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Geographical Accessibility to Gambling Venues and Suicide

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Abstract

Worldwide, gambling can cause economic and health-related harm to individuals and communities. Policy responses to reduce these harms require evidence on the effects of features of the gambling environment. This study explores whether geographical accessibility to gambling venues impacts suicides. We construct a longitudinal spatial data set with information on the number of gambling venues and suicides in Australian neighbourhoods from 2001 to 2018, and exploit changes in accessibility induced by venue openings and closures. The closure of a gambling venue is estimated to decrease the number of suicides per year in that area by 9.8%. Effects of gambling venues in neighbouring areas are small and statistically insignificant, indicating that the relationship between venue access and suicide is concentrated close to the venue location.

Keywords: Gambling; suicide; gambling venues

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1 Introduction

Commercial gambling is rapidly expanding worldwide. It is legal in more than 80% of countries, with almost half of adults globally participating in gambling in the past year, and with net losses by consumers expected to reach US$700billion by 2028 (Tran et al., 2024; Wardle et al., 2024). While online gambling is increasing, land-based gambling still accounts for more than two thirds of total expenditure (H2 Gambling Capital, 2025). Gambling can have positive and negative effects on an individual's utility. It may create excitement, leisure, socialisation, or hope of winning big money (Francis et al., 2015), and improve life satisfaction and reduce stress (Humphreys et al., 2021). However, gambling may also result in economic and health-related harms for the individual, with evidence of an overall negative consumer surplus (Miéra et al., 2023). Gambling is associated with financial hardship, including energy poverty and lower likelihood of home ownership (Baako et al., 2024; Farrell & Fry, 2021), and worse mental health, including lower subjective wellbeing and suicide ideation (Farrell, 2018; Langham et al., 2015; Wardle et al., 2020). Gambling can also impact individual's friends and family and the wider community (Goodwin et al., 2017).

Due to the potential positive and negative effects of gambling, the policy goal is usually not to ban gambling but to reduce the associated harms while preserving the benefits (Productivity Commission, 2001). To do this effectively, it is important to understand the extent of gambling harms and the specific features of the gambling environment that contribute to these harms. This study provides evidence on these issues by using openings and closings of gambling venues to identify the effect of geographical accessibility to gambling venues on suicides.

The setting for this study is Electronic Gaming Machine (EGM)[1] venues in Australia. This is an important setting because Australia has the world's highest per-capita gambling losses, EGM venues are abundant and widespread, and EGMs account for the country's largest percentage of gambling losses and are the most common form of gambling among people experiencing harm (Armstrong & Carroll, 2017; Roth, 2020). Australia is unique because EGMs are abundant outside of casinos, commonly found in venues such as clubs and hotels (Productivity Commission, 2010).[2] These non-casino EGM venues can be found in most of the country, including central business districts of major cities, suburban areas, and rural towns. The widespread nature of non-casino EGM venues results in a large percentage of the population living in areas with high geographical accessibility to EGMs, which may contribute to the high levels of harm associated with EGMs (Badji et al., 2020, 2023; Markham et al., 2016).

To identify the effect of geographical accessibility to gambling venues, we use geocoded data on the exact locations of EGM venues and residence of people who died by suicide in two Australian states (Victoria and Queensland) from 2001 to 2018. We estimate the effect of changes in the number of EGM venues in a

[1]EGMs are often called poker machines, pokies, slot machines, or fruit machines

[2]Australia accounts for an estimated 76% of the world's EGMs in clubs and hotels, despite accounting for less than 1% of the global population (Roth, 2020).

neighbourhood over time, induced by openings and closings of venues, on changes in the number of suicides in that neighbourhood. We include neighbourhood fixed effects to account for stable area characteristics, and local government area-by-year fixed effects to account for time-varying shocks and policy changes affecting neighbourhoods within the same local government area (LGA). Evidence suggests that openings and closings of gambling venues are conditionally exogenous, lending support to a causal interpretation of the estimates.

We find that a decrease of one EGM venue in a neighbourhood predicts a 9.8% decrease in suicides per year in that same area ($p < 0.01$). This highlights the potentially severe harms associated with high geographical accessibility to gambling venues and provides evidence that gambling may contribute to suicide risk. We find minimal evidence that the number of suicides in a neighbourhood is influenced by changes in the number of EGM venues in neighbouring areas, indicating the effect of EGM venues on suicides is concentrated around the location of the EGM venue.

This study contributes to a broad literature on the harmful consequences of gambling. In other contexts, Churchill and Farrell (2018) and Koomson et al. (2022) apply instrumental variable approaches to self-reported survey data and find that experiencing problems due to gambling creates a higher likelihood of depression and financial stress respectively, and Couture et al. (2024) exploit the staggered legalization of online gambling between states in the US and find mixed evidence. In the context of geographical accessibility to gambling venues, Badji et al. (2023) use a cross-sectional, area fixed effects approach and find that greater within-area individual-level proximity to gambling venues increases the risk of mental health problems and financial hardship. A strength of our study is the use of longitudinal methods and administrative data that does not rely on self-reported measures. Badji et al. (2020), Markham et al. (2016), and Markham et al. (2023) similarly use longitudinal and administrative data, exploring the relationship between area-level year-to-year changes in the number of gambling venues and rates of insolvency, police-reported domestic violence, and suicide respectively. However, these studies use measures that are aggregated to relatively large areas, which limits their ability to identify detailed geographical effects.

The study also contributes to the more specific literature on the relationship between gambling and suicide. Suicide is a rarely explored outcome in the gambling literature, and to the best of our knowledge, this is the first study to explore suicide in the context of EGM venues in Australia. However, links between gambling and suicide have been found in a small number of studies using coronial or media reports to identify gambling harm in people who died by suicide (e.g. see Kaggwa et al. (2022), Rintoul et al. (2023), Van Der Maas et al. (2024), and Wong et al. (2010)). In addition, Karlsson and Håkansson (2018) find that people experiencing gambling harm are more likely to die by suicide, and Markham et al. (2023) find that an increase in the number of gambling venues in US counties is associated with an increase in the number of suicides in that county. Our study is most closely related to Markham et al. (2023), but differs by using finer spatial units, allowing us to measure local accessibility more precisely and to distinguish effects near venues from effects in neighbouring areas.

2 Method

2.1 Data

This project combines data on the exact location of electronic gaming machine (EGM) venues and residence of people who died by suicide for two Australian states from 2001 to 2018 (Victoria and Queensland, the only two states with information available for this period). These are respectively Australia's second and third most populous states, and make up roughly two fifths of both Australia's population and number of EGM venues.

The data are a key strength of this study. Three advantages of the data are: (i) the long time period, (ii) the geocoded data with highly accurate geographical information for both the explanatory and outcome variables, and (iii) administrative data that does not rely on any self-reported measures which are prone to sources of inaccurate data such as recall-bias or non-disclosure problems (Joinson et al., 2008; Sedgwick, 2012).

2.1.1 Location of Electronic Gaming Machines

Data on the exact location of EGM venues were collected through venue-level administrative data. Information includes the latitude and longitude of the venue and the years in which the venue was open. There were 2036 EGM venues open during at least one year in the period 2001 to 2018 in these two states, 575 of which either opened or closed during this period, and 1461 were open for the entire 18 year period. Overall, there was a decrease in venues during this period, with 1834 venues open in 2001 and 1645 in 2018, and a maximum of 1867 in 2003 and 2004. See Appendix Figure A1 for the number of venues that opened and closed in each year.

2.1.2 Residence of people who died by suicide

Data on the exact location of residence of people who died by suicide,[3] and the date they died, were collected through coronial data provided by the National Coronial Information System (NCIS). The study uses the location of the person's residence, rather than location of death, because geographical accessibility to EGM venues would be associated with where they lived. There was a mean of 1165.3 suicides per year in Victoria and Queensland combined during the years 2001 to 2018.

The NCIS database provides police reports for some cases, which may include information on whether

[3] Defined as deaths by intentional self-harm

the individual was experiencing gambling harm before their death.[4] However, we do not limit suicides to these cases for two reasons. First, there would likely be significant under reporting because some cases do not attempt to elicit this information and it would only include cases where gambling harm was known to, and reported by, people who knew the individual. This is particularly problematic given the perceived stigma associated with gambling harm likely resulting in this information often being concealed (Hing et al., 2016).[5] Second, EGM venues may impact suicide risk beyond the people experiencing gambling harm. For example, risk of suicide may be influenced by a household member experiencing gambling harm, related relationship breakdown or domestic violence, higher crime rates in the area, or other associated community level changes (Browne et al., 2016; Goodwin et al., 2017).

2.2 Empirical Strategy

2.2.1 Areas of interest - 2km by 2km squares

We define an individual's geographical accessibility to EGM venues as the number of EGM venues in their neighbourhood of residence. Therefore, the approach is to explore whether a change in the number of EGM venues in a neighbourhood, induced by the opening and closing of venues, is associated with a change in the number of suicides in that same area. To do this, we create a grid of 2km by 2km squares to define neighbourhoods, spanning each of Victoria and Queensland. The exact position of the grid is constructed randomly, and we conduct supplementary analyses which respectively shift the grid horizontally, vertically, and diagonally, relative to the grid used for the main analysis. The two sources of data described in Section 2.1 are then used to create a panel data set with variables for the number of EGM venues and suicides in each 2km by 2km square per year. Using data consisting of non-overlapping area-level observations such as this is common in spatial econometrics (e.g. see Anselin (2022)), other studies examining mortality outcomes (e.g. see Kraftman et al. (2021) and Munford et al. (2022)), and other studies of gambling venues (e.g. see Badji et al. (2020) and Markham et al. (2023)).[6] While other studies typically use pre-defined geographical areas (e.g. Census defined statistical areas or local government areas), we instead use a grid of squares because pre-defined areas are often larger and differ significantly in size. Using the grid hence allows for exploration of more detailed geographical effects. The square size of 2km by 2km is chosen to approximate the area of a

[4] Wong et al. (2010) used reports such as these to determine if an individual participated in gambling or had debt due to gambling prior to their death.

[5] In a similar context to our study, Rintoul et al. (2023) estimated that 4.2% of suicides in Victoria are gambling-related, although they recognize this is likely an underestimate for similar reasons to what we have listed.

