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# Universal interventions for suicide prevention in high-income Organisation for Economic Co-operation and Development (OECD) member countries: a systematic review

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## ABSTRACT

**Introduction** To examine the effectiveness of universal suicide prevention interventions on reducing suicide mortality in high-income Organisation for Economic Co-operation and Development (OECD) member countries.

**Methods** We implemented a comprehensive search strategy across three electronic databases: MEDLINE (Ovid), PsycINFO (Ovid) and Embase (Ovid). All studies using time-series, retrospective, prospective, pre–post or cross-sectional study designs were included. Studies were required to examine suicide mortality as the outcome of interest. To help organise the results, studies were grouped into six broad categories of universal interventions consistent with the World Health Organization (WHO) Comprehensive Mental Health Action Plan. A narrative synthesis of results was used to describe the findings.

**Results** Of the 15 641 studies identified through the search strategy, 100 studies were eligible in the following categories: law and regulation reforms (n=66), physical barriers (n=13), community-based interventions (n=9), communication strategies (n=4), mental health policies and strategies (n=7), and access to healthcare (n=1). Overall, 100% (13/13) of the included physical barrier interventions resulted in a significant reduction in suicide mortality. Although only 70% (46/66) of the law and regulation reform interventions had a significant impact on reducing suicide, they hold promise due to their extended reach. Universal suicide prevention interventions seem to be more effective at reducing suicide among males than females, identifying a need to stratify results by sex in future studies.

**Conclusions** These findings suggest that universal suicide prevention interventions hold promise in effectively reducing suicide mortality in high-income OECD countries.

## INTRODUCTION

Suicide is a significant public health concern globally, with an estimated 800 000 people dying by suicide worldwide every year.<sup>1</sup> The causes of suicide are complex and result from a combination of individual, social and economic factors that vary substantially between countries. For instance, the methods used by those who die by suicide, and the risk factors that influence suicide, vary substantially

between low-income and high-income countries.<sup>2–4</sup>

For example, the most common method of suicide in South Africa is hanging followed by poisoning with pesticides and medication; however, in the USA, suicide death most commonly occurs by firearm, followed by suffocation.<sup>3 5</sup> As a result, interventions that work in some countries may not work in others. For this reason, it is important to look at groupings of countries with similar social and economic contexts, such as Organisation for Economic Co-operation and Development (OECD) member countries belonging to the high-income category. Rates of suicide mortality in high-income OECD countries varied substantially in 2016, from 4 deaths per 100 000 individuals in Greece to over 24.6 deaths per 100 000 people in Korea.<sup>6</sup> The impact of suicide mortality in high-income OECD countries are generally highest among older adults (aged >65 years), adolescents (aged 10–14 years) and males when compared with females.<sup>1</sup>

In 2015, the United Nations Sustainable Development Goals (SDG) were released to foster peace and prosperity for people and the planet, including targets set for 2030.<sup>7</sup> The SDGs included goal (#3.4) to reduce global premature mortality from non-communicable diseases by one-third; indicators for this goal include a reduction in suicide mortality rates (SDG Indicator 3.4.2).<sup>7</sup> Among all OECD countries, suicide mortality rates have decreased steadily, falling by close to 30% between 1990 and 2015, with pronounced declines of over 40% in countries such as Hungary, Estonia and Finland.<sup>8</sup> Despite these declines, no OECD country is on-track to meet the SDG goal,<sup>9</sup> which may reflect that current efforts do not adequately include comprehensive, multisectoral strategies to reduce suicide mortality, and that addressing social determinants of health is often overlooked in suicide prevention efforts.<sup>10</sup> Identifying well-designed and transferrable interventions could strengthen suicide prevention strategies among several countries and facilitate meeting the SDG target.

In 2014, World Health Organization (WHO) launched the first global Comprehensive Mental Health Action Plan, of which one goal was to reduce suicide rates worldwide through prevention initiatives.<sup>11</sup> Comprehensive suicide prevention strategies include universal, selective and

indicated interventions.<sup>12</sup> Universal interventions are designed to reach an entire population regardless of risk, as described by Rose.<sup>13</sup> Whereas, selective interventions target sub-populations with potentially high risk for suicide (eg, people who have experienced trauma or abuse, or who are affected by conflict or disaster). Indicated interventions target specific individuals at greater risk (eg, people living with a mental illness, people who abuse substances, those who have previously attempted suicide).<sup>11</sup>

To date, most systematic reviews on suicide prevention have examined the effectiveness of context-specific interventions in school, community or healthcare settings,<sup>14</sup> primary care interventions,<sup>15</sup> psychosocial interventions,<sup>16</sup> pharmacological interventions,<sup>17</sup> technology-enhanced interventions<sup>18</sup> or workplace interventions.<sup>19</sup> Recent systematic reviews have examined universal suicide prevention interventions combined with selective and indicated interventions, which does not allow for a focused examination of universal interventions' characteristics and efficacy.<sup>20 21</sup> Given the demonstrated effectiveness of universal interventions to address other health problems such as universal smoking policies aimed at reducing smoking rates and alcohol access and pricing on rates of harmful alcohol use,<sup>22 23</sup> it is essential to examine universal suicide prevention interventions and their impact in similar contexts. Thus, this systematic review's objective was to examine the effectiveness of universal prevention interventions on reducing suicide mortality, as measured by counts or rates of suicide deaths, among high-income OECD countries.

## METHODS

### Protocol and registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement,<sup>24</sup> and was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO; #CRD42018086273).

### Study inclusion criteria

We followed the Population, Intervention, Comparator, Outcome framework to plan the components of our systematic review.<sup>25</sup>

#### Population

This review included studies with large populations (ie, community, city, state/province, country or region) living in one or multiple of the 33 high-income OECD countries, as categorised by the World Bank. Lithuania was excluded from this study because it was added to the OECD after the original search strategy was conducted in 2018. A full list of high-income OECD countries can be found in online supplemental file 1. No limitations were placed on the age or sex of the population.

#### Interventions

Candidate studies were required to have studied a universal intervention, targeted at a whole geographic population, with the intention or the impact of reducing suicide mortality as rates or counts (eg, country, state or province, or citywide).

#### Comparators

Because this review included studies using a range of study designs, both studies with and without comparator (control) populations, such as a neighbouring state or city where the intervention was not implemented, were included.

## Outcomes

Studies were required to examine changes in suicide mortality in the presence of an intervention. Our primary outcome was the change in the number or rate of intentional self-harm (suicide) deaths, defined as deaths coded to the International Classification of Diseases (ICD) intentional self-harm codes (eg, code ICD-10: X60-X84, Y87) or determined to be due to intentional self-harm, using vital statistics or other death databases, or coroner's or medical examiner's records. Suicide death data could be expressed as counts, proportions or rates.

### Study design

Cross-sectional, time series, retrospective, prospective, and pre-post study designs were included. This includes natural experiment designs, where the intervention is implemented outside of the control of the researcher.

### Publication status and language

Studies were eligible if they were published in peer-reviewed journals in English or French as translation resources were limited to these two languages. We excluded non-peer-reviewed papers, theses, dissertations, government reports, conference proceedings and any other form of grey literature.

### Search strategy

The search strategy was developed by a librarian experienced in systematic review searching. It was peer reviewed by a second librarian using the Peer Review of Electronic Search Strategies guideline. The searches were first conducted on 4 April 2018, across three databases: MEDLINE (Ovid), PsycINFO (Ovid) and Embase (Ovid). Date restrictions were placed on the search to include papers indexed from 1 January 1990 to 31 December 2017. An updated search was conducted on 12 February 2020 to extend the search to include articles from 1 January 2018 to 13 February 2020. The search used a combination of unique subject headings and keywords related to universal suicide prevention interventions. A filter was used to restrict articles to include only 33 high-income OECD countries. See online supplemental file 2 for the final search strategy. Additionally, studies were identified by searching the reference list of included studies and other relevant published reviews.

### Study selection

All of the database records were imported into RefWorks (V.2.0; ProQuest, Ann Arbor, Michigan, USA) to organise and deduplicate records. All records were then imported into Covidence (Veritas Health Innovation, Melbourne, Australia), with a second software deduplication performed before screening. At level one screening, at least two reviewers (JJL, BO and M-CI) independently screened titles and abstracts against the inclusion criteria, with consensus needed for level two inclusion. At level two screening, full texts of each record were obtained and independently screened by at least two reviewers (JJL, M-CI and HS-K), with consensus needed for final inclusion. A third reviewer (HO and JJL) helped resolve discrepancies when agreement was not attained during level one and two screening. Reviewers were not blinded to the authors of the studies.

### Data extraction

Data from all included studies were extracted into a standardised spreadsheet that was peer reviewed by coauthors and pilot tested before use. All data were extracted by one reviewer (M-CI or

HS-K) and verified by a second (HO or JJJ). Disputes were resolved during research team meetings.

Extracted data included the following items: author, publication year, country, study design, estimated target population size, intervention description, intervention period (calendar years), level of intervention (national, regional, community), description of mortality outcome data, source of mortality data, intervention results (eg, preintervention and postintervention results or differences/changes in mortality), comparator details if available, method of statistical analysis and summary of findings.

### Study quality assessment

The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool was used to assess the quality of all included studies.<sup>26</sup> One reviewer (M-CI and HS-K) independently evaluated each study for biases related to sample selection, study design, confounders, blinding, data collection, withdrawals, and dropouts. Each study received a global rating of 'weak,' 'moderate' or 'strong' based on the amount of potential bias incorporated into the study methods. A second assessor (JJL and M-CI) reviewed the evaluation for accuracy, with a third reviewer (HO) consulted to resolve conflicts. The EPHPP does not allow for grading the overall quality of the evidence for each intervention category. However, we highlight the range of global ratings for studies included in each intervention category.

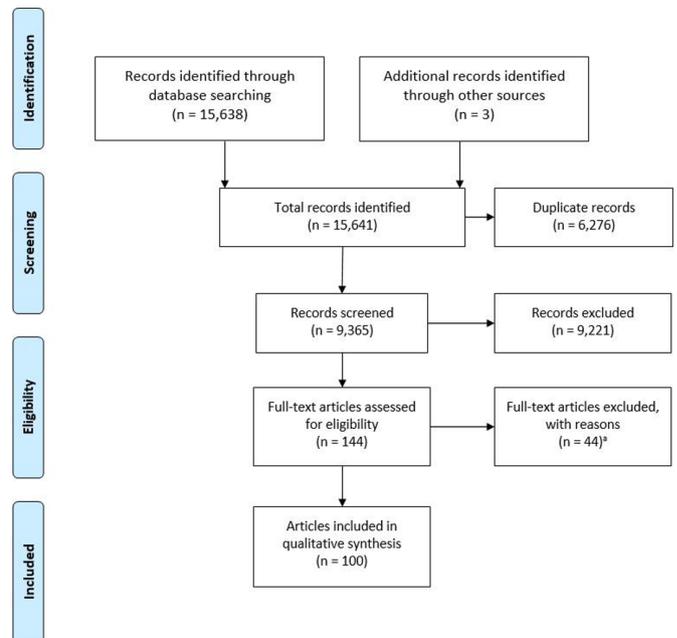
### Narrative synthesis of results

To help organise the results, studies were grouped into six broad categories of universal interventions derived from the WHO Comprehensive Mental Health Action Plan.<sup>11</sup> The categories include access to healthcare (eg, suicide prevention centres), communication (eg, media reporting), community-based interventions (eg, school and community-based programmes and local suicide prevention projects/initiatives such as crisis phone lines), law and regulation reform (split into firearm laws and all other laws, such as alcohol policies, tobacco policies and access to all means, including domestic gas detoxification, catalytic converter legislation, analgesics and pesticides), mental health policies (eg, national programmes/strategies and mental health insurance policies), and physical barriers for transit and bridges (eg, bridge barriers, safety nets, blue lights on train stations, platform screen doors). Studies that included multiple interventions across several categories were included under the community-based interventions category. A narrative synthesis of results was conducted for each intervention category to describe the overall findings. The diversity of intervention types and settings within each category precluded our ability to perform a meta-analysis.

## RESULTS

Figure 1 displays the PRISMA flow diagram for the literature search and screening process. A total of 15 641 records were identified through database searches and additional sources. After deduplication, 9365 records remained for level one screening. Following screening of titles and abstracts, 144 full-text articles were retained for level two screening, with 100 studies identified as eligible (see online supplemental file 3 for references).

The included studies were published from 1 January 1990 to 13 February 2020, with only 15% published in the past 5 years. Studies were conducted among 17 (47%) high-income OECD countries; the number of studies per country ranged from 1 (six countries) to 23 (one country). The most studied countries included the USA (23%), Australia (12%) and Canada (10%).



**Figure 1** PRISMA flow chart for the identification, screening, eligibility and inclusion of articles. \*Reasons for exclusion: 18 studies were not peer-reviewed articles; 9 studies did not evaluate a universal suicide prevention intervention; 11 studies did not use suicide mortality as an outcome; 2 studies were not conducted in a high-income OECD country and 4 studies did not have the full-text article available. OECD, Organisation for Economic Co-operation and Development; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

The majority of included studies (n=66) investigated law and legislation reform interventions (eg, alcohol and tobacco taxes, catalytic converter legislation, laws banning the use of pesticides, etc), with 45 out of the 66 studies investigating firearm-related law interventions. For firearm restriction laws, the most common topics of study were the US Brady Handgun Violence Prevention Act, the Australian National Firearms Agreement (NFA) and the Canadian Bills C-51 and C-17. Thirteen studies investigated physical barriers for suicide prevention (eg, installed on bridges or other jumping sites, train stations), nine investigated community-based interventions (eg, one intervention focused on improving the care of patients with depression by training family doctors, conducting media and general public campaigns, using community facilitators and fostering self-help activities), four investigated communication strategies (eg, media reporting and public awareness campaigns), seven reported on mental health policies and strategies (eg, a new suicide prevention policy) and one investigated access to healthcare as a method to prevent suicide. Tables 1–5 and online supplemental files 4–5 display details on all studies included in this review.

