Population Health Outcome Models in Suicide Prevention Policy

Frances L. Lynch, PhD, MSPH

Background: Suicide is a leading cause of death in the U.S. and results in immense suffering and significant cost. Effective suicide prevention interventions could reduce this burden, but policy makers need estimates of health outcomes achieved by alternative interventions to focus implementation efforts.

Purpose: To illustrate the utility of health outcome models to help in achieving goals defined by the National Action Alliance for Suicide Prevention's Research Prioritization Task Force. The approach is illustrated specifically with psychotherapeutic interventions to prevent suicide reattempt in emergency department settings.

Methods: A health outcome model using decision analysis with secondary data was applied to estimate suicide attempts and deaths averted from evidence-based interventions.

Results: Under optimal conditions, the model estimated that over 1 year, implementing evidence-based psychotherapeutic interventions in emergency departments could decrease the number of suicide attempts by 18,737, and if offered over 5 years, it could avert 109,306 attempts. Over 1 year, the model estimated 2,498 fewer deaths from suicide, and over 5 years, about 13,928 fewer suicide deaths.

Conclusions: Health outcome models could aid in suicide prevention policy by helping focus implementation efforts. Further research developing more sophisticated models of the impact of suicide prevention interventions that include a more complex understanding of suicidal behavior, longer time frames, and inclusion of additional outcomes that capture the full benefits and costs of interventions would be helpful next steps.

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Introduction

Suicide is the tenth-leading cause of death in the U.S., with more than 36,000 deaths as a result of suicide in 2009.[1] The cost of completed suicide is immense, including lost life and potential of the individuals who die from suicide as well as the long-lasting impact of suicide on families and communities. In addition, people who attempt suicide often have significant medical costs, lost time from work, and other impairments in functioning following an attempt.[2,3]

Recently, a public–private partnership, the National Action Alliance for Suicide Prevention (Action Alliance), launched an initiative to apply a comprehensive public health approach to quickly and substantially reduce suicide deaths in the U.S. A part of this initiative, the Action Alliance's Research Prioritization Task Force (RPTF) is charged with defining a research agenda that, if fully implemented, could reduce suicide attempts and deaths by 20% in 5 years.[4] Part of the RPTF initiative is to map the burden of suicide in the U.S., including four steps to improving the evidence base related to suicide prevention: (1) develop a taxonomy of high-risk target subgroups; (2) identify and pair effective practices and policies with specific high-risk groups; (3) estimate the potential impact of implementing effective interventions within targeted intervention platforms; and (4) estimate time horizons for intervention implementation and future research.[4] This paper explores the third step and focuses on one approach that has frequently been used in decision making: models of population health outcomes.

From the Center for Health Research, Kaiser Permanente Northwest, Portland, Oregon

Address correspondence to: Frances L. Lynch, PhD, Center for Health Research, 3800 North Interstate, Portland OR 97227. E-mail: frances.lynch@kpchr.org.

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Models of Population Health Outcomes

Population health outcome models are statistical models that estimate the likely health outcomes that could be achieved by alternative interventions aimed at addressing a specific health issue.[5–7] Health outcome models use estimates from rigorous scientific studies, data on population characteristics, clinical settings, and population risk factors to project likely health outcomes of alternative interventions. Models can be very sophisticated and incorporate many aspects of the disease course, or may be much simpler and focus on a narrower clinical or health policy question.

Estimating Outcomes in the Context of Suicide Prevention

Because death by suicide is a rare event, longitudinal studies of suicide preventive interventions are often small and relatively brief. Therefore, it is difficult for individual studies to follow a sufficient number of subjects to examine important outcomes related to suicide. Models could provide a way to begin to understand the population impact of implementing effective interventions in a population. In addition, the modeling process can help to identify important gaps in knowledge for future research. To date, there is little research estimating population health outcomes related to suicide prevention.[8]

The purpose of this paper is to begin a conversation about health outcome modeling of suicide prevention interventions and to identify gaps in current research that, if filled, could help guide future efforts. The approach is illustrated using the example of one specific policy question: If we optimally delivered evidence-based psychotherapeutic interventions designed to prevent suicide reattempt in emergency department (ED) settings, how many suicide attempts and deaths could we avert in 1 year? In 5 years?

Methods

To address this question, a simple health outcome model was developed. Similar models have been used in previous studies of psychiatric interventions.[9,10] The model is a Markov cohort simulation. Models were constructed in Microsoft Excel 2007. The structure of the model is shown in Figure 1. The cycle length of the model is 1 year. The model estimated suicide attempts and suicide deaths for each therapeutic scenario over 1- and 5-year time frames, as defined by the RPTF.

