drinks will be introduced, with an exception of 3 am last drinks given to venues in 15 late-trading 'Safe Night Precincts'.^{14,15} In addition, from February 2017 a 1 am lockout law was to be introduced to these 15 safe Night Precincts;¹⁵ however, a subsequent policy review removed this requirement before it was implemented.

A challenge for evaluations of these policies is that when balancing the needs of various stakeholders it is difficult to define success. The obvious desirability of lower numbers of assaults and emergency department presentations must be balanced against sociocultural and economic costs to businesses, consumers and the community via reduced participation in the night-time economy. Current evaluations largely focus on the impacts on violence and injury, which means that a full picture of the impacts of policy change is rarely available. Metrics such as venue revenue lost per incident averted can be used to objectively debate various policy impacts, although these data are largely private and unavailable to researchers. Simulation modelling can provide a method of estimating and comparing these measures under a range of policy options before they are actually implemented.

Agent-based models (ABMs) are a type of model that has been successfully applied to alcohol policy analysis.^{16–19} ABMs are powerful in their abilities to represent diverse populations, as they comprise a set of autonomous 'agents' with unique characteristics.²⁰ Each agent in the model

follows simple behavioural rules to interact with other agents and their environment according to their personal characteristics. In this way, different responses to venue lockout policies according to where people live, where they normally drink and other personal characteristics can be captured.^{21–24} 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.

In this paper we use an existing ABM 'SimDrink'²⁵ to simulate the effects of a variety of venue lockout and last-drink policies. In particular, we estimate the reduction in verbal aggression and lost revenue under variations of each policy, and combine these to determine the licensee costs per incident of aggression averted. 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 means that unlike many other models of this kind, we are able to compare hypothetical time-specific (i.e. hour of day specific) policies, such as different lockout and last-drink times.

Methods

The model

SimDrink simulates a population of 18–25 year olds from Melbourne (residing in either inner city (IC) or outer urban (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 Saturday night.²⁶ The model tracks individuals agents' alcohol consumption, spending and whether or not they experience verbal aggression, 'consumption-related harms' (drink more than their pre-determined physiological limits) or 'transport-related harms' (have difficulty getting home). A detailed model description is provided in Appendix A and parameters used for the model are in provided in Appendix B (see the Supplementary file available with the online version of this article). Further information including an extensive investigation of model sensitivities can be found in.²⁵

The model setting is Melbourne, but from the period prior to the introduction of 24-hour public transport in January 2016. There are several reasons for this. First, data to parametrise the model were obtained from

the Young Adults Alcohol Study (YAAS),²⁷ which was conducted in 2012, prior to this major policy change. The YAAS questionnaire asks a cohort of young heavy drinkers detailed questions about their movements and drinking behaviours throughout their most recent 'big night out' in Melbourne, defined as their most recent occasion consuming more than 8 (women) or 10 (men) standard drinks of alcohol. It is unclear what long-term effects 24-hour public transport has had on individual drinking behaviours and therefore whether these data and parameters are still appropriate in 2016. Second, we would like our results to apply more broadly to other settings, in particular Adelaide, Brisbane and Sydney, where public transport operates similarly to how it did in Melbourne in 2012. Ideally, each of these settings would be modelled with unique, locally relevant parameters, but as no studies similar to YAAS are available in other Australian cities, this is not possible. Nevertheless, we believe that the psychosocial characteristics of drinking that the model relies on, which are listed directly below, are similar across other settings, making the results generalisable.

Model assumptions and the psychosocial characteristics of drinking in Australia

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

- Public locations attended by young drinkers from both OU and IC areas are typically in the IC.²⁸
- It is common for people to move between venues (including between public and private settings) throughout the course of a single night.^{27,29}
- Individuals drink at different rates in different settings (i.e. in public-niche versus public-commercial) and when intoxicated.³⁰
- Friendship groups don't split up when changing venues, with the exception of some members going home (the most common reasons for young people to attend drinking environments is either to socialise with friends or for special events/celebrations).²⁹
- 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 (also based on extensive fieldwork from the authors).³¹

- Given the high cost of taxis, 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 (also based on extensive fieldwork from the authors).³¹

The generalisability of this model and its results is determined by the applicability of these assumptions to other settings. In the absence of evidence to the contrary we believe these assumptions to be broadly consistent at least across other capital Australian cities.

