

Analysis of the Cost Effectiveness of a Suicide Barrier on the Golden Gate Bridge

Dayna Atkins Whitmer and David Lauren Woods

Human Cognitive Neurophysiology Research Laboratory,
VA Northern California Healthcare Outpatient Clinic, Martinez, CA, USA

Abstract. *Background:* The Golden Gate Bridge (GGB) is a well-known “suicide magnet” and the site of approximately 30 suicides per year. Recently, a suicide barrier was approved to prevent further suicides. *Aims:* To estimate the cost-effectiveness of the proposed suicide barrier, we compared the proposed costs of the barrier over a 20-year period (\$51.6 million) to estimated reductions in mortality. *Method:* We reviewed San Francisco and Golden Gate Bridge suicides over a 70-year period (1936–2006). We assumed that all suicides prevented by the barrier would attempt suicide with alternative methods and estimated the mortality reduction based on the difference in lethality between GGB jumps and other suicide methods. *Cost/benefit analyses* utilized estimates of value of statistical life (VSL) used in highway projects. *Results:* GGB suicides occur at a rate of approximately 30 per year, with a lethality of 98%. Jumping from other structures has an average lethality of 47%. Assuming that unsuccessful suicides eventually committed suicide at previously reported (12–13%) rates, approximately 286 lives would be saved over a 20-year period at an average cost/life of approximately \$180,419 i.e., roughly 6% of US Department of Transportation minimal VSL estimate (\$3.2 million). *Conclusions:* Cost-benefit analysis suggests that a suicide barrier on the GGB would result in a highly cost-effective reduction in suicide mortality in the San Francisco Bay Area.

Keywords: VSL, lethality, San Francisco, suicide prevention, demographics

Since its opening in 1937, the Golden Gate Bridge (GGB) has become both a tourist attraction, with more than 1.5 million tourists walking its span every year, and increasingly a “suicide magnet” with over 1,400 confirmed victims of suicide. Over a 70-year period, GGB suicides have shown a monotonic increase in incidence, with over 30 deaths occurring annually for each of the past 5 years (2005–2010). Suicides on the GGB surpass the combined totals of lives lost by jumping from the Eiffel Tower, the Clifton Bridge, the Grafton Bridge, and the Empire State Building. However, unlike these other sites, the Golden Gate Bridge lacks a physical suicide barrier. In March 2010, the Golden Gate Bridge Highway and Transportation District (GGBHTD) authorized the construction of a physical barrier to reduce GGB suicides. Construction costs were estimated at \$50 million, with \$78,000 in annual maintenance costs.

In order to evaluate the cost effectiveness of a suicide barrier, we first reviewed the epidemiological data of SF and GGB suicides. Reductions in mortality were estimated from the differences in lethality of GGB jumps and attempted suicides using alternative methods. In the current report, we adopted the conservative assumption that 100% of individuals prevented from jumping from the GGB would attempt suicide using alternative methods.

In evaluating the cost effectiveness of a suicide barrier we reviewed the United States Department of Transportation (USDOT) estimated value of a statistical life (VSL). The VSL is widely used in evaluating the cost/benefit of highway construction projects and laws affecting traffic safety, e.g., safety belts in cars, motorcycle helmets and child-safety seats. The VSL incorporates estimates of wages and salaries lost through injury or death. The USDOT estimated dollar value of the VSL in 2009 was \$6.0 million “based on the Wages and Salaries component of the Employment Cost Index, in constant dollars, and the Consumer Price Index (CPI-U).” The USDOT notes that the VSL may show regional differences and suggests that analyses incorporate low and high VSLs when calculating cost benefits, \$3.2 and \$8.4 million, respectively (United States Department of Transportation, Office of the Secretary of Transportation (USDOT), 2009).