Data Sources

The sample of individuals who could potentially benefit from a psychotherapeutic intervention following a suicide attempt was obtained from the U.S. Consumer Product Safety Commission (CPSC) injury surveillance and follow-back system, the National

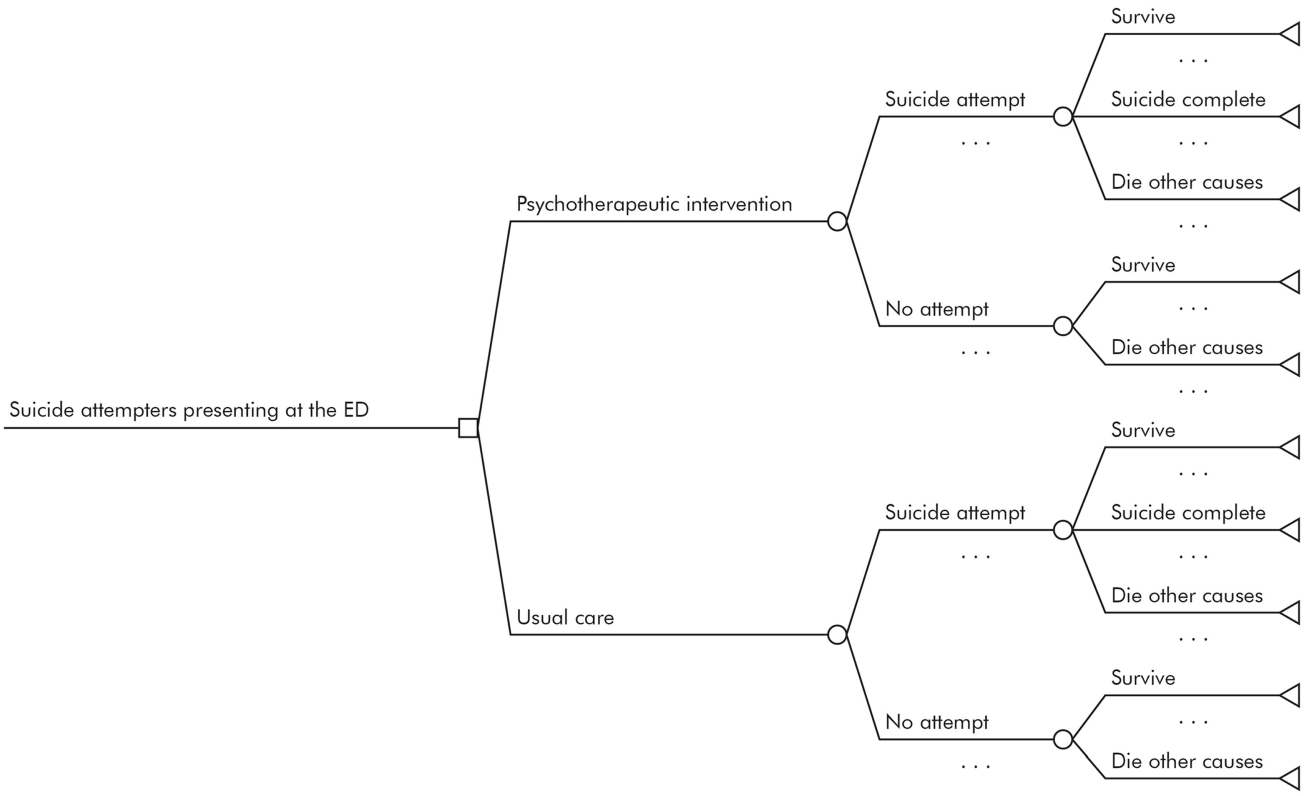

Figure 1. Structure of the model
ED, emergency department

Electronic Injury Surveillance System (NEISS). Since 2000, NEISS includes data on fatal and nonfatal injuries related to suicide. In 2010, NEISS estimated that 390,359 people had a visit to an ED for suicide attempt. Some individuals may have had multiple attempts in that year. The model adjusted for risk of additional attempts and risk of suicide death following an attempt using epidemiologic work on these risks.[11] Specifically, we assumed that in the year following an attempt, there was a 15% risk of nonfatal reattempt and 2% risk of death from suicide. Information on other causes of death were obtained from the CDC,[12] with an average risk of 0.7% for death from other causes.