Several features believed to influence people’s movements and harms and venues’ revenues were unable to be included due to lack of studies and data to inform the model; for example the increasing use of ride-sharing services such as Uber, promotional events, drink discounts and live music. These have been identified as areas for future work.

Measures

For this analysis, the model outputs used to compare different scenarios were: the number of incidents of verbal aggression inside public and private venues; the number of incidents of verbal aggression outside of public venues (‘street-based’ incidents); and the percentage of agents from the OU and IC areas experiencing consumption-related harms. The effect of venue lockout policies on transport-related harms experienced by agents in the model have been considered elsewhere.¹⁹

Venues in the model each have their own set of individual properties and can record the total amount spent on drinks by simulated agents throughout the course of the night, meaning that when policies are tested that affect the movements of individuals, any changes to total revenue from a base scenario are able to be measured. This is how the direct loss of revenue under various lockout and last drink scenarios was estimated.

For each policy scenario being tested, 1000 simulations were run and average outputs were used to account for stochastic model variation. The simulated 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 policies of venue lockouts, agents moving between venues after the lockout time no longer had the option to go to IC public venues. Closing time is a property of each venue in the model, and to implement last-drink policies, at a given time all venues were closed simultaneously and people inside them were moved on using the same process as if this were a regular closing time (see Supplementary file, Appendix A). Policies tested were: lockout times of 1 am, 2 am and 3 am; and last-drink times occurring at 1 am, 2 am, 3 am or the regular venue closing times (up to 7 am for some venues⁵ – see Supplementary file, Appendix B). Each policy was compared to a scenario of no lockouts and current last-drink times, and policies that varied closing times but had no lockouts were implemented as the lockout time being equal to the last-drinks time.

Results

Regardless of last-drink time, 1am lockouts were the most effective in reducing total incidents of verbal aggression. Total incidents decreased by 17–25% under the various 1 am lockout policies, compared to 16–18% under 2 am lockout policies and 10–11% under 3 am lockout policies (Table 1).

Across all policies, the most significant effects were on street-based incidents of verbal aggression – those occurring after people had left venues and were navigating the transport system. Street-based incidents fell by 33–81%, with larger falls observed as the time between lockout and last drinks increased

due to reduced surges and smoothing of transport demand. In the case of 1 am lockouts with current venue closing time—the longest period between lockout time and last drinks – the number of street-based incidents of verbal aggression was reduced by as much as 81%. In particular, street-based incidents accounted for only 16% (11.0/67.2) of baseline incidents, but represented the majority of incidents averted, indicating that this is a key component of the policy impact. Contrasting this is that the reduction in verbal aggression inside of venues was the lowest when last-drink times were earlier; however this simply reflects less person-hours spent inside of venues.

As might be expected, the least revenue was lost when venues were able to accept patrons until later (3 am lockout time) or serve drinks for longer (current closing times). Depending on the additional hours of service allowed, the estimated loss of revenue to venues ranged from 4–9% with 1 am lockouts, 3–5% with 2 am lockouts and 1–2% with 3 am lockouts. These figures relate only to direct losses in revenue over a single night. The model does not consider any longer-term behavioural response to the policies that may result in lower patronage and revenues over time, or any rebound effects in patron behaviour such as starting earlier. As such, our results cannot be directly compared with values of 20–50% reported in Sydney.⁹

Policies that had the longest period between the lockout time and last drinks had both the maximum reduction in street-based incidents and the least loss of revenue as venues could continue serving for longer. These policies

Table 1: Results of policy simulations. The percentage change in the number of incidents of verbal aggression in public venues, private venues and in the street; the loss of revenue to public venues; the cost per incident of verbal aggression averted; and the percentage change in the prevalence of consumption-related harms among inner city and outer urban residents.