Method

Knowing the lethality of suicide methods is critical for estimating the number of lives saved when an individual

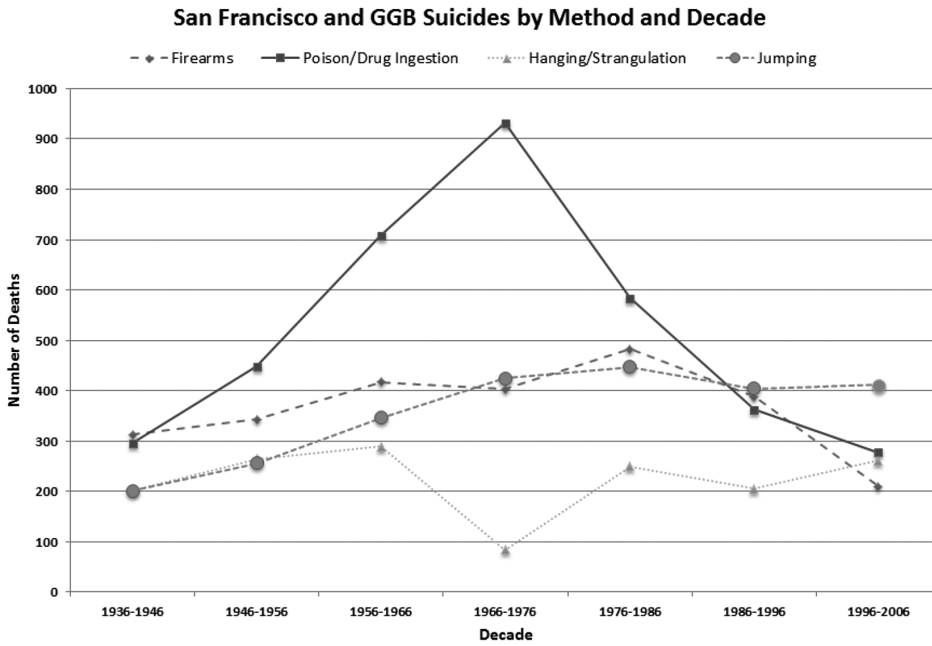


Figure 1. Suicide method by decade for San Francisco including Golden Gate Bridge jumps.

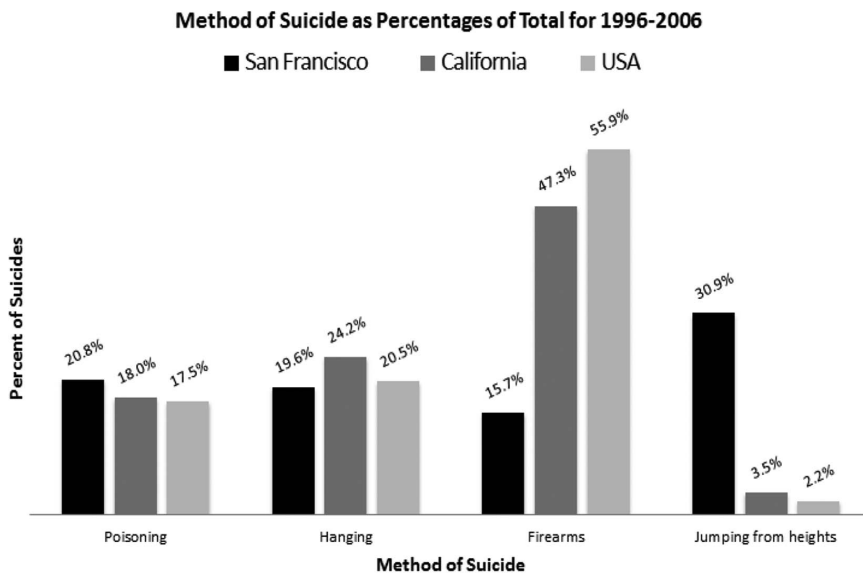


Figure 2. Comparison of suicide methods of San Francisco to California and United States.

substitutes another method of suicide instead of jumping from the GGB. We reviewed suicide data obtained from the San Francisco Medical Examiner’s annual reports from 1936–2006. This included the demographics of victim sex, age, ethnicity, and lethality among the four major methods of suicide.

A few years were unavailable for review, and after 1969 some data (e.g., marital status, residency, and nativity) were incompletely reported. These data were supplemented with data of GGB suicides from the Marin County Coroner’s office from 1991 through 2009. Finally, older studies of GGB and other San Francisco suicides were also reviewed (Cohen, 1965; Wendling, 1954). The data were grouped into decades beginning in 1936, just before the opening of the GGB in May 1937.