The overall summary of the findings is outlined in table 5. Thirteen (100%) physical barrier studies reported favourable results, as did two of four (50%) communication strategy studies, and three of nine (33%) community-based interventions. In total, 46 of 66 (70%) law and regulation reform studies reported favourable results, of which 30 of 45 (67%) firearm-related studies reported favourable results. Several specific interventions were the topic of multiple papers. The proportion of studies reporting a novel intervention was 75% for communication strategies, 78% for community-based interventions, 44% for law and regulation reform, 100% for mental health policies and strategies, and 85% for physical barriers. The study-specific

**Table 1** Access to healthcare

Study	Design	Time period	Country (region)	Intervention	Results	Direction of association
Lester <i>et al</i> , 1996 <sup>51</sup>	Time-Series	1971–1989	Japan	Opened 35 suicide prevention centres during the intervention period.	Suicide prevention centres were associated with reductions in suicide mortality among men ( $\beta=-0.52$ ; $p<0.05$ ) but not women ( $\beta=0.07$ ) only when adjusting for birth rate.	Total: - Male: -- Female: +

--, statistically significant reduction;  $\beta$ , beta coefficient; -, not statistically significant reduction; +, not statistically significant increase.

quality assessment ranged from weak to strong, depending on the intervention category. Details on the study quality assessment scoring can be found in online supplemental file 6.

## DISCUSSION

The WHO comprehensive framework launched in 2014 emphasised the importance of using a range of suicide prevention strategies (including universal, selective and indicated interventions),<sup>11</sup> at different levels based on the unique situation and distribution of risk factors in each country. Relatively few studies have examined the effectiveness of universal suicide prevention interventions, with many doing this in combination with selective and indicated interventions. To the best of our knowledge, this is the first systematic review to examine the effectiveness of universal suicide prevention interventions with suicide mortality as the outcome.

### Overall suicide mortality

This systematic review examined results from 100 studies conducted in 17 high-income OECD countries that investigated the association between specific universal suicide prevention interventions and changes in suicide mortality. Overall, we found that the relationship between universal suicide prevention interventions and reductions in suicide mortality varied largely depending on the type of intervention. We found that nearly all physical barriers interventions (100%) were effective at reducing suicide mortality at specific sites. The majority of the included studies in our study investigated law and legislation reform interventions, with roughly three-quarters (70%)

of the included studies showing significant reductions in suicide mortality. Due to the reach of these interventions, they should be considered an important component of universal suicide prevention. Previous reviews have reported similar results by demonstrating that the most promising universal interventions were laws and legislative reforms restricting means to suicide (eg, guns, domestic gas, barbiturates, vehicle emissions, analgesics, pesticides, etc) and the control of locations frequently used for suicide by jumping (eg, physical barriers).<sup>20 21</sup> Similar to other reviews, limited evidence demonstrated the effectiveness of communication strategies (eg, general public education and media guidelines) or community-based interventions (multilevel interventions) on suicide mortality. In our review, community-based interventions were often multi-level making it difficult to identify which specific components of the intervention had direct impacts on suicide mortality. Also, the evaluation of some of the community-based interventions combined suicide attempts and suicide deaths, further complicating the comparability of findings. In our review, we also included a broad range of interventions, such as healthcare access interventions and mental health policies (eg, national strategies, plans, health insurance policies). These types of interventions had limited impacts, except for mental health policies, which were significantly effective among specific age categories.

### Sex-stratified results

Overall, there was more evidence supporting the effectiveness of universal suicide prevention interventions among males compared with females. Of the 27 studies that reported sex-specific effects,

**Table 2** Communication strategies

Study	Design	Time period	Country (region)	Intervention	Results	Direction of association
Etzersdorfer and Sonneck 1998 <sup>52</sup>	Prospective Field Experiment	1980–1996	Austria (Vienna)	National media reporting guidelines for suicide were released in mid-1987.	Following the implementation of the media reporting standards the number of people who died by suicide on the Viennese subway system dropped from nine in 1987 to two in 1988.	Total: -
Niederkrotenthaler and Sonneck, 2007 <sup>53</sup>	Interrupted time series	1946–2005	Austria	National media reporting guidelines for suicide were released in mid-1987.	The media guidelines were associated with a significant reduction in the number of annual suicide mortalities ( $\beta=-80.95$ ; 95% CI -149.11 to -12.78; $p=0.024$ ).	Total: --
Till <i>et al</i> 2013 <sup>54</sup>	Pre-post, with control group	2011	Austria (Styria)	In 2011, the city of Styria launched an awareness campaign through billboards and info screens in public areas aimed at suicide prevention and increasing help seeking behaviours.	There was a small increase in the number of suicide mortalities from 52 during the control period (January–March) to 69 during the intervention period (April–June) in 2011 ( $\chi^2=1.13$ ; $p=0.28$ ).	Total: +
Matsubayashi <i>et al</i> 2014 <sup>55</sup>	Time series	2010–2012	Japan (Nagoya)	In 2009, a city-wide campaign was launched to increase the awareness of depression and heighten help seeking behaviours.	There was a significant decrease in the number of suicides 2 months following the distribution of campaign materials (incidence rate ratio=0.97; 95% CI 0.96 to 0.97). The impact was greater in men compared with women.	Total: -- Male: -- Female: --

+, not statistically significant increase; -, not statistically significant reduction;  $\beta$ , beta coefficient; --, statistically significant reduction; ++, statistically significant increase.

Table 3 Mental health policies and strategies

Study	Design	Study time period	Country (region)	Intervention	Results	Direction of association
Ohberg <i>et al</i> 1997 <sup>581</sup>	Time series	1980–1995	Finland	In 1990, a national suicide prevention project was implemented.	There was a significant decline in suicide rates among men aged >15 years from 61.7 deaths per 100 000 in 1990 to 54.1 in 1995, with the largest impact occurring in youth aged 15–24 years. The decline in suicide rates among women was not significant.	Male 15–24 years: -- 25–34 years: - 35–64 years: - >65 years: - Female 15–24 years: - 25–34 years: + 35–64 years: - >65 years: -
Bellanger <i>et al</i> 2006 <sup>582</sup>	Quasi-experimental	1988–2001	France	Since 1994, a new suicide prevention policy has been introduced in France.	Following the implementation of the new policy, the decrease in suicide rates was significantly greater in the exposed group (-12.7%) compared with the non-exposed group (-7.6%), after adjusting for sex and initial death rates.	Total: --
Nakanishi <i>et al</i> 2020 <sup>583</sup>	Interrupted Time series	1996–2016	Japan	In 2006, the Basic Act for Suicide Prevention implemented, which included nine initiatives that covered almost all aspects of suicide prevention, with the exception of policies to reduce harmful alcohol use.	After the 2006 implementation of the Act, there was a reduction in suicide mortality across most age and sex groups (April 2006–February 2011), but none of the reductions were considered statistically significant.	Total: - Male: - Female: + ≤19 years: - 20–39 years: - 40–59 years: - >60 years: +
Lee <i>et al</i> 2018 <sup>584</sup>	Time series	1993–2016	South Korea	In the early 2000s (first: year 2004; second: year 2009), South Korea implemented the national suicide prevention programme, which included different suicide prevention policies for both high-risk groups, and the general population.	From 1993 to 2010, the national suicide mortality rate increased by an annual percent change of 5.6% (95% CI 4.4% to 6.9%). After 2010, the suicide mortality rate declined by an annual percent change of 5.5% (95% CI -10.3% to -0.5%) until 2016.	Total: -- Male: - Female: --
Baran <i>et al</i> 2015 <sup>585</sup>	Pre–post with no control group	2002–2014	Sweden	In 2008, the Swedish government approved a national programme for suicide prevention that recommended nine strategies. Specific details on the programme are not provided.	Before the implementation of the national programme, the suicide rate in Sweden was 12.9 per 100 000 (2002–2007), which declined to 12.33 per 100 000 following the implementation (2009–2014). The overall slope of the regression was not significant, suggesting that the programme had a minimal impact on suicide rates. The programme may have only reduced suicide rates in older men age >65 years (2.41 suicide rate reduction, $p=0.02$ ).	Male 0–24 years: + 25–44 years: - 45–64 years: - >65 years: -- Female 0–24 years: + 25–44 years: - 45–64 years: - >65 years: -
Lang, 2013 <sup>586</sup>	Pre–post, with control group	1990–2004	USA	States began enacting mental health insurance laws between the mid-1990s and early 2000s. By 2002, 45 states had enacted some type of mental health insurance law.	Following the enactment of mental health insurance laws that were at parity physical health insurance laws in 29 states, the state-level suicide rate was 10.24 per 100 000. If these laws were not enacted the suicide rate would have been 10.61 per 100,000, which equates to approximately 592 suicide deaths prevented per year.	Total: --
Matsubayashi <i>et al</i> 2011 <sup>587</sup>	Pre–post, with no control group	1980–2004	11 high-income OECD countries	Between 1995 and 2003, 11 high-income OECD countries had implemented a nationwide suicide prevention programme. These programmes varied by country, were multifaceted and include a variety of activities, some of which constituted universal interventions.	Following the implementation of a national suicide prevention programme, the national suicide rate per 100 000 declined by 1.38 (SE=0.5, $p<0.05$ ). The effect was larger in men (suicide rate=-1.43, SE=0.513, $p<0.05$ ) than women (suicide rate=-0.37, SE=0.51, not significant).	Male 0–24 years: -- 25–64 years: - >65 years: -- Female 0–24 years: -- 25–64 years: + >65 years: --

+, not statistically significant increase; -, not statistically significant reduction; --, statistically significant reduction; ++, statistically significant increase; OECD, Organisation for Economic Co-operation and Development; SE, SE error.

eleven (41%) found strong evidence of reductions in suicide mortality for males, but not for females (S1, S18, S29, S32, S33, S44, S79, S81, S83, S87, S100). While 12 (44%) reported equal effectiveness between males and females (S5, S11, S16, S17, S20, S23, S30, S43, S54, S55, S60, S85) and 4 (15%) reported effective results for females only (S7, S22, S42, S84). In Western contexts, more females attempt suicide, while more males die by suicide. This is known as the 'gender paradox' of suicide.<sup>27</sup> The greater number of studies with positive results for males may be due, in part, to the significantly higher levels of suicide death among males and the greater power to detect significant effects.

It is also possible that different types of interventions may be effective for females as compared with males, particularly as they relate to means restrictions. For example, while means restrictions interventions have been widely applied to more violent forms of suicide which are more common among men, including firearm suicide and jumping from heights, means restriction for some methods more common among women, such as poisoning by drugs,<sup>28 29</sup> may be somewhat more challenging to implement. Finally, it is possible that the use of coroner or medical examiner data, which have been shown to have a lot of missing data, particularly for antecedents of suicide attempts and recent

Table 4 Physical barriers

Study	Design	Study time period	Country (region)	Intervention	Results	Direction of association
Law <i>et al</i> 2014 <sup>588</sup>	Pre-post, with no control group	1990–2012	Australia (Brisbane)	In 1993, a fence barrier on the Gate Bridge in Brisbane was first installed, and later replaced in 2010 to deter individuals from dying by suicide while jumping off the bridge.	Following the installation of the barrier the suicide rate per 100 000 declined from 0.67 in 1990–1993 to 0.32 in 1994–1997, representing a 53% rate reduction. The suicide rate from the Gate Bridge continued to fall with each subsequent year. Following the installation of the new barrier in 2010 there were no suicide mortalities recorded from the bridge (2010–2012).	Total: --
Perron <i>et al</i> 2013 <sup>589</sup>	Time series	1990–2009	Canada (Montreal)	In 2004, the construction of a barrier on the Jacques-Cartier Bridge was completed to help deter suicide by jumping.	The suicide rate following the completion of the bridge barrier showed a steep decline in suicide by jumping (incidence rate ratio=0.24; 95% CI 0.13 to 0.43).	Total: --
Sinyor <i>et al</i> 2010 <sup>590</sup>	Time series	1993–2007	Canada (Toronto)	Between 2002 and 2003 a barrier was built on the Bloor Street Viaduct called the 'luminous veil'.	Following the installation of a bridge barrier on the Bloor Street Viaduct the mean number of suicide mortalities declined from 9.3 (1993–2002) to 0 (2004–07) (incidence rate ratio=0.05; 95% CI 0.01 to 0.31).	Total: --
Sinyor <i>et al</i> 2017 <sup>591</sup>	Pre-post, with no control group	1993–2014	Canada (Toronto)	Between 2002 and 2003 a barrier was built on the Bloor Street Viaduct called the 'luminous veil'.	A per-capita rate of 9.0 suicide deaths per year took place prior to the barrier construction, which declined to 0.1 suicide deaths per year after the construction of the barrier (IRR=0.009, 95% CI 0.0005 to 0.19).	Total: --
Matsubayashi <i>et al</i> 2013 <sup>592</sup>	Quasi-experimental	2000–2010	Japan (Tokyo)	Between 2008 and 2010, blue light-emitting diode (LED) lamps were installed on train platforms at 11 Tokyo railway stations.	Following the installation of blue LED lamps, the number of suicides per year declined by 84% (95% CI 14% to 97%; incidence rate ratio=0.17; 95% CI 0.03 to 0.87).	Total: --
Matsubayashi <i>et al</i> 2014 <sup>593</sup>	Quasi-experimental	2000–2013	Japan	Between 2008 and 2013, 14 railway or metro stations in Japan installed blue light-emitting-diode (LED) lamps to help prevent suicide by jumping onto the rail.	The annual mean no of suicides mortalities at the 14 intervention stations declined from 0.44 to 0.19 following the installation of the blue LED lamps (incidence rate ratio=0.026; 95% CI 0.13 to 0.52), equivalent to a 74% reduction in the number of deaths by suicide.	Total: --
Ueda <i>et al</i> 2015 <sup>594</sup>	Time series	2004–2014	Japan (Tokyo)	On April 2004, 19 of 168 railway stations had half-height platform screen doors installed to prevent access to the rail tracks. Between 2004 and 2014, a total of 52 additional stations were retrofitted with half-height platform screen doors, for a total of 71 stations.	Following the installation of half-height platform screen doors there was a total of 7 deaths by suicide (2004–2014). The incidence rate ratio associated with the installation of the doors was 0.24 (95% CI 0.09 to 0.67), equivalent to a 76% reduction in suicide deaths.	Total: --
Beautrais <i>et al</i> 2009 <sup>595</sup>	Pre-post, with no control group	1991–2006	New Zealand (Auckland)	In 1937, barriers were installed on Grafton Bridge in Auckland, New Zealand. After public complaint about the unsightly barriers, they were removed from the bridge in 1996. In 2003, new barriers were erected on the bridge.	From 1991 to 1995, while the old barriers were erected, there was a mean of 1 suicide by jumping per year. This increased to 3.17 per year from 1997 to 2002 during the period where no barriers were installed. The per year mean number of suicide mortalities by jumping dropped to 0 once the new barriers were constructed on the Grafton Bridge.	Total: --
Skegg <i>et al</i> 2009 <sup>596</sup>	Time series	1996–2008	New Zealand (Dunedin)	Lawyer's Head cliff is a scenic outlook in the city of Dunedin that overlooks the Pacific Ocean. In 2006, vehicle access to the Lawyer's Head cliff was closed for construction.	In the 10-year period prior to the road closure there were 13 suicide mortalities at Lawyer's Head cliff, which was reduced to 0 following the intervention (incidence rate difference=1.3 per year; 95% CI 0.6 to 2.0).	Total: --