	Baseline	1 am lockouts			2 am lockouts			3 am lockouts		
		1 am last-drinks	2 am last-drinks	3 am last-drinks	Current last-drinks	2 am last-drinks	3 am last-drinks	Current last-drinks	3 am last-drinks	Current last-drinks
Incidents of verbal aggression per 1,000 people										
Public venues	16.0	-26%	-23%	-19%	-16%	-20%	-16%	-12%	-17%	-8%
Private venues	40.3	-2%	-9%	-11%	-13%	-6%	-7%	6%	-2%	-3%
Street-based	11.0	-55%	-73%	-72%	-81%	-56%	-59%	-58%	-33%	-41%
Total incidents	67.2	-17%	-23%	-23%	-25%	-17%	-18%	-16%	-11%	-10%
Total public revenue per 1,000 people	\$26,761	-9%	-5%	-4%	-4%	-5%	-3%	-3%	-2%	-1%
Lost revenue per public incident averted	N/A	\$227	\$124	\$108	\$84	\$140	\$88	\$95	\$100	\$66
Percentage of population who experienced consumption-related harms (columns represent percentage change)										
Outer urban residents	13.4	-1%	0%	2%	1%	1%	0%	1%	0%	-1%
Inner city residents	13.1	5%	8%	8%	9%	5%	5%	6%	1%	2%

also had the lowest licensee cost per incident of aggression averted and so could therefore be considered the most 'effective'.

It is important to note that in all of these scenarios, in particular when the lockout time was earlier, there was an increase in consumption-related harms among IC residents. The prevalence of consumption-related harms among IC residents increased by 5–9% for 1 am lockouts, 5–6% for 2 am lockouts and 1–2% for 3 am lockouts. This was because before lockout policies were introduced, IC residents were able to move from private to public venues late at night (OU residents did not do this once public transport had stopped); however venue lockouts prevented this and led to IC residents spending more time in private venues. As drinking rates were modelled to be faster in private venues – which studies suggest occurs due to convenience and lower costs³² – there was an increased prevalence of consumption-related harms.

The increase in the prevalence of consumption-related harms may also explain the decrease in verbal aggression in private venues under these policies, as experiencing consumption-related harms was considered to end the night for individuals, thus ending their chances of experiencing verbal aggression. In particular for many of the higher-risk individuals (i.e. people in the model who had consumed greater than a harms threshold for experiencing verbal aggression, see Supplementary file, Appendix A) their nights were likely to be ending earlier.

Discussion

We have used an ABM to simulate single drinking occasions of young, heavy drinkers in order to implement and compare several time-specific venue lockout and last-drink policies. These policies were most effective in reducing our measure of harm, incidents of verbal aggression, when there was a longer period between the lockout time and last-drinks time. In particular, their effectiveness in the model was primarily due to the smoothing of transport demand, which led to large reductions in the number of street-based incidents. This is an important illustration of how simulation models can be used to explore the intended and unintended consequences of policy change, as well as highlighting knowledge gaps and uncertainties, in order to develop rational and practical recommendations in the absence of conventional evidence.

A more direct method of addressing street-based incidents of aggression may be by extending public transport operating hours, which is being trialled in Melbourne in the form of 24-hour public transport on Friday and Saturday nights. Not only has similar modelling work shown that this policy may be more effective in reducing incidents of aggression than venue lockouts,¹⁹ but it is likely to have more public support and subsequently face fewer political barriers. It remains to be seen how the introduction of 24-hour public transport in Melbourne has actually affected individual behaviours and drinking-related harms, in particular those of OU residents who have increased access to IC entertainment precincts late at night; for example it is plausible that these individuals may start their nights out later or have different movement patterns between venue types as a result of the policy. A review of the 24-hour public transport is due to occur in January 2017, however following the popularity of the first six months of operation the policy has been extended from a 12 month to an 18 month trial. Important comparisons should be drawn between this and the two-year review of the Kings Cross lockout policy, which at the time of writing was not yet concluded but was due in 2016.³³

