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Reducing Suicide Without Affecting Underlying Mental Health

Theoretical Underpinnings and a Review of the Evidence Base Linking the Availability of Lethal Means and Suicide

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Introduction

Worldwide, over 800,000 people die annually by suicide, approximately 3 out of 10 as the result of intentional pesticide ingestion, a toll that has led the World Health Organization (2014) to call efforts to lower suicide rates "a global imperative." Few suicide prevention interventions have been found to have an evidentiary base to achieve this goal; one that has is reducing access to highly lethal means used in suicides, often referred to as means restriction (Mann et al., 2005). Means restriction is now commonly seen as a vital component of any effective national strategy for reducing suicide rates. In the United States, for example, the 2012 *National Strategy for Suicide Prevention* (Office of the Surgeon General [US]; National Action Alliance for Suicide Prevention, 2012) notes that reducing access to lethal suicide methods is "a proven strategy for decreasing suicide rates" (Office of the Surgeon General [US]; National Action Alliance for Suicide Prevention, 2012, p. 43), while the World Health Organization (2014, p. 9) notes succinctly that "restricting access to the means for suicide works." Despite widespread endorsement by the public health community, and an increasingly compelling evidentiary base, interventions to reduce access to lethal means remain uncommon in many parts of the world (e.g., rural China, the United States), perhaps because little guidance exists as to how to implement these efforts or as to where and under which conditions any such intervention is most likely to be effective.

In this chapter, we provide a synthesis of the empirical literature that assesses the relationship between ready access to highly lethal means of suicide and overall suicide rates. We begin by laying out the theoretical underpinnings of the assertion that

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reducing access to lethal means of suicide can reduce suicide rates. Next, we specify the kind of empirical evidence that is of sufficient quality to test this assertion. We provide a summary of the leading suicide methods involved in suicides worldwide, and an overview of the case fatality ratio (the number of suicide deaths divided by the number of acts of deliberate self-harm, both fatal and nonfatal, by a given method) associated with methods commonly used in suicidal acts. We then describe the search strategy and eligibility criteria for identifying articles we employ in this review, summarize the empirical literature, and conclude with observations about the implications of and inferences that can be drawn from our review. See also Chapter 35, by Chen, Wu, Wang, and Yip, which discusses issues around means restriction and hotspots. For the purposes of this chapter, we use the following nomenclature: *suicidal act*: an act of deliberate self-harm, undertaken with the aim of ending the actor's life, including both acts that do not result in death (*suicide attempt*) and acts that do (*suicide*). In contrast, acts of *deliberate self-harm* are those acts for which it is unknown or undetermined whether the actor's intention was to end his or her own life.

Why Means Matter

As depicted in Figure 36.1 (below), reducing access to lethal means has the potential to save lives to the extent that people who cannot readily obtain a method of equal or greater lethality either (a) attempt suicide with a method less likely to prove fatal or (b) do not attempt suicide at all.

The argument that restricting access to a highly lethal method can save lives rests on three well-established observations. First, many suicidal crises are fleeting (de Moore, Plew, Bray, & Snars, 1994; Deisenhammer et al., 2009; Drum, Brownson, Burton Denmark, & Smith, 2009; Eddleston et al., 2006; Hawton et al., 1995; Li et al., 2002; Simon et al., 2001). Data in support of this contention come from surveys of people who have seriously considered suicide and those who have engaged in suicidal acts. For example, among college students in the United States who had

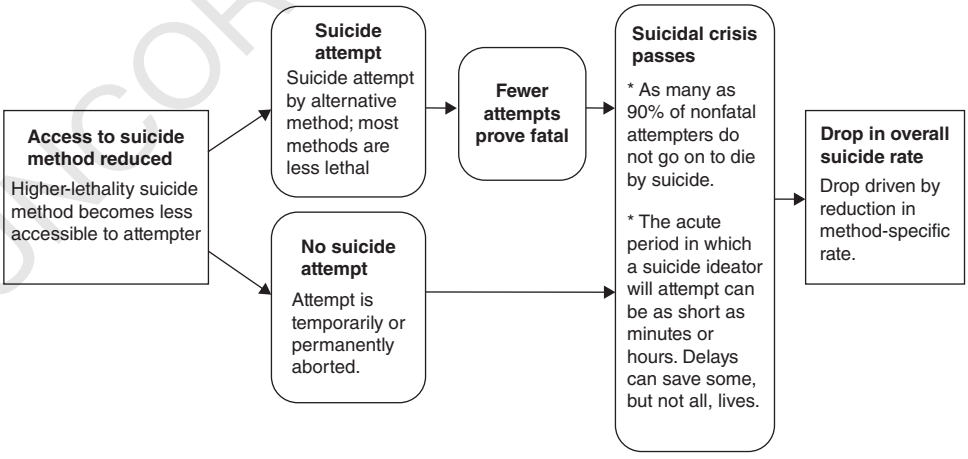

Figure 36.1 Pathways through which reductions in access to lethal means may result in lower suicide rates.

seriously considered suicide in the past year, approximately 30% reported that their suicidal period lasted under an hour (Drum et al., 2009). In a study that assessed characteristics of people taking large paracetamol (acetaminophen) overdoses in the United Kingdom, three quarters of whom said they wanted to die, over half took the overdose within an hour of first thinking of it (Hawton et al., 1995). Other surveys of people who have survived suicide attempts have found that the interval between deciding on suicide and actually attempting was 10 min or less for 24%–74% of attempters (with the lower end of the range reported by patients who nearly died in their attempt; Deisenhammer et al., 2009; Hawton et al., 1995; Simon et al., 2001; Williams, Davidson, & Montgomery, 1980). In one study, for example, of 326 people who had carried out serious but nonfatal acts of deliberate self-harm in China (Li et al., 2002; 83% had ingested pesticides), 35% reported that they first considered harming themselves 10 min or less before acting. Studies from China, India, and Malaysia also suggest that among people who died from an act of deliberate self-harm (most from pesticide ingestion, which affords an opportunity to interview patients before they die), the ultimately fatal act tended to emerge abruptly, often in the midst of an interpersonal conflict, rather than after an extended period of premeditation (Phillips et al., 2002).

Second, the method people use in suicidal acts depends, to a vital extent, on the method's ready availability, over and above—and perhaps even independent of—the attempter's assessment of a method's intrinsic lethality (which indeed may not be correlated with its actuarial lethality [de Moore et al., 1994; Eddleston et al., 2006; Hawton et al., 1995; Li et al., 2002]). For example, in the few near-lethal suicide attempt studies involving firearms (de Moore et al., 1994; Peterson, Peterson, O'Shanick, & Swann, 1985), firearms were readily available in the home of all cases and this ready availability was usually the reason given for using firearms rather than another method. Because the case fatality ratio for commonly used methods varies by nearly an order of magnitude (see Table 36.1), this observation suggests that when access to suicide methods with particularly high intrinsic lethality is reduced, on average less lethal means, if any, may be chosen.