[6] Economic studies using similar geocoded data to us in other contexts often employ a circle based approach, defining the area of interest as within a given radius of the venue (e.g. Currie et al. (2015) define houses as 'near' industrial plants if they are within half or one mile of the plant). This is not appropriate in our context because some areas have a high density of gambling venues and hence these circles would regularly overlap. This creates issues with identification and interpretation of results since people may already have been exposed to another venue before a given venue opens, or still exposed to another venue after a given venue closes. A potential concern of instead using our grid-based approach is that people living near the boundary actually live closer to a venue in a neighbouring square than one in their own square. However, our econometric model accounts for venues in neighbouring areas and results suggest that this is not commonly occurring.

circle with a 1km radius, based on existing findings that gambling venues increase participation in gambling particularly for those living within 1km of a venue (Badji et al., 2023), what they describe as "essentially comfortable walking distances".[7] Supplementary analyses explore square sizes ranging from 1km by 1km to 4km by 4km.

To ensure appropriate temporal sequencing, the number of suicides in year t is compared with the number of EGM venues in the previous year, $t-1$.[8] All squares which have at least one suicide or one EGM venue during the relevant time period (2001–17 for EGM venues and 2002–18 for suicides) are included in the analysis.[9] Squares containing a casino (a total of five casinos in five separate squares) and their neighbouring squares are excluded. This is because casinos are typically much larger, destination style gambling venues, regularly attended by tourists rather than local residents. Therefore, these venues and nearby areas are not the focus of this study.

Our main analysis includes 4614 2km by 2km squares, which have an average of 0.365 EGM venues and 0.242 suicides per year. In total, 1137 squares have at least one EGM venue during the period 2001 to 2017, and 386 (33.9%) of these squares have a change in the number of EGM venues during this period. Table 1 presents the average number of EGM venues and suicides in these and neighbouring squares.

There is high stability in the number of EGM venues per square over time, and hence any change in geographical accessibility to EGMs induced by the opening and closing of venues is predominantly a change that remains rather than a temporary shock. The vast majority (93.8%) of EGM venues that open or close stay open or closed for the remainder of the period of analysis, 342 of the 386 squares with a change in the number of EGM venues have just a one EGM venue difference between their minimum and maximum (88.6%), and 310 of these 386 squares experience only a single change (80.3%). See Appendix Table A1 for details on the maximum and minimum number of EGM venues throughout the years 2001 to 2017 in each square used in the main analysis.

[7]Badji et al. (2023) also found that the effect of EGM venues on poor mental health was particularly for those living within 250m of a venue, suggesting that perhaps even smaller squares may be appropriate. However, if the square size is too small then it may not capture much variation in the suicide variable (e.g. there are likely to be a high proportion of squares with zero suicides for the entire period of analysis), which could create high standard errors and imprecise estimates.

[8]If comparing suicides in year t with EGM venues in year t, a suicide occurring before a new EGM venue opens in that year would be incorrectly attributed to when the EGM venue was opened, and similarly a suicide occurring before an existing EGM venue closes in that year would be incorrectly attributed to when the EGM venue was closed.

[9]We do not include the full grid spanning Victoria and Queensland because large parts of these states have no or very low population and hence are not the focus of the study. Further, the neighbourhood fixed effects included in the econometric model account for squares with no suicides or EGM venues for the entire period.

2.2.2 Econometric Model

This study estimates the effect of a change in the number of EGM venues in a 2km by 2km square (measure of geographical accessibility)[10] on a change in the number of suicides in that square.[11] Spatial data such as that used in this study is likely to contain spatial dependence between observations (LeSage, 2015). Specifically, people may gamble at venues outside of the square they live in and/ or their closest gambling venue may be in a neighbouring square. To account for this, a spatial lag of X (SLX) model is employed (Halleck Vega & Elhorst, 2015). The SLX model has been implemented in economic studies across fields including energy and ecology (e.g. see Balado-Naves et al. (2023) and Mannaf et al. (2023)). In general, a spatial lag of X refers to the value of an explanatory variable across the neighbouring areas. Therefore, in this study, the SLX model controls for the number of EGM venues in neighbouring squares. The number of suicides in square i, Local Government Area (LGA) l, and year t ($suicides_{ilt}$) is estimated with the following equation

$$suicides_{ilt} = \beta EGM_{il,t-1} + \theta W_{ij} EGM_{j,t-1} + u_i + v_{lt} + \varepsilon_{ilt} \tag{1}$$

$EGM_{il,t-1}$ denotes the number of EGM venues in square i, LGA l, and year $t-1$. W_{ij} denotes an element in the spatial weights matrix where $W_{ij} = 1$ if squares i and j are adjacent (including squares sharing a single point, i.e. queen continuity) and $W_{ij} = 0$ otherwise. Defined in this way, $W_{ij}EGM_{j,t-1}$ denotes the total number of EGM venues in the squares neighbouring square i (i.e. the spatial lag).[12] u_i denotes fixed effects at the individual square level to account for characteristics specific to the geographical location that are unchanged over time. v_{lt} denotes fixed effects at the year and LGA[13] level to account for characteristics of the broader area that change over time (e.g. gaming laws, population, demographics, urban environment) and ε_{ilt} are unobserved effects. The main coefficient of interest is β, which is an estimate for the effect of a change in the number of EGM venues in a 2km by 2km square on a change in the number of suicides in that same square. θ is an estimate for the effect of a change in the number of EGM venues in neighbouring squares on a change in the number of suicides in a given square, providing information on spatial spillover

[10]There are factors which may affect the impact of EGM venues on gambling related outcomes which can not be explored in this study due to lack of available data. These include the size of the venue, the venue's opening hours, and accessibility to the venue by public transport or car. However, this study is interested specifically in the effect of geographical accessibility to venues and hence these other factors are outside the scope of this study.

[11]This is an intention-to-treat analysis. The only outcome we observe is suicides, and so we can not comment precisely on the mechanisms of the effect. However, a plausible mechanism by which accessibility to gambling venues could lead to suicide is through higher likelihood of participation in gambling, greater gambling losses, financial stress, and mental health problems.

[12]Studies often row-normalize the spatial weights matrix (e.g. in our case $W_{ij} = \frac{1}{8}$) such that the spatial lag estimates the effect on a given square of a change in the average number of EGM venues in the neighbouring areas. In that case, the coefficient on the spatial lag is interpreted as the effect on a given square if a new EGM venue opens in all eight neighbouring squares. However, we are specifically interested in the effect of an individual EGM venue opening or closing on people living close to that venue versus further away, and our specification allows the coefficients on the main effect and the spatial lag to be comparable in this context.

[13]LGAs play a role in the administration of gaming laws in that area including the ability to specify trading hours and the maximum patrons in a venue, or object to gambling licence applications. There are a total of 156 LGAs in Victoria and Queensland combined.

effects. We cluster standard errors at the individual square level. Note that the estimates from equation (1) pool the effects of venue openings and closings, which may not be symmetric. In supplementary analysis we explore these separately.

As mentioned in Section 2.2.1, EGM venues are measured in year $t-1$ to ensure temporal sequencing. Additionally, including a time lag is appropriate because there is likely a delay between a venue opening or closing and its influence on suicide. There is limited evidence on the exact nature of this delay to inform our decision of what lag length to use, and the rarity of suicides in such granular area sizes makes it difficult to estimate detailed temporal effects and hence that is not the focus of this study. We measure EGM venues at year $t-1$ because this captures the largest period for which suicides could be impacted by changes in EGM venues while still ensuring the model does not incorrectly attribute a suicide to when an EGM venue did or did not exist.[14] As robustness checks, we also conduct analyses with EGM venues measured at year t, $t-2$, and $t-3$ respectively.[15]

Equation (1) is modelled using a Poisson regression because the outcome variable (number of suicides per year in a square) follows a Poisson distribution with a high proportion of zeros (see Appendix Figure A2). Equation (2) presents the formula for the probability density function of a Poisson distribution, where μ is equal to both the mean and variance of the distribution (Zeileis et al., 2008). The exponential of coefficient estimates from a Poisson regression provide the incident rate ratios (IRRs), which indicate a percentage change in the outcome variable predicted by a one unit change in the explanatory variable. To support the use of a Poisson model, we test for and find no evidence of overdispersion (see dispersion ratio presented in Table 2).

$$f(x;\mu) = \frac{exp(-\mu) \cdot \mu^x}{x!} \tag{2}$$

2.2.3 Identification assumptions

We can interpret β and θ from equation (1) as causal effects under the assumptions that (i) individuals do not choose their place of residence based on the proximity to EGM venues and (ii) openings and closings of EGM venues are uncorrelated with other area-level attributes which also impact suicides.

Given the square fixed effects and LGA-year fixed effects included in the model, threats to identification assumption (i) would require certain types of people within an LGA to move in (or out) of a specific square because an EGM venue has opened (or closed). Our data does not contain the information required to explore this formally as we do not have information on how long people lived at their recorded place of

[14] Given the stability of the number of EGM venues in squares over time, measuring EGM venues at year $t-1$ still captures any effect that occurs two or more years after the opening/ closing of an EGM venue. However, an effect could be underestimated if the delay in effect is more than a year. Conversely, including time lags risks underestimating an effect if the temporal effect is short (this risk is greater for longer time lags).

[15] We do not conduct a model with multiple time lags because the stability of the number of EGM venues across time means this would introduce very high collinearity.

residence. However, findings from a previous study set in a similar context suggest that this is unlikely to occur (Badji et al., 2023) - after accounting for area-level characteristics (e.g. proximity to non-gambling alcohol venues, house price, rental price, and indexes for socio-economic status), they find that individual-level characteristics such as employment, income, education, risk preferences, and health behaviours do not predict proximity of residence to EGM venue.

Similarly, for threats to identification assumption (ii) to occur, there would need to be changes in an area-level attribute that is specific to a 2km by 2km square without neighbouring squares experiencing similar changes. Although the presence of such time-varying square-specific characteristics is possible, we believe it is unlikely. We nevertheless undertake several robustness checks to support the exogeneity of EGM openings and closings. We first explore the effect of gambling venues on a placebo outcome (unintentional deaths), and second, the possibility that venue openings/ closures and suicides may be influenced by potentially confounding area-level factors (population, socioeconomic status, gambling expenditure, and non-gambling alcohol venues).[16] All results are supportive of our assumptions. These are discussed in detail in Section 4.

