Impact of the Garrett Lee Smith Youth Suicide Prevention Program on Suicide Mortality

Christine Walrath, PhD, Lucas Godoy Garraza, MA, Hailey Reid, MPH, David B. Goldston, PhD, and Richard McKeon, PhD

Objectives: We examined whether a reduction in youth suicide mortality occurred between 2007 and 2010 that could reasonably be attributed to Garrett Lee Smith (GLS) program efforts.

Methods: We compared youth mortality rates across time between counties that implemented GLS-funded gatekeeper training sessions (the most frequently implemented suicide prevention strategy among grantees) and a set of matched counties in which no GLS-funded training occurred. A rich set of background characteristics, including preintervention mortality rates, was accounted for with a combination of propensity score–based techniques. We also analyzed closely related outcomes that we did not expect to be affected by GLS as control outcomes.

Results: Counties implementing GLS training had significantly lower suicide rates among the population aged 10 to 24 years the year after GLS training than similar counties that did not implement GLS training (1.33 fewer deaths per 100 000; $P = .02$). Simultaneously, we found no significant difference in terms of adult suicide mortality rates or nonsuicide youth mortality the year after the implementation.

Conclusions: These results support the existence of an important reduction in youth suicide rates resulting from the implementation of GLS suicide prevention programming. (*Am J Public Health*. Published online ahead of print March 19, 2015: e1–e8. doi:10.2105/AJPH.2014.302496)

Suicide is the 10th leading cause of death in the United States, the third leading cause of death among youths aged 10 to 14 years, and the second leading cause of death among youths aged 15 to 24 years.[1] As such, suicide prevention is a federal priority, and the Substance Abuse and Mental Health Services Administration has continually invested in long-standing programs such as the Garrett Lee Smith (GLS) Memorial Youth Suicide Prevention Program[2] to combat the problem. These federally funded programs are implemented in states, in tribes, and on campuses and are guided in part by the National Strategy for Suicide Prevention. The National Action Alliance for Suicide Prevention was formed in 2010 with partial support from the Substance Abuse and Mental Health Services Administration (SAMHSA) to revise and implement the National Strategy for Suicide Prevention through best-practice recommendations and a prioritized research agenda to advance the field and save lives. One of these research goals is to "prevent the emergence of suicidal behavior by developing and delivering the most effective prevention programs to build resilience and reduce risk in broad-based populations."[3(p47)]

Although many suicide prevention programs have been developed and implemented with a variety of embedded complementary activities and interventions, evaluating the connection between the proximal products of such programs and their intended long-term outcomes remains challenging. Community-based suicide prevention programs are often implemented for a short period of time and vary in their focus between more dispersed or more concentrated geographic areas.[4] These methods of implementation, as well as the relatively low base rate of suicide mortality, make examination of outcomes challenging.[5] Synthesizing what is known about the effects of gatekeeper training in particular, Isaac et al.[6] noted that studies have shown a positive impact on suicide prevention knowledge, skills, and attitudes.

The broad scale and longevity of the GLS Memorial Youth Suicide Prevention Program provides a unique opportunity to examine the impact of community-based suicide prevention programs on youth outcomes. As of June 2014, 154 GLS grants had been awarded to 49 states and 48 tribes. (Twenty-six additional grants in 16 states and 10 tribes were awarded in September 2014. In addition, 144 grants have been awarded to college campuses since program inception. Data from the Campus GLS prevention program, however, were not included in this study.) Consistent with comprehensive public health suicide prevention planning, all GLS grantees include multiple activities in their prevention and early intervention programs to address the unique needs of their communities (Figure 1).

Gatekeeper training has been a core part of all GLS programs, and grantees have consistently reported spending the largest proportion of their budget on this 1 strategy (32% on average). As such, training serves as a time- and region-stable proxy for GLS suicide prevention program implementation. Gatekeeper training sessions aim to teach specific groups of people to identify individuals at risk for suicide and refer them to appropriate support.[7(p273)] Gatekeepers include individuals who have contact with a large number of youths on regular basis, such as teachers, public school staff, peer educators, and physicians. The duration of training ranges from a few hours to a few days. A core component of all programs involves learning the warning signs of suicide and asking people identified as at risk whether they are thinking about killing themselves. Longer training sessions may aim at building skills to provide additional assistance such as collaboration with suicidal youths to develop a safety plan. Because of their focus on identifying and appropriately referring a large number of youths at risk—who might otherwise have not sought help—gatekeeper programs were