We estimated mortality reductions due to the GGB barrier using data from the California Department of Health and San Francisco Department of Health, based on the number of fatalities by method compared to self-inflicted, nonlethal injuries serious enough to require hospitalization. This approach overestimates the true lethality of most methods, since some failed suicide attempts do not result in hospital admission. Estimates of the number of lives saved and the cost of barrier construction and maintenance were used to calculate the cost per life saved over a 20-year period. The cost-effectiveness of a suicide barrier was compared to value of a statistical life (VSL) estimates from the United States Department of Transportation. Considerations of lethality of substitution methods and repeat suicide attempts were integrated into the analysis.

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Table 1. Total suicides by method in San Francisco per decade

Method	1936–1946	1946–1956	1956–1966	1966–1976	1976–1986	1986–1996	1996–2006
Firearms	314	358	417	474	465	388	209
Poison/drug/CO2 ingestion	310	471	817	1046	584	404	277
Hanging/strangulation/asphyxiation	276	311	338	304	269	285	312
Jump from heights (all)	201	252	363	461	447	404	411

Note. Top four methods of suicide only – excludes miscellaneous suicides.

Results

San Francisco and Golden Gate Bridges Suicides

Figure 1 shows the overall suicide rate in San Francisco over the past 70 years with the rates of suicide by the top four methods.

San Francisco suicide rates are similar to state and national averages, with one exception: The relative incidence of suicides by jumping from heights, including the GGB, are respectively 8.8 and 13.9 times higher than state and national averages, as shown in Figure 2. Indeed, San Francisco suicide deaths by jumping represented 33.1% of all jump-related suicide in California from 1996–2006.

Incidence and Method of Suicides in San Francisco

In San Francisco in 1900 and 1904 the suicides rates were 49.9 and 72.6 per 100,000, respectively (Pilgrim, 1907). Since that time, the suicide rate has decreased dramatically. In the most recent decade, San Francisco experienced the lowest rate of suicide in over 100 years at 16.6 per 100,000.

As Table 1 shows, the most frequent suicide method was self-poisoning, which more than tripled in incidence from 1936 to 1976 (Cohen, 1965) and then sharply declined. Since 1962, when San Francisco Suicide Prevention services were initiated, the San Francisco suicide rate has dropped by nearly 40% (San Francisco Suicide Prevention (SFSP), 2011) with particular dramatic decreases in self-poisoning.

Firearms were the second most utilized method until the 1966–1976 decade, when increasingly strict gun-control laws limited firearm access. Thereafter, there was a steep decline in firearm suicides so that in the final decade of 1996–2006, firearms became the fourth most frequent method of suicide. Hanging/suffocation was the third most frequent method from 1938–1942, but increased in 1996–2006, when it caused more fatalities than either firearms or poisoning.

Jumping from heights showed a gradual increase over the first three decades (1936–1966) and did not decrease as much as other methods in the 1986–1996 decade to become the most lethal method of suicide in San Francisco during the last decade.

Overall jumping deaths did not significantly change in the last decade reviewed, despite a significant decrease in jumping from all other structures than the GGB. Jumping from the GGB had averaged of 4–11 suicides per year over the first 3 decades, but climbed to 20 per year during the 1976–1986 period and has continued to increase to over 30 per year in the last 5 years. As a result, the majority of San Francisco suicides due to jumping from heights in the final decade were from the GGB (59.4%), as shown in Figure 3. GGB suicides alone (244) surpassed total suicides by firearms (209) and approached the suicide total for self-poisoning (277). Indeed, during the most recent decade GGB suicides accounted for 20% of all suicides by jumping in California. From 2000 through 2009, there were also 59 potential suicides (witnessed or suspected jumps without body recovery). These were not included in our analyses as full information was unavailable.

The current methods for preventing suicide on the GGB are guardian interventions. Foot patrols were started in 1966 by Golden Gate Bridge Patrol (GGBP). The pedestrian walkway was closed at dusk beginning in 1970, to prevent late-night suicides. In the 1970s, the addition of bicycle and motorcycle patrols were begun in conjunction with the California Highway Patrol (CHP). Training in suicide prevention has also been implemented for bridge staff. Crisis telephones were installed in 1980 that enabled the GGBP Sergeant's office to dispatch trained staff to potential suicide victims on the bridge and alert the CHP. Closed circuit cameras were also installed to monitor traffic flow and on occasion to alert first responders to suspicious behavior of individuals.