Third, the prognosis if one survives a suicide attempt is excellent, despite the fact that a prior suicide attempt is the strongest known predictor of subsequent suicide (Nock et al., 2008). For example, in a review of over 90 studies of suicide attempt survivors, Owens, Horrocks, and House (2002) found that fewer than 10% of people who attempt suicide and live later go on to die by suicide. This finding holds true even for suicide attempts that are medically serious, such jumping in front of a train (O'Donnell, Arthur, & Farmer, 1994), and for attempts that were aborted or otherwise averted (Seiden, 1978). The implication of this favorable prognosis with respect to dying by suicide is that saving someone's life in the short run is very likely to save his or her life in the long run.

Methods Accounting for the Greatest Proportion of Suicides Worldwide

More than 3 out of 10 suicides globally are the result of pesticide ingestion (Gunnell & Eddleston, 2003; Gunnell, Eddleston, Phillips, & Konradsen, 2007). In China alone, best estimates are that over 180,000 people deliberately ingest pesticides and die each year; approximately another 100,000 to 200,000 pesticide suicides in aggregate occur annually in the rest of the world, most of which occur in rural areas in developing

countries in Asia and some parts of Central and South America (Gunnell, Eddleston, et al., 2007). In high-income countries, the most common method of suicide is hanging. Hanging is a method that is difficult to reduce access to effectively, other than in settings, such as jails and locked psychiatric facilities, where extraordinary control over the physical environment is possible. In many high- and middle-income countries, however, other suicide methods, access to which can be plausibly reduced, still account for a substantial proportion of all suicides. For example, firearms are involved in approximately half of all suicides in the United States; carbon monoxide poisoning from burning charcoal in enclosed spaces accounted, at its peak, for 25%–30% of all suicides in Hong Kong and Taiwan; and jumping, at its peak, accounted for over 40% of all suicides in Hong Kong and approximately 70% of all suicides in Singapore (Wu, Chen, & Yip, 2012).

Method-Specific Case Fatality Ratios

Leading means of suicide, especially those favored by men, are often methods with high case fatality ratios. For example, 80%–90% of suicide attempts with a firearm are fatal (Miller, Azrael, & Hemenway, 2004; Spicer & Miller, 2000). In countries in which poisoning with agricultural products is a common method of suicide, the type of poison that is ingested has a dramatic effect on the probability of death. Table 36.1 provides case fatality ratio estimates for a variety of methods commonly used in acts of intentional self-harm (for a more detailed consideration of pesticide case fatality ratios, see the excellent articles by Dawson et al. [2010] and Lin et al. [2008]).

The case fatality ratio for a given method, although influenced by several factors, is primarily determined by the method's intrinsic deadliness (e.g., paraquat is inherently more lethal than paracetamol) or its toxicity in a specific place or time (e.g., domestic gas containing high levels of carbon monoxide is more toxic than gas containing little or no carbon monoxide). Other factors, depending on the method, may influence the likelihood of death in a given attempt, including the underlying health of the victim (e.g., older people, on average, will be frailer, and more susceptible to death given a specific insult, than younger people [Miller, Azrael, et al., 2004]), and for those methods that require technical knowledge to be most efficient, death may be less likely when used by less "expert" attempters.

Calculating the case fatality ratio for a given method of intentional self-harm is made difficult by several factors. First, in many less developed countries, vital records information is poor, and there may be little or no information about the number of suicides by method in a given location (the numerator in the case fatality ratio). Even when good numerator information is available, however, very few countries have good information on suicide attempts. As such, most estimates of the case fatality ratio use the number of emergency department visits for deliberate self-harm plus suicide deaths as the denominator. Acts of deliberate self-harm that do not come to medical attention are not accounted for. In practice, this denominator issue probably has little influence on the case fatality ratio due to firearms or jumping from extreme heights—as most nonlethal acts with these methods will require medical attention—but will tend to overestimate the case fatality ratio for many other methods (for which nonfatal acts may not come to medical attention).

Table 36.1 Case Fatality Ratios for Selected Methods Commonly Used in Intentional Self-Harm

Suicide method	*Case fatality ratio (range)*
Firearm (Miller, Hemenway, et al., 2004; Spicer & Miller, 2000; Vyrostek et al., 2004)	83%–91%
Drowning (Miller, Hemenway, et al., 2004; Spicer & Miller, 2000)	66%–84%
Suffocation/Hanging (Elnour & Harrison, 2008; Miller, Hemenway, et al., 2004; Spicer & Miller, 2000; Vyrostek et al., 2004)	61%–83%
Charcoal Burning (Lee et al., 2014)	50%
Poison, Gas (Elnour & Harrison, 2008; Miller, Hemenway, et al., 2004; Spicer & Miller, 2000)	42%–64%
Jump (Elnour & Harrison, 2008; Miller, Hemenway, et al., 2004; Spicer & Miller, 2000; Vyrostek et al., 2004)	31%–79%
Cut/Pierce (Elnour & Harrison, 2008; Miller, Hemenway, et al., 2004; Spicer & Miller, 2000; Vyrostek et al., 2004)	1–3%
Poison, Drug (Elnour & Harrison, 2008; Gunnell, Ho, & Murray, 2004; Miller, Hemenway, et al., 2004; Spicer & Miller, 2000)	<0.5%–2%
Pesticides	
Paraquat (Dawson et al., 2010; Hettiarachchi & Kodithuwakku, 1989)	43%–68%
Aluminum Phosphate (Chugh, Dushyant, Ram, Arora, & Malhotra, 1991)	60%–80%
Organophosphate Pesticides	
Monocrotophos (Dewan & Rajendran, 2009)	35%
Parathion (Lin et al., 2008)	25%
Endosulfan (Dewan & Rajendran, 2009)	22%
Dimethoate (Dawson et al., 2010; Eddleston et al., 2005)	21%–23%
Chlopyrifos (Dawson et al., 2010; Eddleston et al., 2005)	8%
Herbicides	
Glyphosate (Dawson et al., 2010)	2%
MCPA (2-methyl-4-chlorophenoxyacetic acid) (Dawson et al., 2010)	5%
Plants	
Yellow Oleander (Eddleston et al., 1999)	5%

Another potential denominator issue is that even for those patients who seek medical attention for an act of deliberate self-harm, if the patient's intent is unclear or if he or she denies suicidal intent when interviewed, the act may be coded as unintentional self-harm (leading to overestimates of the case fatality ratio calculated for suicidal acts). On the other hand, emergency department visits for acts of deliberate self-harm include both those with and without suicidal intent, artificially inflating the denominator and thereby yielding underestimates of the case fatality ratio for suicidal acts (though accurately reflecting the case fatality ratio for deliberate self-harm). How these countervailing influences on the actual case fatality ratio balance out in absolute terms for different methods in different contexts is uncertain. It is unlikely, however, that these biases would be so large as to appreciably affect relative rankings, because the influence of these considerations in calculating case fatality ratios are likely small compared with the differences in the intrinsic lethality of particular methods. For example, even if poisoning with therapeutic agents had a case fatality ratio double the reported ratio, it would still have a case fatality ratio of less than 5%.