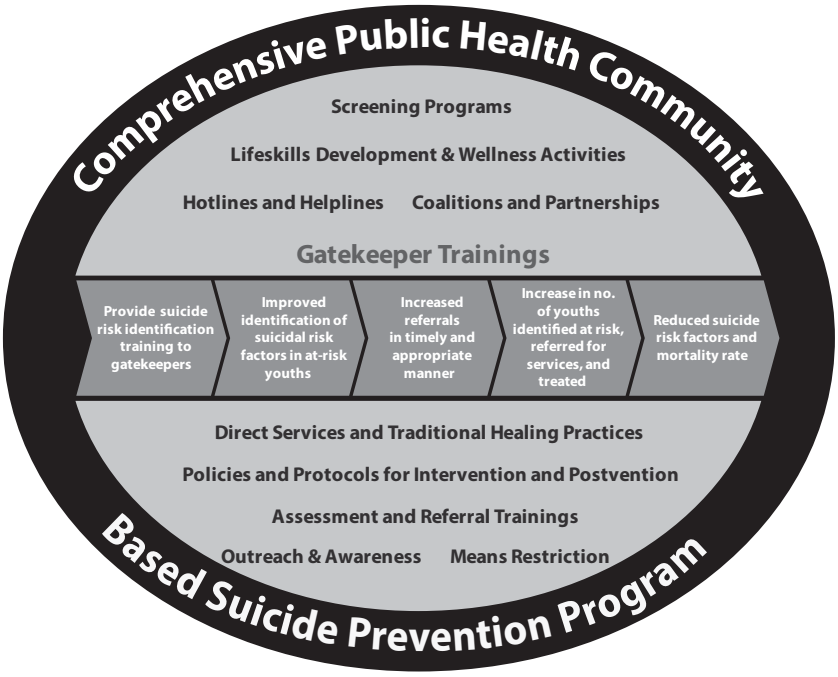


FIGURE 1—Model of the comprehensive, community-based Garrett Lee Smith Memorial Suicide Prevention Program.

recognized as having a potential impact on reducing suicide incidence[7(p315)] and explicitly incorporated as an area of emphasis in the GLS Memorial Act of 2004. Additional details on GLS-funded gatekeeper training implementation, including gatekeeper identification and referral behavior after participation in training, have recently been published.[8]

GLS-funded gatekeeper training, however, is implemented not in isolation but rather in concert with other prevention strategies selected by grantees to be consistent with their locale and cultural context. These other activities are considered necessary comprehensive suicide prevention program components to effect change in suicidal behavior. Descriptions of the GLS program history, structure, and outcomes related to GLS grantees' youth suicide prevention efforts have recently been produced.[9,10]

We analyzed data collected through the SAMHSA–funded cross-site evaluation[9] and examined whether a reduction in youth suicide mortality occurred between 2007 and 2010 that could be reasonably attributed to GLS program efforts. Specifically, we compared youth mortality rates across time between counties that implemented GLS-funded training sessions and a set of matched counties in which no GLS-funded training occurred.

METHODS

The analysis focused on the initial years of the GLS program implementation (2006–2009) in counties across the United States. (The year 2010 was the latest for which mortality information was available during the analysis. Therefore, we restricted the analysis to the GLS training implementation that occurred before 2010.) All counties with a population of at least 3000 youths aged between 10 and 24 years were considered for inclusion in the sample. (We did not consider smaller counties for inclusion because the large variability of youth suicide mortality among them made it extremely difficult to detect any systematic difference. Of 3142 counties, 1047 did not reach the 3000-youth threshold.) Of these, 479 were exposed to GLS suicide prevention efforts during that period as signaled by the implementation of at least 1 GLS gatekeeper training (intervention counties). On average, nearly 9 training sessions were implemented in each county, and approximately 28 participants were trained each time.

In the remaining 1616 counties, no GLS training sessions (i.e., no GLS programs) were implemented during that period. This group of counties constituted a pool of potential control counties from which we selected a sample of 1161 counties. Control counties shared key preintervention characteristics with the intervention counties using propensity score matching techniques. We were not able to find adequate matches for 13 of the 479 intervention counties, and we therefore excluded them from the analysis. In some of the 466 intervention counties, training implementation occurred in more than 1 year; as a result, the sample contained a total of 776 county-years in which at least 1 GLS training was implemented. The intervention counties reflected the efforts of 46 state and 12 tribal GLS grantees supporting the implementation of more than 4000 training sessions in which more than 100 000 gatekeepers participated.

Measures and Sources

The main outcome of interest was the county's suicide mortality rate the year after the implementation of GLS training sessions among the population aged 10 to 24 years between 2007 and 2010. Secondary analyses focused on suicide rate by age subgroups 10 to 18 years and 19 to 24 years. Control outcomes were other mortality outcomes not expected to be affected by GLS activities. These outcomes included suicide mortality among individuals aged 25 years and older and mortality rates among youths aged 10 to 18 years and 19 to 24 years from causes other than suicide. We obtained mortality information from the Compressed Mortality File.[11] Mortality information is collected by state registries and provided to the National Vital Statistics System; it includes cause of death and demographic descriptors indicated on death certificates.