These interventions proved effective in preventing in aborting more than two-thirds of GGB potential suicides. From 2000 to 2010, there were 697 people removed from the bridge because of suicidal intent (Golden Gate Bridge Highway and Transportation District, 2010), including 90 persons in 2007 alone. Nevertheless, the number of GGB suicides has continued to increase.

Demographics of San Francisco Suicides

Over the past 70 years the ratio of male to female suicides in San Francisco varied slightly from 2.75–3 to 1. This is below the overall male/female ratios for California in the final decade (3.57 to 1) and below the national ratio of 4.15 to 1 (Centers for Disease Control and Prevention, 2003, 2009).

Table 2. Ethnicity as percent of suicide and population in San Francisco per decade

Decade	1936–1946	1946–1956	1956–1966	1966–1976	1976–1986	1986–1996	1996–2006
Year of census	1940	1950	1960	1970	1980	1990	2000
Caucasian % of suicides	92	94	93	90	85	78	71
Caucasian % of SF population	95	89	82	62	47	40	39
Asian % of suicides	3	5	5	3	8	11	17
Asian % of SF population		4	8	13	22	29	31
African-American % of suicides	5	1	2	5	6	6	5
African-American % of SF population	1	6	10	13	13	11	8
Others % of suicides	0	0	0	2	0	2	2
Others % of SF population	4	1	0	2	6	6	9
Hispanic % of suicides					6	4	4
Hispanic % of SF population				10	12	13	14

Percentage of Suicides via Jumping from Heights at Different Locations

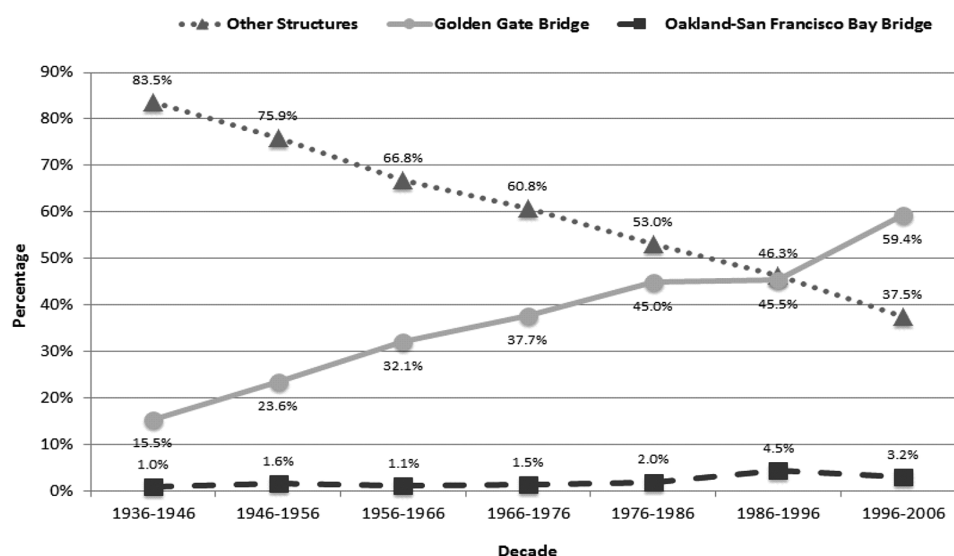


Figure 3. Suicide deaths by jump site per decade in the San Francisco.

The middle-age group of 30–59-year-olds remained the majority of victims of suicide in San Francisco, constituting 47% to 63% over these seven decades. The percentage of suicides in the 14–29 year age range rose significantly to 30% of all suicides in the 1976–1986 decade, a nearly four-fold increase in relative percentage from 1936. This is also reflected in national statistics where suicide is the third leading cause of death among persons 14–35 years (Centers for Disease Control and Prevention, 2003, 2009). The rate of suicides in the oldest age group (above 60 years) declined in frequency in San Francisco from 36% in 1946–1956 to 22% in 1996–2006.