Principles Guiding This Review

Almost 40 years ago, in his finely executed study of the relationship between changes in the concentration of carbon monoxide in domestic gas and suicide rates in the United Kingdom, Kreitman (1976) articulated a set of fundamental epidemiologic and epistemological considerations essential to assessing whether reducing access to lethal means can reduce suicide rates. These considerations were (a) whether the study credibly defines and specifies different levels of exposure, (b) whether the change in exposure is shown to be associated with a change in total suicide rates through its effect on suicide rates by the method in question, and (c) in so far as could be ascertained, whether other putative explanations for the decline in overall suicide rates (or differences in suicide rates across space) plausibly account for the specificity of the observed result.

Since the 1970s, scores of researchers have written hundreds of papers exploring the relationship between access to lethal means and suicide rates. Although many of these papers are of high quality and make a significant contribution to our understanding of the relationship between access to lethal means and suicide, in this chapter, following Kreitman, we undertake a review of the subset of the empirical literature that can put to test the hypothesis that access to highly lethal means of suicide can affect individual-level risk and population-level rates of both method-specific and overall suicide (and by extension, that reducing access to highly lethal means of suicide can—under specific conditions—lead to reductions in both method-specific and overall suicide rates). Although not an exhaustive review of every published study of the association between the availability of lethal means and death by suicide, the scope of this chapter is nonetheless broad, with an international focus and coverage of the full range of leading suicide methods that have been examined in the empirical literature.

Eligibility Criteria

We require a credible measure of exposure that is explicitly modeled or measured directly. Because no measurable impact of means restriction on overall suicide rates is likely to be observed if the method in question constitutes a very small proportion of all suicides (even if, on balance, lives are saved), our primary focus is on studies in which the suicide method in question makes up at least one out of every three suicides in the population and time of interest. These methods include poisoning by pesticides, poisoning by domestic gas, poisoning by barbiturates, and firearms. For other methods, we provide an overall summary with citation to the literature.

Because suicide is a rare outcome, there are few cohort studies that are powered to assess the association between access to lethal means and completed suicide. There are also only a small number of case-control studies that have explored the relationship between access to lethal means and suicide. As such, this review focuses largely on ecologic-level studies, the majority of which are time-series analyses. We reference individual-level studies where appropriate, especially in the section on firearms in the United States, the one method and location where case-control studies have contributed greatly to the literature.

Search Strategy

To locate English-language, peer-reviewed articles regarding reducing access to lethal means (or means restriction), we used an iterative process that included (a) searches of multiple electronic databases, including PubMed, Google Scholar, Psych Info,

EBSCO Host, and ERIC, using the term *suicide* in combination with the terms *availability*, *access*, *means*, *means restriction*, *restriction*, and variants of leading methods of suicide (e.g., firearm* gun*, poison, pesticide, jump*, drug overdose, hanging, carbon monoxide, etc.), (b) review of abstracts for those articles potentially meeting eligibility criteria, (c) review of full articles identified in the abstract search to identify those meeting eligibility criteria, (d) review of reference lists from these articles, (e) review of abstracts from previously unidentified articles, etc. All articles that met eligibility criteria for this review are described in individual sections, below.

Empirical Studies

Poisoning by Liquids and Solids

Pesticides Pesticide poisoning is the single most common means of suicide worldwide (Bertolote, Fleischmann, Eddleston, & Gunnell, 2006), killing more than 250,000–370,000 people every year, the great majority in rural Asia, and accounting for about one third of all global suicides (Gunnell, Eddleston, et al., 2007). The evidence for the life-saving effect of reducing the toxicity of available pesticides is consistent across studies by different investigators, using different analytic approaches, and across different countries. In particular, population-level studies of the relationship between centralized decisions to reduce pesticide toxicity (through banning specific pesticides or changing pesticide formulations to reduce bioavailability) are supported by individual-level studies that identify pesticide availability as a strong and independent predictor of suicide.

The most convincing evidence that restricting access to highly toxic pesticides saves lives comes from a series of papers by researchers who have been working to prevent suicide in Sri Lanka, where pesticides are the leading suicide method. In the early 1990s, Sri Lanka had one of the highest suicide rates in the world (Gunnell, Eddleston, et al., 2007; Gunnell, Fernando, et al., 2007). In subsequent years, its suicide rate declined dramatically, by 50% over a 10-year period (from 47/100,000 in 1995 to 24/100,000 in 2005), which coincided with a series of bans on several of the most commonly used and highly human-toxic agents (Gunnell, Fernando, et al., 2007). The decline in suicide was driven by a decline in poisoning suicides; nonpoisoning suicides did not change appreciably, though an increase in the number of hanging deaths, which first became apparent in the 1980s (before the bans), continued, but the latter did not come close to offsetting the much steeper decline in pesticide poisoning (Gunnell, Fernando, et al., 2007). The rate at which rural Sri Lankans, mostly young adult men, swallowed pesticides in acts of deliberate self-harm did not appear to change (rates of *nonfatal* deliberate self-poisonings did not change). The decline in suicide rates did not appear to be associated with secular trends in other suicide risk factors including unemployment, alcohol misuse, divorce, or Sri Lanka's civil war (1983–2009; Gunnell, Fernando, et al., 2007), nor was the decline related to birth-cohort effects (Knipe et al., 2014). As Eddleston and Bateman (2011) point out, the profound fall in suicides in Sri Lanka occurred without any psychosocial intervention and, importantly, pesticide bans during the 1990s did not make agriculture either more expensive or less efficient (Manuweera, Eddleston, Egodage, & Buckley, 2008). A similarly dramatic drop in suicides was observed in Western Samoa when the pesticide paraquat became less available (Bowles, 1995).

By contrast, a study from Taiwan (Chang, Lu, Eddleston, et al., 2012), where pesticide poisoning was the most commonly used method of suicide in 1987, found that although age-standardized rates of pesticide suicide fell 67%, from 7.7 per 100,000 (42% of all suicides) in 1987 to 2.5 per 100,000 (12% of all suicides) in 2010, this decline was offset by a 69% increase in overall suicide rates by other methods. The reduction in suicide by pesticides occurred over a period when the workforce involved in agriculture fell by 66%, but there was no evidence that the reduction in suicide rates by pesticides paralleled trends in pesticide sales, bans on selected pesticide products, or unemployment. Data for nonfatal pesticide self-poisoning were unavailable, and therefore the authors were unable to determine whether the reduction in pesticide suicide was due to declines in the incidence of deliberate self-harm with poisons or in the case fatality ratio. The authors suggest that the reduction in the number of people working in agriculture is likely the reason for the reduction in pesticide poisoning and that the most likely explanation for the limited impact of the bans on overall suicide is that the bans did not include the pesticides accounting for the greatest number of deaths, for example, paraquat, which is still commonly used in Taiwan. Findings from this study, as well as an earlier time-series study in Sri Lanka (Roberts et al., 2003), underscore the importance of devising and enforcing restrictions on access to all highly toxic pesticides commonly involved in suicide deaths, not only the agents that are the most highly toxic according to World Health Organization classification schemes (which, it may be surprising to note, are not based on human-toxicity data; Dawson et al., 2010). Such would be the case with what has been called a "minimum pesticides list," which aims to restrict pesticide use to a small number of pesticides with the least human toxicity (Eddleston et al., 2002).