The model estimates that by including additional hours between lockout time and last-drinks time the loss of revenue to venue owners could be minimised, and that in the worst scenario losses would not exceed 10%; however this does not include losses from longer-term behavioural changes as people adjust to policies. For example, changes to the atmosphere of particular entertainment precincts may feedback to make the area less attractive as a night-time destination, reducing the number of people looking to have 'big nights' and producing additional revenue losses due to less participation in the night-time economy. This may be more likely to occur in areas such as Kings Cross, where a nearby precinct exists (e.g. Newtown) that does not have lockout policies in place. This was unable to be tested due to a lack of data to inform the modelling, and therefore we emphasise that our results should be used to compare policies, rather than to estimate their absolute impact. With this in mind, additional hours between lockout time and last-drinks time also came out to be the preferred policy options for venue owners.

It should be noted that these simulated findings are not entirely consistent with

the evaluation literature,¹ which generally suggests that trading hour or 'last drinks' restrictions are more effective than lock-out policies. This may be related to limitations of this study. First, these results are based on a theoretical model and there is uncertainty in the model parameters. To better understand these uncertainties, model sensitivities have been tested in detail elsewhere;²⁵ the model was found to be robust to parameter variations, providing us with some confidence in the results. Despite this, a major strength of this study is the use of a simulation model to highlight policy implications that may otherwise be overlooked. We recommend that evidence from modelling work, which can capture the broader impact of policy changes, be used to inform future policy decisions.

Second, as mentioned in the methods, the parameters apply to young, heavy drinkers in Melbourne before 24-hour public transport was introduced, which we are generalising to other settings. The specific assumptions about drinking characteristics that are included in the model have been explicitly highlighted and, notwithstanding some likely variation in drinking behaviours between settings, we believe they can be applied beyond Melbourne, at least across capital cities.

Third, the model has been designed to capture the effects of policies on individuals throughout the course of a single night, in order to measure the impact of time-specific policies. However, this means that it does not capture the effects of behavioural change over time, most notably reduced patronage and revenues, as well as any rebound over time. Policies are also implemented uniformly to all venues, meaning that the simulated agents cannot plan their nights or make decisions to go to venues or suburbs that may be exempt. Furthermore, agents do not fundamentally alter their nights out in response to policy changes. For example, if people started their nights out earlier in response to policy changes, this could shift the harm and revenue distribution among different types of venues. Instead, due to the lack of data available to inform alternative approaches, we assume similar behaviours and decision making up until restrictions limit the agents' options. This is likely to be a simplification of the actual effects of policy change, so we have therefore been careful to draw conclusions about comparing policies, rather than estimating the actual effect sizes.

This study has highlighted numerous data gaps and the need to better understand factors leading to aggression in the night-time economy in order to make informed alcohol policy decisions. Although novel data from studies of young people have been used for our model parameters, larger studies and studies from more locations would improve the model's generalisability to other settings and enable additional features to be included. The model also does not include incidents of physical violence due to the unavailability of individual-level data. This means that model outcomes cannot be directly validated against crime statistics or emergency department data. Further, even if data were available to inform the model of physical violence, there is still limited evidence on what the denominators for hospital and crime statistics data are – for example how many people were having a 'big night out' in order to produce the observed number of events – making it hard to draw conclusions on the effectiveness of policies without further understanding of participation in the night-time economy.

Conclusions

Simulation models are useful tools for policymakers and researchers to explore intended and unintended consequences of policy change. Our simulation suggests that including additional hours between lockout times and last drinks could be explored as a way to reduce aggression by easing transport demand while also minimising the loss of revenue to venue owners. However, all lockout policies resulted in greater consumption-related harms among inner city residents. Policies to minimise late-night transport-related disputes should be considered as a more direct way of reducing aggression in the night-time economy.