We used whether, for each year between 2006 and 2009, at least 1 GLS-funded gatekeeper training was implemented in the county as an indicator of GLS program implementation, the main independent variable. Subsequent analysis focused on the number of

TABLE 1—Sample Characteristics Before and After Matching: Garrett Lee Smith Memorial Suicide Prevention Program, Substance Abuse and Mental Health Services Administration Cross-Site Evaluation, United States, 2007–2010

	All Counties			Matched Sample		
Covariates (Average 2000–2006)	Mean Intervention Group (n = 479)	Mean Control Group (n = 1616)	Absolute Standardized Difference[a]	Mean Intervention Group (n = 466)	Mean Control[b] Group (n = 1161)	Absolute Standardized Difference[a]
Suicide rate by age (per 100 000)						
10–18 y	4.9	4.3	13.6	4.8	4.8	1.4
19–24 y	15.7	15.6	0.8	15.5	15.4	0.4
≥ 25 y	17.4	16.5	16.8	17.4	17.4	0.5
Nonsuicide mortality by age (per 100 000)						
10–18 y	39.2	39.7	3.2	39.2	39.1	0.4
19–24 y	97.7	102.9	11.4	98.4	98.1	0.8
Poverty	13.6	13.6	0.0	13.5	13.7	3.0
Unemployment	5.3	5.4	9.1	5.3	5.3	4.6
Total population, in 1000s	208.7	111.8	22.1	190.3	187.7	0.6
Population by age, %						
10–18 y	13.1	13.3	16.0	13.1	13.2	3.2
19–24 y	8.8	8.3	14.9	8.7	8.8	2.6
≥ 25 y	64.9	65.2	6.6	65.1	64.9	3.5
% female	50.8	50.4	22.3	50.8	50.8	1.3
Population by race/ethnicity, %						
Hispanic	5.7	7.5	16.2	5.5	5.5	0.7
Non-Hispanic African American	9.3	10.2	6.0	9.4	10.1	4.7
Non-Hispanic American Indian/Alaska Native	2.1	1.3	13.8	1.9	2.0	2.0
Non-Hispanic Asian	1.6	1.2	15.6	1.5	1.4	2.3
Non-Hispanic other races	1.6	1.2	28.2	1.5	1.4	4.1
Median household income, in $1000s	39.9	39.5	4.0	39.9	39.7	1.9
% rural	39.8	48.4	32.1	40.2	40.1	0.5
Propensity score (logit scale)	−0.6	−1.8	94.2	−0.6	−0.7	3.3
Mean			13.3			2.0
Median			13.8			1.9
Maximum			32.1			4.7

[a]Absolute difference divided by the standard deviation before matching.
[b]Weighted average across the 5 subclasses, where the weights are given by the proportion of counties in each subclass among the intervention counties.

gatekeepers trained in the same period. To assess longer term effects, the analyses also included indicators of any previous implementation through each year, that is, a cumulative lag version of the independent variables. Information on each training event supported by GLS, such as location of the training and number of participants, has been collected regularly since program inception using standardized forms as part of the cross-site evaluation. Covariates included the county's total population, age group composition, racial–ethnic composition (percentage Hispanic and non-Hispanic White, African American, American Indian or Alaska Native, Asian, and other race), percentage female, median household income, poverty rate, unemployment rate, and percentage of rural population.

We also included preintervention levels of suicide rate as covariates. We assessed relatively permanent characteristics of the counties through the average of each covariate between 2000 and 2006 (time-fixed covariates). Recent changes in these characteristics were assessed through their value in each of the previous 4 years as well as the moving average throughout that 4-year period (time-varying covariates). The source of demographic information was the US Census Bureau's Intercensal Estimates.[12] Income, poverty, and unemployment rates were based on small area estimations by the US Census Bureau[13] and the Bureau of Labor Statistics.[14]

Analysis

To examine the effect of the main independent variable on the outcome of interest in the context of a nonrandomized study, we had to address the issue of the comparability between the intervention and control samples. A frequently used approach is to parcel out the effect of the main independent variable and

that of the covariates using a single regression model. This approach has serious known drawbacks.[15] In contrast to this approach, we addressed the issue of the comparability between the intervention and control samples before performing the main analysis.

This strategy relies on the estimation of the propensity score—the probability of being in the intervention sample as opposed to the control sample as a function of the observed covariates.[16,17] Specifically, in this study, we used sequential propensity score models to (1) select the sample of control counties (trimming step), (2) create 5 homogeneous subgroups across the intervention and control samples (subclassification step), and, finally, (3) develop the inverse probability of exposure weights within each subgroup (weighting step). In the first 2 steps, the propensity models predicted the implementation of at least 1 GLS training at any time during 2006 to 2009 as a function of relatively permanent characteristics of the county, that is, average values of the covariates between 2000 and 2006. The third step incorporated time-varying covariates in addition to time-fixed covariates to predict training implementation in each year.