A variation on reducing access to a highly toxic pesticide is to engineer formulations of the pesticide that are designed to reduce its bioavailability or otherwise reduce its human toxicity. In Sri Lanka, Wilks et al. (2008) assessed a novel formulation of the herbicide paraquat (Inteon), which was developed to be less toxic than the highly toxic standard formulation. The new formulation, introduced in 2004, included three components designed to reduce paraquat absorption from the stomach and intestines. Over the study period, 586 patients were seen for deliberate self-harm by paraquat poisoning in nine large hospitals across Sri Lanka; 297 had taken the standard formulation and 289 the new formulation. Although the new formulation was still toxic, the proportion of cases surviving for at least 3 months increased from 27% (standard formulation) to 37% (new formulation). Adjusted analyses accounted for sex, age, and weight of the patient; treatments received; use of adsorbent; and time from ingestion to presentation at a medical center. The overall improvement in survival among patients who had ingested the new formulation was seen in every ingestion group except the 0.5 mL group, in which survival was already high.

In a pair of cross-sectional studies addressing pesticides and suicide in Taiwan, Chang et al. (2012) found that areas with a high proportion of the labor force working in agriculture had higher rates of overall suicide, pesticide suicide, but not nonpesticide suicide, both before and after controlling for area socioeconomic disadvantage. Moreover, geographic variation in the incidence of pesticide suicide (which accounted for as little as 2% of all suicides to as much as 38% of all suicides across seven levels of urbanization in Taiwan) was correlated with overall suicide rates. In contrast, nonpesticide suicides showed no strong spatial patterning. The researchers also showed that pesticide suicide accounted for most of the rural–urban disparity in overall suicide

rates in Taiwan, although this disparity diminished following the emergence of charcoal-burning suicides, which tend to occur more frequently in urban areas, where charcoal is more readily available (Chang, Gunnell, Wheeler, Yip, & Sterne, 2010).

A case-control study in rural China provides further evidence that ready access to highly toxic pesticides is an independent risk factor for suicide, even after controlling for individuals' mental disorders and socioeconomic status (Kong & Zhang, 2010). In this study, 370 rural 15–34-year-olds who had died by suicide and 370 living controls were matched on age, gender, and residence (rural/urban location). Data were collected using a psychological autopsy design with proxy respondents. Informants were asked if, at the time of death (for those who had died by suicide) or interview (for controls), there was a pesticide kept at home. Two thirds of all suicides involved pesticides; 66% of suicides had at least one pesticide in their home, compared with 50% of controls. Pesticide access was a significant risk factor for suicide among both men and women even after controlling for education level, living situation, marital status, family annual income, and mental disorders.

Nonpesticide Poisoning (by Liquids and Solids) Three drugs have been particularly well studied with respect to their effect on method-specific suicide: barbiturates, dextropropoxyphene, and paracetamol (acetaminophen). In Australia between 1959 and 1973, a large enough proportion of all suicides involved barbiturate poisoning for a limited number of studies to assess the relation between changes in barbiturate prescribing and both method-specific and overall suicide rates.

Barbiturates In 1960, the Australian government began subsidizing payment for barbiturates and other prescription sedative hypnotics, a class of drugs with a significantly higher case fatality ratio than most other readily available drugs. Consumption of sedatives more than doubled over the next 6 years, accompanied by a rapid rise in the rate of suicide, with most of the increase accounted for by increasing rates of suicide by drugs (Oliver & Hetzel, 1972). In response to rising costs and abuse of these agents, legislation passed in July 1967 restricted the number of hypnotic strength barbiturates per prescription to 25 tablets or capsules, and refills were not allowed. Estimated drug suicides declined by approximately 30% without significant changes in suicides by other methods (Oliver & Hetzel, 1972). In 1959, for example, 18% of all suicides were drug related (10% of male suicides and 28% of female suicides); by 1967, 46% were drug related (30% of male suicides and 69% of female suicides); and by 1970, drug suicides declined to 38% of all suicides. Because all suicides due to overdose of therapeutic agents were classified together in mortality statistics, it was not possible for the authors to more specifically identify the agents responsible. However, Oliver and Hetzel (1972) noted that information from other sources (Burvill, 1971; Oliver, Kaminski, Tudor, & Hetzel, 1971) suggested that the overwhelming majority of these agents were barbiturates.

Whitlock (1975) examined more granular data related to sedative hypnotic prescribing and suicide than were available to Oliver et al. (1971). Like Oliver et al.'s findings about Australia more generally, Whitlock's analysis of data from Brisbane, Australia, between 1959 and 1973, found a tight correlation between prescribing rates of barbiturates and rates of both suicide by barbiturates and suicide overall for both sexes.

Co-Proxamol Death by co-proxamol usually results from the respiratory depressant effects of dextropropoxyphene, the opioid that, combined with paracetamol, constitutes co-proxamol (Hudson, Barringer, & McBay, 1977; US Food and Drug Administration. FDA Drug Bulletin, 1979; Whittington, 1977). Death can occur rapidly, even at low doses, especially when effects are potentiated by alcohol and other central nervous system depressants.

Between 1997 and 1999, approximately 20% of all suicides in the United Kingdom were poisonings with drugs, of which approximately 20% involved co-proxamol. In response to concerns about co-proxamol use in deliberate self-poisoning in the United Kingdom, as well as about its safety profile more generally, the U.K. Committee on Safety of Medicines announced on January 31, 2005, that the drug would be withdrawn completely from use in the United Kingdom by December 31, 2007, and that between 2005 and 2007, doctors should not prescribe co-proxamol to any new patients and should try to switch patients already taking the drug onto other medications (Hawton et al., 2012). The study with the longest follow-up to assess morbidity and mortality following the U.K. legislation (Hawton et al., 2012) found a substantial reduction in poisoning suicides involving co-proxamol over the 6-year period following the phased withdrawal of co-proxamol from the United Kingdom, 2005–2010. There was little observed change in deaths involving other analgesics, apart from a small increase in oxycodone poisonings. This study did not assess suicides related to the use of multiple drugs or investigate whether suicides involving methods other than drug poisoning increased after co-proxamol was withdrawn from the market.