Continued

Table 4 Continued

Study	Design	Study time period	Country (region)	Intervention	Results	Direction of association
Chung <i>et al</i> 2016 <sup>597</sup>	Time series	2003–2012	South Korea (Seoul)	Between 2005 and 2009, the Seoul Metro installed platform screen doors at 121 subway stations (119 full-height, and two half-height).	There was a total of 3 deaths by suicide following the installation of platform screen doors, compared with 132 deaths by suicide in stations without platform screen doors (incidence relative ratio=0.11; 95% CI 0.03 to 0.43). This was equivalent to an 89% (95% CI 57% to 97%) reduction in suicide deaths following the installation of a platform screen door.	Full-height doors Total: -- Half-height doors Total: +
Reisch <i>et al</i> 2005 <sup>598</sup>	Pre–post, with no control group	1988–2002	Switzerland (Bern)	In 1998, a safety net was installed under the Muenster Terrace to save those who attempt suicide by jumping.	In the 4 years prior to the installation of the safety net six people died by suicide by jumping from the Muenster Terrace. Following the installation, three people jumped from the Terrace, but nobody died at the site.	Total: --
Hemmer <i>et al</i> 2017 <sup>599</sup>	Time series	1990–2013	Switzerland	This study investigated the impact of 15 jump sites in Switzerland with installed suicide-prevention measures (13 bridges, 1 terrace, 1 multistory car park).	The installation of barriers resulted in a prevention rate of 68.7% (rate ratio=0.34; 95% CI 0.18 to 0.64), whereas the installation of safety nets resulted in a prevention rate of 77.1% (rate ratio=0.21; 95% CI 0.07 to 0.62).	All barriers Total: -- Partial barriers Total: -- Full barriers Total: -- Safety nets Total: --
Bennewith <i>et al</i> 2007 <sup>5100</sup>	Time series	1994–2003	UK (Bristol)	In December 1998, a barrier was installed on the Clifton suspension bridge in Bristol.	Prior to the installation of the bridge barrier there was a mean of 8.2 suicides by jumping per year (1994–1998), which declined to 4.0 suicides by jumping per year (difference in mean=-4.2; 95% CI -5.9 to -1.4).	Total: -- Male: -- Female: +

++, statistically significant increase; --, statistically significant reduction; -, not statistically significant reduction; +, not statistically significant increase.

events that could have precipitated the suicide,<sup>30 31</sup> explain at least in part the presence or absence of sex differences across studies. Future research using additional information, such as those collected from the psychology of death, is necessary to disentangle sex and gender differences in the universal suicide prevention interventions' effectiveness. Regardless, research on universal suicide prevention interventions' effectiveness should continue to apply a sex and gender lens.

### Substitution hypothesis

In this review, 17 studies examined whether restricting suicide means from one method would result in an increase in suicide from other methods, described as the 'substitution hypothesis'.<sup>32</sup> However, findings from those studies are mixed, with eight studies providing evidence to supporting a substitution hypothesis (S19, S25, S26, S38, S54, S55, S90, S93), and nine studies not yielding such evidence (S36, S44, S48, S88, S89, S91, S96, S98, S100). For example, Klieve *et al* found that when the firearm suicide rate for Australian males declined following the introduction of restrictions on weapon purchases, the rate of suicide death by hanging increased simultaneously (S38). Similarly, Caron *et al* found that the firearm suicide rate decreased among males in Quebec (Canada) following the implementation of Bill C-17, while the rate of suicide death by hanging increased simultaneously (S55). Conversely, Lester and Leenaars (S50), Carrington *et al* (S51) and Leenaars and Lester rejected the substitution hypothesis (S52). They found that firearms were not replaced by other methods for suicide following passage and enforcement of Canadian Bill C-51. Several factors could explain these discrepancies, such as the availability of

the method of suicide and study methodology. Duration of the follow-up may also explain these mixed findings across studies. For example, Sinyor *et al* demonstrated that by extending the follow-up period by seven additional years from a previous study (S90), the substitution hypothesis was no longer supported for suicide mortality by other means (S91). There is also the potential for individuals to switch from one method to another based on availability of means, and based on acceptability and country-specific sociocultural norms that may influence the use of other suicide methods.<sup>33 34</sup>

### Years of follow-up

The historical period of our included studies ranges from 1907 to 2020, and consequentially, the length of follow-up across the studies, from less than 5 years (short term), to 20 years and longer (long term). In our review, six studies examined both the short-term and long-term association of the intervention and suicide mortality (S7, S14, S47, S56, S57, S91). Stack *et al* (S14), examined the short-term and long-term trends in suicide following a crisis phone line intervention to reduce suicide by jumping at the St.Petersburg (Florida) Skyway bridge. They found that over the short term (2 years), there was no impact of the intervention, while 13 years after the intervention, suicide mortality increased, suggesting the need for a more substantial intervention. Sinyor *et al* (S90), investigated the effectiveness of an intervention to reduce access to a jumping point in Toronto (Canada) with 3 years of follow-up, and found that the intervention, although effective, led to an increase in suicide mortality by other means in Toronto. However, in a 7-year follow-up, the authors found that the intervention was, in fact, more effective

Table 5 Overall summary of findings

Intervention category	# of unique interventions (# of papers)	Pooled time period	High-level findings	Study quality assessment
Access to healthcare	1 (1)	1971–1989	One study reported both null and statistically significant effects for suicide prevention centres on reducing suicide rates among both men and women.	Weak <sup>S1</sup>
Communication strategies	3 (4)	1946–2012	Two studies reported a statistically significant effect for communication strategies on reducing suicide mortality. Two studies reported null findings for the effect of communication strategies on reducing suicide mortality.	Weak to moderate ▶ 1 weak <sup>S2</sup> ▶ 3 moderate <sup>S3–S5</sup>
Community-based interventions	7 (9)	1986–2016	Two studies reported a statistically significant effect for community-based intervention on reducing suicide mortality, one study reported both null and statistically significant effects on reducing suicide mortality, one study reported both null and statistically significant effects on increasing suicide mortality and five studies reported null findings.	Weak to strong (largely moderate) ▶ 1 weak <sup>S7</sup> ▶ 7 moderate <sup>S8–S14</sup> ▶ 1 strong <sup>S6</sup>
Law and regulation reform	29 (66)	1907–2017	Of the 21 law and regulation reforms, nine studies reported a statistically significant effect for reforms on reducing suicide mortality, seven showed mixed null and statistically significant effects on reducing suicide mortality, two showed mixed null and statistically significant effects on both increasing and decreasing suicide mortality, and three studies reported null findings.  Of the 45 firearm law and regulation reform studies, 19 reported a statistically significant effect for reforms on reducing suicide mortality, eleven studies reported mixed null and statistically significant effects on reducing suicide mortality, five studies reported null and statistically significant effects on both reducing and increasing suicide mortality, and ten studies reported null findings.	Weak to strong (largely moderate to strong) ▶ 5 weak <sup>S56, S57, S60, S73, S74</sup> ▶ 32 moderate <sup>S28–S31, S34, S36–S46, S49–S53, S58, S61, S64, S65, S67, S71, S75–S77, S79, S80</sup> ▶ 29 strong <sup>S15–S27, S32, S33, S35, S47, S48, S54, S55, S59, S62, S63, S66, S68–S70, S72, S78</sup>
Mental health policies and strategies	7 (7)	1980–2016	Two studies reported a statistically significant effect for mental health policies on reducing suicide mortality, four studies reported both null and significant effects on reducing suicide mortality and one study reported null findings.	Moderate to strong ▶ 3 moderate <sup>S82, S84, S85</sup> ▶ 4 strong <sup>S81, S83, S86, S87</sup>
Physical barriers	11 (13)	1988–2014	Eleven studies reported statistically significant effects for physical barriers on reducing suicide mortality, and two studies reported both null and statistically significant effects on reducing suicide mortality.	Moderate to strong (largely strong) ▶ 3 moderate <sup>S92, S94, S100</sup> ▶ 10 strong <sup>S88–S91, S93, S95–S99</sup>

in the long term (S91). This suggests that some universal interventions might not be short-term solutions, as they may be more likely to be effective in the long-term period. The lower base rate of suicide mortality may also result in few events over short-term periods, with longer follow-up being needed to have adequate power to detect significant effects. Many of the studies that have used short-term follow-up period (eg, (S56) and (S57)) found no statistically significant changes in suicide mortality. In contrast, many studies with longer-term follow-up periods (eg, (S47)) showed that suicide mortality was significantly lower after the intervention and over time (~10 years after implementation).

### Sustainable Development Goals

Our systematic review highlights a number of universal interventions that hold promise for reducing suicide mortality, such as law and legislation reforms and physical barriers. It is likely that to meet the SDGs to reduce suicide mortality rates, countries will need to take a multilevel approach that incorporates a variety of universal, selective and indicated interventions. Future research should focus on how universal interventions act in synergy with targeted and indicated approaches to reduce suicide mortality, identifying well-designed and transferrable interventions that

can strengthen suicide prevention efforts within countries to meet the SDG target.

### Strengths and limitations

The current systematic review has several strengths. First, we followed PRISMA guidelines to identify relevant studies, appraised the study-specific risk of bias (study quality assessment), and synthesised the results in a transparent, unbiased and reproducible manner. Second, the review captured a large number of studies on universal suicide prevention intervention published in English or French across 17 high-income OECD countries. Third, studies used a wide range of study designs with most of the primary data used in these studies being obtained from reliable sources (eg, vital statistics, coroners and medical examiners data). Fourth, we used the EPHPP Quality Assessment Tool to assess the quality of all included studies, this tool is widely used and designed to assess the quality of the evidence to support public health interventions and related research.<sup>26</sup> Fifth, we ensured that studies evaluated the same interventions were identified to avoid ‘double-counting’ interventions. Sixth, while randomised controlled trials are considered the gold standard in intervention evaluation, this design would be regarded

as unethical, not feasible politically, nor appropriate in the case of universal suicide prevention interventions.<sup>35</sup> The natural experiments summarised in our study provide an excellent way to overcome the drawbacks of randomised controlled trials while still providing a way to study the impact of real-world interventions. Unfortunately, few studies evaluated concurrent universal interventions or interventions across multiple jurisdictions. Not all used a comparison group, but having a 'control' group without randomisation strengthened the study design in a number of cases. Finally, some studies used a repeated cross-sectional design, which is not as strong as longitudinal designs. There may be issues with internal validity because of unmeasured changes in the samples' composition over time.

The quality of studies included impacts the confidence of the conclusions derived by a systematic review. The current systematic review included a large and diverse number of studies from around the world, providing more confidence to our findings. Second, due to heterogeneous data, we were unable to perform a meta-analysis to identify the pooled effects for each category of universal suicide prevention interventions. Third, the present systematic review did not identify any significant differences in intervention effectiveness by race, ethnicity, or immigration status, which represent important areas of future research. Fourth, we did not include studies published before 1 January 1990, and as a result, we may have missed some important studies published before this date. However, it is important to note that this study included many interventions implemented prior to 1990, but evaluated and published after 1990. Additionally, the policies enacted during these times may have less relevance in more recent contexts. We also may have missed important studies conducted in countries outside of the high-income OECD context. Finally, it is important to recognise the variability and incomplete nature of the information collected by coroners and medical examiners within and between countries,<sup>30 31</sup> particularly on antecedents of suicide attempts and recent events, that could have precipitated the death by suicide.

## CONCLUSIONS

This systematic review among high-income OECD countries found that universal suicide prevention interventions, especially those that include physical barriers and law and regulation reforms, were largely effective in reducing suicide mortality among the countries included in this study. While they are generally effective, their success widely varied by intervention type, follow-up period and sex. When investigating universal suicide prevention interventions, researchers should make an effort to stratify results by sex and to investigate the short-term and long-term impact of the interventions.

### What is already known on the subject

- Suicide continues to be a leading cause of death worldwide, and a significant public health concern.

### What this study adds

- Universal suicide prevention interventions provide an effective means to reduce suicide mortality in high-income OECD countries.
- Physical barriers and law and regulation reform interventions seem to hold the most promise in preventing suicide.

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**Contributors** JLL conceived the idea and designed the study. JLL, BO and HO drafted the protocol. M-CI, BO and JLL participated in the screening level 1. M-CI, JLL, HO and HS-K participated in level 2 screening. M-CI, JLL and HO completed data extraction. M-CI, HS-K and JLL completed the risk of bias assessment. M-CI, JLL and HS-K drafted the first version of the manuscript. All authors participated in the preparation of the submitted manuscript.

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**Online Supplemental File 1: High-income OECD countries***25 European countries*

- Austria
- Belgium
- Czech Republic
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Ireland
- Italy
- Latvia
- Luxembourg
- Netherlands
- Norway
- Poland
- Portugal
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- United Kingdom (England, Ireland, Wales, Scotland)

*3 Asian countries*

- Israel
- Japan
- South Korea

*3 Americas countries*

- Canada
- Chile
- United States

## *2 Oceania countries*

- Australia
- New Zealand

Note: Lithuania joined the OECD in 2018 and was not included in the original search strategy for this systematic review.