The trimming and subclassification steps had the common goal of making intervention and control counties as similar as possible regarding relatively permanent historical characteristics. An additional benefit of subclassification was that we could explore variation in the effect of training implementation by subclass. Furthermore, we fitted the propensity model for the weighting step separately within each subclass, making it more likely that the overall model for the weights was correctly specified. The goal of the weighting step was to account for time-varying covariates, in particular recent changes in suicide rates before the implementation of the GLS program and the history of exposure to a GLS program in previous years.[18–20]

A separate version of the weighting step was required to analyze the effect of the number of trainees, that is, a continuous instead of a binary conceptualization of the intervention. To accomplish this, we estimated a new set of inverse probability of exposure weights. We estimated the propensity score for the continuous exposure using a linear rather a logistic model.[20] We used transformation of the number of trainees, the square root, in the analysis to more closely satisfy model assumptions.[21]

Because of the steps taken to increase comparability, we were able to use a relatively simple regression model for the main analysis. The outcome measure (i.e., the suicide rate in each county and year) was regressed on the independent variables (the measures of training implementation) using the weighted sample. We assessed sensitivity of the results to extreme weights by refitting the regression after truncating 1% and 5% of the weights at each extreme of the distribution. We estimated all of the regression models using weighted generalized estimating equations with the errors assumed to be clustered at the state level. Additional details regarding the analytic approach are provided in the Appendix (available as a supplement to the online version of this article at http://www.ajph.org).

RESULTS

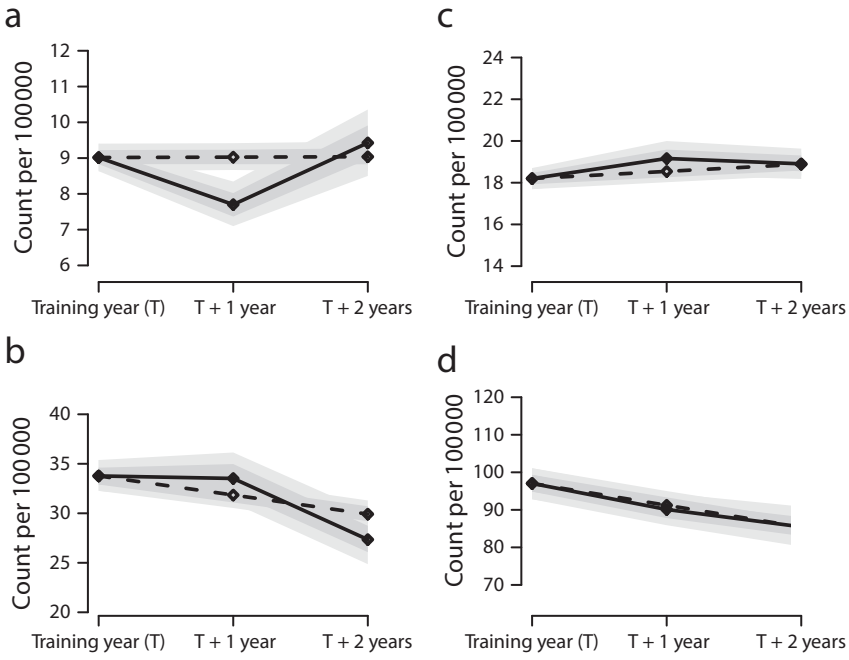
In Table 1, we compare intervention and control counties before and after matching in terms of their characteristics before GLS implementation. As depicted, intervention and control samples were quite similar. In Appendix Table A, we report the characteristics of the matched intervention and control samples for each of 5 subclasses. County size and percentage of the population living in rural areas stood out as the characteristics that differed the most across subclasses. Although the average size of the county varied markedly, the average number of gatekeepers trained during the years when training sessions were implemented remained relatively constant across subclasses.