An earlier review by Simkin et al. (2005) assessed the international literature on reducing deaths from co-proxamol poisoning and concluded that deaths from dextropropoxyphene overdose appear to reflect the drug's availability, but did not report on studies that examined if the availability of co-proxamol was related to either overall poisoning suicides or suicides in general. In their review, Simkin et al. noted that several international initiatives designed to reduce prescribing of dextropropoxyphene seem to have been successful in reducing admissions for self-poisoning and deaths due to the drug. For example, restrictions on prescribing introduced in Sweden in 2001, in combination with other measures, were said to contribute to a major decline in fatal dextropropoxyphene poisoning (Jonasson & Jonasson, 2004). In Denmark, restrictions on prescribing in the early 1980s appeared to have little impact on dextropropoxyphene fatalities early on, but coincident declines in death rates and daily prescribed doses were observed after 1985 (Segest, Harris, & Bay, 1993) and more dramatically after stricter prescribing regulations were enforced in 1988, with subsequent declines in dextropropoxyphene death rates by 45% between 1986 and 1992.

Paracetamol Toward the end of 1998, new laws were introduced in the United Kingdom to try to reduce the number of paracetamol overdoses. These laws banned pharmacies from selling packs of paracetamol containing more than 32 tablets and other shops from selling packs with more than 16 tablets. Following the introduction of these laws, the number of deaths by paracetamol overdose in the United Kingdom dropped. Whether the decline in deaths came about as a result of the new laws on paracetamol pack size, however, remains a contentious issue. On the one hand, prominent researchers have published studies suggesting benefits not only in declines in the frequency of liver transplants (a proxy for overdoses that would prove deadly

otherwise; Hawton et al., 2001), but also in declines in overall poisoning deaths (Hawton, 2002; Prince, Thomas, James, & Hudson, 2000; Robinson, Smith, & Johnston, 2000; Sheen, Dillon, Bateman, Simpson, & MacDonald, 2002; Turvill, Burroughs, & Moore, 2000). Consider, for example, the study with the longest follow-up (Hawton et al., 2013). In this interrupted times series, there was a 43% reduction in poisoning death rates following the legislation and through 2009, compared with the prelegislation period (1993–1998). This decrease was largely unaltered after controlling for a nonsignificant reduction in deaths involving other methods of poisoning and suicides by all methods.

On the other hand, other researchers (Bateman, 2009; Morgan, Griffiths, & Majeed, 2007) have published analyses that call these claims into question. For example, Morgan et al., (2007) reexamined national data and found that when comparing trends for paracetamol deaths with other poisoning or suicide deaths, the fall in paracetamol deaths was similar to the overall trend in poisoning and suicide death rates, and, furthermore, that the reduction in paracetamol-related deaths preceded implementation of the legislation (Morgan, Griffiths, & Majeed, 2005). In a separate study, Bateman et al. (2006) analyzed data from Scotland and found no evidence of an effect of the legislation on deaths (Bateman et al., 2006; Sheen et al., 2002). As Hawkins et al. (2007) noted in an excellent review of the literature, the limited number of studies, the short-term follow-up, the difficulty in clearly differentiating between the paracetamol preparations covered by the legislation and those preparation not covered in available data, make it difficult to feel confident about whether or not the legislation has been a success.

Summary The striking success in preventing suicides in Sri Lanka by reducing access to the most highly toxic pesticides is one of the strongest empirical arguments that suicide rates can be substantially reduced without necessarily targeting underlying mental health or suicidality. Evidence for the success of means restriction with pharmaceutical poisoning is stronger for compounds with higher case fatality ratios, such as pesticides and barbiturates, than for compounds with lower case fatality ratios, such as paracetamol. Nonetheless, reducing access to large quantities of commonly used compounds with relatively low case fatality ratio, as in the case of paracetamol, appear to have clinically meaningful benefits on morbidity.

Carbon Monoxide Poisoning

Domestic Gas Suicide by domestic gas, now uncommon, was the leading cause of suicide in England, Wales, and Scotland throughout the 1950s and early 1960s (Kreitman, 1976). In 1962–1963, for example, 43% of suicides in England and Wales, and approximately half of all suicides in Scotland, involved carbon monoxide poisoning from domestic gas. Between 1964 and 1972, sources of domestic gas in these countries changed, with the net result that, over this period, carbon monoxide levels in domestic gas were reduced from about 20% (a highly toxic level) to effectively zero, creating a natural experiment that put to test whether reductions in the toxicity of a leading method of suicide could reduce overall suicide rates.

Building on early work by Hassall and Trethowan (1972) in Birmingham, England, Kreitman (1976) analyzed data from England and Wales and, separately, from Scotland, for the years 1960–1971. He found that aggregate-level reductions in the

carbon monoxide content of domestic gas over time were associated with a steep decline in suicide by domestic gas, accompanied by a 30% drop in overall suicide in England and Wales (and a smaller drop in Scotland). The magnitude of the decline in overall suicide rates varied by age and gender (greatest among older males, least among young women), but was of sufficient size to reduce overall suicide in all age- and sex- subgroups.

Subsequent analyses by Kreitman and others (Gunnell, Middleton, & Frankel, 2000; Kreitman & Platt, 1984) extended these analyses. In the first of these studies, Kreitman and Platt (1984) concluded that the co-occurrence of increases in unemployment in the United Kingdom with declines in suicide strengthened the inference that declines in suicides by domestic gas had been responsible for declines in suicide over the period. Indeed, it was the inverse association between rates of unemployment and suicide in the United Kingdom, not seen in other European nations over the same period, that called for a closer inspection of method-specific suicide rates in the United Kingdom. In a careful analysis of data more disaggregated than those examined by Kreitman (1976), Gunnell et al. (2000) found that as the toxicity of domestic gas declined, and domestic gas poisoning suicides decreased, suicides involving drug poisoning increased—though to a lesser extent—with the net effect, as Kreitman reported, that reductions in domestic gas suicides were accompanied by a large reduction in overall suicides.

In other countries in which the carbon monoxide content of domestic gas also changed, the proportion of all suicides accounted for by domestic gas, though never as high as that in the United Kingdom, declined in tandem with reduced carbon monoxide levels in the gas supply (Burvill, 1980, 1990; Lester, 1990a, 1990b, 1991; Lester & Abe, 1989; Nordentoft, Qin, Helweg-Larsen, & Juel, 2007). In Australia, for example, Burvill (1980, 1990) found that declines in domestic gas suicide were accompanied by increases in suicide by exhaust gas among men, but not women. Similarly, a study in Denmark found that the decline in suicides using domestic gas was partially offset by increases in suicide using automotive exhaust among men, but not among women (Nordentoft et al., 2007).