## Online Supplemental File 2: Electronic search strategy

Databases searched: Medline, Embase, PsycINFO

Original searches executed on April 4, 2018

Search update executed on February 20, 2020

Database(s): Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R) 1946 to March 28 2018

Search Strategy:

#	Searches	Results
1	(suicid* or parasuicid* or automutilat* or auto mutilat*).ti,kf.	39961
2	(self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)).ti,kf.	6522
3	((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*)).ti,kf.	490
4	(suicid* or parasuicid* or automutilat* or auto mutilat* or (self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)) or ((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*))).ab. /freq=2	34195
5	*suicide/ or *suicide, attempted/ or *self-injurious behavior/ or *self mutilation/	39951
6	1 or 2 or 3 or 4 or 5	59345
7	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline* or firearm* or gun or guns or law or laws or legislation*).ti,kf.	926694
8	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline*).ab. /freq=2	1239484
9	*public policy/ or *health policy/ or *firearms/ or *guidelines as topic/	60438
10	7 or 8 or 9	1834064
11	6 and 10	10220
12	*suicide/pc or *suicide, attempted/pc or *self-injurious behavior/pc or *self mutilation/pc	5311
13	11 or 12	12695
14	(australia* or new south wales or queensland or tasmania or victoria or sydney or melbourne or brisbane or austria* or vienna or viennese* or belgium* or belgian* or brussels or flemish* or canad* or ottawa* or british columbia* or colombie britannique* or vancouver* or alberta* or edmonton* or calgar* or saskatchewan* or regina* or saskatoon* or manitoba* or winnipeg* or ontari* or toronto* or quebec* or montreal* or new brunswick* or nouveau brunswick* or fredericton* or nova scotia* or nouvelle ecosse* or halifax* or haligonian* or prince edward island* or ile du prince edouard* or pei or charlottetown* or newfoundland* or terre neuve* or labrador* or nfld or yukon* or whitehorse* or northwest territor* or territoires du nord ouest* or nwt or yellowknife* or nunavut* or iqaluit* or chile* or santiago or czech* or prague or denmark* or danish or dane* or faroe* or copenhagen or estonia* or tallinn or finland* or finnish* or helsinki* or france* or french* or paris* or marseille or lyon or lille or nice or toulouse or bordeaux or german* or deutschland* or berlin* or hamburg or munich or cologne or frankfurt or stuttgart or dusseldorf or greece* or hellenic* or greek* or athens or macedonia* or hungary* or hungarian* or budapest or iceland* or reykjavik or ireland* or irish* or dublin* or israel* or jerusalem or tel aviv or italy or italian* or rome or milan or naples or turin or sicily or japan* or tokyo or yokohama or osaka or nagoya or sapporo or kobe or kyoto or korea* or seoul or busan or daegu or daejeon or gwangju or incheon or ulsan or latvia* or riga or luxembourg* or netherlands* or holland* or dutch* or amsterdam or rotterdam or hague or new zealand* or aotearoa or wellington or auckland or maori or norway* or norwegian* or oslo or poland* or polish or warsaw or krakow or wroclaw or lodz or portugal* or lisbon or slovak* or bratislava or	2367096

	slovenia* or slovene* or ljubljana or spain* or spanish* or spaniard* or madrid or barcelona or catalonia* or valencia* or seville or zaragoza or malaga or basque or scandinavia* or sweden or swedish or swede* or stockholm or switzerland* or swiss* or zurich or geneva or bern or britain* or british* or united kingdom* or scotland* or scottish or wales* or welsh or england* or belfast or london or manchester or glasgow or birmingham or leeds or bradford or liverpool or alabama* or alaska* or arizona* or arkansas* or california* or colorado* or connecticut* or delaware* or florida* or georgia* or hawaii* or idaho* or illinois* or indiana* or iowa* or kansas* or kentucky* or louisiana* or maine* or maryland* or massachusetts* or michigan* or minnesota* or mississippi* or missouri* or montana* or nebraska* or nevada* or new hampshire* or new jersey* or new mexico* or new york* or north carolina* or north dakota* or ohio* or oklahoma* or oregon* or pennsylvania* or rhode island* or south carolina* or south dakota* or tennessee* or texas* or utah* or vermont* or virginia* or washington* or west virginia* or wisconsin* or wyoming* or montgomery* or juneau* or anchorage* or phoenix* or little rock* or sacramento* or los angeles* or san diego* or san francisco* or denver* or hartford* or dover* or tallahassee* or miami* or orlando* or atlanta* or honolulu* or boise* or springfield* or chicago* or des moines* or topeka* or frankfort* or baton rouge* or new orleans* or augusta* or annapolis* or boston* or lansing* or detroit* or st?paul* or jackson* or jefferson city* or helena* or lincoln* or carson city* or reno* or las vegas* or concord* or trenton* or santa fe* or albania* or raleigh* or bismarck* or columbus* or oklahoma city* or salem* or harrisburg* or providence* or columbia* or peirre* or nashville* or austin* or dallas* or salt lake city* or montpelier* or richmond* or olympia* or seattle* or charleston* or madison* or cheyenne* or district of columbia* or usa or united states).tw,kf.	
15	exp australia/ or austria/ or exp belgium/ or exp canada/ or chile/ or czech republic/ or exp "scandinavian and nordic countries"/ or estonia/ or exp france/ or exp germany/ or greece/ or hungary/ or exp ireland/ or israel/ or exp italy/ or exp japan/ or exp republic of korea/ or latvia/ or luxembourg/ or exp netherlands/ or exp new zealand/ or poland/ or exp portugal/ or slovakia/ or slovenia/ or exp spain/ or exp switzerland/ or exp united kingdom/ or exp united states/	2733812
16	14 or 15	3968914
17	13 and 16	5938
18	limit 17 to yr="1990 - 2017"	5289
19	limit 18 to (english or french)	4918
20	*suicide, assisted/ or exp *euthanasia/	12767
21	(euthan* or assisted suicide* or assisted death* or assisted dying* or "physician* aid in dying" or "assistance in death" or "assistance in dying").ti,kf.	17066
22	(euthan* or assisted suicide* or assisted death* or assisted dying* or "physician* aid in dying" or "assistance in death" or "assistance in dying").ab. /freq=2	4241
23	20 or 21 or 22	22736
24	19 not 23	4626

Database(s): **Embase** 1974 to 2018 April 03

Search Strategy:

#	Searches	Results
1	(suicid* or parasuicid* or automutilat* or auto mutilat*).ti,kw.	48776
2	(self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)).ti,kw.	8020
3	((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*)).ti,kw.	583
4	(suicid* or parasuicid* or automutilat* or auto mutilat* or (self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)) or ((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*))).ab. /freq=2	43312

5	*suicide/ or *suicide attempt/ or *self poisoning/ or *automutilation/	44467
6	1 or 2 or 3 or 4 or 5	73237
7	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline* or firearm* or gun or guns or law or laws or legislation*).ti,kw.	1164585
8	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline*).ab. /freq=2	1658604
9	*public policy/ or *health care policy/ or *firearm/ or *practice guideline/	122244
10	7 or 8 or 9	2391603
11	6 and 10	12634
12	*suicide/pc or *suicide attempt/pc or *self poisoning/pc or *automutilation/pc	5457
13	11 or 12	15365
14	(australia* or new south wales or queensland or tasmania or victoria or sydney or melbourne or brisbane or austria* or vienna or viennese* or belgium* or belgian* or brussels or flemish* or canad* or ottawa* or british columbia* or colombie britannique* or vancouver* or alberta* or edmonton* or calgar* or saskatchewan* or regina* or saskatoon* or manitoba* or winnipeg* or ontari* or toronto* or quebec* or montreal* or new brunswick* or nouveau brunswick* or fredericton* or nova scotia* or nouvelle ecosse* or halifax* or haligonian* or prince edward island* or ile du prince edouard* or pei or charlottetown* or newfoundland* or terre neuve* or labrador* or nfld or yukon* or whitehorse* or northwest territor* or territoires du nord ouest* or nwt or yellowknife* or nunavut* or iqaluit* or chile* or santiago or czech* or prague or denmark* or danish or dane* or faroe* or copenhagen or estonia* or tallinn or finland* or finnish* or helsinki* or france* or french* or paris* or marseille or lyon or lille or nice or toulouse or bordeaux or german* or deutschland* or berlin* or hamburg or munich or cologne or frankfurt or stuttgart or dusseldorf or greece* or hellenic* or greek* or athens or macedonia* or hungary* or hungarian* or budapest or iceland* or reykjavik or ireland* or irish* or dublin* or israel* or jerusalem or tel aviv or italy or italian* or rome or milan or naples or turin or sicily or japan* or tokyo or yokohama or osaka or nagoya or sapporo or kobe or kyoto or korea* or seoul or busan or daegu or daejeon or gwangju or incheon or ulsan or latvia* or riga or luxembourg* or netherland* or holland* or dutch* or amsterdam or rotterdam or hague or new zealand* or aotearoa or wellington or auckland or maori or norway* or norwegian* or oslo or poland* or polish or warsaw or krakow or wroclaw or lodz or portug* or lisbon or slovak* or bratislava or slovenia* or slovene* or ljubljana or spain* or spanish* or spaniard* or madrid or barcelona or catalonia* or valencia* or seville or zaragoza or malaga or basque or scandinavia* or sweden or swedish or swede* or stockholm or switzerland* or swiss* or zurich or geneva or bern or britain* or british* or united kingdom* or scotland* or scottish or wales* or welsh or england* or belfast or london or manchester or glasgow or birmingham or leeds or bradford or liverpool or alabama* or alaska* or arizona* or arkansas* or california* or colorado* or connecticut* or delaware* or florida* or georgia* or hawaii* or idaho* or illinois* or indiana* or iowa* or kansas* or kentucky* or louisiana* or maine* or maryland* or massachusetts* or michigan* or minnesota* or mississippi* or missouri* or montana* or nebraska* or nevada* or new hampshire* or new jersey* or new mexico* or new york* or north carolina* or north dakota* or ohio* or oklahoma* or oregon* or pennsylvania* or rhode island* or south carolina* or south dakota* or tennessee* or texas* or utah* or vermont* or virginia* or washington* or west virginia* or wisconsin* or wyoming* or montgomery* or juneau* or anchorage* or phoenix* or little rock* or sacramento* or los angeles* or san diego* or san francisco* or denver* or hartford* or dover* or tallahassee* or miami* or orlando* or atlanta* or honolulu* or boise* or springfield* or chicago* or des moines* or topeka* or frankfort* or baton rouge* or new orleans* or augusta* or annapolis* or boston* or lansing* or detroit* or st?paul* or jackson* or jefferson city* or helena* or lincoln* or carson city* or reno* or las vegas* or concord* or trenton* or santa fe* or alban* or raleigh* or bismarck* or columbus* or oklahoma city* or salem* or harrisburg* or providence* or columbia* or peirre* or nashville* or austin* or dallas* or salt lake city* or montpelier* or richmond* or	3753659

	olympia* or seattle* or charleston* or madison* or cheyenne* or district of columbia* or usa or united states).tw,kw.	
15	exp "australia and new zealand"/ or australian/ or indigenous australian/ or austria/ or austrian/ or exp belgium/ or belgian/ or exp canada/ or canadian/ or canadian aboriginal/ or chile/ or chilean/ or czech republic/ or "czech (citizen)"/ or exp scandinavia/ or danish citizen/ or estonia/ or "estonian (citizen)"/ or "finn (citizen)"/ or exp france/ or frenchman/ or exp germany/ or "german (citizen)"/ or greece/ or "greek (citizen)"/ or hungary/ or "hungarian (citizen)"/ or icelander/ or ireland/ or "irish (citizen)"/ or israel/ or israeli/ or exp italy/ or "italian (citizen)"/ or japan/ or "japanese (citizen)"/ or south korea/ or south korean/ or latvia/ or "latvian (citizen)"/ or luxembourg/ or netherlands/ or dutchman/ or new zealander/ or "norwegian (citizen)"/ or poland/ or polish citizen/ or exp portugal/ or "portuguese (citizen)"/ or slovakia/ or "slovak (citizen)"/ or slovenia/ or "slovenian (citizen)"/ or exp spain/ or spaniard/ or swedish citizen/ or switzerland/ or swiss/ or exp united kingdom/ or exp british citizen/ or exp united states/ or american/ or american indian/ or alaska native/	3068116
16	14 or 15	5313046
17	13 and 16	6792
18	limit 17 to yr="1990 - 2017"	6119
19	limit 18 to (english or french)	5639
20	*assisted suicide/ or exp *euthanasia/	13014
21	(euthan* or assisted suicide* or assisted death* or assisted dying* or "physician* aid in dying" or "assistance in death" or "assistance in dying").ti,kw.	7777
22	(euthan* or assisted suicide* or assisted death* or assisted dying* or "physician* aid in dying" or "assistance in death" or "assistance in dying").ab. /freq=2	5322
23	20 or 21 or 22	17256
24	19 not 23	5364

Database(s): PsycINFO 1806 to March Week 4 2018

Search Strategy:

#	Searches	Results
1	(suicid* or parasuicid* or automutilat* or auto mutilat*).ti,id.	38089
2	(self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)).ti,id.	7301
3	((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*)).ti,id.	147
4	(suicid* or parasuicid* or automutilat* or auto mutilat* or (self adj3 (harm* or mutilat* or injur* or wound* or poison* or violen* or kill*)) or ((deliberat* or intention* or voluntar*) adj2 (overdose* or drug death* or drug related death* or poison*))).ab. /freq=2	38749
5	*suicide/ or *attempted suicide/ or exp *self-injurious behavior/	30790
6	1 or 2 or 3 or 4 or 5	48436
7	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline* or firearm* or gun or guns or law or laws or legislation*).ti,id.	437743
8	(interven* or strateg* or prevent* or policy or policies or restrict* or program* or guideline*).ab. /freq=2	504766
9	*intervention/ or *government policy making/ or *health care policy/ or *mental health programs/ or *firearms/ or *gun control laws/	62634
10	7 or 8 or 9	685642
11	6 and 10	11397
12	*suicide prevention/	3412