In Table 2 and Figure 2, we present the estimated average effect of GLS training implementation on the main and control outcomes. Counties implementing GLS training exhibited significantly lower suicide rates among the population aged 10 to 24 years in the year after the implementation than similar counties that did not implement GLS training sessions (1.33 fewer deaths per 100 000; $P = .02$). Simultaneously, we found no significant difference in terms of adult suicide mortality rates ($P = .34$) or nonsuicide mortality

TABLE 2—Estimated Average Effect of Training Implementation on Main and Control Outcomes: Garrett Lee Smith Memorial Suicide Prevention Program, Substance Abuse and Mental Health Services Administration Cross-Site Evaluation, United States; 2007–2010

Variable	Average Effect of GLS Training	
	Estimate (SE)	Pr(> t)
Suicide rate 10–24 age group		
GLS training sessions last y	−1.33 (0.49)	.0160
GLS training sessions ≥ 2 y ago	0.39 (0.71)	.5911
Suicide rate 10–18 y age group		
GLS training sessions last y	−0.73 (0.44)	.1188
GLS training sessions ≥ 2 y ago	0.01 (0.53)	.9865
Suicide rate 19–24 y age group		
GLS training sessions last y	−2.16 (1.27)	.1090
GLS training sessions ≥ 2 y	1.17 (1.76)	.5162
Suicide rate ≥ 25 y age group		
GLS training sessions last y	0.62 (0.58)	.3010
GLS training sessions ≥ 2 y ago	0.02 (0.52)	.9684
Nonsuicide mortality 10–18 y age group		
GLS training sessions last y	1.67 (1.82)	.3701
GLS training sessions ≥ 2 y ago	−2.57 (1.79)	.1692
Nonsuicide mortality 19–24 y age group		
GLS training sessions last y	−1.12 (3.13)	.7254
GLS training sessions ≥ 2 y ago	0.07 (4.00)	.9863

Note. GLS = Garrett Lee Smith.



Note. Solid lines represent the estimated trajectory of the outcome after Garrett Lee Smith (GLS) program training implementation. Dashed lines represent the estimated trajectory of the outcome during the same period had GLS not been implemented. The 90% and 50% confidence intervals around the trajectory are in dark and light gray, respectively.

FIGURE 2—Main and control outcomes after Garrett Lee Smith Memorial Suicide Prevention Program training implementation for (a) suicide among those aged 10–24 years, (b) suicide among those aged ≥ 25 years, (c) mortality among those aged 10–18 years, and (d) mortality among those aged 19–24 years: Substance Abuse and Mental Health Services Administration cross-site evaluation, United States, 2007–2010.

rates among the population aged 10 to 18 years or 19 to 24 years ($P = .37$ and .72, respectively) in the year after the implementation. The results appeared fairly robust to the truncation of extreme weights (Appendix Table B). We found no significant effect 2 or more years after GLS training sessions, however, in the suicide rates among the population aged 10 to 24 years. When the main outcome was disaggregated by age subgroup (10–18 years and 19–24 years), the difference was not significant for either subgroup in the year after training or for 2 or more years after implementation. We should note that suicide rates within the age subgroups, and particularly among the subgroup aged 10 to 18 years, were much more variable across counties and years than the rate among the entire 10- to 24-year age range, thus potentially accounting for the inability to detect effects.

In Table 3, we present the estimated average effect of the number of GLS trainees on the main and control outcomes. Consistent with the findings, the number of gatekeepers trained was significantly associated with lower suicide rates among the population aged 10 to 24 years in the subsequent year ($P = .01$). The difference increased with the square root of the number of trainees. For example, for 25, 55, and 148 trainees (the quartiles of the distribution), we predicted a drop in 0.06, 0.08, and 1.3 deaths per 100 000 youths, respectively.

When we disaggregated the main outcome by age subgroup (10–18 years and 19–24 years), we obtained virtually the same estimate for the subgroup aged 10 to 18 years, but we observed no significant difference in the subgroup aged 19 to 24 years, suggesting that the overall difference was driven mostly by a drop in the suicide rate in the younger subgroup.

The number of gatekeepers trained was not associated with a significant difference in any of the control outcomes. We found no significant difference in the suicide rates (either overall or by age subgroup) among the population aged 10 to 24 years that was associated with the number of gatekeepers trained, 2 or more years after the training. The weights used for the analysis of the number of gatekeepers trained (compared with those used for the analysis of training implementation) were more variable, and, in particular, we found some additional significant or close-to-significant differences when using the untruncated weights that were not confirmed when truncating the most extreme weights. These results should therefore be considered with additional caution. The estimates presented in Table 3 correspond to the results after truncating 1% of the weights at each extreme of the distribution. Results with untruncated weights and with 5% of the most extreme weights truncated are presented in Appendix Table C.

In Appendix Tables D and E, we present 5 subclass estimates of the effect of GLS training implementation on youth suicide in the subsequent year, as well as the effect of the number of gatekeepers trained. The results suggest that the effects of the training implementation and the number of gatekeepers trained were heterogeneous across subclasses. In particular, the overall results seem to be driven mostly by the effect among smaller, more rural counties (subclasses 1 and 2). Approximately half of the counties implementing GLS training sessions fall into that category.