Table 2 shows the ethnicities of San Francisco suicide victims. Although the percentage of Caucasians in the San Francisco population declined significantly, from 95% of the population in 1940 census to 39% in the 2000 census, there was only a minor decrease in the percentage of Caucasian victims among suicides in San Francisco: Caucasians continued to account for the overwhelming majority

of suicides (71%) in 1996–2006. Suicide rates for Caucasians in San Francisco were elevated by nearly 20% above the California Caucasian suicide rate and by 60% relative to the nationwide Caucasian suicide rate (Centers for Disease Control and Prevention, 2003, 2009).

Demographic Characteristics of Suicide Victims on the Golden Gate Bridge

The data provided by the death and investigational records from the Marin County Coroner's office over 18 years provided more specific information about GGB suicide victims. The majority of the GGB victims were male (75%), Caucasian (78%) and, by marital status, unattached (77%), either single (55%) or divorced or widowed (22%). There were 10% military veterans with service in various eras, from World War I through the Iraqi wars, including Operation Enduring Freedom. About 80% of the victims were

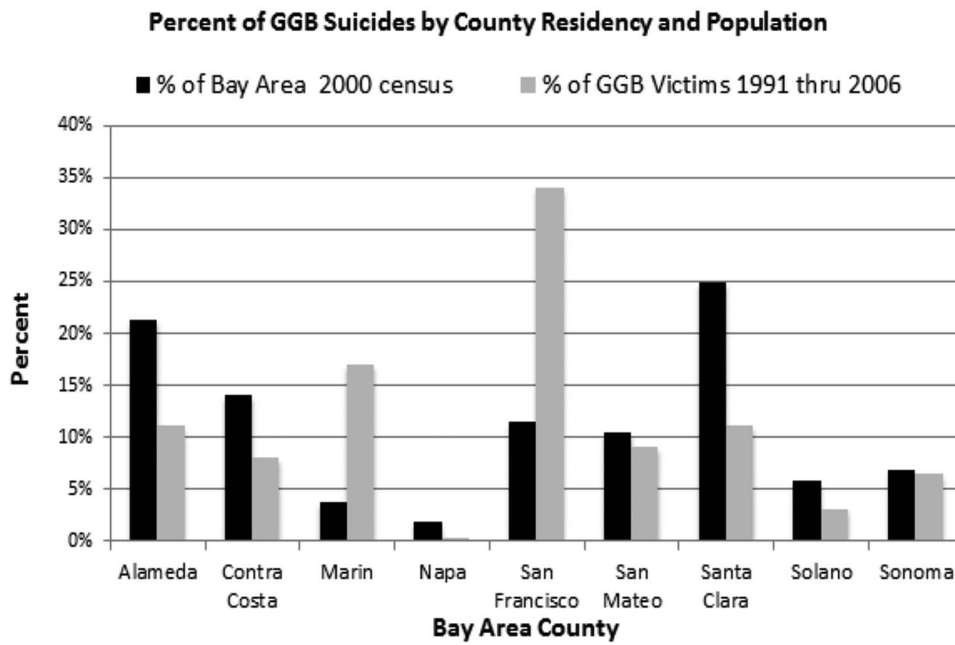


Figure 4. Golden Gate Bridge suicide victims as percentage of county of residence compared to percentage of county population for San Francisco Bay Area.