3 Results

3.1 Main model

Table 2 presents the coefficient estimates β and θ from equation (1), and the related IRRs. Model 1 estimates equation (1) assuming $\theta = 0$ (i.e. no spatial lag). The coefficient on the number of EGM venues is 0.107 ($p < 0.01$), and the related IRR of 1.113 indicates that one additional EGM venue in a square increases suicides by 11.3% per year in that square. This result is similar in Model 2 which includes a spatial lag of EGM venues - the IRR of 1.109 indicates that one additional EGM venue in a square increases suicides by 10.9% per year in that square. Equivalently, by taking the reciprocal of the IRR, we can interpret this as a one EGM venue *decrease* in a square causes a 9.8% *decrease* in suicides per year in that square.[17] This interpretation may be more relevant given the overall decrease in the number of EGM venues during the period analysed.

The coefficient on the number of EGM venues in neighbouring squares is much smaller in magnitude, and not statistically different from zero. This indicates the effect of an EGM venue opening or closing is predominantly on people living in the same square, with minimal spatial spillover to people living in neighbouring areas (i.e. proximate spatial effects).[18]

[16] These variables are not included as covariates in the main model because data are not available at the square level and/ or for every year of the analysis.

[17] Because the IRR is in percentage terms, the effect of a decrease in EGM venues can be calculated by taking the reciprocal of the IRR: $\frac{1}{IRR} - 1 = \frac{1}{1.109} - 1 = -0.098$

[18] Note that the spatial lag captures geographical accessibility specifically. It is possible that other factors of accessibility to nearby areas such as public transport or road are important, but they are not the focus of this study.

3.2 Different square sizes

To test the impact on our results of square size, we conduct supplementary analyses estimating equation (1) but using data constructed from grids of squares ranging from a length of 1km through to 4km at 250m increments. The coefficient estimates and 95% confidence intervals are presented in Figure 1. The five largest estimates for the coefficient on the number of EGM venues are when using data constructed from grids of squares with length 2km or less, with four of these statistically significant at the 5% level.[19] The coefficient is smaller and loses statistical significance when using data constructed from grids of squares with length greater than 2km. These results suggest that the effect of EGM venues on suicides is diluted when the area size becomes larger. This is consistent with the finding in the main model that suicides are not greatly influenced by a change in the number of EGM venues in neighbouring squares, indicating proximate spatial effects. There is no clear trend for the coefficient on the number of EGM venues in neighbouring squares as the square size changes, and it is not statistically different from zero for any square size.

3.3 Opening versus closing of venues

Changes in the number of EGM venues in a square can come from a new venue opening or an existing venue closing. The main analysis pools these effects, however, it is possible that the effects from openings and closings are asymmetrical. We explore this in two complementary ways: first by comparing squares which increase in venues with those which decrease in venues, and second by comparing squares based on the number of EGM venues they have in 2001 (i.e. the first period of our data), where squares with fewer EGM venues in 2001 are relatively more likely to have an EGM venue open during the analysis period.[20]

We conduct split-sample analysis of squares which have an overall increase in EGM venues during the analysis period (i.e. have more openings than closings, 125 squares) and squares which have an overall decrease in venues (231 squares) - both analyses also include the 4,228 squares with no change in EGM venues throughout the analysis period to act as 'never-treated' controls and to maintain sample size. These results are presented in the first two columns of Table 3. The coefficient on the number of EGM venues is larger for squares which decrease in venues (0.1394), relative to squares which increase in venues (0.0529). This provides evidence that the effect of a change in geographical accessibility on suicides is greater when an EGM venue closes relative to opens.

[19]The coefficient on the number of EGM venues is larger for squares of length 1km, 1.25km, and 1.75km, compared with 2km. However, the estimates when using grids constructed from these smaller squares have larger standard errors, and hence are less precise estimates. This is likely due to less variation in the suicide variable for smaller squares (e.g. a higher proportion of squares have zero suicides through the entire period). This is a limitation of decreasing the size of the squares and is supportive of the choice to use a square size of 2km by 2km, which has more precise estimates but is able to detect the proximate spatial effect.

[20]Of the 3569 squares with zero EGM venues in 2001, 86 squares have an overall increase in venues during the analysis period while none have an overall decrease. Of the 691 squares with one EGM venue in 2001, 25 squares have an overall increase in venues while 109 squares have an overall decrease. Of the 354 squares with two or more EGM venue in 2001, 14 squares have an overall increase in venues while 122 squares have an overall decrease.

The above analysis selects the samples based on how the independent variable changes throughout the analysis period, which could introduce selection bias. Therefore, we also conduct an analysis which stratifies the sample based on the number of EGM venues in 2001 (zero, one, two or more). This analysis also enables exploration of the importance of accessibility to other venues in the area (e.g. the impact of a closure may be smaller if there are nearby venues that remain open). These results are presented in the final three columns of Table 3. The coefficient on the number of EGM venues is largest for squares with one EGM venue in 2001 (0.2447). Squares with one EGM venue in 2001 are more likely to experience a decrease in venues relative to an increase, and mostly change from one to zero venues during the period of analysis. The coefficient is much smaller for squares with two or more EGM venues in 2001 (0.0212). These squares are also more likely to experience a decrease in venues relative to an increase, but rarely reduce to zero EGM venues (only two of these 354 squares decrease to zero venues). The analysis of squares with zero EGM venues in 2001 yields a small, negative coefficient (-0.0183), providing no evidence that adding venues to an area increases the likelihood of suicide. This analysis hence provides consistent evidence that the closure of an existing venue has a bigger impact on suicides than the opening of a new venue, and suggests the largest marginal effect occurs when removing all EGM venues from an area.

3.4 Difference-in-difference and event study analysis

We consider an alternative methodological approach – a staggered difference-in-difference (DiD) approach (Callaway & Sant'Anna, 2021) – commonly used when treatment is staggered over time. Our setting differs from a typical staggered DiD setup in a number of key ways: (i) we use a Poisson regression, (ii) we are interested in exploring spatial spillovers, and our treatment is (iii) non-binary (including changes between different treated doses) and (iv) non-absorbing (most areas experience a maximum of one change, but some both enter and exit treatment and/ or change dosage of treatment multiple times, and many areas are always-treated). While approaches have been developed to consider non-binary and non-absorbing treatments (De Chaisemartin & d'Haultfoeuille, 2024), this is not compatible with a Poisson regression or exploring spatial spillovers (although the spatial lag can be controlled for). We nevertheless supplement our main analysis with a linear heterogeneity-robust DiD and event study analysis using the approach outlined in De Chaisemartin and d'Haultfoeuille (2024). This approach, rather than comparing treated and non-treated groups, compares 'switchers' (i.e. groups that experience a change in treatment dosage) with 'non-switchers' that had the same treatment dosage in the baseline period (e.g. compares a square going from one to two venues with squares that remain with one venue throughout the analysis period).

We conduct this analysis using the 'did_multiplegt_dyn' package in Stata (De Chaisemartin & d'Haultfoeuille, 2024). We consider a ten-year period (five pre-switch periods, including the period the treatment switches at event time zero, and five post-switch periods). As in our main analysis, we compare squares within the same LGA, control for the number of EGM venues in neighbouring squares, and cluster standard errors by square.

The estimated post-switch effect is 0.0505 (standard error 0.0518). While this is not statistically different from zero, the point estimate translates to a 10.1% reduction in suicides per year following the closure of an EGM venue (for squares with at least one EGM venue).[21] This is very similar to the estimate of 9.8% in the main analysis, suggesting that the lack of statistical significance may be due to lower statistical power rather than the estimate in the main analysis being biased. For example, the heterogeneity-robust DiD approach is more restrictive, and removes some squares from the analysis due to there not being any appropriate comparator in the same LGA, and the linear model may not capture the distribution of suicides as precisely as a Poisson model. Further, estimating our main analysis with a linear model yields a coefficient of 0.0331 (standard error 0.0241). This is a smaller magnitude than the heterogeneity-robust DiD estimate, and hence there is no evidence that our main analysis is producing upward-biased estimates.

The event study plot is presented in Appendix Figure B1. We see no evidence of a pre-trend, and all post-switch point estimates are positive.[22] The largest point estimates occur from event time three onwards. This provides evidence that the impact of EGM venues on suicides may be delayed in some instances. However, due to the wide confidence intervals, it is difficult to make strong conclusions about this.

4 Robustness checks

Our estimates in equation (1) could be biased if there were characteristics of the 2km by 2km square that (i) influence a company's decision of where to open or close an EGM venue and (ii) are correlated with the number of suicides in an area. Given the fixed effects included in the model control for time-varying characteristics of the LGA and time-invariant characteristics of each square, such confounding factors would need to be time-varying and square-specific. We contend that this is unlikely to commonly occur, however, we undertake several robustness checks to explore this potential. We first check the likelihood that time-varying square-specific factors may be spuriously driving suicides by estimating unintentional deaths as placebo outcomes. Second, we specifically explore the possibility that EGM venue openings/ closures and suicides may be influenced by square-specific changes in: (i) population density; (ii) socioeconomic status; (iii) attitudes towards gambling leading to changes in expenditure and venue profits; and, (iv) access to alcohol-serving venues. Third, we conduct the analysis using different specifications of the time lag on the number of EGM venues. Finally, we test the robustness of the results to shifts in the grid used to construct

[21]In any given year in our analysis period, there are 1,050.5 squares with at least one EGM venue, with a mean of 0.5017 suicide per year. Dividing the DiD estimate of 0.0505 by 0.5017 yields an estimated percentage reduction of 10.1%.

[22]None of these estimated post-switch effects are statistically different from zero. However, because suicides are rare events when measured at such granular area sizes, imprecise estimates for individual time periods are expected. This is why, as discussed earlier, estimating detailed temporal effects is not a focus of this study. We hence caution against over-interpreting the specific temporal effects estimated here.

the panel data.

4.1 Unintentional deaths

If underlying time-varying square-specific characteristics were driving the relationship between EGM venues and suicides, we may also expect to see a similar relationship between EGM venues and unintentional (or accidental) deaths. To explore this, we estimate equation (1), but with unintentional deaths as a placebo outcome. We first examine all unintentional deaths (as classified by the NCIS), and second examine all non-drug or alcohol related unintentional deaths (based on information on the cause of death provided by the NCIS). Drug and alcohol related unintentional deaths are excluded from the second classification because gambling may be related to drug and alcohol use (Grant & Chamberlain, 2020), and hence there is a logical explanation for greater gambling accessibility increasing drug or alcohol related unintentional deaths.