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References

- Kypri K, McElduff P, Miller P. Restrictions in pub closing times and lockouts in Newcastle, Australia five years on. *Drug Alcohol Rev.* 2014;33(3):323-6.
- Lancaster K, Hughes CE, Chalmers J, Ritter A. More than problem-solving: Critical reflections on the 'problematisation' of alcohol-related violence in Kings Cross. *Drug Alcohol Rev.* 2012;31(7):925-7.
- Department of Environment, Land, Water and Planning. *Information About Victoria's 79 Local Councils and How We Work with Them* [Internet]. Melbourne (AUST): State Government of Victoria; 2015 [cited 2016 Aug]. Available from: <http://www.dpcd.vic.gov.au/localgovernment/find-your-local-council#councils>
- KMPG. *Evaluation of the Temporary Late Night Entry Declaration, Final Report*. Melbourne (AUST): Victorian Department of Justice; 2008.
- Victorian Commission for Gambling and Liquor Regulation. *Victorian Liquor Licences by Category* [Internet]. Melbourne (AUST): State Government of Victoria; 2015 [cited 2016 Aug]. Available from: <http://www.vcglr.vic.gov.au/home/resources/data+and+research/victorian+liquor+licences+by+category>
- Kypri K, Jones C, McElduff P, Barker D. Effects of restricting pub closing times on night-time assaults in an Australian city. *Addiction.* 2011;106(2):303-10.
- Menéndez P, Weatherburn D, Kypri K, Fitzgerald J. Lockouts and last drinks: The impact of the January 2014 liquor licence reforms on assaults in NSW, Australia. *Crime Justice Bull.* 2015 April:183.
- Fulde GW, Smith M, Forster SL. Presentations with alcohol-related serious injury to a major Sydney trauma hospital after 2014 changes to liquor laws. *Med J Aust.* 2015;203(9):366.
- NSW Legislative Assembly Committee on Law and Safety. *Measures to Reduce Alcohol and Drug-related Violence: Preliminary Inquiry* [Internet]. Sydney (AUST): New South Wales Parliament; 2014 [cited 2016 Aug]. Available from: <https://www.parliament.nsw.gov.au/committees/DBAssets/InquiryReport/ReportAcrobat/5969/Measures%20to%20Reduce%20Alcohol%20and%20Drug-related%20Violence.pdf>. 2014;ISBN 9781921012129
- City of Sydney. *Late Night Management Areas Research Project* [Internet]. Sydney (AUST): Sydney Council; 2015 [cited 2016 Aug]. Available from: <http://www.cityofsydney.nsw.gov.au/vision/towards-2030/business-and-economy/sydney-at-night/late-night-research#page-element-dload>
- Mazerolle L, White G, Ransley J, Ferguson P. Violence in and around Entertainment Districts: A Longitudinal Analysis of the Impact of Late-Night Lockout Legislation. *Law Policy.* 2012;34(1):55-79.
- Andrade D, Homel R, Townsley M. Trouble in paradise: The crime and health outcomes of the Surfers Paradise licensed venue lockout. *Drug Alcohol Rev.* 2016;35(5):564-72.
- Miller P, Coomber K, Sønderlund A, McKenzie S. The long-term effect of lockouts on alcohol-related emergency department attendances within Ballarat, Australia. *Drug Alcohol Rev.* 2012;31(4):370-6.
- Queensland Government. *Safe Night Precincts* [Internet]. Brisbane (AUST): State Government of Queensland; 2016 [cited 2016 Aug]. Available from: <https://www.business.qld.gov.au/industry/liquor-gaming/safe-night-out-strategy/safe-night-precincts>
- Queensland Government. *Overview of the Tackling Alcohol-Fuelled Violence Legislation Amendment Bill for Licenses* [Internet]. Brisbane (AUST): State Government of Queensland; 2016 [cited 2016 Aug]. Available from: <https://www.business.qld.gov.au/industry/liquor-gaming/tackling-alcohol-fuelled-violence>