13	11 or 12	11732
14	(australia* or new south wales or queensland or tasmania or victoria or sydney or melbourne or brisbane or austria* or vienna or viennese* or belgium* or belgian* or brussels or flemish* or canad* or ottawa* or british columbia* or colombie britannique* or vancouver* or alberta* or edmonton* or calgar* or saskatchewan* or regina* or saskatoon* or manitoba* or winnipeg* or ontari* or toronto* or quebec* or montreal* or new brunswick* or nouveau brunswick* or fredericton* or nova scotia* or nouvelle ecosse* or halifax* or haligonian* or prince edward island* or ile du prince edouard* or pei or charlottetown* or newfoundland* or terre neuve* or labrador* or nfld or yukon* or whitehorse* or northwest territor* or territoires du nord ouest* or nwt or yellowknife* or nunavut* or iqaluit* or chile* or santiago or czech* or prague or denmark* or danish or dane* or faroe* or copenhagen or estonia* or tallinn or finland* or finnish* or helsinki* or france* or french* or paris* or marseille or lyon or lille or nice or toulouse or bordeaux or german* or deutschland* or berlin* or hamburg or munich or cologne or frankfurt or stuttgart or dusseldorf or greece* or hellenic* or greek* or athens or macedonia* or hungary* or hungarian* or budapest or iceland* or reykjavik or ireland* or irish* or dublin* or israel* or jerusalem or tel aviv or italy or italian* or rome or milan or naples or turin or sicily or japan* or tokyo or yokohama or osaka or nagoya or sapporo or kobe or kyoto or korea* or seoul or busan or daegu or daejeon or gwangju or incheon or ulsan or latvia* or riga or luxembourg* or netherlands* or holland* or dutch* or amsterdam or rotterdam or hague or new zealand* or aotearoa or wellington or auckland or maori or norway* or norwegian* or oslo or poland* or polish or warsaw or krakow or wroclaw or lodz or portug* or lisbon or slovak* or bratislava or slovenia* or slovene* or ljubljana or spain* or spanish* or spainard* or madrid or barcelona or catalonia* or valencia* or seville or zaragoza or malaga or basque or scandinavia* or sweden or swedish or swede* or stockholm or switzerland* or swiss* or zurich or geneva or bern or britain* or british* or united kingdom* or scotland* or scottish or wales* or welsh or england* or belfast or london or manchester or glasgow or birmingham or leeds or bradford or liverpool or alabama* or alaska* or arizona* or arkansas* or california* or colorado* or connecticut* or delaware* or florida* or georgia* or hawaii* or idaho* or illinois* or indiana* or iowa* or kansas* or kentucky* or louisiana* or maine* or maryland* or massachusetts* or michigan* or minnesota* or mississippi* or missouri* or montana* or nebraska* or nevada* or new hampshire* or new jersey* or new mexico* or new york* or north carolina* or north dakota* or ohio* or oklahoma* or oregon* or pennsylvania* or rhode island* or south carolina* or south dakota* or tennessee* or texas* or utah* or vermont* or virginia* or washington* or west virginia* or wisconsin* or wyoming* or montgomery* or juneau* or anchorage* or phoenix* or little rock* or sacramento* or los angeles* or san diego* or san francisco* or denver* or hartford* or dover* or tallahassee* or miami* or orlando* or atlanta* or honolulu* or boise* or springfield* or chicago* or des moines* or topeka* or frankfort* or baton rouge* or new orleans* or augusta* or annapolis* or boston* or lansing* or detroit* or st?paul* or jackson* or jefferson city* or helena* or lincoln* or carson city* or reno* or las vegas* or concord* or trenton* or santa fe* or albany* or raleigh* or bismarck* or columbus* or oklahoma city* or salem* or harrisburg* or providence* or columbia* or peirre* or nashville* or austin* or dallas* or salt lake city* or montpelier* or richmond* or olympia* or seattle* or charleston* or madison* or cheyenne* or district of columbia* or usa or united states).ti,ab,id.	783820
15	13 and 14	3527
16	limit 15 to yr="1990 - 2017"	3225
17	limit 16 to (english or french)	3056

**Online Supplemental File 3: Included references**

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## Online Supplemental File 4

Table 3. Community-based interventions

Study	Design	Study time period	Country (region)	Intervention	Results	Direction of association
Lockley et al., 2014 <sup>S6</sup>	Time-series	2001–2011	Australia (Gap Park)	In 2010, the Gap Park Masterplan was implemented to reduce mortality at a suicide hotspot. The Masterplan included restricting access to means by constructing a new fence, encouraging help through a newly installed crisis telephone and signs, and installed close-circuit televisions to monitor the site.	A trend toward increasing jumping-related suicide mortality was observed (2001-2011), however, it did not reach statistical significance (estimated annual percent change = 6.71%; 95% CI: -2.5%, 16.8%; $p = 0.14$ ).	Total: +
Ross et al., 2020 <sup>S7</sup>	Mixed Methods Study	2000–2016	Australia (Gap Park)	In 2010, the Gap Park Masterplan initiative implemented a series of suicide prevention measures, which included fencing, increased surveillance, protocols with police, prevention signs, and the installation of a crisis telephone.	Following the intervention, there was a slight upward trend in suicide mortalities from 2000 to 2016 (annual percent change = 5.4%; 95% CI: -0.38%, 11.53%; $p = 0.07$ ). From 2010 to 2016, suicide mortality declined significantly for women (annual percent change = -21.27%; 95% CI: -33.14%, -7.30%; $p = 0.01$ ), but increased among men (annual percent change = 6.23%; 95% CI: -0.41%, 13.30%; $p = 0.06$ ).	Total: + Male: + Female: --
Hegerl et al., 2019 <sup>S8</sup>	Pre-post, with control group	2008–2011	Europe (Germany, Hungary,	In 2008, the Optimizing Suicide Prevention Programmes and Their Implementation in Europe project was implemented, which focused on	The number of suicide mortalities increased from 138 at baseline to 163 (18.1% increase) in the two years following the onset of the intervention. This increase was not statistically	Total: +

			Portugal, and Ireland)	four main interventions: (1) training of primary care providers, (2) a public awareness campaign, (3) training of community facilitators, and (4) support for patients and their relatives.	different from the control regions (OR = 0.93; 95% CI: 0.65, 1.33; $p = 0.68$ ).	
Hegerl et al., 2006 <sup>S9</sup>	Pre-post, with control group	1992–2002	Germany (Nuremberg; control group, Wuerzburg)	In 2001–02, a four-level community-based intervention was implemented to improve the care of patients with depression: (i) training of family doctors, (ii) media and general public campaigns, (iii) community facilitators, (iv) self-help activities.	During the first year of the intervention the number of suicide mortalities declined from 100 at baseline to 75 (-25%), and 89 (-11%) during the second year. There was no significant difference between the control and intervention groups.	Total: -
Hegerl et al., 2010 <sup>S10</sup>	Pre-post, with control group	1989–2006	Germany (Nuremberg);	In 2001–02, a four-level community-based intervention was implemented to improve the care of patients with depression: (i) training of family doctors, (ii) media and general public campaigns, (iii) community facilitators, (iv) self-help activities.	Following the intervention the number of suicide mortalities were at their lowest levels since 1989 (2003: 88; 2004: 87; 2005: 68; 2006: 72), although the decline was not statistically significant.	Total: -
Szekely et al., 2013 <sup>S11</sup>	Pre-post, with control group	1998–2009	Hungary (Szolnok; control group, Szeged)	From 2004 to 2006, the European Alliance Against Depression intervention was implemented which included: (i) co-operation with general practitioners, (ii) public relations campaign, (iii)	Suicide rates declined during the two-year intervention (mean change -55.9%; $p < 0.01$ ), while no significant changes in suicide rates were observed in the control region (+2.0%).	Total: -- Male: -- Female: --

				community facilitators, and (iv) high risk groups and self-help.		
Motohashi et al., 2007 <sup>S12</sup>	Quasi-experiment, with control group	1999–2006	Japan (Akita)	In 2001, a 3-year multi-component intervention was implemented that included awareness-raising activities, a mental health survey, specialist training in suicide prevention, resident engagement, compiled list of counselling centers, and community networking activities.	There was a significant decrease in the suicide rate per 100,000 in the intervention group (70.8 pre-intervention [1999] to 34.1 post-intervention [2004], $p = 0.01$ ). There were no significant changes observed in the control group during the same time period.	Total: --
King and Frost, 2005 <sup>S13</sup>	Retrospective design	1988–2001	United Kingdom (England, New Forest)	From October 1998 to September 2001, the New Forest suicide prevention initiative was implemented by installing awareness signs in high-risk car parks, raising staff awareness, and providing support to those likely to come in contact with individuals at risk of suicide.	There was a large decrease in suicide mortality in New Forest from an average of 23.3 suicide mortalities per year pre-intervention to 18.7 per year during the intervention period.	Total: -
Stack, 2015 <sup>S14</sup>	Pre-post, no control group	1986–2012	United States (St. Petersburg, Florida)	In 1999, a crisis phone line with signs to increase awareness were installed on the Skyway bridge in St. Petersburg.	The short-term two-year impact showed a non-significant average decline of five suicide mortalities when compared with the control. The long-term 13-year impact showed a significant increase in average suicide mortality of 4.5 suicide mortalities when compared with the control.	<i>2-year impact</i> Total: - <i>13-year impact</i> Total: ++

Note: CI = confidence interval; OR = odds ratio; - = not statistically significant reduction; -- = statistically significant reduction; + = not statistically significant increase; ++ = statistically significant increase

## Online Supplemental File 5

Table 4. Law and Regulation Reforms

Study	Design	Study time period	Country (region)	Intervention	Results	
<b>Other law and regulation reforms</b>						
Studdert et al., 2010 <sup>S15</sup>	Time-series	2001–2006	Australia	In 1986, all new cars were required to have a catalytic converter to limit carbon monoxide emissions. From 1997 to 1999 subsequent laws were implemented to further reduce carbon monoxide emissions.	During the study period there was a decline in suicide rates by motor vehicle exhaust from 2.6 deaths per 100,000 in 2001 to 1.1 in 2006, representing a 57% decline in annual incidence.	Total: -
Nordentoft et al., 2006 <sup>S16</sup>	Time-series	1970–2000	Denmark	Law aimed at restricting access: household gas without carbon monoxide (1980), introduction of automobile catalytic converters (1989), the availability of barbiturates (1987), analgesics (1984 and 2000).	There was a decrease in household gas suicide rates (from 5.3 for men and 1.3 for women in 1970 to 0.0 deaths per 100,000 for both sexes in 2000), an increase in car exhaust suicide rates (from 0.3 for men and 0.0 for women in 1970 to 2.3 and 0.1 deaths per 100,000 for men and women, respectively), a decrease in barbiturates suicide rates (from 3.4 for men and 4.5 for women to 0.0 deaths per 100,000 for both sexes), and an increase in analgesics suicide rates (from 0.1 for men and 0.3 for women in 1970 to 0.8 and 0.6 deaths per 100,000 for men and women, respectively).	<i>Household gas</i> Male: - Female: - <i>Car exhaust</i> Male: + Female: + <i>Barbiturates</i> Male: - Female: - <i>Analgesics</i> Male: + Female: +
Nordentoft et al., 2007 <sup>S17</sup>	Time-series	1970–2000	Denmark	Law aimed at restricting access: household gas without carbon monoxide (1980), introduction of automobile catalytic converters (1989), and the availability of barbiturates (1987).	Same results as Nordentoft et al 2006	<i>Household gas</i> Male: - Female: - <i>Car exhaust</i> Male: + Female: + <i>Barbiturates</i> Male: - Female: -

Pridemore et al., 2009 <sup>S18</sup>	Interrupted time-series	1997–2006	Slovenia	In January 2003, legislation was introduced to establish a minimum age of 18 years to purchase and consume alcohol. There were also new laws limiting where and when alcohol could be purchased.	Following the intervention there was no statistically significant change in suicide mortality among women. Among men there was an 10% decrease in suicide mortality, equivalent to a decrease of 3.6 suicide deaths per month.	Total: - Male: -- Female: -
Myung et al., 2015 <sup>S19</sup>	Cross-sectional	2005–2013	South Korea	In 2011–12, a national policy was implemented restricting the use of paraquat, a common farming agrochemical.	Following the intervention, the suicide rate from herbicides or fungicides decreased from 31.4 to 16.9 per 10 million, representing a 46% reduction.	Total: --
Cha et al., 2016 <sup>S20</sup>	Time-series	1983–2013	South Korea	In 1999, South Korea implemented a paraquat (non-selective herbicide) management plan that was later revised in 2005. In 2011 the re-registration of paraquat was cancelled, and a ban on all sales was implemented in October 2012.	Between 2011 and 2013 the suicide mortality rate from pesticides decreased from 5.26 to 2.67 per 100,000. Compared with expected trends, the suicide rate from pesticides declined by an additional 37% (rate ratio = 0.63; 95% CI: 0.55, 0.73), equivalent to 847 (95% CI: -1180, -533) saved lives.	Total: -- Male: -- Female: --
Kim et al., 2017 <sup>S21</sup>	Pre-post, with no control group	2009–2013	South Korea	In 2011–12, a national policy was implemented restricting the use of paraquat, a common farming agrochemical.	The intervention was associated with a 39% reduction in pesticide-related suicide mortality (AOR = 0.61; 95% CI: 0.58, 0.64).	Total: --
Yamasaki et al., 2005 <sup>S22</sup>	Time-series	1965–1994	Switzerland	In 1994, the Swiss tax on tobacco increased fourfold in comparison with that in 1965. Excise taxes for alcoholic beverages did not change during the time period.	Increasing tobacco tax laws were associated with a reduction in the suicide rate ( $\beta = -0.15$ ; $p < 0.001$ ), and increasing alcohol tax laws were associated with an increase in the suicide rate ( $\beta = 0.042$ ; $p < 0.001$ ) among men. These laws were not significantly associated with suicide rates among women.	<i>Tobacco tax</i> Male: -- Female: NA <i>Alcohol tax</i> Male: ++ Female: NA
Morgan et al., 2007 <sup>S23</sup>	Interrupted time-series	1993–2004	United Kingdom (England and Wales)	In September 1998, legislation was introduced to limit paracetamol (acetaminophen) packaging to 16 tablets in general stores, 32 tablets in pharmacies, and retailers were no longer able to sell more than 100 tablets at a time to those without a prescription.	There was a downward step-change in the annual age-standardised mortality rate of -2.7 (SE: 0.6; $p = 0.003$ ) per million following the 1998 intervention. This trend was similar for poisoning deaths involving aspirin, antidepressants, and to a lesser degree, paracetamol compounds.	Total: --