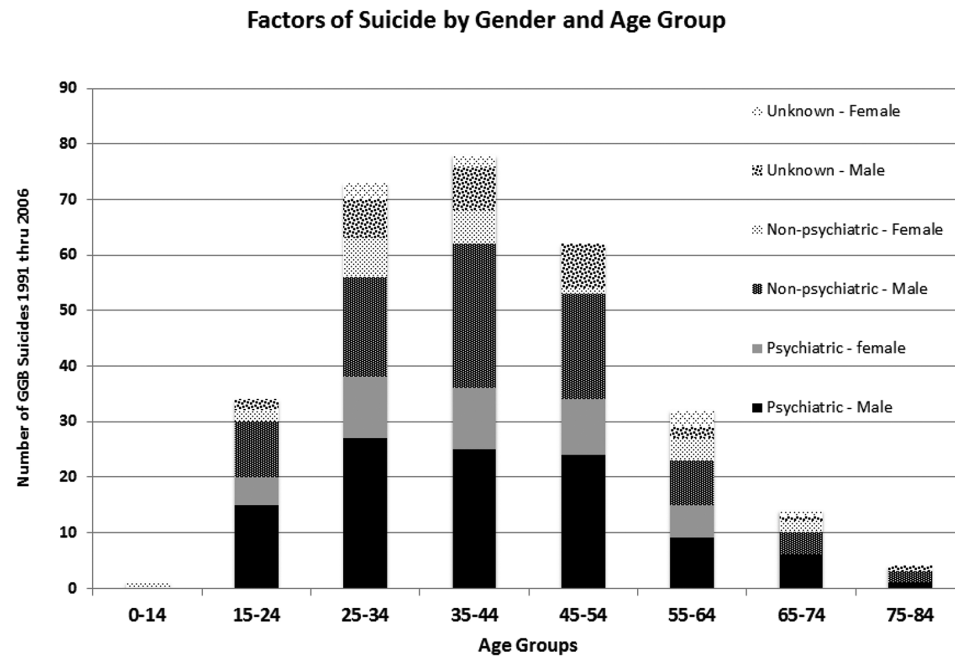


Figure 5. Influencing factors of suicide by sex and age group 1991–2006.

American born, with 37% of the total born in California. More than 94% of the victims were California residents with 83% residing within the San Francisco Bay Area.

Figure 4 shows the county of residence of Bay Area suicide victims. Overall, 34% were from San Francisco County, and 17% from Marin County, with other counties contributing less than 11% to the total. Although San Francisco and Marin county residents represent the majority of GGB victims (51%), they account for only 15.5% of the Bay Area population (2000 census, United States Census Bureau, 2000). Accessibility appears to play an important role: San Francisco and Marin Counties lie at the opposite ends of the GGB.

A review of coroner records classified potential causes for

suicides as psychiatric and nonpsychiatric factors. The psychiatric factors included findings of bipolar disorder, schizophrenia, psychosis, and depression. Nonpsychiatric factors included duress due to legal or financial problems, despondency due to emotional upsets (divorce, custody problems, arguments, loss of employment), and medical problems such as chronic pain or terminal cancer. Also included are “unknown factors” where no determination could be made.

Figure 5 indicates that 60% of the GGB victims had a known psychiatric disorder, similar to some previous reports (Schechter, Klassen, O’Connor, Potts, & Ochitill, 2005) but lower than others (Beautrais et al., 1996; Fleischmann, Bertolote, Belfer, & Beautrais, 2005). When compared by age

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Table 3. Lethality of suicide method weighted by frequency of method

1996–2006 method	Rate	Percent	Lethality	Weighted lethality
Poison/drug ingestion	3.61	20.80%	8%	1.66%
Hanging/strangulation	4.06	23.50%	89%	20.92%
Firearms	2.72	15.70%	95%	14.92%
Jumping (not GGB)	2.18	12.60%	47%	5.92%
Total	12.57	72.60%		43.42%

Note. Top four methods of suicide only – excludes miscellaneous and GGB suicides. Lethality = fatal/fatal + self-inflicted injuries requiring hospitalization.

groups, psychiatric factors exceed both the nonpsychiatric and unknown factors in nearly every age group. The 20–39 age group was the most likely to have a diagnosed mental disorder. The most commonly diagnosed or treated disorder was depression, accounting for 34% of all GGB suicides.

Suicide Method Lethality in San Francisco

Table 3 shows the lethality of San Francisco suicide attempts from 1996–2006 with the four most popular suicide methods, excluding GGB suicides. The lethality of different suicide methods varied substantially. A comparison of fatalities and suicide-related hospital admissions showed that the lethality of poisoning in the San Francisco area was only 8%, possibly because of controls of the quantity and strength of prescription and nonprescription drugs and the time it takes for poison to take effect, allowing rapid intervention by medical professionals. In contrast, hanging and suffocation were lethal 89% of the time. Although firearm suicide was 95% lethal (Rhyne, Templer, Brown, & Peters, 1995), it was rare in the San Francisco region because of limited firearm availability. Finally, jumping from sites other than the GGB was 47% lethal.