- Giabbanelli P, Crutzen R. An agent-based social network model of binge drinking among Dutch adults. *J Artif Soc Soc Simul.* 2013;16(2):10.
- Gorman DM, Mezić J, Mezić I, Gruenewald PJ. Agent-based modeling of drinking behavior: A preliminary model and potential applications to theory and practice. *Am J Public Health.* 2006;96(11):2055-60.
- Lamy F, Perez P, Ritter A, Livingston M. SimARC: An Ontology-driven Behavioural Model of Alcohol Abuse. *Proceedings of the SIMUL 2011: 3rd International Conference on Advances in System Simulation*; 2011 Oct 23-2; Barcelona, ESP. Wilmington, DE: International Academy, Research, and Industry Association; 2012.
- Scott N, Hart A, Wilson J, Livingston M, Moore D, Dietze P. 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. *Int J Drug Policy.* 2016;32:44-9.
- Gilbert N. *Agent-based Models*. Thousand Oaks (CA): Sage Publications; 2008.
- Callinan S, Room R, Livingston M, Jiang H. Who purchases low cost alcohol in Australia? *Alcohol Alcohol.* 2015;50(6):647-53.
- Hart A. Assembling Interrelations Between Low Socioeconomic Status and Acute Alcohol-Related Harms Among Young Adult Drinkers. *Contemp Drug Probl.* 2015;4(2):148-67.
- MacLean S, Ferris J, Livingston M. Drinking patterns and attitudes for young people in inner-urban Melbourne and outer-urban growth areas: Differences and similarities. *Urban Policy Res.* 2013;31(4):417-34.
- Meier PS, Purshouse R, Brennan A. Policy options for alcohol price regulation: The importance of modelling population heterogeneity. *Addiction.* 2010;105(3):383-93.
- Scott N, Livingston M, Hart A, Wilson J, Moore D, Dietze P. SimDrink: An agent-based NetLogo model of young, heavy drinkers for conducting alcohol policy experiments. *J Artif Soc Soc Simul.* 2015;19(1):10.
- Barton A, Husk K. Controlling pre-loaders: alcohol related violence in an English night time economy. *Drugs Alcohol Today.* 2012;12(2):89-97.
- Dietze PM, Livingston M, Callinan S, Room R. The big night out: What happens on the most recent heavy drinking occasion among young Victorian risky drinkers? *Drug Alcohol Rev.* 2014;33(4):346-53.
- MacLean S, Moore D. 'Hyped up': Assemblages of alcohol, excitement and violence for outer-suburban young adults in the inner-city at night. *Int J Drug Policy.* 2014;25(3):378-85.
- Miller P, Pennay A, Droste N, Jenkinson R, Quinn B, Chikritzh T. Patron offending and intoxication in night time entertainment districts (POINTED): Final report. *National Drug Law Enforcement Research Fund.* 2013; Monograph No: 46.
- Lindsay J. *Drinking in Melbourne Pubs and Clubs: A Study of Alcohol Consumption Context*. Clayton (AUST): Monash University School of Political and Social Inquiry; 2005.
- Duff C, Moore D. Going out, getting about: Atmospheres of mobility in Melbourne's night-time economy. *Soc Cult Geogr.* 2015;16(3):299-314.
- Foster J, Read D, Karunanithi S, Woodward V. Why do people drink at home? *J Public Health.* 2010;32(4):512-18.
- Liquor Law Review. *Statutory Review of Lock Outs and Last Drinks Background Paper* [Internet]. Sydney (AUST): New South Wales Department of Justice; 2016 [cited 2016 Aug]. Available from: <http://www.liquorlawreview.justice.nsw.gov.au/Documents/Statutory-review-of-lock-outs-and-last-drinks-Background-Paper-Updated%2021.03.16-2.pdf>

Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Appendix A: Detailed model description.

Supplementary Appendix B: Model parameters and references.