DISCUSSION

We observed a reduction in the rate of suicide mortality among youths in counties implementing GLS suicide prevention programs compared with counties that were not targeted by GLS programs. We did not note similar reductions among adults older than the groups targeted with GLS programs or in youth mortality for reasons other than suicide. On the basis of the point estimate of the drop in suicide rates among the population aged 10 to 24 years in the year after the training implementation, the number of counties and years in which GLS training was implemented, and the

TABLE 3—Estimated Average Effect of Number of Trainees on Main and Control Outcomes: Garrett Lee Smith Memorial Suicide Prevention Program, Substance Abuse and Mental Health Services Administration Cross-Site Evaluation, United States, 2007–2010

Variable	Average Effect of GLS Training	
	Estimate (SE)	Pr(> t)
Suicide rate 10–24 age group		
No. of trainees last y (sqrt)	−0.11 (0.04)	.0126
Cumulative no. of trainees ≤ 2 y ago (sqrt)	0.01 (0.05)	.8231
Suicide rate 10–18 y age group		
No. of trainees last y (sqrt)	−0.11 (0.02)	.0002
Cumulative no. of trainees ≤ 2 y ago (sqrt)	0.07 (0.04)	.0850
Suicide rate 19–24 y age group		
No. of trainees last y (sqrt)	−0.10 (0.09)	.3051
Cumulative no. of trainees ≤ 2 y ago (sqrt)	−0.07 (0.10)	.4722
Suicide rate ≥ 25 y age group		
No. of trainees last y (sqrt)	0.06 (0.04)	.1756
Cumulative no. of trainees ≤ 2 y ago (sqrt)	−0.05 (0.05)	.3426
Nonsuicide mortality 10–18 y age group		
No. of trainees last y (sqrt)	0.04 (0.22)	.8712
Cumulative no. of trainees ≤ 2 y ago (sqrt)	−0.09 (0.12)	.4544
Nonsuicide mortality 19–24 y age group		
No. of trainees last y (sqrt)	−0.25 (0.16)	.1335
Cumulative no. of trainees ≤ 2 y ago (sqrt)	0.20 (0.25)	.4206

Note. GLS = Garrett Lee Smith. One percent of the inverse probability weights at each extreme of the distribution were truncated.

average population in the 10- to 24-year age range in the intervention counties, these results suggest that approximately 427 deaths were avoided between 2007 and 2010 after GLS program implementation. For comparison purposes, the enactment of strong mental health parity laws in 34 states between 1990 and 2010 was estimated to result in the prevention of about 700 suicide deaths.[3(p131–137),22]

Notwithstanding the preceding results, we found no evidence of an effect beyond 1 year after training implementation. Many factors may have contributed to these results, including staff turnover as well as the potential need for refresher training as suggested by GLS local evaluation studies.[23] In addition, as shown by the Air Force Suicide Prevention Program, adherence and focus on comprehensive suicide prevention activities may fade over time.[24] Although the circumstances surrounding the Air Force Suicide Prevention Program are rather specific (e.g., the activation of the Air Force for warfare), our results support an analogous conclusion: effectively preventing suicides requires sustained public health efforts.

We took advantage of the scale, longevity, and accumulation of GLS program evaluation data by identifying a large number of counties with different exposures to the program. To that end, the initial comparison (i.e., some training implementation vs none) was clear cut but encompassed multiple variants of the actual intervention in terms of differences in both the training activities implemented and the type and intensity of other GLS program components implemented simultaneously. In the subsequent analysis, we explored 1 of these variations: the number of gatekeepers trained. The results were generally consistent with the initial findings. They suggest, in particular, that the reduction in youth suicide rates increased with the number of gatekeepers trained. Furthermore, the reduction in the suicide rate among youths aged 10 to 18 years appeared to be the main driver of the overall reduction. The results regarding the number of gatekeepers trained, however, appeared less robust to minor variation in the analytic strategy (in particular, the truncation of extreme weights) and should therefore be considered with additional caution.

We explored other indications of heterogeneity in the subclass analysis. Results by subclass suggested that GLS training implementation made more of a difference in smaller and more rural counties. These findings have different potential explanations. For example, it may have been more difficult in larger communities for prevention efforts to reach the scale necessary to generate a reduction in youth suicide that could be detected at the county level. It is possible, however, that we could have observed more homogeneous effects had data with additional spatial granularity (e.g., by neighborhood) been available. Moreover, some features of the GLS program may have been especially suitable to more rural communities. In particular, the emphasis on the gatekeeper role (educators, spiritual leader, physicians) may have been particularly effective in a context in which professional mental health support was less available, accessible, or socially acceptable.[25] Finally, it is possible that the GLS program may have been more effective in addressing particular risk factors with higher prevalence in rural areas, such as firearm access. Although we did not differentiate among these alternative explanations, they do suggest avenues for future research.