Hawton et al., 2013 S24	Interrupted time-series	1993–2009	United Kingdom (England and Wales)	In September 1998, legislation was introduced to limit paracetamol (acetaminophen) packaging to 16 tablets in general stores, 32 tablets in pharmacies, and retailers were no longer able to sell more than 100 tablets at a time to those without a prescription.	In the 11 years following the intervention there was an estimated overall decrease in paracetamol poisoning deaths of 43%, representing 765 fewer deaths than what would have been predicted without the intervention.	Total: --
Lester et al., 1992 S25	Pre-post, with no control group	1950–1975	United Kingdom (Scotland)	In 1963, domestic gas was detoxified by lowering the carbon monoxide content.	Prior to 1963 the slope in suicide rate from domestic gas was +0.19. The slope in suicide rate from domestic gas declined (-0.22) following the intervention.	Total: --
Skilling et al., 2008 S26	Pre-post, with no control group	1980–2003	United Kingdom (Scotland and Grampian)	On January 1 <sup>st</sup> 1993, all new cars were required to be fitted with a catalytic converter to remove carbon monoxide from the emissions.	There was a significant decrease in suicide rates by motor vehicle gas inhalation in Grampian (from 134.1 to 64.1 deaths per 100,000; $p = 0.017$ ) and Scotland (from 94.1 to 38.9 deaths per 100,000; $p = 0.001$ ).	Total: --
Cylus et al., 2014 S27	Time-series	1968–2008	United States	In 1935, the Federal Unemployment Insurance Program was created, providing each State with the autonomy to organize their own unemployment program. As a result, the amount of unemployment benefits vary substantially by State, which may have a differential impact on suicide rates during economic downturns.	The impact of unemployment rates on suicide mortality was offset by higher unemployment benefits ( $\beta = -0.57$ ; 95% CI: -0.86, -0.27). These findings were similar between men and women, but had a greater effect on younger individuals (20–24 years) when compared with older individuals (45–54 years).	Total: --
Kaufman et al., 2019 S28	Quasi-experimental	1990–2015	United States	The federal minimum wage has increase from US\$3.80 in 1990 to US\$7.25 in 2015, adjusting for inflation reveals no substantial change. A total of 29 states have increased their minimum wage above the federal limit, whereas 21 states have maintained the lower federal minimum wage.	Among adults aged 18-64 year with a high school education or less, a US\$1 increase in minimum wage was associated with between a 3.4% (95% CI: 0.4%, 6.4%) and 5.9% (95% CI: 1.4%, 10.2%) reduction in the suicide rate. From 1990 to 2015, it was estimated that a US\$1 increase above the federal minimum could have prevented 27,550 suicide deaths. No effect was found among those with a college degree or more.	<i>With high school education or less</i> Total: -- <i>With college degree or more</i> Total: +

Gertner et al., 2019 <sup>S29</sup>	Panel design (with and without laws)	2006–2016	United States	In 2007, the Fair Minimum Wage Act was implemented to increase the federal minimum wage. Several states adopted the Act between 2007 and 2009.	A one-dollar increase in the real minimum wage was associated on average decrease of 1.9% (95% CI: -0.031%, -0.007%) in the annual state suicide rate. This decrease resulted in roughly 8,000 fewer deaths by suicide.	Total: -- Male: -- Female: -
Rambotti; 2020 <sup>S30</sup>	Pooled cross-sectional design	2000–2015	United States	The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program, was first introduced in 1964. The Earned Income Tax Credit (EITC) has been adopted by 29 states plus DC, and aims to provide tax credits to low and moderate income working individuals and families.	A one standard deviation increase in SNAP and EITC participation across states was associated with a 0.17 and 0.04 standard deviation reduction in the suicide death rate, respectively. A one standard deviation increase in SNAP participation was associated with 31,612 fewer suicide mortalities overall (24,811 fewer male suicide mortalities) during the study period.	<i>SNAP</i> Total: -- Male: -- Female: - <i>EITC</i> Total: - Male: - Female: -
Birckmayer et al., 1999 <sup>S31</sup>	Time-series	1970–1990	United States	The minimum legal drinking age (MLDA) between states changed considerable in the 1970s and 1980s. In 1970, 33 states had a legal drinking age of 21 years. Between 1970 and 1975 some states began lowering the MLDA. These laws were then increased again in 1977. By 1988 all states had a MLDA of 21 years.	Between 1970 and 1990 the states with a MLDA of 18 years had an 8% and 6% higher suicide rate in youth aged 18–20 and 21–23 years, respectively, in comparison with states that had a legal limit of 21 years. These laws were not significantly associated with suicide rates in youth aged 15–17 years.	<i>Lower MLDA</i> 15–17 years: + 18–20 years: ++ 21–23 years: ++
Grucza et al., 2012 <sup>S32</sup>	Retrospective	1990–2004	United States	The minimum legal drinking age (MLDA) between states changed considerable in the 1970s and 1980s. In 1970, 33 states had a legal drinking age of 21 years. Between 1970 and 1975 some states began lowering the MLDA. These laws were then increased again in 1977. By 1988 all states had a MLDA of 21 years.	When looking at the full cohort (born 1949–72) women who lived in states with lower MLDA had a higher risk of dying by suicide (OR = 1.12, 95% CI: 1.05, 1.18, $p = 0.0003$ ) in comparison with men (OR = 0.97, 95% CI: 0.95, 1.00, $p = 0.048$ ). Younger women (born 1960–72) who lived in states with a lower MLDA had a higher risk of dying by suicide (OR = 1.17, 95% CI: 1.10, 1.24, $p < 0.0001$ ) than their older counterparts (born 1949–59).	<i>Full cohort</i> Total: + Male: -- Female: ++ <i>Younger cohort</i> Male: - Female: ++ <i>Older cohort</i> Male: - Female: -

Markowitz et al., 2003 <sup>S33</sup>	Time-series	1976–1999	United States	Excise taxes on beer have been implemented at various times across states, and within state changes to the nominal tax occur often. The state laws on blood alcohol concentration (BAC) for youth while driving were first implemented in 12 states at a level of 0.10 during 1976. Since 1976 the alcohol laws for youth drivers have become stricter with lower limits of 0.08 first introduced in Oregon in 1983. Beginning in the 1980s some states introduced zero tolerance laws for alcohol consumption for youth drivers under the legal age.	A 10% increase in beer excise taxes was associated with a significant reduction of 2.4 to 5% in suicide mortality among males, depending on the age group. States with 0.08 BAC laws and zero tolerance laws while driving were associated with a 0.7% and 0.8% reduction in suicide mortality, respectively, among males aged 20–24 years. Beer excise taxes and alcohol consumption laws for youth drivers were not significantly associated with suicide mortality among females.	<i>Real beer tax</i> Male 10–14: -- Male 15–19: -- Male 20–24: -- Female 10–14: - Female 15–19: - Female 20–24: -- <i>0.08 BAC</i> Male 10–14: + Male 15–19: - Male 20–24: -- Female 10–14: - Female 15–19: -- Female 20–24: - <i>Zero tolerance</i> Male 10–14: - Male 15–19: -- Male 20–24: -- Female 10–14: - Female 15–19: -- Female 20–24: -
Son et al., 2011 <sup>S34</sup>	Time-series	1995–2004	United States	Excise taxes for spirits, wines, and beer have been used as a method to deter problematic substance use. Each state in the US implements their own laws and excise taxes for alcohol.	State excise tax for beer and spirits were not significantly associated with suicide mortality. A 10% increase in state excise taxes in any given year for wine was significantly associated with a 0.3% decrease in the state-level suicide deaths, equivalent to 3 lives saved per 100,000.	<i>Wine tax</i> Total: -- <i>Spirit tax</i> Total: - <i>Beer tax</i> Total: +
Grucza et al., 2014 <sup>S35</sup>	Repeated cross-sectional	1990–2004	United States	During the 1990s many states started adopting smoke-free air legislation that banned individuals from smoking in private worksites, restaurants, and bars. At the same time, many states started increasing excise taxes for cigarettes and other tobacco products.	A \$1 increase in state-level excise taxes per pack of cigarettes was associated with an 12% reduction in suicide mortality (OR = 0.89, 95% CI: 0.87, 0.93; $p < 0.001$ ). A one-point increase on a six-point scale for smoke-free air policies was associated with a 3% reduction in suicide mortality (OR = 0.97, 95% CI: 0.96, 0.98; $p < 0.001$ ). These policies were more effective in men than women, and younger individuals (18–40 years) than older (>40 years) individuals.	<i>Cigarette tax</i> Total: -- <i>Smoke-free laws</i> Total: --
<b>Firearm law and regulation reforms</b>						

Chapman et al., 2006 <sup>S36</sup>	Time-series	1979–2003	Australia	In 1996, Australia introduced major gun law reforms that included a ban on semi-automatic firearms, pump-action shotguns, and rifles. They also initiated a firearm buyback program.	Prior to the law there was an annual mean of 491.7 firearm suicide mortalities (1979–96), which decreased to 246.6 after the intervention (1996–2003). This represents a significant difference of trends (rate ratio = 0.95; 95% CI: 0.92, 0.99; $p = 0.007$ ).	Total: --
Baker et al., 2007 <sup>S37</sup>	Time-series	1979–2004	Australia	In 1996–97, the National Firearms Agreement (NFA) was implemented in Australia, which prohibited certain types of firearms, in particular semi-automatic rifles and semi-automatic and pump action shotguns.	Suicide rates by firearm pre- and post-NFA both showed decline, but the observed suicide rates post-NFA were consistently lower than the predicted values and fell outside the 95 percent confidence interval limits for the predicted rates. This suggested that the NFA legislation had a significant effect on reducing firearm suicide mortality.	Total: --
Klieve et al, 2009 <sup>S38</sup>	Quasi-experimental	1964–2005	Australia (Queensland)	The 1997 national firearms agreement (NFA).	Prior to 1988, the rate of firearm suicides in Australia was around 6 per 100,000. For Queensland, significant declines in firearm suicide rates were observed both before and after the introduction in the NFA: -7.2% before (rate ratio = 0.93; $p < 0.0001$ ) and 6.5% after (rate ratio = 0.94; $p = 0.0002$ ), resulting in a 2004 suicide rate of 2.2 per 100,000. No significant difference was observed between these trends ( $p = 0.7878$ ). For Australia, while significant declines were observed before and after the NFA (1988–1996: 3.9% reduction; rate ratio = 0.96; $p < 0.0001$ ; 1997–2004: 7.1% reduction; rate ratio = 0.93; $p < 0.0001$ ), resulting in a 2004 suicide rate of 1.7 per 100,000, the difference between these trends was significant ( $p = 0.01$ ).	Male: -
Lee et al., 2010 <sup>S39</sup>	Time-series	1915–2004	Australia	In 1996–1997, the National Firearms Agreement (NFA), which involved stricter firearm laws and the buy-back and destruction of over 600,000 firearms within a few months.	Using multiple tests, there was no evidence of structural breaks that occurred around the time of the NFA legislation, suggesting that the NFA did not have any large effects on reducing firearm suicide rates in Australia.	Total: -

McPhedran et al., 2012 <sup>S40</sup>	Time-series	1907–2007	Australia	In 1996, Australian firearms legislation, called National Firearms Agreement (NFA), was tightened significantly.	Suicide rates by firearm pre- and post-NFA showed decline. There was a lack of structural breaks in firearm suicide for those aged 15–44 years, suggesting the intervention had little impact on reducing firearm suicide mortality among these age groups. The intervention may have had an impact in those aged 35–44 years, but it is unlikely due to inconsistencies in the data.	15–24 years: - 25–34 years: - 35–44 years: --
Chapman et al. 2016 <sup>S41</sup>	Time-series	1979–2013	Australia	In 1996, Australia introduced major gun law reforms that included a ban on semiautomatic rifles and pump-action shotguns and rifles and also initiated a program for buyback of firearms.	In the 17 years following the announcement of the new gun laws, the rate of firearm suicide declined to a mean of 0.99 (95% CI: 0.87, 1.13) per 100 000. The rate of firearm suicide was declining by an average of 3% per year before gun law reforms, and this decline increased to 4.8% per year after the introduction of revised gun laws. Total (firearm + nonfirearm) suicide annual death rates had been increasing by a mean of 1.0% per year before the introduction of the gun control laws, for an overall mean of 12.3 (95% CI: 11.9, 12.7) per 100 000, but declined to a mean of 1.5% per year after the introduction of the 1996 gun laws, for an overall mean of 11.7 (95% CI: 11.1, 12.3) per 100 000.	Total: --
Gilmour et al., 2018 <sup>S42</sup>	Quasi-experimental	1961–2015	Australia	In 1997, the Australian National Firearms Agreement (NFA) was implemented. This agreement restricted access to some classes of firearms, regularized and tightened state-level licensing laws, and introduced a gun buyback scheme and amnesty that led to the recall of approximately 640000 guns	Among women, the NFA had no additional impact on firearm-related suicides (the difference-in-difference term = 0.98; $p = 0.3$ ). Among men, the NFA had less of an effect on the trend for firearm-related suicide deaths (the difference-in-difference term = 1.01; $p < .001$ ).	Male: ++ Female: -
Snowdown et al., 1992 <sup>S43</sup>	Quasi-experimental	1968–1989	Australia (South Australia)	In 1977, South Australia adopted the <i>Firearm Act</i> , which resulted in stricter laws on gun ownership. The law was implemented in 1980.	Firearms suicide rates in South Australia declined significantly after 1980, following proclamation of gun legislation, in contrast to the four other larger States where an increase in firearms suicides was recorded. Among	Male: - Female: -