Table 4 presents the results of these models. The coefficient on the number of EGM venues is smaller, compared with suicides, and not statistically different from zero for both classifications of unintentional deaths. This indicates that the effect of EGM venues on suicides is not a spurious relationship that extends to all deaths.

4.2 Exploring possible square-specific time-varying confounders

First, we explore changes in population. Areas with higher-than-average population growth may be more likely to see an increase in the number of suicides and to have a new EGM venue open in the area. An extreme example is if there was a new housing development, it may be profitable to open an EGM venue nearby. Without data on square-level population, it is difficult to control for such population growth. However, we argue that this is unlikely to be driving our estimates because while most squares would have experienced an *increase* in population during the period of analysis (due to overall population growth),[23] squares more commonly experienced a *decrease* in the number of EGM venues. Further, we conduct an analysis which excludes squares that have zero EGM venues in 2001 and have an EGM venue open during our analysis period (areas most likely to have a new EGM venue open in response to a new housing development).[24] Results are very similar to the main analysis(see Appendix Table C1).

Second, we explore changes in gambling expenditure. A gambling venue may be more likely to close if expenditure at that venue is decreasing. Fewer suicides may be associated with this lower gambling expenditure, or related demographic changes, rather than reduced access to gambling itself. There are no available data to control for expenditure in the main model. However, we utilise annual data on expenditure

[23]It is rare for an area to experience a sudden decrease in population, converse to a sudden increase due to a housing development

[24]Of the 125 squares with an overall increase in the number of EGM venues during our analysis period, 86 squares have zero EGM venues in 2001 (68.8%).

at EGM venues in Victoria from 2009 to 2019 to analyse, among venues that were open in 2009, whether a difference in expenditure relative to 2009 predicts the closure of a venue. Conducting a series of linear models, we find no evidence that a change in expenditure is associated with closure likelihood (see Appendix Table C2 for details).

Third, we explore changes in socioeconomic status. Places of low social advantage have higher rates of suicide (Taylor et al., 2005) and, in Australia, LGAs with low social advantage typically have higher EGM venue density (Livingstone, 2001). This between LGA variation is accounted for by the area fixed effects in the model. However, our estimates could be biased if square-specific changes in socioeconomic status were driving changes in both EGM venues and suicides. To explore this, we estimate whether a change in a square's socioeconomic status is associated with a change in the square's number of EGM venues (controlling for LGA fixed-effects). Data on socioeconomic status is available at the Statistical Area 1 level (SA1, the smallest geographical areas with information on socioeconomic status). This can be mapped to the square level, giving a good approximation of a square's socioeconomic status. The measure of socioeconomic status we use is the Index of Relative Social Advantage and Disadvantage score (IRSAD).[25] Only data from 2011 and 2016 could be mapped to individual squares, so we estimate changes between these years. We find no evidence that square-specific changes in socioeconomic status predicts changes in the number of EGM venues (see Appendix Table C3 for details).

Finally, we explore changes in access to alcohol. Alcohol use is associated with heightened suicide risk, and hence greater access to alcohol may increase suicides (Carpenter & Dobkin, 2009; Rizk et al., 2021). Most EGM venues also serve alcohol. Therefore, changes in alcohol access may drive the relationship between EGM venues and suicides. To test for this, we estimate a model which controls for the number of non-EGM alcohol venues in each square, each year (data available for Victoria only). The estimates for non-EGM venues are very small and not statistically significant, suggesting that the effect of geographical accessibility to EGM venues on suicides is specific to EGM venues and is not driven by changes in access to alcohol (see Appendix Table C4). This result also provides evidence that our estimates are not being driven by square-specific changes in the urban landscape generally, as this would be partly captured by the number of alcohol venues.

4.3 Time lag on EGM venues

Here we test the robustness of the main estimates to alternative specifications of the time lag on the number of EGM venues. We consider no time lag, and time lags of two and three years respectively, in comparison to the main specification using a time lag of one year. For each of these models, the number of EGM venues remains positive and statistically different from zero (see Appendix Table C5). As discussed in Section

[25] This is an Australian Bureau of Statistics measure of socioeconomic status released every five years, based on information from the Census (Australian Bureau of Statistics, 2023).

2.2.2, we choose a time lag of one year for our main model because this captures the largest period for which suicides could be impacted by changes in EGM venues while ensuring the model does not incorrectly attribute a suicide to when an EGM venue did or did not exist, but note that this could underestimate the effect if there is commonly a delay of more than one year between a venue opening or closing and its impact on suicides. Indeed, we see the magnitude of coefficient monotonically increases with a longer time lag, suggesting that the temporal effect of accessibility to EGM venues on suicides may be more than a year in many cases. This is consistent with our event study analysis, which showed the largest effects occurring from three years after the opening/ closing of a venue (see Appendix Figure B1).

4.4 Grid position

The exact position of the grid used to construct the panel data set determines which specific square contains each EGM venue and suicide. While the position of the grid is constructed at random, and hence is unlikely to bias results, we conduct additional analyses which use data constructed from grids respectively shifted 1km east-west, 1km north-south, and diagonally (i.e. 1km east-west and 1km north-south), relative to the position of the grid used for the main analysis. The coefficient on the number of EGM venues remains statistically different from zero for each of these analyses (see Appendix Table C6).

5 Heterogeneity analysis

This section explores whether the influence of EGM venues on suicides may differ between individual characteristics, areas, and the period of analysis. Such differences are important to understand because it could signal that interventions are particularly important for given areas or sub-populations.

5.1 Individual characteristics

Here we use additional information from the NCIS on the individuals who die by suicide to compare differences in the effect of EGM venues on suicides by gender, age group, marital status, and employment status. Figure 2 presents the coefficient estimates and 95% confidence intervals for the number of EGM venues when only including suicides of the respective individual characteristics. Mean suicides per square and year for each group are also presented. Coefficient estimates are higher for females relative to males, people aged 35 and under and over 65 relative to people aged from 36 to 65, retired and unemployed people relative to employed people, and single people relative to people in a relationship.

5.2 Area-level socioeconomic status

This analysis stratifies squares based on 2016 SA1-level IRSAD scores (Australian Bureau of Statistics, 2018) to explore whether the effect of EGM venues on suicides differs between areas based on socioeconomic status. Squares are split into terciles, with an additional analysis combining squares in areas of high and medium advantage. Results are presented in Table 5. The coefficient on the number of EGM venues is largest for squares in areas of medium and high advantage (0.1042), and lowest for squares in areas of low advantage (0.0687), providing no evidence that the effect of accessibility to EGM venues on suicides is greater in socially disadvantaged areas.

5.3 Area-level urbanicity

The definition of 'accessible' or 'proximate spatial effect' may differ for people living in large cities compared with rural areas. Cities are more concentrated and hence residents may more commonly walk to places such as gambling venues, compared with people living in less densely populated towns who may be used to travelling further for activities and more commonly drive. Therefore, larger square sizes may still be considered to capture proximate spatial effects in rural areas but not large cities. To explore this, the effect of EGM venues on suicides is compared between squares based on if they are in a capital city (Melbourne, the capital of Victoria, and Brisbane, the capital of Queensland), for a range of square sizes.

Figure 3 presents these results. Regarding the coefficient on the number of EGM venues, there is no clear difference between the two samples. They each show a similar trend to the full sample (i.e. a generally larger effect when using data constructed from grids made of squares with length 2km or less) and there is no consistency in terms of which sample has a larger coefficient. Regarding the coefficient on the number of EGM venues in neighbouring squares, the coefficient is generally larger in the non-capital city sample (in all but squares with length 1.75km and 2km). This suggests that EGM venues may have a greater spatial spillover effect in rural areas, but the coefficients are typically not statistically different from zero or from each other and hence limited conclusions can be made.

5.4 Period heterogeneity

The gambling environment changed during the period analysed in this study, in ways which may influence the effect of accessibility to EGM venues on suicides. One example is policy changes such as removal of cash machines from gambling venues, a cap on the number of EGMs allowed in each LGA, and increased 'responsible gambling' messaging at gambling venues (Livingstone et al., 2014). These aimed to reduce the harm caused by EGM venues, and hence may decrease the harmful effect of accessibility to these venues. Another example is the emergence of online gambling (Rockloff et al., 2020), which may be a substitute for gambling at EGM venues. This could decrease the effect of accessibility to EGM venues since most people have high accessibility to some form of gambling regardless of their accessibility to EGMs, and people may be less likely to gamble at EGM venues in general.

This analysis stratifies the data by the period included in the analysis, comparing the years 2002 to 2010 with 2011 to 2018.[26] It is difficult to have strong justification for how these samples should be stratified because policy changes happened gradually throughout the analysed period and differed between Victoria and Queensland and between areas within Victoria and Queensland, and online gambling has likely increased gradually and continuously during the period of analysis. Therefore, it is logical to split the sample roughly in half. The results are presented in Table 6. The coefficient on the number of EGM venues is larger for the years 2002 to 2010 (0.1095) compared with the years 2011 to 2018 (0.0596). This indicates a possible decrease in effect in recent years, which may be attributable to increased online gambling and/ or policy changes that have effectively reduced harm. However, the coefficient is still positive for the years 2011 to 2018, and there is a lack of statistical power when stratifying the sample which limits the ability to conclude whether the effect has diminished in recent years.

6 Discussion

This study explores whether a change in geographical accessibility to gambling venues, due to the opening and closing of venues, influences the number of suicides in an area. We do this using a panel data set containing information on the number of EGM venues and suicides per year in each 2km by 2km square of a grid spanning two Australian states (Victoria and Queensland) over a 17-year period. We find that a one EGM venue decrease in a square predicts a 9.8% decrease in suicides per year in that square. We find minimal evidence that the number of suicides is influenced by a change in the number of EGM venues in neighbouring squares, indicating the effect of EGM venues on suicides is concentrated around the location of the EGM venue. This is consistent with evidence of a proximate spatial effect of EGM venues on harms such as mental health problems and financial hardship (Badji et al., 2023). A causal interpretation of these estimates requires that, conditional on square fixed effects and LGA-by-year fixed effects, there are no time-varying changes within squares that are correlated with both venue locations and suicide risk. This includes, for example, systematic changes in the composition of residents within LGAs across squares, or other square-specific changes that coincide with venue activity. We conduct a series of robustness checks and find no evidence that the results are driven by these types of square-specific time-varying potential confounders.