The lethality of jumps from the GGB (98%) was greater than that of any other suicide method (Lukas, Hutton, Lim, & Mathewson, 1981). Fatality of suicide attempts by jumping depends on the height of the structure, landing position, and the substance on which the body lands. Jumps from above the 50–60 feet are usually lethal with 50% mortality occurring for 30-foot (3rd floor) jumps (Buckman & Buckman, 1991). Lethality increases with height. The GGB is over 220 feet in height. Autopsies suggest that over 93% of GGB fatalities resulted instantly from impact trauma, with the remainder of victims drowning due to unconsciousness or the severity of injury (Snyder & Snow 1968).

Discussion

Suicide Method Substitution Following GGB Barrier Installation

Rosen (1975) interviewed seven of the 10 survivors of GGB jumps. Six of the seven survivors said the GGB was

their preferred site, and four stated they would not have attempted suicide anywhere else. The survivors noted the reasons for selecting the GGB were its easy access, lethality, and beauty.

Nevertheless, most suicidal individuals will attempt suicide with another method if a preferred method is unavailable. (Marzuk et al., 1992; Reisch, Schuster, & Michel, 2007). Assuming 30 GGB suicide attempts per year over a 20-year period with a lethality of 98%, there would be 600 attempts and 588 fatalities from GGB jumps in the 20-year cohort. The average lethality of non-GGB suicide attempts in San Francisco weighted by their frequency was 43.4%. Assuming that all GGB suicides substituted another method with average lethality, there would be approximately 260 fatalities from 600 attempts, i.e., 328 lives would be saved in the initial attempt.

Individuals who survive a suicide attempt are at risk for subsequent suicide. Studies of individuals who were prevented from jumping on the GGB found that 5% went on to commit suicide over a 26-year interval (Beautrais, 2003; Seiden, 1978). While some studies suggest that suicide survivors show smaller increases in subsequent suicide rate compared to the general population (Beautrais, 2007; Gunnell, Nowers, & Bennewith, 2005; Hawton, 2007; Pelletier, 2007), Suominen et al. (2004) found that 13% of 98 attempted suicides in Finland eventually become suicide victims over a 37-year period.

Runeson and colleagues (Runeson, Tidemalm, Dahlin, Lichtenstein, & Langstrom, 2010) also found an elevated incidence of suicide mortality among Swedes who had attempted suicide. Of the 48,649 individuals treated for attempted suicide in Sweden 1973–1982, 12% died in subsequent suicide attempts, usually with the same method as on the initial attempt. Assuming that 12% (Runeson, Tidemalm, Dahlin, Lichtenstein, & Langstrom, 2010) to 13% (Suominen et al., 2004) of the 328 survivors of an initial suicide attempt by jumping from another structure than the GGB went on to complete suicide, approximately 286 lives would ultimately be saved.

Would a Suicide Barrier Be Effective?

There is substantial evidence that physical barriers are the most effective method to prevent suicides from bridg-

es and other high structures (Beautrais et al., 2007; Beautrais, 2001; Beautrais, Gibb, Fergusson, Horwood, & Larkin, 2009; Bennewith, Nowers, & Gunnell, 2007; Daigle, 2005). For example, Reisch and Michel (2005) found that after a safety net was placed on the Muenster Terrace in Bern, Switzerland, no further suicides occurred there and the number of deaths by jumping elsewhere in the area was reduced as well. Sinyor and Levitt (2010) found that, after construction of the barrier at the Bloor Street Viaduct in Toronto, Canada, no further suicides occurred at that site. However, while the overall rate of suicide by jumping remained unchanged, the overall rate of suicides in Toronto decreased by 28 victims per year (2003–2007) once the barrier was in place. Since firearms and lethal doses of medication have become more difficult to obtain, there may have been a relative increase in the incidence of jumping that was only partially mitigated by the Bloor Street Viaduct suicide barrier.

Would a Suicide Barrier Be Cost Effective?