Charcoal Burning The incidence of suicide by charcoal burning, which represented no more than 1% of all suicides throughout East/Southeast Asia in the mid-1990s, has increased dramatically over the past decade and a half. In Hong Kong, where the widespread use of this method of suicide appears to have begun after a highly publicized suicide in the context of an acute economic downturn (Law, Yip, & Caine, 2011), the proportion of all suicides accounted for by charcoal burning increased rapidly from near zero in the late 1990s to a peak of more than 25% of all suicides by 2003 (Chang et al., 2014; Chen, Yip, Lee, Gunnell, & Wu, 2015; Pan, Liao, & Lee, 2010), before falling to 13% by 2011 (Chang et al., 2014). Over the same time period in Taiwan, the percentage of all suicides that involved charcoal burning increased from a similar baseline to more than 30% (Chang et al., 2014; Chen et al., 2015; Pan et al., 2010) by 2006 before falling to 24% by 2011 (Chang et al., 2014). Charcoal burning, as of the time this manuscript was written, represented a significant proportion of all suicides in other East/Southeast Asian countries as well. For example, approximately 10% of all suicides in Japan (Yoshioka, Hanley, Kawanishi, & Saijo, 2014) involved charcoal burning, as did 8% of those in Korea (Chang et al., 2014; Lee, Ahn, Lee, Park, & Hong, 2014).

Contemporaneous with increases in charcoal-burning suicide, rates of suicide overall rose across the East/Southeast Asia region through the early 2000s. In some countries in which charcoal burning represented a large enough percentage of overall suicides to plausibly affect not just method-specific but overall suicide rates (e.g., Hong Kong and Taiwan), the increase in overall suicide appears to have been driven primarily by increased rates of charcoal-burning suicide (Chan, Yip, Au, & Lee, 2005; Chang et al., 2014; Liu et al., 2007; Pan et al., 2010). However, findings are not consistent across all countries (Chang et al., 2014) and time periods (Chang et al., 2014; Law et al., 2011), nor are they consistent across age and sex strata (Chen et al., 2015; Law et al., 2011; Yoshioka et al., 2014). In the absence of a measure of exposure (not least how that exposure has changed, particularly during later periods of declining suicide rates), conclusions from the literature on charcoal burning remain suggestive, but inconclusive.

The most significant challenge to assessing whether changes in the availability of charcoal burning as a method of suicide are associated with increases in method-specific and overall suicide rates is to model changes in "exposure." Several scholars have suggested that media coverage of charcoal burning as a suicide method may not only have communicated technical information about how to use the method, but also increased its acceptability. Chang et al. (2010), in a study of patterns of suicide by method in Taiwan, found that increases in charcoal-burning suicide in Taiwan were concentrated in urban areas, were significant enough to substantially influence the urban–rural suicide gradient in that country over time, and were distributed in a pattern consistent with gradients in media exposure. In a later paper, Chang et al. (2014) suggest that temporal patterns in the diffusion of charcoal burning through East/Southeast Asia may be explained in part by variation in how and in what language charcoal-burning suicides were reported.

Two studies have explored the relationship between media coverage and the incidence of charcoal-burning suicide using direct measures of reporting. In the first of these studies, Chen, Chen, Gunnell, and Yip (2013) assessed the association between the intensity of newspaper reporting of charcoal-burning suicides and the incidence of charcoal-burning suicide in Taiwan (1998–2002). Using the number of newspaper stories per charcoal-burning suicide as their measure of the intensity of reporting, and next-day suicides as their outcome, the authors found that each additional newspaper report of a charcoal-burning suicide was associated with a 16% increase in next-day suicide by that method. The effect of media reporting on charcoal burning was apparent in the early period of increasing rates of charcoal-burning suicide in Taiwan, but the association did not persist beyond 2002. The second study, by Lee et al. (2014) in Korea in 2007–2011, used a monthly measure of the number of (a) posts regarding charcoal-burning suicides and (b) user-initiated Internet searches to assess the relationship between rates of charcoal-burning suicide and "media" thus defined. The authors found that an initial spike in both Internet postings and Internet searches in 2008 were coincident with a sudden and then persistent increase in charcoal-burning suicides, but that the relationship between media and uptake of charcoal burning after this inflection point is noninformative.

Although the mechanism by which charcoal-burning suicide became a commonly used method of suicide has not been well characterized, a single, cluster randomized controlled trial lends credence to the notion that reducing physical access to this method may nonetheless be an effective method of reducing rates of suicide. In this study, Yip et al. (2010) selected two geographically adjacent districts with similar demographic and socioeconomic characteristics, randomizing one to intervention

status and the other to serve as a control. In the intervention district, charcoal was removed from the shelves of most retail stores, requiring customers who wanted to buy charcoal to ask for it from a clerk, whereas in the control district, charcoal was available as usual. In a comparison of suicide rates (by method, gender, and age) in the year before the intervention to suicide rates in the year of the intervention, overall suicide rates fell significantly from 17.9 to 12.2 per 100,000 in the intervention district, whereas rates in the control district remained stable (12.7/12.5). Moreover, the decline in the intervention district was driven by a statistically significant decline in charcoal-burning suicides (4.3 to 2 per 100,000), with a nonstatistically significant decrease in suicide rates by other methods (13.6 to 10.2). By contrast, in the control district, there were nonstatistically significant increases in charcoal-burning suicide rates accompanied by nonsignificant decreases in suicide by other methods.

Motor Vehicle Exhaust Gas (Catalytic Converters) Catalytic converters for automobiles, developed in a form suitable for widespread use in the early 1970s, substantially reduce the amount of carbon monoxide (and other pollutants) released in automotive exhaust. Many countries, beginning with the United States in 1975, established emissions standards for automobiles as a means of reducing air pollution, leading car manufacturers to include catalytic converters in new cars manufactured for sale in locales affected by these regulations. A felicitous consequence of lower levels of carbon monoxide in motor vehicle exhaust gas (MVEG) was that MVEG became a less efficient method of suicide. Because automobiles have a limited useful life and a measurable "replacement rate" (i.e., the proportion of the stock of cars that is represented by new cars in a given year), new emissions regulations in the United States, the United Kingdom and Europe, Switzerland, and Australia created natural experiments that allowed researchers to assess the impact of reducing ready access to highly toxic levels of carbon monoxide through MVEG on suicide rates involving asphyxiation.

Time-series studies from the United Kingdom (Amos, Appleby, & Kiernan, 2001; Kendell, 1998; McClure, 2000; Skilling, Sclare, Watt, & Fielding, 2008), US (Mott et al., 2002), Switzerland (Hepp et al., 2010), Denmark (Thomsen & Gregersen, 2006), and Australia (Brennan, Routley, & Ozanne-Smith, 2006; Routley & Ozanne-Smith, 1998) have explored the relationship between declining MVEG and suicide rates due to asphyxiation, comparing rates pre- and post-promulgation of emissions standards. All but one of these studies (Routley & Ozanne-Smith, 1998) observed a substantial fall in MVEG suicide rates following introduction of catalytic converters (Amos et al., 2001; Hepp et al., 2010; Mott et al., 2002; Skilling et al., 2008). However, even among those studies that provide data on the proportion of vehicles with catalytic converters at a point in time, none attempt to explicitly measure and account for the variation in exposure provided by such data. The study that comes closest to modeling exposure explicitly, by Studdert, Gurrin, Jatkar, and Pirkis (2010), compared suicide rates across areas of Australia with fewer versus more noxious (i.e., older) vehicles per capita and found a strong positive association between the area-level prevalence of older cars and rates of suicide by MVEG. Although the authors note that their findings are consistent with declines in MVEG suicides contributing to the sharp decline in national rates of overall suicide in Australia, they do not address this question directly.