Our estimated magnitude of effect is large but, given the small area sizes we use, the treatment is highly targeted and hence the effect is only on a relatively small proportion of the total population. Indeed, applying

[26]Due to the time lag, 2002 to 2010 correlates to data on EGM venues from 2001 to 2009, and 2011 to 2018 correlates to EGM data from 2010 to 2017

our estimate to squares with at least one EGM venue translates to a reduction in suicides of 4.4% for Victoria and Queensland as a whole (representing 52 lives saved per year).[27] Estimated effect sizes in other contexts vary greatly. For example, Breuer (2015) find that a 1 percentage point increase in unemployment leads to a 0.55% increase in suicides, Dow et al. (2020) estimate that increasing minimum wage by 10% reduces suicides by 2.7%, and Carpenter and Dobkin (2009) find that increased access to alcohol after turning 21 increase suicides by 16%.

Through sample stratification, we find consistent evidence that the effect of venue closure is greater than that of a new venue opening. This could be due to a closure creating an immediate shock to people's gambling behaviour, whereas introducing gambling to an area may have a more gradual effect (e.g. it could take time for it to cause someone to participate in gambling, and even longer for that gambling to cause severe harm for individuals). While people can substitute with other ways to gamble (e.g. online or another land-based venue), EGM venues are often seen as welcoming, warm, social environments (Bestman et al., 2020; Thomas et al., 2009), and hence it is feasible that the closure of a familiar venue would not always translate to them gambling in other ways. Further, we found that the largest effect is seen when removing all EGM venues from an area (i.e. squares going from one venue to zero venues), which indicates that a closure of a venue may have a particularly large impact when there is limited ability for people to substitute to other land-based venues.

While our data do not allow a formal exploration of the underlying mechanisms through which geographical accessibility of gambling venues effects suicides,[28] a number of plausible mechanisms can be drawn from previous studies and our heterogeneity analysis. Previous analyses have found that individuals who live closer to a gambling venue are more likely to gamble and more likely to experience gambling-related harms such as mental health problems and financial stress (Badji et al., 2023). This suggests that an increase in gambling participation and its impacts on mental health and financial stress are likely channels. Supporting this hypothesis is the sizable literature that shows that gambling is associated with financial hardship, including energy poverty and lower likelihood of home ownership (Baako et al., 2024; Farrell & Fry, 2021), and worse mental health, including lower subjective wellbeing and suicide ideation (Farrell, 2018; Langham et al., 2015; Wardle et al., 2020). Both mental health problems and financial stress are known predictors of high suicide risk (e.g. see Breuer (2015) and Orsolini et al. (2020)).

Heterogeneity analyses found that effects were greatest for people who are female, aged 35 and under or over 65, not employed, and single. This may be explained by the likelihood of substituting to other forms of gambling if a decrease in accessibility to EGM venues occurs. Females are more likely to only gamble at

[27] In any given year in our analysis period, there are 1,050.5 squares with at least one EGM venue, with a mean of 0.5017 suicide per year. Using the estimate of 9.8%, removing one EGM venue from all of these squares would predict a total reduction of 51.7 suicides per year (0.098*0.5017*1050.5). Based on the baseline mean of 1165.3 suicides per year for Victoria and Queensland combined, this is a 4.4% reduction.

[28] Exploration of underlying mechanisms would require annual, population-representative information on, for example, gambling participation or mental health at the square level. We are not aware of any available data sets with such characteristics.

land-based venues than males (i.e. not gamble online) (Hing et al., 2022), suggesting that females are less likely to substitute to other forms of gambling if the venue they usually gamble at closes. Similarly, older and retired people are more likely to gamble on EGMs but less likely to participate in sports betting (Armstrong & Carroll, 2017), and older people are more likely to only gamble at land-based venues (Hing et al., 2022).

This study has important policy implications for Australia, both in terms of the need for stricter regulation and the types of supply-side interventions that could reduce harm.[29] The results suggest that reducing the number of EGM venues, or locating venues in areas of low residential density, could reduce the number of suicides. The impact of these venues on suicide also indicates the importance of interventions to reduce harmful gambling at these venues (Velasco et al., 2021). Although the setting for this study is specific to Australia, and gambling environments differ between countries, our findings may also be relevant for other countries with non-casino EGMs, such as England and New Zealand. More broadly, the harmful effect of geographical accessibility may extend to other forms of land-based gambling that are common internationally, including betting shops and casinos.

A related question is whether these findings remain policy relevant as gambling increasingly moves online. The growth of online gambling may reduce the importance of geographical accessibility to land-based venues, particularly for products that can be accessed easily from home. However, venue-based gambling remains important in many countries, and some high-harm products continue to be concentrated in physical venues because of legal, regulatory or commercial constraints. In Australia, for example, EGM gambling remains illegal online, while online gambling is largely restricted to forms such as sports and race betting. Our findings are therefore most directly relevant to settings where harmful gambling opportunities remain geographically concentrated, but they also point to the broader importance of reducing access to gambling products and environments that generate harm.

[29] A reminder that the study is set specifically in the context of Victoria and Queensland, and hence may not translate to the whole of Australia. New South Wales, the most populated Australian state, has a similar EGM venue context to Victoria and Queensland so results are likely to translate to there. South Australia, Tasmania, and the Northern Territory also have EGM venues so results may translate, but they are much less populated. EGM venues are not legal in Western Australia, so our results are unlikely to translate to there.

	All squares	Squares with > 0 EGM venues	Squares with change in EGM venues		
			All	Overall increase	Overall decrease
Number of squares	4614	1137	386	125	231
Mean EGM venues	0.365	1.481	1.694	1.2	1.907
Mean EGM venues in neighbouring squares	1.930	3.911	4.426	3.138	5.379
Mean suicides	0.242	0.479	0.498	0.423	0.556
Mean suicides in neighbouring squares	1.372	2.680	2.665	2.130	3.027

Table 1: Descriptive statistics of EGM venues and suicides per square. 'All squares' includes any square with either an EGM venue or a suicide during the relevant period, excluding squares with a casino and neighbouring squares (i.e. all squares used in the main analysis).

	Model 1		Model 2	
	Coefficient	IRR	Coefficient	IRR
EGMs	0.1070** (0.0391)	1.113**	0.1033** (0.0391)	1.109**
W*EGMs	–		0.0177 (0.0137)	1.018
Num. observations	78438		78438	
Num. groups: squares	4614		4614	
Num. groups: LGA years	2601		2601	
Dispersion ratio	0.860		0.860	
Mean EGM venues	0.3650		0.3650	
Mean suicides	0.2417		0.2417	

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2: Main model results. Model 1 does not include a spatial lag. Model 2 includes a spatial lag of X. Models use a Poisson regression. IRR: incidence rate ratios - calculated by taking the exponential of the coefficient estimate. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

	Increase in venues	Decrease in venues	2001 EGM venues = 0	2001 EGM venues = 1	2001 EGM venues $\geq$ 2
EGMs	0.0529	0.1394**	-0.0183	0.2447*	0.0212
	(0.0716)	(0.0497)	(0.1291)	(0.1189)	(0.0605)
W*EGMs	0.0321	0.0166	0.0616*	0.0270	-0.0229
	(0.0181)	(0.0143)	(0.0272)	(0.0227)	(0.0273)
Num. observations	74001	75803	60673	11747	6018
Num. groups: squares	4353	4459	3569	691	354
Num. groups: LGA years	2584	2601	2550	1921	1785
Mean EGM venues	0.2711	0.3298	0.0156	0.9526	2.740
Mean suicides	0.2242	0.2358	0.1675	0.3707	0.7381

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 3: Comparing effect of a venue opening vs closing. 'Increase in venues' - analysis when only including squares that have an overall increase, or no change, in venues between 2001 and 2017. 'Decrease in venues' - analysis when only including squares that have an overall decrease, or no change, in venues between 2001 and 2017. '2001 EGM venues = 0' - analysis when only including squares that have zero EGM venues in 2001. '2001 EGM venues = 1' - analysis when only including squares that have one EGM venue in 2001. '2001 EGM venues $\geq$ 2' - analysis when only including squares that have two or more EGM venues in 2001. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

	Suicides (main analysis)	Unintentional deaths (all)	Unintentional deaths (non-drug related)
EGMs	0.1033**	0.0251	0.0381
	(0.0391)	(0.0385)	(0.0463)
W*EGMs	0.0177	-0.0135	-0.0020
	(0.0137)	(0.0125)	(0.0132)
Num. observations	78438	78438	78438
Num. groups: squares	4614	4614	4614
Num. groups: LGA years	2601	2601	2601
Mean EGM venues	0.3650	0.3650	0.3650
Mean type of death	0.2417	0.3637	0.2967

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 4: Comparing the effect of EGM venues on suicides versus unintentional deaths (all and non-drug related). The mean EGM venues and type of death per square and year are reported - type of death refers to the outcome variable of the respective analyses (i.e. suicides, all unintentional deaths, and non-drug related unintentional deaths respectively). Standard errors clustered by square presented in parenthesis.