Limitations

Our findings must be interpreted in the context of this study's limitations. First, we did not address important related questions regarding the nature of the intervention, such as specific types of training sessions or gatekeepers that may have been more effective and the specific components of the GLS program beyond the training sessions that contributed to the results. Moreover, an increase in early identifications and referrals of youths at risk was not directly examined or distinguished from alternative mechanisms (e.g., a change in awareness and sensitivity to the issue in the communities) through which other program components may have contributed to the results. With that said, however, the relationship between identification and referral and the type

of training and trainee in the context of GLS was the focus of a recent study,[8] although that study used information not available at the county level. A related limitation arises from the use of information on training activities as a marker of GLS implementation. The relative consistency across results from the binary and continuous approaches offered some support to this assumption, but this study would have benefited from information about additional program activities with the same level of spatial detail.

Finally, our analysis has limitations that apply more generally to causal claims outside the context of the ideal randomized experiment. In particular, despite the use of a rich set of covariates as well as analysis of control outcomes, unaccounted-for differences between exposed and control counties may possibly have influenced the results. In addition, using propensity scores to construct weights relies on the correct specification of the statistical model predicting exposure, an issue that was only partially addressed by the use of separate models for each subclass and the sensitivity analysis. Because of these limitations, replicating the findings is essential. Replication studies could take advantage of larger samples of counties as information on suicide mortality becomes available for additional years. They could also focus on other, complementary outcomes, such as nonfatal suicide attempts, that should be consistent with those analyzed here. Finally, they could explore alternative analytical strategies, particularly to understand the effects of the different variations of the intervention.

Conclusions

Despite these limitations, our study provides compelling, if not definitive, evidence of the lifesaving impact of the GLS Youth Suicide Prevention Program's efforts and contributes to advancing the research agenda for suicide prevention in an effort to dramatically reduce suicide over the next 5 years.[3] Unlike studies examining the impact of gatekeeper training alone, in this study we used training data drawn from GLS grantees implementing multifaceted community-based suicide prevention programs that included training as a major component of their programs. As such, although they do provide evidence supporting a relationship between training and youth lives saved, they support gatekeeper practice guidelines[26,27] that recommend implementing gatekeeper training sessions as a part of a larger portfolio of suicide prevention strategies tailored specifically to reduce youth suicide in a particular community.

Comprehensive community-based public health youth suicide prevention approaches such as GLS and other programs[3,28] appear to provide a pathway toward fewer suicide deaths. Continued investigation into the impact of variations in suicide prevention strategies, such as training models, as well as the effect of prevention activities on suicide attempts, will help to further shape that pathway. ■

About the Authors

Christine Walrath, Lucas Godoy Garraza, and Hailey Reid are with the Public Health Division, ICF International, New York, NY. David B. Goldston is with the Duke University School of Medicine, Durham, NC. Richard McKeon is with the Substance Abuse and Mental Health Services Administration, Rockville, MD.

Correspondence should be sent to Christine Walrath, PhD, ICF International, 40 Wall Street, Suite 3400, New York, NY 10005 (e-mail: Christine.Walrath@icfi.com). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted November 25, 2014.

Contributors

C. M. Walrath served as principal investigator, supervised the project, and participated in conceptualization of the study, interpretation of the findings, and writing of the article. L. Godoy Garraza participated in the conceptualization of the study; managed a portion of the project; prepared, analyzed, and interpreted the data; and co-led the writing of the article. H. Reid managed a portion of the project, participated in interpretation of the data and dissemination of the findings, and co-led the writing of the article. D. B. Goldston contributed to the writing and conceptualization of the article. R. McKeon participated in the conceptualization of the study, interpretation of the data, and dissemination of findings. All authors contributed significant intellectual content, reviewed each draft of the article, and approved the final version.

Acknowledgments

The cross-site evaluation was supported through a SAMHSA contract to ICF Macro (#280-03-1606).

We acknowledge the Garrett Lee Smith Suicide Prevention Program grantees for their participation in the cross-site evaluation and the ICF International staff on the evaluation team, particularly Erin Maher, Anne Marie Schipani, Hope Sommerfeldt, and Ye Xu, for their contributions to the discussion group for this analysis.

Human Participant Protection

The cross-site evaluation data collection protocols used in this analysis were determined to be exempt from review board approval by the ICF International institutional review board.

References

1. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. 10 leading causes of death by age group, United States–2011. Available at: http://www.cdc.gov/injury/wisqars/pdf/leading_causes_of_death_by_age_group_2011-a.pdf. Accessed July 3 2014.

2. Garrett Lee Smith Memorial Act, Pub. L. 108–355, 118 Stat 1404 (2004).

3. National Action Alliance for Suicide Prevention. *Research Prioritization Task Force: A Prioritized Research Agenda for Suicide Prevention: An Action Plan to Save Lives*. Rockville, MD: National Institute of Mental Health and the Research Prioritization Task Force; 2014.