					men, firearm suicide declined from 8.0 per 100,000 (1977–79) to 6.2 following the intervention (1980–82). A similar decline took place among women (0.9 per 100,000 [1977–79] to 0.5 [1980–82]).	
Cantor et al., 1995 <sup>S44</sup>	Retrospective	1990–1993	Australia (Queensland)	In January 1992, the Weapons Act took effect, which requires owners of long arms (rifles and shotguns) to be licensed.	Mean annual firearm suicide rates declined significantly ( $p < 0.05$ ) in metropolitan and provincial city areas after the legislation (from 3.6 to 2.3 per 100,000, and from 5.2 to 3.1 per 100,000, respectively). Significant declines also occurred among men and in those aged 15–29 years.	<i>Metropolitan</i> Male: -- Female: - <i>Provincial city</i> Male: -- Female: + <i>Rural</i> Male: + Female: -
Ozanne-Smith et al. 2004 <sup>S45</sup>	Quasi-experimental	1979–2000	Australia (Victoria)	In 1988, a national firearm amnesty and buyback scheme was implemented in Victoria. The Victorian response, the 1996 Firearms Act, changed existing regulations.	After the 1988 legislative revisions, statistically significant reductions in Victorian frequencies of firearm related suicides ( $p = 0.008$ ) was seen. Further declines in overall firearm related suicides followed the additional legislative reforms in 1996.	<i>1988 legislation</i> Total: -- <i>1996 legislation</i> Total: --
Kapusta et al., 2007 <sup>S46</sup>	Time-series	1985–2005	Austria	In July 1997, more stringent legislation laws were implemented restricting the acquisition and possession of firearm in Austria.	In the period following the intervention (1998–2005), there was a significant negative trend ( $\chi^2 = 88.0$ ; $p < 0.0001$ ) with a steady decline in the firearm suicide rate of 4.7% per year. The rate of firearm suicides among some age groups significantly decreased after a more stringent firearm law had been implemented.	Total: --
Niederkrötenenthaler et al., 2009 <sup>S47</sup>	Time-series/ Pre-post, with no control group	1986–2006	Austria	In July 1997, the Austrian firearm law was tightened. The new legislation increased the minimum age for purchase of handguns, semiautomatic, and repeating firearms to 21 years. Regular checks of safe gun storage in homes were also implemented.	The new legislation was associated with a significant downward trend in firearm suicide rates among youth aged 10–19 years ( $\beta = -0.2$ ; 95% CI: -0.3, 0.1). On the whole, firearm suicide rates after the firearm legislation reform were significantly lower than before.	Total: --
König et al. 2018 <sup>S48</sup>	Interrupted Time-Series	1985–2016	Austria	In 1997, firearm legislation reform added several prerequisites necessary before	The firearm suicide rate per 100,000 was relatively stable for the Austrian population from 1985 to 1998 (1985: 4.0; 1998: 3.7).	Total: --

				obtaining a firearm certificate, such as background checks, passing a psychological test, installation of safe storage for firearm and ammunition, etc.	Following the 1997 legislation, the firearm suicide rate declined down to its lowest rate in 2008 with 2.4 per 100,000.	
Rich et al. 1990 <sup>S49</sup>	Time-series	1973–1977	Canada (Toronto, Ontario)	In 1978, Canadian gun control legislation (Bill C-51) was enacted.	The 1978 legislation may have led to a decrease in suicide mortality by firearm among men, as the number of firearm deaths decreased from 20 in 1973 to 14 in 1982.	Male: --
Lester et al., 1993 <sup>SS0</sup>	Pre-post, with no control group	1969–1985	Canada	In 1977, legislation (Bill C-51) was implemented to restrict the use of firearms in Canada.	The mean annual firearms suicide rate increased slightly from 4.3 per 100,000 (1969–1976) to 4.72 per 100,000 following the legislation (1977–85). However, the linear trend following the legislation (1977–85) showed a significant reduction in firearm suicide rates ( $\beta = -0.13, p < 0.05$ ).	Total: +
Carrington et al., 1994 <sup>SS1</sup>	Interrupted time-series	1965–1989	Canada	In 1978, Bill C-51 was enacted, making it mandatory to obtain a Police permit before acquiring a firearm, and prohibiting the possession of handguns.	The firearm suicide rate increased from 1965 to 1977 from 3.2 to 5.5 per 100,000 ( $p < 0.001$ ), then decreased to 4.1 per 100,000 in 1989 ( $\beta = -0.07; p = 0.03$ ).	Total: -- 15–19 years: - 20–24 years: -- 25–29 years: - 30–34 years: - 35–39 years: - 40–44 years: - 45–49 years: - 50–54 years: - 55–59 years: - 60–64 years: - >65 years: +
Leenaars et al., 1997 <sup>SS2</sup>	Pre-post, with no control group	1969–1985	Canada	In 1977, legislation (Bill C-51) was enacted which placed restrictions on the acquisition, availability, possession, storing, and selling of firearms in Canada.	Prior to the passage of the Act, the firearm suicide rate was increasing, however, after passage of the Act the firearm suicide rate began to decrease between 1977 and 1985 (the slope of the regression line = $-0.13; p < 0.05$ ).	Total: + 15–24 years: ++ 25–34 years: + 35–44 years: -- 45–54 years: -- 55–64 years: -- 65–74 years: + >75 years: ++
Bridges, 2004 <sup>SS3</sup>	Pre-post, with no control group	1984–1998	Canada	In 1991, Canadian Bill C-17 was implemented to restrict the use of firearms.	After the passage of Bill C-17, the rates of firearm suicide declined from 4.1 per 100,000 (1984–90) to 3.2 (1991–98) ( $p < 0.001$ ). The	Total: --

					slope of the regression line following the legislation was $\beta = -0.19$ ( $p = 0.02$ ).	
Caron, 2004 <sup>SS4</sup>	Time-series	1981–1996	Canada (Northern Québec)	In 1992, the Canadian Firearms Act (Bill C–17) aimed at improving the safe storage of firearms.	The firearm suicide rate decreased significantly following the legislation ( $p < 0.001$ ). There were age and sex-differences in the associations between firearm suicides and change in suicide by other means.	Total: -- Male: -- Female: -- 0–24 years: -- 25–34 years: -- 35–44 years: -- 45–64 years: - >65 years: -
Caron et al. 2008 <sup>SS5</sup>	Interrupted time-series	1987–2001	Canada (Québec)	In 1992, Canada implemented the regulations associated with Bill C–17, which forced firearm owners to safely store their firearms.	Firearm suicide rates have dropped among men and women, but the downward trends were not significant when compared to those prior to the law (4.4 deaths per 100,000 [1987–91] to 3.7 deaths per 100,000 [1992–2001] following the legislation).	Total: - Male: - Female: -
Thomsen et al., 1991 <sup>SS6</sup>	Pre-post, with no control group	1984–1987	Denmark	On January 1, 1986, a more rigorous Firearms Act took effect, which required a licence for all shotguns owners.	A reduction in the number of suicides is seen after the introduction of the legislation (reduction of 17%), but it could not be ascribed to an effect of the law as the number of shotgun suicide cases was almost unchanged (before: 129; after: 107).	Total: -
Lubin et al. 2010 <sup>SS7</sup>	Pre-post, with no control group	2003–2008	Israel	In 2006, a policy change in the Israeli Defense Forces was implemented to reduce adolescents' access to firearms.	Following the change in policy there was a decrease in firearm suicide rates over the weekend among those aged 18–21 years, from a mean of 10 per year (2003–2005) to a mean of 3 per year (2007–2008) ( $p < 0.001$ ). There were no significant changes in rates of suicide during weekdays.	Total: --
Beautrais et al. 2006 <sup>SS8</sup>	Time-series	1985–2002	New Zealand	By the end of 1996, a more restrictive firearms legislation was introduced in New Zealand. The legislation was an amendment to the 1992 Arms Act.	After the legislation, the mean annual rate of firearm-related suicides decreased by 46% for the total population ( $p < 0.0001$ ), 66% for youth (15–24 years; $p < 0.0001$ ) and 39% for adults ( $\geq 25$ years; $p < 0.01$ ) from 1993–2002.	Total: -- 15–24 years: -- >25 years: --
Ludwig et al., 2000 <sup>SS9</sup>	Time-series/ Pre-post, with control group	1985–1997	United States	In 1994, the Brady Handgun Violence Prevention Act was established, which created a mandatory waiting period and	Changes in rates of firearm suicide for the treatment states were significantly lower than the control states for those aged $\geq 55$ years (-0.92 per 100,000; 95% CI: -1.43, -0.42). This reduction in firearm suicides for those aged	$\geq 21$ years: - $\geq 55$ years: -- <i>No waiting period (partial Brady)</i>

				background checks for handgun sales.	≥55 years was much stronger in states that had instituted both waiting periods and background checks (-1.03 per 100,000; 95% CI: -1.58, -0.47) than in states that only changed background check requirements (-0.17 per 100,000; 95% CI: -1.09, 0.75).	≥21 years: - ≥55 years: - <i>Full Brady</i> ≥21 years: - ≥55 years: --
Conner et al., 2003 <sup>S60</sup>	Repeated Cross-sectional	1999–2000	United States	Firearm restriction laws, such as the Brady Handgun Violence Prevention Act (Public Law 103-109) and the Violence Against Women Act (Public Law 103-322) carried federal mandates on firearm restrictions that necessitated implementation in many states whereas other states had similar, pre-existing laws already in effect.	Compared to states with restrictive firearm laws, women had higher suicide incidence rate ratios in states with modest (incidence rate ratio = 1.6; 95% CI: 1.3, 2.0) and unrestrictive laws (incidence rate ratio = 1.6; 95% CI: 1.2, 2.0). The analysis of men showed comparable results: modest firearm laws (incidence rate ratio = 1.5; 95% CI: 1.3, 1.8); unrestrictive firearm laws (incidence rate ratio = 1.5; 95% CI: 1.2, 1.8).	<i>Unrestrictive compared to restrictive laws</i> Male: ++ Female: ++ <i>Modest compared to restrictive laws</i> Male: ++ Female: ++
Madhavan et al. 2019 <sup>S61</sup>	Cross-sectional study	2014–2015	United States	The Brady score ranks 50 states based on a series of 33 firearm policies, state firearm death rates, and state crime firearm export rates. Child access prevention laws have been implemented in several states with the aim to keep firearms away from youth.	After controlling for state-level sociodemographic factors, the state-level Brady score was not associated with pediatric firearm suicide rates. Child access prevention laws were associated with firearm suicide rates among youth ( $\beta = -0.22$ ; 95% CI: -0.44, -0.00; $p = 0.04$ ).	<i>Brady laws</i> Total: - <i>Child access prevention laws</i> Total: --
Cummings et al. 1997 <sup>S62</sup>	Ecological study	1979–1994	United States	From 1989–1993, firearm safe storage laws were adopted in 12 states. The laws required firearms owners to store their loaded firearms in such a way that children could not readily obtain access to them.	The associations of state safe storage laws with firearm-related suicide deaths among youth younger than 15 years was weak (rate ratio = 0.81; 95% CI: 0.66, 1.01) and was not statistically significant.	Total: -
Sen et al., 2012 <sup>S63</sup>	Repeated cross-sectional/time-series	1996–2005	United States	State background checks for firearm purchase. States with laws are compared with states without the laws.	Firearm suicide deaths were lower when states had background checks for mental illness (incidence rate ratio: 0.96; 95% CI: 0.92, 0.99), fugitive status (incidence rate ratio: 0.95; 95% CI: 0.90, 0.99) and misdemeanors	Total: -- <i>Restraining order</i> Total: -- <i>Mental illness</i> Total: -- <i>Fugitive</i>

					(incidence rate ratio: 0.95; 95% CI: 0.92, 1.00).	Total: -- <i>Misdemeanor</i> Total: - <i>Other miscellaneous</i> Total: ++
Sloan et al. 1990 <sup>S64</sup>	Repeated cross-sectional with control	1985–1987	United States and Canada (King County, Washington [control: Vancouver, Canada])	King County, Washington, was compared with Vancouver, Canada (control group), where firearm regulations are more restrictive.	The rate of suicide by firearms was significantly higher in King County (relative risk = 2.34; 95% CI: 1.90, 2.88), because the rate of suicide by handguns was 5.7 (95% CI: 4.08, 7.93) times higher than the control.	Total: --
Loftin et al. 1991 <sup>S65</sup>	Time-series	1968–1987	United States (District of Columbia)	In 1976, the District of Columbia adopted a law that placed strict regulations on the purchase, sale, transfer, or possession of handguns by civilians.	The mean frequency of firearm suicide mortalities declined by about one quarter in the period after the law went into effect. Firearm suicides declined from a mean of 2.6 per month to 2.0 per month, equivalent to a 23% reduction.	Total: --
Crifasi et al. 2015 <sup>S66</sup>	Quasi-experimental	1981–2012	United States (Connecticut and Missouri)	In 1995, Connecticut established a mandatory permit-to-purchase (PTP) system applicable to all handgun buyers, making background check and training compulsory to purchase a handgun. In 2007, Missouri repealed its PTP system.	Connecticut's firearm suicide rate was 15.4% lower than the synthetic control states. In comparison, Missouri's repeal of its PTP law was associated with a firearm suicide rate that was 16.1% higher than the synthetic control states	<i>Connecticut laws</i> Total: -- <i>Missouri laws</i> Total: ++
Marinelli et al., 2013 <sup>S67</sup>	Pre-post, with no control group	2005–2010	United States (Connecticut)	In 2009, Connecticut implemented a firearm buy-back program.	The incidence of firearm-related deaths, including firearm suicide mortality, was unchanged in the two years following the implementation of the firearm-back program.	Total: unchanged
Kivisto et al. 2018 <sup>S68</sup>	Quasi-experimental study	1981–2015	United States (Indiana and Connecticut)	In 1999, Connecticut became the first state to enact firearm seizure legislation. In 2005, Indiana followed suit and enacted their own fire seizure laws.	In the ten years following its enactment, Indiana's firearm seizure law was associated with a 7.5% reduction in firearm suicides mortality. The enactment of Connecticut's law was associated with a 1.6% reduction in firearm suicides immediately after its passage and a 13.7% reduction in firearm suicides in the post-Virginia Tech period (2007), when	Indiana: -- Connecticut: --