	High advantage	Medium advantage	High and medium advantage	Low advantage
EGMs	0.0767	0.0988	0.1042*	0.0687
	(0.0724)	(0.0719)	(0.0496)	(0.0648)
W*EGMs	0.0113	0.0700	0.0206	0.0215
	(0.0180)	(0.0368)	(0.0153)	(0.0298)
Num. observations	25874	25976	51850	26588
Num. groups: squares	1522	1528	3050	1564
Num. groups: LGA years	2091	2023	2295	2227
Mean EGM venues	0.3120	0.3174	0.3147	0.4630
Mean suicides	0.2704	0.1918	0.2310	0.2626

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 5: Comparing model results based on socioeconomic status. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

	2002 to 2010	2011 to 2018
EGMs	0.1095	0.0596
	(0.0626)	(0.0649)
W*EGMs	0.0369	-0.0362
	(0.0304)	(0.0301)
Num. observations	41526	36912
Num. groups: squares	4614	4614
Num. groups: LGA years	1377	1224
Mean EGM venues	0.3730	0.3559
Mean suicides	0.2219	0.2641

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 6: Comparing model results based on the years of data included in the analysis. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

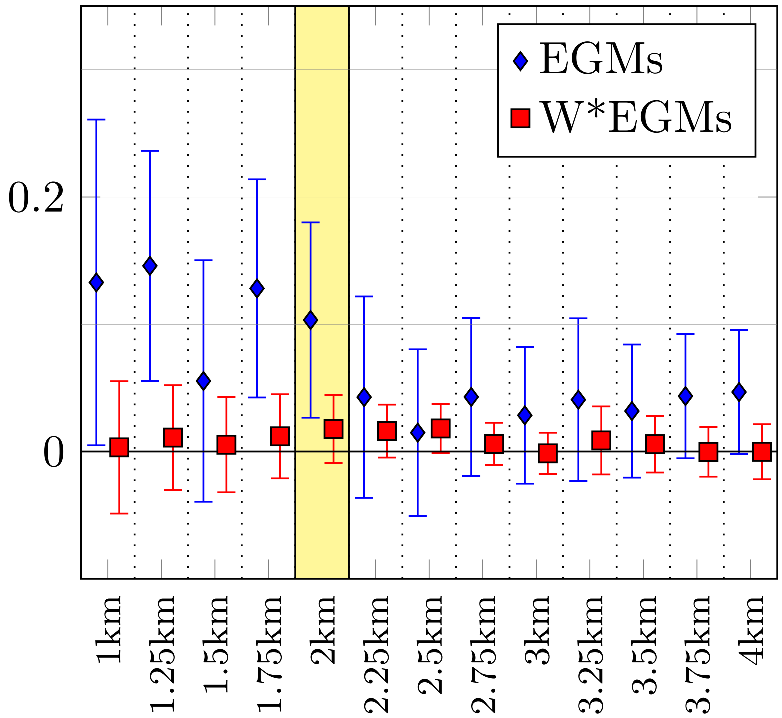


Figure 1: Comparing coefficient estimates (and 95% confidence intervals) by square size. The results of the main analysis (2km squares) are highlighted.

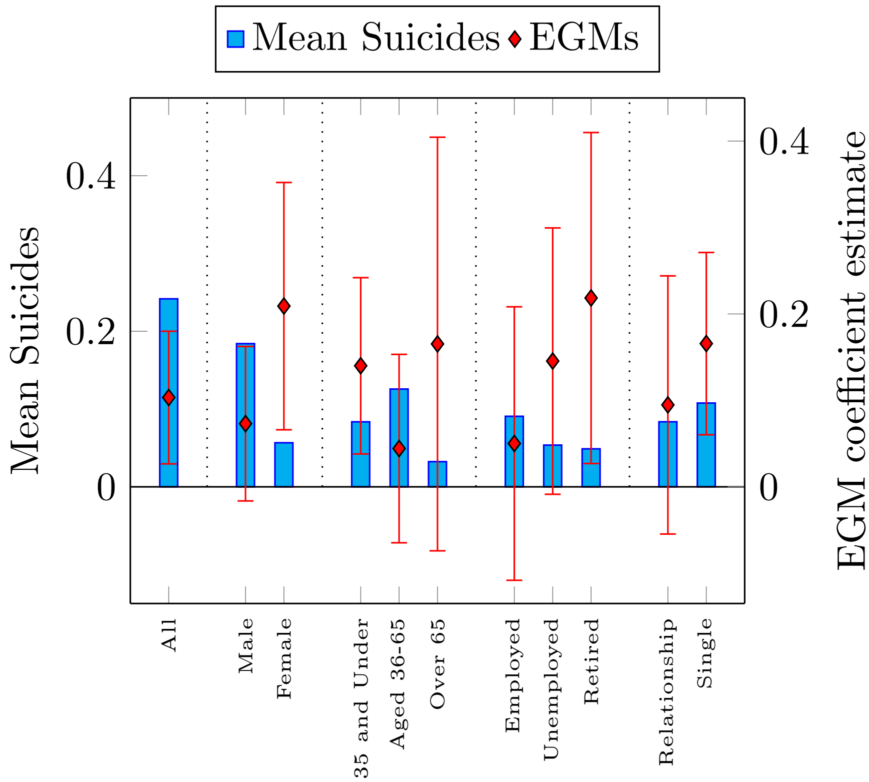
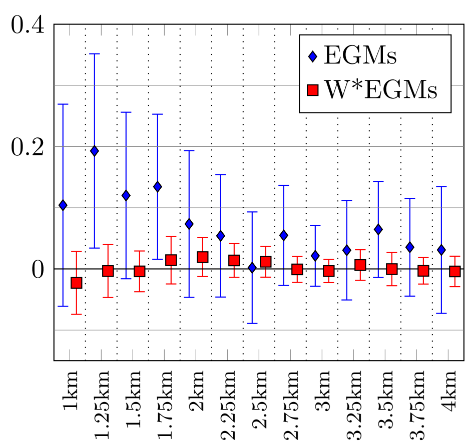
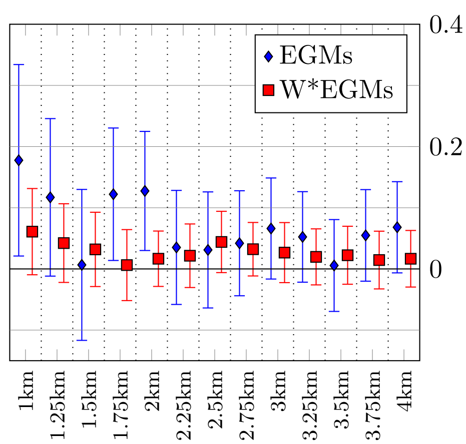


Figure 2: Mean suicides per square and year (blue columns) and estimated coefficient on the number of EGM venues (red diamond, 95% confidence intervals) for various individual characteristics.



(a) Capital cities



(b) Non-capital cities

Figure 3: Comparing coefficient estimates (and 95% confidence intervals) of equation (1) by square size and urban area type.

References

Anselin, L. (2022). Spatial econometrics. *Handbook of spatial analysis in the social sciences*, 101–122.

Armstrong, A., & Carroll, M. (2017). Gambling activity in australia. *Findings from wave*, *15*.

Australian Bureau of Statistics. (2018). *Socio economic indexes for areas (seifa) 2016*. Retrieved June 6, 2023, from https://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001

Australian Bureau of Statistics. (2023). *Socio-economic indexes for areas (seifa), australia*. Retrieved June 6, 2023, from https://www.abs.gov.au/statistics/people/people-and-communities/socio-economic-indexes-areas-seifa-australia

Baako, K. T., Mintah, K., Churchill, S. A., & Farrell, L. (2024). Betting on the house: The impact of gambling on homeownership in australia. *Journal of Gambling Studies*, *40*(1), 159–179.

Badji, S., Black, N., & Johnston, D. W. (2020). Association between density of gaming venues in a geographical area and prevalence of insolvency: Longitudinal evidence from australia. *Addiction*, *115*(12), 2349–2356.

Badji, S., Black, N., & Johnston, D. W. (2023). Economic, health and behavioural consequences of greater gambling availability. *Economic Modelling*, 106285.

Balado-Naves, R., Baños-Pino, J. F., & Mayor, M. (2023). Spatial spillovers and world energy intensity convergence. *Energy Economics*, *124*, 106807.

Bestman, A., Thomas, S. L., Randle, M., Pitt, H., Cassidy, R., & Daube, M. (2020). 'everyone knows grandma'. pathways to gambling venues in regional australia. *Health Promotion International*, *35*(6), 1273–1282.

Breuer, C. (2015). Unemployment and suicide mortality: Evidence from regional panel data in europe. *Health economics*, *24*(8), 936–950.

Browne, M., Langham, E., Rawat, V., Greer, N., Li, E., Rose, J., Rockloff, M., Donaldson, P., Thorne, H., Goodwin, B., et al. (2016). *Assessing gambling-related harm in victoria: A public health perspective* (tech. rep.). Victorian Responsible Gambling Foundation.

Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of econometrics*, *225*(2), 200–230.

Carpenter, C., & Dobkin, C. (2009). The effect of alcohol consumption on mortality: Regression discontinuity evidence from the minimum drinking age. *American Economic Journal: Applied Economics*, *1*(1), 164–182.

Churchill, S. A., & Farrell, L. (2018). The impact of gambling on depression: New evidence from england and scotland. *Economic Modelling*, *68*, 475–483.

Couture, C., Cross, J., & Wu, S. (2024). Impact of sports gambling on mental health. *Economics Letters*, *243*, 111922.

Currie, J., Davis, L., Greenstone, M., & Walker, R. (2015). Environmental health risks and housing values: Evidence from 1,600 toxic plant openings and closings. *American Economic Review*, *105*(2), 678–709.

De Chaisemartin, C., & d'Haultfoeuille, X. (2024). Difference-in-differences estimators of intertemporal treatment effects. *Review of Economics and Statistics*, 1–45.

Dow, W. H., Godøy, A., Lowenstein, C., & Reich, M. (2020). Can labor market policies reduce deaths of despair? *Journal of health economics*, *74*, 102372.

Farrell, L. (2018). Understanding the relationship between subjective wellbeing and gambling behavior. *Journal of Gambling Studies*, *34*, 55–71.

Farrell, L., & Fry, J. M. (2021). Australia's gambling epidemic and energy poverty. *Energy economics*, *97*, 105218.

Francis, K., Dowling, N. A., Jackson, A. C., Christensen, D. R., & Wardle, H. (2015). Gambling motives: Application of the reasons for gambling questionnaire in an australian population survey. *Journal of Gambling Studies*, *31*(3), 807–823.

Goodwin, B. C., Browne, M., Rockloff, M., & Rose, J. (2017). A typical problem gambler affects six others. *International Gambling Studies*, *17*(2), 276–289.

Grant, J. E., & Chamberlain, S. R. (2020). Gambling and substance use: Comorbidity and treatment implications. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *99*, 109852.

H2 Gambling Capital. (2025). *H2 gambling capital*. Retrieved August 21, 2025, from https://h2gc.com/

Halleck Vega, S., & Elhorst, J. P. (2015). The slx model. *Journal of Regional Science*, *55*(3), 339–363.

Hing, N., Nuske, E., Gainsbury, S. M., & Russell, A. M. (2016). Perceived stigma and self-stigma of problem gambling: Perspectives of people with gambling problems. *International Gambling Studies*, *16*(1), 31–48.