Summary The evidence that reductions in the toxicity of domestic gas resulted in declines in overall suicides in the United Kingdom is among the most persuasive

natural experiments that speak to the potential that reducing the lethality of a commonly used suicide method can dramatically affect population-level suicides rates. Without an adequate measure of exposure, or measurable variation in exposure, the literature on the relationship between charcoal burning and suicide is suggestive, but not conclusive. In particular, although the near instantaneous rise in charcoal burning as a method of suicide in countries such as Hong Kong and Korea seem to suggest a specific inflection point in the cognitive availability of charcoal burning as a method of suicide—possibly attributable to media reporting—few data are available to test this hypothesis, and more recent declines in rates of charcoal-burning suicides in locations such as Hong Kong and Taiwan have not been well explained. Modeling carbon monoxide exposure from MVEG is also problematic, rendering evidence from studies of the effect of catalytic converters on suicide rates suggestive but inconclusive.

Jumping

Jumping represents a small percentage of all suicides in the locales in which reducing access to jumping has been studied to date. Indeed, with the exception of city-states, such as Hong Kong and Singapore, jumping is a relatively rare (<10% total) method of suicide (Gunnell & Nowers, 1997); deaths from specific hotspots are fewer still. Accordingly, the empirical studies reviewed below do not examine whether overall suicide rates are affected by restricting access to jumping at one or several sites. Rather, they examine whether reducing access to jumping from one site, often, but not always an iconic site, reduces jumping suicides overall (in a given area).

Jumping from man-made structures (e.g., bridges and viaducts) and natural points of elevation (e.g., cliffs) is highly lethal. Suicides by jumping often receive prominent media coverage (Hamilton, Metcalfe, & Gunnell, 2011; Pirkis & Blood, 2001; Vyrostek, Annest, & Ryan, 2004), which may increase the risk of copycat acts (Chen, Wu, & Yip, 2011). Structural barriers and safety nets have been put in place at some of these sites in an effort to reduce suicides by jumping (Beautrais, 2007; Gunnell & Nowers, 1997), a prevention approach that has been opposed by critics who object to such efforts on the basis of monetary and aesthetic cost (Beautrais, 2001; Beautrais, Gibb, Fergusson, Horwood, & Larkin, 2009; Friend, 2003), an argument often accompanied by the belief that such barriers merely shift jumping suicides to other sites or methods that are just as likely to prove lethal (Friend, 2003).

A recent meta-analysis of the existing literature by Pirkis et al. (2013) covered 11 studies: 5 studies of barriers installed on bridges or viaducts—the Grafton Bridge (Auckland, New Zealand), the Clifton Suspension Bridge (Bristol, the United Kingdom), the Ellington Bridge (Washington, DC), the Memorial Bridge (Augusta, ME), and the Bloor Street Viaduct (Toronto, Canada); 2 studies on the effectiveness of fencing off road access to cliffs—Lawyers Head Cliff (Dunedin, New Zealand) and Beachy Head (Sussex, the United Kingdom); and 1 of installing a safety net below the top of Muenster Terrace (Bern, Switzerland). In the meta-analysis, pre-intervention, there was a mean of 5.7 deaths per year. Post-intervention, there was a mean of 0.5 deaths per year. The overall effect of the introduction of the interventions was an 86% reduction in the number of jumping suicides per year from the study site where barriers were installed. At other jump sites in the same cities, there was a mean of 2.8 deaths per year, and the interventions were associated with a 44% increase in the number of jumping suicides per year at nearby sites. When all jumping suicides were

considered in aggregate (i.e., those at the sites under study and those at nearby sites), the net overall effect of jump-site interventions was significant, reducing the number of deaths per year by jumping from heights by 28%.

Summary Studies about jumping from heights illustrate and underscore how much we still need to learn about what determines method choice in addition to access to a particular method. For example, as the authors of a study that failed to show an effect of a barrier at the Bloor Street Bridge point out, people who jump from bridges that, like the Bloor Street Bridge, span hard surfaces (rather than water) and do not have the iconic status or aesthetic distinction of the Golden Gate or Clifton Suspension Bridge, may differ from those who jump from iconic sites. Further exploration of the role of method choice in suicidal acts, and the interplay between physical and cognitive access in this choice, is badly needed.

Firearms

Firearms are the leading method of suicide death in the United States and, as such, data from the United States are used in the vast majority of studies on the relationship between access to firearms and suicide that meet eligibility criteria. Of note, we include only those studies that used validated measures of firearm exposure or validated proxies of firearm exposure. These include individual-level case-control studies; cross-sectional ecologic studies that compare suicide rates among populations with differing levels of firearm ownership; ecologic time-series studies that compare suicide rates over a time during which firearm exposure at the population level changed appreciably; and cohort studies that measure firearm exposure in a defined population at baseline and observe suicide risk over time. We did not include studies of firearm-related legislation, because these studies have not measured whether actual exposure to firearms changed in relation to legislation. Moreover, given that the stock of U.S. firearms is so large relative to the marginal firearm likely affected by the kinds of legislation studied to date, we were, in the absence of validated confirmatory measures, unwilling to assume that firearm exposure changed sufficiently to warrant inferences one way or the other about the effects of legislation. For a more detailed and discursive review of the early literature on firearms and suicide, see Brent (2001) and Miller and Hemenway (1999).

Firearm suicide rates and overall suicide rates in the United States are higher where guns are more prevalent (Lubin et al., 2010; Miller, Barber, White, & Azrael, 2013). By contrast, rates of suicide by methods other than firearms are *not* significantly correlated with rates of household firearm ownership (Miller et al., 2013). This pattern has been reported in ecologic studies that have adjusted for several potential confounders, including measures of psychological distress, alcohol and illicit drug use and abuse, poverty, education, and unemployment (Miller, Azrael, & Barber, 2012; Miller, Hemenway, & Azrael, 2004; Miller, Lippmann, Azrael, & Hemenway, 2007), and even when controlling for underlying suicide attempt rates (Miller et al., 2013). Earlier studies that relied on validated cross-sectional proxies of firearm ownership showed similar relationships (Miller, Azrael, & Hemenway, 2002a, 2002b, 2002c).