					enforcement of the law substantially increased.	
Castillo-Carniglia et al. 2019 <sup>S69</sup>	Quasi-experimental study	1981–2000	United States (California)	In 1991, California implemented legislation that mandated a background check for all firearm purchases. The laws also prohibited firearm purchase and possession for persons convicted within the past 10 years of certain violent crimes.	Between 1997 and 2000 there was an overall decline in firearm-related suicides. The average difference in the rate of firearm suicides between California and synthetic control in the ten years following the intervention period was -0.7 per 100,000, corresponding to a 10.9% decrease.	Total: -
Rosengart et. 2005 <sup>S70</sup>	Time-series	1979–1998	United States.	State-level firearm laws: (1) “shall issue” laws permitting an individual to carry a concealed weapon unless restricted by another statute; (2) a minimum age of 21 years for handgun purchase; (3) a minimum age of 21 years for private handgun possession; (4) one firearm a month laws which restrict handgun purchase frequency; and (5) junk firearm laws which ban the sale of certain cheaply constructed handguns.	No law was associated with a statistically significant change in firearm suicide rates.	<i>Shall issue law</i> Total: - <i>Minimum purchase age</i> Total: no difference <i>Minimum possession age</i> Total: - <i>One a month</i> Total: + <i>Junk gun ban</i> Total: -
Rodriguez Andres et al., 2011 <sup>S71</sup>	Time-series	1995–2004	United States	State-level firearm legislation across three categories: (1) general prohibition, (2) behavioural prohibition, and (3) criminal prohibition	Firearms regulations which function to reduce overall gun availability (general prohibition) have a significant deterrent effect on male suicide (incidence rate ratio = 0.94; standard error = 0.01), while regulations that seek to prohibit high risk individuals from owning firearms have a lesser effect.	<i>General prohibition</i> Male: -- <i>Behavioural prohibition</i> Male: -- <i>Criminal prohibition</i> Male: +
Fleegler et al. 2013 <sup>S72</sup>	Ecological and repeated cross-sectional	2007–2010	United States	State-level firearm legislation across five categories of laws: (1) curb firearm trafficking, (2) strengthen Brady background checks, (3) improve child	Compared with the quartile of states with the fewest laws, the quartile with the most laws had a lower firearm suicide rate (incidence rate ratio = 0.63; 95% CI: 0.48, 0.83).	<i>Firearm trafficking</i> Total: + <i>Strengthen Brady checks</i>

				safety, (4) ban military-style assault weapons, and (5) restrict guns in public places.		Total: -- <i>Child safety</i> Total: -- <i>Ban assault weapons</i> Total: -- <i>Guns in public places</i> Total: --
Anestis et al. 2015a <sup>S73</sup>	Cross-sectional	2010	United States	Impacts of three state laws: (1) permit to purchase a handgun, (2) registration of handguns, and (3) license to own a handgun.	States with any of these laws in place in 2010 exhibited lower firearm suicide rates, and an overall smaller proportion of suicides in such states resulted from firearms.	<i>Permit to purchase a handgun</i> Total: -- <i>Registration of handguns</i> Total: -- <i>License to own handguns</i> Total: --
Anestis et al., 2015b <sup>S74</sup>	Cross-sectional	2013	United States	Impact of four handgun laws: (1) waiting periods, (2) universal background checks, (3) gun locks, and (4) open carrying regulations.	Each of the four handgun laws were associated with significantly lower firearm suicide rates. In addition, states that implemented any of the four laws saw a decreased suicide rate in subsequent years, whereas the only state that repealed one of these laws saw an increased suicide rate.	<i>Waiting period</i> Total: -- <i>Universal background</i> Total: -- <i>Gun locks</i> Total: -- <i>Open carrying regulations</i> Total: --
Anestis et al. 2017 <sup>S75</sup>	Time-series	2013–2014	United States	Impact of four state handgun laws: (1) mandatory waiting periods, (2) universal background checks, (3) gun lock requirements, and (4) limitations on open carry.	States with universal background checks and mandatory waiting periods were associated with a decrease in suicide rates from 2013 to 2014. States with regulating gun lock use and restricting open carry of handguns laws did not differ significantly from states that did not have the laws implemented.	<i>Mandatory waiting periods</i> Total: -- <i>Universal background checks</i> Total: -- <i>Gun lock requirements</i> Total: -

						<i>Limitations on open carry</i> Total: -
Kaufman et al. 2018 <sup>S76</sup>	Time-series	2010–2014	United States	State-level firearm laws: (1) dealer regulations; (2) background checks for private sale; (3) license to purchase or own; (4) junk gun regulations; (5) reporting requirements for lost or stolen gun; (6) multiple purchase.	Stronger state-level firearm laws were associated with lower firearm suicide rates regardless of the strength of the other states' laws. Counties with low state scores had the highest rates of firearm suicide.	Total: --
Anestis et al., 2018 <sup>S77</sup>	Cross-sectional study	2014–2017	United States	Three state-level firearm laws: (1) universal background checks; (2) mandatory waiting periods; (3) child access prevention.	States with strong firearm legislation were inversely associated with the statewide overall ( $\beta = -0.44, p = 0.012$ ) and firearm suicide rates ( $\beta = -0.55, p < 0.001$ ), but not with non-firearm suicide rates ( $\beta = -0.02, p = 0.925$ ). Firearm ownership rates moderated the association between firearm legislation strength and statewide overall suicide rates.	Total: --
Siegel et al. 2019 <sup>S78</sup>	Panel design (with vs without laws)	1991–2016	United States	Included 10 laws: (1) universal background checks, either through point-of-purchase checks or a permit to purchase requirement; (2) ban on handgun possession for people convicted of a violent misdemeanor; (3) age 21 limit for handgun possession; (4) "shall issue" laws; (5) permitless carry laws; (6) prohibition against gun trafficking; (7) ban on "junk guns"; (8) "stand your ground" laws; (9) assault weapons ban; and (10) ban on large-capacity ammunition magazines.	When examined individually, four of the 10 firearm laws were significantly associated with overall suicide rates. However, after simultaneously controlling for all 10 firearm laws, only two laws were significantly related to suicide rates: bans on junk guns were associated with 6.6% lower suicide rates (95% CI: 3.6%, 9.7%) and permits to carry laws were associated with 5.0% higher suicide rates (95% CI: 0.2%, 9.9%). None of the other laws were significantly associated with overall suicide rates.	<i>Universal background checks</i> Total: - <i>Violent misdemeanor</i> Total: - <i>21 age limit</i> Total: - <i>Shall issue</i> Total: + <i>Permitless carry laws</i> Total: ++ <i>Trafficking</i> Total: - <i>Junk gun ban</i> Total: -- <i>Stand your ground law</i> Total: -

						<i>Assault weapon ban</i> Total: + <i>Large-capacity ammo ban</i> Total: -
Ghiani et al. 2019 <sup>S79</sup>	Time-series	2005–2015	United States	Index of state-level firearm control (sum of dichotomous indicators for 133 regulations from 14 types of state-level gun laws, including three provisions restricting access to individuals with a history of mental health issues or who have been deemed in court to be a danger to themselves.	Overall, a six-point increase in the score was associated with 3.3% decrease (incident rate ratio = 0.97; 95% CI: 0.94, 1.00) in the firearm suicide incidence rate. The association was stronger in men than women.	Total: -- <i>Male</i> Total: -- 15–24 years: -- 25–34 years: -- 35–44 years: -- 45–54 years: -- 55–64 years: -- 65–74 years: -- 75–84 years: - > 85 years: - <i>Female</i> Total: - 15–24 years: -- 25–34 years: -- 35–44 years: -- 45–54 years: - 55–64 years: - 65–74 years: - 75–84 years: - > 85 years: -
Leung et al. 2019 <sup>S80</sup>	Cross-sectional study	2017	United States	Four state-level firearm legislations were included: (1) dealer regulations; (2) mandatory waiting periods; (3) local authority, and (4) universal background checks.	States with more firearm control policies had lower firearm ownership rates, which were further associated with lower firearm suicide rates among men	<i>Dealer regulations</i> 15–24 years: -- 25–44 years: - 45–64 years: - > 65 years: - Total: - <i>Waiting period</i> 15–24 years: -- 25–44 years: - 45–64 years: - >65 years: - Total: --

						<i>Local authority</i> 15–24 years: - 25–44 years: - 45–64 years: - > 65 years: - Total: - <i>Background checks</i> 15–24 years: - 25–44 years: - 45–64 years: + > 65 years: - Total: -
--	--	--	--	--	--	--

*Note:* CI = confidence interval; AOR = adjusted odds ratio;  $\beta$  = beta coefficient; SE = standard error; OR = odds ratio;  $\chi^2$  = chi-square; - = not statistically significant reduction; -- = statistically significant reduction; + = not statistically significant increase; ++ = statistically significant increase

**Supplemental 4:** Risk of Bias assessments

Reference		Selection bias	Study design	Confounders bias	Blinding bias	Data collection	Withdrawal and drop-out	Global rating
Lester et al. 1996	S1	Strong	Moderate	Weak	Strong	Weak	Not Applicable	WEAK
Etzersdorfer et al. 1998	S2	Weak	Moderate	Weak	Strong	Weak	Not Applicable	WEAK
Niederkrötenhaler et al. 2007	S3	Weak	Moderate	Strong	Strong	Strong	Not Applicable	MODERATE
Till et al. 2013	S4	Strong	Moderate	Strong	Strong	Weak	Not Applicable	MODERATE
Matsubayashi, Ueda, et al 2014	S5	Strong	Moderate	Strong	Strong	Moderate	Not Applicable	MODERATE
Lockley et al. 2014	S6	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Ross et al. 2020	S7	Moderate	Weak	Weak	Strong	Strong	Not Applicable	WEAK
Hegerl et al. 2019	S8	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Hegerl et al. 2006	S9	Moderate	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Hegerl et al. 2010	S10	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	MODERATE
Szekely et al. 2013	S11	Moderate	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Motohashi et al. 2007	S12	Moderate	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
King et al. 2005	S13	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	MODERATE
Stack et al. 2015	S14	Strong	Moderate	Strong	Strong	Weak	Not Applicable	MODERATE
Studdert et al. 2010	S15	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Nordentoft et al. 2006	S16	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Nordentoft et al. 2007	S17	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Pridemore et al. 2009	S18	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Myung et al. 2012	S19	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Cha et. 2015	S20	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Kim et al. 2017	S21	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Yamasaki et al. 2005	S22	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Morgan et al. 2007	S23	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Hawton et al. 2013	S24	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Lester et al. 1992	S25	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Skilling et al. 2008	S26	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Cylus et al. 2014	S27	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG

Kaufman et al. 2020	S28	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Gertner et al. 2019	S29	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Rambotti et al. 2020	S30	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Birckmayer et al. 1999	S31	Strong	Moderate	Strong	Strong	Weak	Not Applicable	MODERATE
Grucza et al. 2012	S32	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Markowitz et al. 2003	S33	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Son et al. 2011	S34	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Grucza et al. 2014	S35	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Chapman et al., 2006	S36	Strong	Moderate	Weak	Strong	Moderate	Not Applicable	MODERATE
Baker et al., 2007	S37	Strong	Moderate	Weak	Strong	Moderate	Not Applicable	MODERATE
Klieve et al. 2009	S38	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Lee et al., 2010	S39	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
McPhedran et al., 2012	S40	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Chapman et al. 2016	S41	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Gilmour et al. 2018	S42	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Snowdown et al., 1992	S43	Strong	Weak	Weak	Strong	Strong	Not Applicable	MODERATE
Cantor et al., 1995	S44	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Ozanne-Smith et al. 2004	S45	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Kapusta et al., 2007	S46	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Niederkrötenhaler et al., 2009	S47	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
König et al. 2018	S48	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Rich et al. 1990	S49	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Lester et al., 1993	S50	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Carrington et al., 1994	S51	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Leenaars et al., 1997	S52	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Bridges, 2004	S53	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Caron, 2004	S54	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Caron et al. 2008	S55	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Thomsen et al., 1991	S56	Strong	Weak	Weak	Strong	Strong	Not Applicable	WEAK
Lubin et al. 2010	S57	Weak	Moderate	Weak	Strong	Weak	Not Applicable	WEAK
Beutrais et al. 2006	S58	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Ludwig et al., 2000	S59	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Conner et al., 2003	S60	Weak	Weak	Strong	Strong	Weak	Not Applicable	WEAK

Madhavan et al. 2019	S61	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Cummings et al. 1997	S62	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Sen et al., 2012	S63	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Sloan et al. 1990	S64	Strong	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Loftin et al. 1991	S65	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Crifasi et al. 2015	S66	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Marinelli et al., 2013	S67	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Kivisto et al. 2018	S68	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Castillo-Carniglia et al. 2019	S69	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Rosengart et. 2005	S70	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Rodriguez Andres et al., 2011	S71	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Fleegler et al. 2013	S72	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Anestis, Khazem, et al. 2015	S73	Strong	Weak	Weak	Strong	Moderate	Not Applicable	WEAK
Anestis & Anestis, 2015	S74	Strong	Weak	Weak	Strong	Moderate	Not Applicable	WEAK
Anestis et al. 2017	S75	Strong	Moderate	Weak	Strong	Moderate	Not Applicable	MODERATE
Kaufman et al. 2018	S76	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Anestis et al. 2019	S77	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Siegel et al. 2019	S78	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Ghiani et al. 2019	S79	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Leung et al. 2019	S80	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Ohberg et al. 1997	S81	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Bellanger et al. 2006	S82	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Nakanishi et al. 2020	S83	Moderate	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Lee et al. 2018	S84	Moderate	Weak	Strong	Strong	Strong	Not Applicable	MODERATE
Baran et al. 2015	S85	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE
Lang et al. 2011	S86	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Matsubayashi et al. 2011	S87	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Law et al. 2014	S88	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Perron et al. 2013	S89	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Sinyor et al. 2010	S90	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Sinyor et al. 2016	S91	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Matsubayashi et al. 2013	S92	Strong	Moderate	Strong	Strong	Moderate	Not Applicable	MODERATE

Matsubayashi, Swada, Ueda. 2014	S93	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Ueda et al. 2015	S94	Strong	Moderate	Strong	Strong	Weak	Not Applicable	MODERATE
Beautrais et al. 2009	S95	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Skegg et al. 2009	S96	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Chung et al. 2016	S97	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Reisch et al. 2005	S98	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Hemmer et al. 2017	S99	Strong	Moderate	Strong	Strong	Strong	Not Applicable	STRONG
Bennewith et al. 2007	S100	Strong	Moderate	Weak	Strong	Strong	Not Applicable	MODERATE