Hing, N., Russell, A. M., Black, A., Rockloff, M., Browne, M., Rawat, V., Greer, N., Stevens, M., Dowling, N. A., Merkouris, S., et al. (2022). Gambling prevalence and gambling problems amongst land-based-only, online-only and mixed-mode gamblers in australia: A national study. *Computers in Human Behavior*, *132*, 107269.

Humphreys, B. R., Nyman, J. A., & Ruseski, J. E. (2021). The effect of recreational gambling on health and well-being. *Eastern Economic Journal*, 1–47.

Joinson, A. N., Paine, C., Buchanan, T., & Reips, U.-D. (2008). Measuring self-disclosure online: Blurring and non-response to sensitive items in web-based surveys. *Computers in Human Behavior*, *24*(5), 2158–2171.

Kaggwa, M. M., Mamum, M. A., Najjuka, S. M., Muwanguzi, M., Kule, M., Nkola, R., Favina, A., Kihumuro, R. B., Munaru, G., Arinaitwe, I., et al. (2022). Gambling-related suicide in east african community countries: Evidence from press media reports. *BMC public health*, *22*(1), 1–13.

Karlsson, A., & Håkansson, A. (2018). Gambling disorder, increased mortality, suicidality, and associated comorbidity: A longitudinal nationwide register study. *Journal of behavioral addictions*, *7*(4), 1091–1099.

Koomson, I., Churchill, S. A., & Munyanyi, M. E. (2022). Gambling and financial stress. *Social Indicators Research*, *163*(1), 473–503.

Kraftman, L., Hardelid, P., & Banks, J. (2021). Age specific trends in mortality disparities by socio-economic deprivation in small geographical areas of england, 2002-2018: A retrospective registry study. *The Lancet Regional Health–Europe*, *7*.

Langham, E., Thorne, H., Browne, M., Donaldson, P., Rose, J., & Rockloff, M. (2015). Understanding gambling related harm: A proposed definition, conceptual framework, and taxonomy of harms. *BMC public health*, *16*, 1–23.

LeSage, J. (2015). Spatial econometrics. In *Handbook of research methods and applications in economic geography* (pp. 23–40). Edward Elgar Publishing.

Livingstone, C. (2001). The social economy of poker machine gambling in victoria. *International Gambling Studies*, *1*(1), 46–65.

Livingstone, C., Rintoul, A., & Francis, L. (2014). What is the evidence for harm minimisation measures in gambling venues? *Evidence Base: A Journal of Evidence Reviews in Key Policy Areas*, (2), 1–24.

Mannaf, M., Wheeler, S. A., & Zuo, A. (2023). Global and local spatial spill-overs: What matters most for the diffusion of organic agriculture in australia? *Ecological Economics*, *209*, 107835.

Markham, F., Doran, B., & Young, M. (2016). The relationship between electronic gaming machine accessibility and police-recorded domestic violence: A spatio-temporal analysis of 654 postcodes in victoria, australia, 2005–2014. *Social Science & Medicine*, *162*, 106–114.

Markham, F., Gobaud, A. N., Mehranbod, C. A., & Morrison, C. N. (2023). Casino accessibility and suicide: A county-level study of 50 us states, 2000 to 2016. *Addiction*.

Miéra, M., Massin, S., & Eroukmanoff, V. (2023). The social value of gambling: Surplus estimates by gambling types for france. *The European Journal of Health Economics*, *24*(9), 1531–1543.

Munford, L., Khavandi, S., & Bambra, C. (2022). Covid-19 and deprivation amplification: An ecological study of geographical inequalities in mortality in england. *Health & Place*, *78*, 102933.

Orsolini, L., Latini, R., Pompili, M., Serafini, G., Volpe, U., Vellante, F., Fornaro, M., Valchera, A., Tomasetti, C., Fraticelli, S., et al. (2020). Understanding the complex of suicide in depression: From research to clinics. *Psychiatry investigation*, *17*(3), 207.

Productivity Commission. (2001). *Australia's gambling industries* (tech. rep.). University Library of Munich, Germany.

Productivity Commission. (2010). Gambling (report no. 50).

Rintoul, A., Dwyer, J., Millar, C., Bugeja, L., & Nguyen, H. (2023). Gambling-related suicide in victoria, australia: A population-based cross-sectional study. *The Lancet Regional Health–Western Pacific*, *41*.

Rizk, M. M., Herzog, S., Dugad, S., & Stanley, B. (2021). Suicide risk and addiction: The impact of alcohol and opioid use disorders. *Current addiction reports*, *8*, 194–207.

Rockloff, M., Browne, M., Hing, N., Thorne, H., Russell, A., Greer, N., Tran, K., Brook, K., & Sproston, K. (2020). Victorian population gambling and health study 2018–2019. *Victorian Responsible Gambling Foundation: North Melbourne, Australia*.

Roth, L. (2020). Gambling: An update. *NSW Parliamentary Research Service*.

Sedgwick, P. (2012). What is recall bias? *BMJ*, *344*.

Taylor, R., Page, A., Morrell, S., Harrison, J., & Carter, G. (2005). Mental health and socio-economic variations in australian suicide. *Social science & medicine*, *61*(7), 1551–1559.

Thomas, A. C., Allen, F. C., & Phillips, J. (2009). Electronic gaming machine gambling: Measuring motivation. *Journal of Gambling Studies*, *25*(3), 343–355.

Tran, L. T., Wardle, H., Colledge-Frisby, S., Taylor, S., Lynch, M., Rehm, J., Volberg, R., Marionneau, V., Saxena, S., Bunn, C., et al. (2024). The prevalence of gambling and problematic gambling: A systematic review and meta-analysis. *The Lancet Public Health*.

Van Der Maas, M., DiMeglio, R., & Nower, L. (2024). Gambling as a precipitating factor in deaths by suicide in the national violent death reporting system. *Public Health*, *235*, 180–186.

Velasco, V., Scattola, P., Gavazzeni, L., Marchesi, L., Nita, I. E., & Giudici, G. (2021). Prevention and harm reduction interventions for adult gambling at the local level: An umbrella review of empirical evidence. *International Journal of Environmental Research and Public Health*, *18*(18), 9484.

Wardle, H., Degenhardt, L., Marionneau, V., Reith, G., Livingstone, C., Sparrow, M., Tran, L. T., Biggar, B., Bunn, C., Farrell, M., et al. (2024). The lancet public health commission on gambling. *The Lancet Public Health*, *9*(11), e950–e994.

Wardle, H., John, A., Dymond, S., & McManus, S. (2020). Problem gambling and suicidality in england: Secondary analysis of a representative cross-sectional survey. *Public health*, *184*, 11–16.

Wong, P. W., Cheung, D. Y., Conner, K. R., Conwell, Y., & Yip, P. S. (2010). Gambling and completed suicide in hong kong: A review of coroner court files. *The Primary Care Companion for CNS Disorders*, *12*(6), 27298.

Zeileis, A., Kleiber, C., & Jackman, S. (2008). Regression models for count data in r. *Journal of statistical software*, *27*(8), 1–25.

Appendix A: Descriptive Statistics

Appendix A.1: Number of venues that open and close per year

Figure A1: The number of EGM venues that open and close in each year (Victoria and Queensland combined).

Appendix A.2: Minimum and maximum number of venues per square

		Maximum EGM venues															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum EGM venues	0	**3477**	203	4	-	-	-	-	-	-	-	-	-	-	-	-	-
	1		**549**	67	8	1	-	-	-	-	-	-	-	-	-	-	-
	2			**147**	35	8	2	-	-	-	-	-	-	-	-	-	-
	3				**40**	22	10	-	-	-	-	-	-	-	-	-	-
	4					**11**	7	3	-	-	-	-	-	-	-	-	-
	5						**3**	7	3	-	-	-	-	-	-	-	-
	6							**-**	-	1	-	-	1	-	-	-	-
	7								**-**	1	-	-	1	-	-	-	-
	8									**1**	-	-	-	-	-	-	-
	9										**-**	-	-	-	-	-	-
	10											**-**	-	1	-	-	-
	11												**-**	-	-	-	1

Table A1: The minimum and maximum number of EGM venues in each square for the 4614 squares included in the main analysis.

Appendix A.3: Distribution of suicides

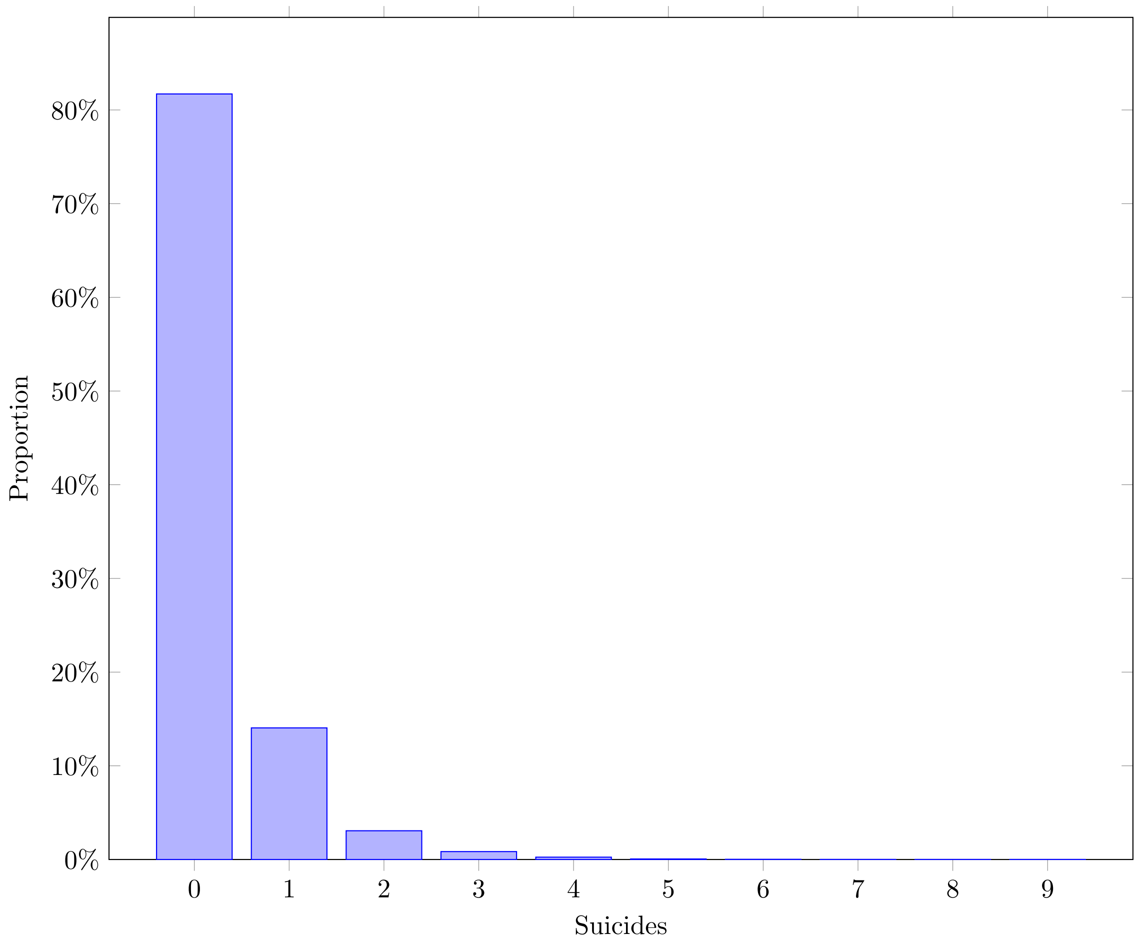


Figure A2: The distribution of the number of suicides in each square and year.