The US Department of Transportation (United States Department of Transportation, 2009) estimates the value of a life saved to be worth \$3.2M to \$8.0M, based on regional factors including average income. The GGB connects two of the wealthiest counties in California, San Francisco County and Marin County, with median family incomes that are respectively 39.8% and 72% above the national average. Therefore, the appropriate statistical value of life would be at the high end of the USDOT range. Assuming that the 20-year cost of the GGB suicide barrier is \$51.6M, and that it results in the saving of 286 lives, the cost per life saved is \$180,419, well under 6% of the *minimal* USDOT VSL. This suggests that the GGB suicide barrier would be a highly cost-effective highway safety project.

We also estimated the cost-effectiveness using the WHO guidelines, which evaluate disability-adjusted life years (DALYs), following the procedures used by Law and Yip (2011) to analyze the cost-effectiveness analysis of platform screen doors to prevent suicides and accidental falls onto railway tracks in Hong Kong. Given a mean age of GGB suicide victims of 41.3 years (Figure 5) and an average life expectancy in the US of 78.3 years, an average suicide prevention is associated with an increase of 37 DALYs. Over 20 years, we estimated that 286 lives would be saved, resulting in an increase of 10,582 DALYs. Assuming a cost of \$51.6M, this results in an incremental cost-effectiveness ratio (ICER, US\$ per person-year) of \$4,876. The WHO suggests that projects are cost-effective if the ICER is less than three times the per-capita GDP. In the US, the per-capita GDP is \$48,160. Therefore, based on WHO analysis, the GGB suicide barrier would be 29.6 times more cost-effective than the cost-effectiveness threshold proposed by the WHO. Indeed, the GGB suicide barrier would pass the WHO cost-

effective threshold, based on ICER analysis, less than 9 months after construction.

The suicide barrier would also generate considerable cost savings not included in our calculations. These result from the fact that suicide-prevention activities on the GGB are considerably more expensive than at most other sites. Costs include cost of suicide surveillance, suicide negotiation, and suicide recovery actions that involve bridge workers, first responders, Golden Gate Bridge Patrol, California Highway Patrol, and the United States Coast Guard. Each witnessed GGB jump requires mobilizing staff, vehicles, watercraft, and aircraft. The suicide recovery attempt to rescue an individual who has jumped from the bridge requires coordinated efforts by Bridge Patrol, Highway Patrol, and U. S. Coast Guard boats (not including helicopter searches) over at least 2 hours at a minimal cost of approximately \$10,600 per incident. At 30 suicides per year the cost of recovery attempts alone is \$318,000, i.e., \$6.36 million over 20 years.

Conclusion

The GGB remains one of the most lethal suicide sites in the world lacking a suicide barrier. With nonphysical interventions proven to be only moderately effective, a physical barrier remains the only preventative system that will completely stop GGB suicides. We evaluated the cost-effectiveness of a proposed barrier using the conservative assumptions that (1) all GGB suicides would attempt suicide with alternate methods, (2) all GGB suicides were witnessed or verified by autopsy, and (3) survivors of attempted suicide using alternative methods would eventually commit suicide at high rates (12–13%). Our results suggest that the proposed GGB suicide barrier would save lives in a highly cost-effective manner as a result of the reduced lethality of alternate suicide methods in comparison with jumps from the GGB.

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About the authors

Dayna Atkins Whitmer manages the EEG and Sleep Labs at the VA Northern California Healthcare Outpatient Clinic in Martinez, CA, USA. She has been a board member of BridgeRail Founda-

tion since 2008, following the disappearance of her youngest son, Matthew, a suspected suicide from the Golden Gate Bridge.

David Woods is a Professor of Neurology at the University of California, Davis, and Chief of Clinical Neurophysiology and Director of the Human Cognitive Neurophysiology Research Laboratory at the VA Northern California Healthcare Outpatient Clinic in Martinez, CA, USA.

Dayna Atkins Whitmer

EEG/Sleep Labs – 127

VA Northern California Health Care System

150 Muir Road

Martinez, CA 94553

USA

Tel. +1 925 372-2056

Fax +1 925 372-2111

E-mail dayna.whitmer@va.gov