Between 1981 and 2002, household firearm ownership in the United States fell from approximately one in two households to one in three households—a change in exposure to firearms that created a natural experiment exploited by one team of

researchers to examine how changes in firearm prevalence are related to changes in suicide by firearms, suicide by nonfirearm methods, and overall (Miller, Azrael, Hepburn, Hemenway, & Lippmann, 2006). Using panel data at the regional level, a strong and significant relationship was found between declines in household firearm ownership and declines in rates of firearm suicide and overall suicide; rates of nonfirearm suicide had an indifferent relation to changes in firearm prevalence. The authors noted that the declines in household firearm ownership and suicide rates occurred over a period when other investigators, using individual-level data from national surveys, found no changes in the prevalence of underlying mental illness, suicidal ideation, and suicide attempts (Kessler, Berglund, Borges, Nock, & Wang, 2005).

Household firearm ownership has also been consistently found to be a strong predictor of suicide risk in studies that examined individual-level data. Every U.S. case-control study has found that the presence of a gun in the home or purchase from a licensed dealer is a strong risk factor for suicide (Bailey et al., 1997; Brent et al., 1993; Brent et al., 1991; Brent et al., 1988; Brent et al., 1994; Conwell et al., 2002; Cummings, Koepsell, Grossman, Savarino, & Thompson, 1997; Grassel, Wintemute, Wright, & Romero, 2003; Kellermann et al., 1992; Kung, Pearson, & Liu, 2003; Wiebe, 2003). The relative risk is large, varying from twofold to tenfold depending on the age group and how firearms are stored in the home, and applies not only to the firearm owner but to all other household members as well (Anglemyer, Horvath, & Rutherford, 2014; Brent et al., 1991; Conwell et al., 2002; Grossman et al., 2005; Kellermann et al., 1992; Miller & Hemenway, 1999). Of note, other individual-level studies have found that members of households that contain firearms do not have higher rates of psychiatric illness, substance use disorders, suicidal ideation, or suicide attempts—or any other established risk factor for suicide (i.e., except for living in a home with firearms; Ilgen, Zivin, McCammon, & Valenstein, 2008; Miller, Barber, Azrael, Hemenway, & Molnar, 2009; Sorenson & Vittes, 2008).

Individual-level studies that have examined method-specific suicide risk have found that the relationship between firearm availability and overall suicide is driven by the relationship between firearm availability and firearm suicide (Cummings et al., 1997; Wiebe, 2003; Wintemute, Parham, Beaumont, Wright, & Drake, 1999). Other studies suggest a dose–response relationship: with guns stored less safely conferring higher risk (Conwell et al., 2002; Grossman et al., 2005; Shenassa, Rogers, Spalding, & Roberts, 2004).

The only large U.S. cohort study to examine the firearm–suicide connection found that suicide rates among California residents who purchased handguns from licensed dealers were over twice as likely to die by suicide as were age- and sex-matched members of the general population (Wintemute et al., 1999). Here too, the increase in suicide risk was attributable entirely to an excess risk of suicide with a firearm. Risk of suicide was elevated not only immediately after the purchase, but throughout the 6-year study period (Wintemute et al., 1999), consistent with findings in a case-control study by Cummings et al. (1997), in which the relative risk for suicide given a family handgun purchase was greatest within the first year after purchase but remained elevated throughout the 5-year study period.

There has been a single study to date, in Israel, examining a targeted intervention designed to reduce exposure to firearms sufficiently to effect suicide rates (Lubin et al., 2010). The intervention in question was a response to high suicide rates among Israeli Defense Force (IDF) personnel and the observation that a disproportionate number of suicides among IDF soldiers occurred on weekends when soldiers were on

leave. The IDF changed its policy in 2006, requiring soldiers to leave their firearms at their bases when headed home for weekend leave. The suicide rate decreased by 40%; weekend firearm suicides fell significantly, with no significant change in weekday suicides, and no change in nonfirearm suicides.

Summary The places in the United States where suicide rates are highest are not places where more adults and children have higher rates of mental illness. Neither are they places where more people think about suicide, plan suicide, or even attempt suicide. Instead, they are places where more Americans live in homes with firearms and where suicide attempts, on average, are far more likely to prove fatal. The case-control literature mirrors the ecologic literature in direction and magnitude. The consistency of findings across different populations, using different study designs, and across different time periods is striking.

Conclusion

Taken as a whole, the literature reviewed here suggests that ready access to highly lethal suicide methods imposes a suicide risk above and beyond the risk that would otherwise apply were access to these methods made more difficult. Using data from diverse places and times, the studies reviewed here that meet our primary eligibility criteria find a strong and consistent relationship between access to a variety of commonly used, physically and cognitively accessible methods of suicide and rates of both method-specific and overall suicide.

Studies that allow assessment of a hierarchy of suicide risk within a given method find something akin to a dose–response relationship. For example, firearms in the home not only increase suicide risk relative to the absence of firearms, but among households with firearms, those households in which firearms are stored more securely have lower suicide risk than those households in which firearms are stored unlocked and loaded. Similarly, where a particular method has differential human toxicity, be it the carbon monoxide content of domestic gas and car exhaust, or the human toxicity of different formulations of a pesticide, where and when toxicity is lowest, so too will be the risk of suicide. Overall, the research summarized here strongly confirms the World Health Organization's (2014, p. 9) assertion that "means restriction works," specifically, that when access to a highly lethal method (or the lethality of a given method) declines, both method-specific and overall suicide rates can be expected, at least in the short run, to decline commensurately.

The question that remains, however, is how to act on the promise of reducing access to lethal means as a suicide prevention strategy. From a global perspective, reducing access to highly toxic pesticides will save more lives than any other approach. The good news here is that the capacity to reduce access and save lives from pesticide poisoning often resides in a centralized mechanism—to save tens if not hundreds of thousands of lives a year requires action by a relatively small number of decision makers. For other leading suicide methods, such as firearms in the United States, suicide prevention approaches that aim to reduce ready access require motivating not a few dozen members of a bureaucracy, but tens of millions individual decision makers. Unfortunately, the evidence base to guide the latter type of approach is sorely lacking, and research in this area should be a high priority.

Overall, the studies reviewed here suggest that whether access to highly lethal methods is reduced by legislation, fiat, or through interventions that affect individual decision making, suicide risk can be dramatically reduced. Because saving someone's life in the short run is very likely to save their life in the long run, strategies that reduce access to highly lethal, cognitively or physically accessible methods of suicide can have profound effects on population-level suicide rates.

Key Resources

1. Means Matter—http://www.hsph.harvard.edu/means-matter/
2. Office of the Surgeon General (US); National Action Alliance for Suicide Prevention. (2012). *National Strategy for Suicide Prevention: Goals and objectives for action: A report of the US Surgeon General and of the National Action Alliance for Suicide Prevention*. Washington, DC: US Department of Health & Human Services.
3. World Health Organization. (2014). Preventing suicide: A global imperative. http://www.who.int/mental_health/suicide-prevention/world_report_2014/en/.

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