Appendix B: Difference-in-difference and event study analyses

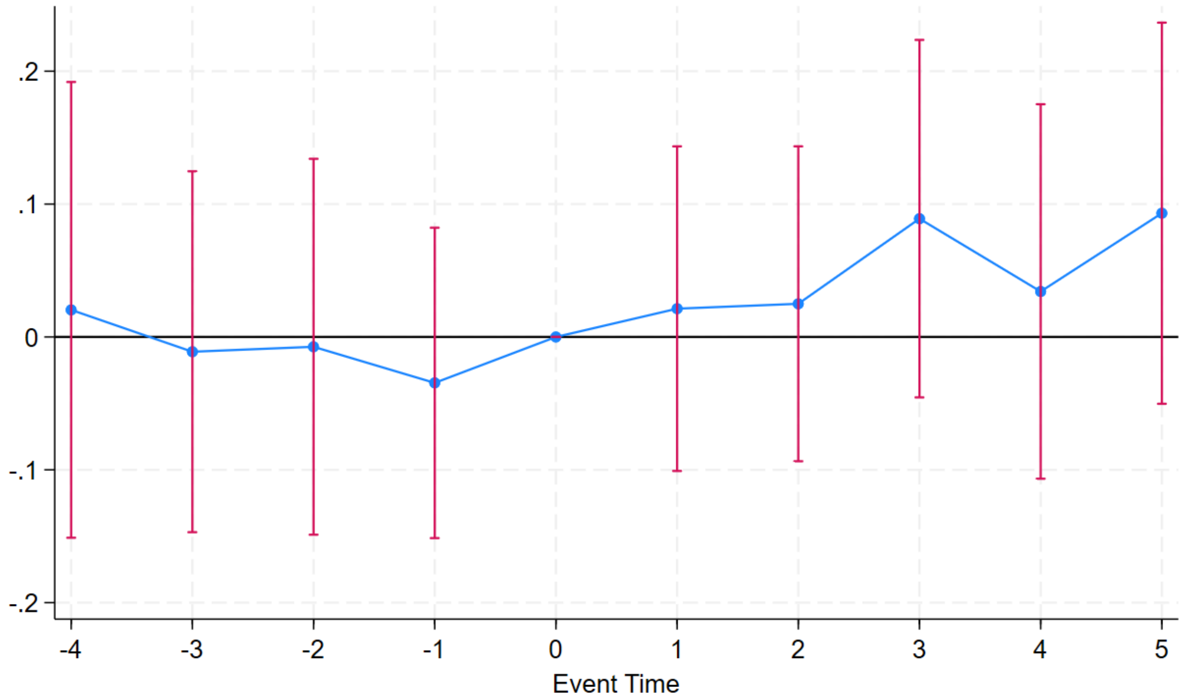


Figure B1: Estimated effects and 95% confidence intervals are presented. Effects are relative to not yet and never-switchers. t = 0 represents the year when an EGM venue opens or closes (it is not known if suicides occurring in event time 0 occur before or after the change in EGM venue status)

Appendix C: Robustness Checks

Appendix C.1: Population growth

	Coefficient
EGMs	0.1080**
	(0.0408)
W*EGMs	0.0143
	(0.0141)
Num. observations	76874
Num. groups: squares	4522
Num. groups: LGA years	2601
Mean EGM venues	0.3601
Mean suicides	0.2408

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C1: Model excluding squares with both: (i) zero EGM venues in 2001 and (ii) at least one EGM venue open during the analysis period. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

Appendix C.2: Gambling expenditure

	Model 1	Model 2	Model 3
(Intercept)	0.96278***		
	(0.00281)		
Change in expenditure	0.00239	0.00289	0.00307
	(0.00235)	(0.00296)	(0.00271)
Num. obs.	4812	4812	4812
Num. groups: LGA	NA	70	70
Num. groups: year	NA	NA	10

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C2: Linear models estimating the effect of a change in venue gambling expenditure on venue closure. Data includes all EGM venues in Victoria that were open in 2009 (N = 511). Outcome variable: equal to 1 if a venue closes during the relevant period (48 venues) and equal to 0 if the venue remains open for the entire period. Change in expenditure: calculated as venue's expenditure in year t minus expenditure in 2009 (in millions). Data excludes the year 2009 since all expenditure change would be equal to 0. Model 1 has no fixed effects. Model 2 has fixed effects at the LGA level. Model 3 has fixed effects at the LGA level and year level. A positive coefficient indicates a venue is more likely to close if expenditure increases. Standard errors are presented in parenthesis.

Appendix C.3: Socioeconomic status changes

Using the 2011 and 2016 IRSAD scores, the following model is estimated

$$(EGM_{il,2016} - EGM_{il,2011}) = \beta(IRSAD_{il,2016} - IRSAD_{il,2011}) + u_l + \varepsilon_{il} \tag{3}$$

where $EGM_{il,2016}$ and $EGM_{il,2011}$ denote the number of EGM venues in square i in 2016 and 2011 respectively, $IRSAD_{il,2016}$ and $IRSAD_{il,2011}$ denote the IRSAD scores for square i in 2016 and 2011 respectively, u_l denotes LGA level fixed effects to explore within LGA differences, ε_{il} are unobserved effects, and β, is a parameter to be estimated.

To define a square's IRSAD score, each square is assigned to an SA1 based on which SA1 the square has the largest overlap with. Squares are then given an IRSAD score based on the IRSAD score of the SA1 they are assigned to. Some SA1s have insufficient information to receive an IRSAD score (e.g. low population and/ or Census response rate). For squares assigned to these SA1s (a total of 466 squares), their IRSAD score is based on the SA2[30] that their SA1 is in. Like with SA1s, some SA2s have insufficient information to receive an IRSAD score. For squares in these SA2s (a total of 31 squares), their IRSAD score is based on the IRSAD score of the LGA they are in.

($IRSAD_{il,2016}$ - $IRSAD_{il,2011}$)	-0.0038 (0.0078)
Num. observations	4614
Num. groups: LGAs	153

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C3: Linear model estimating the relationship between within LGA variation in socioeconomic status (measured using IRSAD) and the number of EGM venues. IRSAD scores are divided by 100 for ease of viewing results. A negative coefficient indicates that an increase in socioeconomic status is associated with a decrease in the number of EGM venues. Standard errors are presented in parenthesis.

[30] SA2 refers to statistical area 2, the second smallest geographical area with IRSAD information, made up of multiple SA1s

Appendix C.4: Non-EGM alcohol venues

	Model 1	Model 2	Model 3
EGMs	0.1806**	–	0.1954**
	(0.0699)		(0.0686)
W*EGMs	0.0246	–	0.0355
	(0.0359)		(0.0358)
Non-EGM alcohol venues	–	-0.0096	-0.0131
		(0.0131)	(0.0129)
W*Non-EGM alcohol venues	–	-0.0049	-0.0066
		(0.0042)	(0.0044)
Num. observations	34969	34969	34969
Num. groups: squares	2057	2057	2057
Num. groups: LGA years	1343	1343	1343
Mean EGM venues	0.2429	0.2429	0.2429
Mean non-EGM alcohol venues	0.8775	0.8775	0.8775
Mean suicides	0.2661	0.2661	0.2661

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C4: Models 1, 2, and 3 present the model results when the explanatory variables respectively include EGM venues only (i.e. the same as the main analysis but restricted to Victoria data - Model 1), non-EGM alcohol venues only (Model 2), and both EGM venues and non-EGM alcohol venues (Model 3). The mean EGM venues, non-EGM alcohol venues, and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

Appendix C.5: Time lag on EGM venues

	$EGM_{il,t}$	$EGM_{il,t-1}$	$EGM_{il,t-2}$
EGMs	0.0784^{*}	0.1033^{**}	0.1218^{**}
	(0.0357)	(0.0391)	(0.0406)
W*EGMs	0.0292^{*}	0.0177	0.0152
	(0.0127)	(0.0137)	(0.0152)
Num. observations	83052	78438	73824
Num. groups: squares	4614	4614	4614
Num. groups: LGA years	2754	2601	2448
Mean EGM venues	0.3633	0.3650	0.3665
Mean suicides	0.2395	0.2417	0.2425

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C5: Comparing the main model estimates when using different specifications for the time lag on the number of EGM venues. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.

Appendix C.6: Shifting the grid

	No shift (main analysis)	Shift 1km east-west	Shift 1km north-south	Shift diagonally
EGMs	0.1033**	0.0889*	0.0773*	0.0970*
	(0.0391)	(0.0402)	(0.0375)	(0.0422)
W*EGMs	0.0177	0.0129	0.0177	0.0078
	(0.0137)	(0.0128)	(0.0164)	(0.0118)
Num. observations	78438	78421	78574	78506
Num. groups: squares	4614	4613	4622	4618
Num. groups: LGA years	2601	2584	2601	2601
Mean EGM venues	0.3650	0.3653	0.3623	0.3632
Mean suicides	0.2417	0.2429	0.2410	0.2422

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table C6: Comparing the main model estimates when shifting the grid. The mean EGM venues and suicides per square and year are reported. Standard errors clustered by square presented in parenthesis.