4. York J, Lamis DA, Friedman L, et al. A systematic review process to evaluate suicide prevention programs: a sample case of community-based programs. *J Community Psychol*. 2013;41(1):35–51.

5. Brown CH, Wyman PA, Brinales JM, et al. The role of randomized trials in testing interventions for the prevention of youth suicide. *Int Rev Psychiatry*. 2007;19(6):617–631.

6. Isaac M, Elias B, Katz LY, et al. Gatekeeper training as a preventative intervention for suicide: a systematic review. *Can J Psychiatry*. 2009;54(4):260–268.

7. Goldsmith SK, Pellmar TC, Kleinman AM, Bunney WE, eds. *Reducing Suicide: A National Imperative*. Washington, DC: National Academies Press; 2002.

8. Condron DS, Godoy Garraza L, Walrath CM, et al. Identifying and referring youths at risk for suicide following participation in school-based gatekeeper training. *Suicide Life Threat Behav*. 2013;Epub ahead of print.

9. Goldston DB, Walrath CM, McKeon R, et al. The Garrett Lee Smith Memorial Suicide Prevention Program. *Suicide Life Threat Behav*. 2010;40(3):245–256.

10. US Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, Center for Mental Health Services. *The Garret Lee Smith Suicide Prevention Program: Cross-Site Evaluation Annual Report, 2013*. Rockville, MD: National Evaluation Team; 2013.

11. Centers for Disease Control and Prevention WONDER. Available at: http://wonder.cdc.gov/cmf-icd10.html. Accessed November 27, 2013.

12. Population Estimates: County Intercensal Estimates (2000–2010). Washington, DC: US Census Bureau. Available at: http://www.census.gov/popest/data/intercensal/county/county2010.html. Accessed February 12, 2013.

13. Model-Based Small Area Income & Poverty Estimates for School Districts, Counties, and States [database online]. Washington, DC: US Census Bureau. Available at: http://www.census.gov/did/www/saipe/index.html. Accessed August 19, 2013.

14. Local Area Unemployment Statistics. Washington, DC: Bureau of Labor Statistics. Available at: http://www.bls.gov/lau/#data. Accessed August 19, 2013.

15. Rubin DB. Estimating causal effects from large data sets using propensity scores. *Ann Intern Med*. 1997;127(8 pt 2):757–763.

16. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika*. 1983;70(1):41–55.

17. Rosenbaum PR, Rubin DB. Reducing bias in observational studies using subclassification on the propensity score. *J Am Stat Assoc*. 1984;79(387):516–524.

18. Cole SR, Hernán MA. Constructing inverse probability weights for marginal structural models. *Am J Epidemiol.* 2008;168(6):656–664.

19. Hernán MA, Brumback BA, Robins JM. Estimating the causal effect of zidovudine on CD4 count with a marginal structural model for repeated measures. *Stat Med.* 2002;21(12):1689–1709.

20. Robins JM, Hernán MA, Brumback B. Marginal structural models and causal inference in epidemiology. *Epidemiology.* 2000;11(5):550–560.

21. Fox J. *Applied Regression Analysis and Generalized Linear Models.* 2nd ed. Los Angeles, CA: Sage Publications; 2008.

22. Lang M. The impact of mental health insurance laws on state suicide rates. *Health Econ.* 2013;22(1):73–88.

23. Keller DP, Schut LJA, Puddy RW, et al. Tennessee Lives Count: statewide gatekeeper training for youth suicide prevention. *Prof Psychol Res Pr.* 2009;40(2): 126–133.

24. Knox KL, Pflanz S, Talcott GW, et al. The US Air Force Suicide Prevention Program: implications for public health policy. *Am J Public Health.* 2010;100 (12):2457–2463.

25. US Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy. *Mental Health and Rural America: 1994–2005, An Overview and Annotated Bibliography.* Rockville, MD: US Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy; 2005. Available at: ftp://ftp.hrsa.gov/ruralhealth/RuralMentalHealth.pdf. Accessed October 23, 2014.

26. US Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, Center for Mental Health Services. Recommendations for: youth suicide prevention training for early identification and referral (gatekeeper training). Available at: http://www.sprc.org/sites/sprc.org/files/library/RecommendationsGatekeeperTraining.pdf. Accessed July 14, 2014.

27. US Department of Health and Human Services, Office of the Surgeon General and National Action Alliance for Suicide Prevention. *2012 National Strategy for Suicide Prevention: Goals and Objectives for Action.* Washington, DC: US Department of Health and Human Services; 2012.

28. Gould MS, Greenberg T, Velting DM, et al. Youth suicide risk and preventive interventions: a review of the past 10 years. *J Am Acad Child Adolesc Psychiatry.* 2003;42(4):386–405.