To estimate the effectiveness of psychotherapeutic interventions for the prevention of suicide attempt and death, a recent systematic evidence review of suicide screening and prevention interventions was used.[1] This review by O'Connor et al.[1] estimated the effectiveness of psychotherapeutic approaches to suicide prevention based on 11 psychotherapy trials in adults. Approaches included cognitive behavioral treatment (CBT); interventions that incorporate elements of CBT (e.g., dialectical behavior therapy); and other non-CBT treatments such as psychodynamic or interpersonal therapy. This review estimated that the effect for all adult psychotherapy trials reporting suicide attempts demonstrated a 32% reduction in suicide attempts following intervention (relative risk [RR]=0.68, 95% CI=0.56, 0.83).[1] Another recent systematic review also suggested psychotherapeutic interventions are beneficial.[8] This review found a similar pattern of results to O'Connor and colleagues,[1] estimating a 24% reduction in suicide attempts following intervention (RR=0.76, 95% CI=0.61, 0.96). However, this review included studies directed at youth aged <18 years. The focus of this analysis is on adults; thus, estimates from O'Connor et al.[1] were used.

Because previous studies of suicide prevention intervention have observed few deaths, the systematic review could not assess whether or not psychotherapeutic interventions reduced the risk of suicide death.[1] Other models of the impact of depression treatment on the risk of suicide death have estimated the RR of no treatment versus treatment to be 1.8.[13] However, this estimate is not specific to persons with a prior suicide attempt, and we found no other estimate of this parameter in the literature. Given that there were no specific data available, we assumed the same impact for suicide attempt and suicide death following intervention (RR=0.68).

Modeling Approach

The number of people aged 18–64 years who attempted suicide in 2010, as identified by the NEISS, was modeled through a simple Markov chain with 1-year cycles for a period of 5 years or until they were predicted to have died. The comparator program was usual ED care. All individuals entered the cycle with an attempt, and all people entered the model in the health state of alive having survived a recent suicide attempt. From there, probabilities of suicide attempt, suicide death, and death from other causes determined who made transitions to other health states over time. Other health states included survive with additional suicide attempt, survive no additional suicide attempt, dead from suicide, and dead from other causes. For the first year of the model, transition probabilities were 15% risk of nonfatal reattempt, 2% risk of death from suicide, and 0.7% risk of death from other causes.

Definition of being seen for suicide attempt, as opposed to being seen for another concern, was determined by the NEISS system. The age of 18 years was chosen as the lower age limit for our models because it is the commonly accepted threshold for legal adulthood, and there are no known effective, evidence-based suicide psychotherapeutic suicide prevention interventions for children and adolescents to date.[1] The age of 64 years was chosen as the upper age limit because the lethality of suicide attempt rises substantially among individuals aged >64 years, and most studies in the systematic reviews did not include people aged >64 years.[1]

The model estimated the total number of suicide attempts and deaths that could be averted over the 1- and 5-year time frames if the intervention was provided every year for 5 years to all people coming to ED settings with a suicide attempt. Five-year estimates include five cohorts of individuals entering the system beginning with Year 1 and ending with Year 5. The model terminated prior to final absorption state (e.g., death) such that a half-cycle correction is often used.[14] However, this model is only intended to show the incremental difference between the two interventions such that the half-cycle correction is unlikely to have a significant influence and is not included.[15]

The focus of this modeling exercise was to estimate health outcomes that could be achieved under optimal circumstances. Therefore, our main analysis assumes optimal conditions including that all people coming to ED settings with a suicide attempt would receive the intervention, that the intervention will be effective as demonstrated in research studies, and that it could be implemented in typical ED settings.

However, experts have suggested that there are substantial differences in the outcomes achieved by interventions as they move from research into clinical practice.[16,17] For instance, Glasgow and colleagues[16] suggest five areas that are critical to effective implementation. *Reach* measures the participation rate among those approached. *Effectiveness* is the impact of the intervention on outcomes of interest. *Adoption* refers to how many organizations choose to offer an intervention, which is influenced by factors such as the cost of the intervention and its fit with the organization's culture. *Implementation* refers to the degree to which typical clinical settings can deliver the intervention with high quality and consistency. *Maintenance* refers to how long the effect lasts over time for participants and how well the intervention becomes integrated into usual care practice.

As an intervention moves into clinical practice, some of these factors may not be optimal. Subanalyses were conducted to begin to examine how estimates might change if circumstances were not "optimal." Data were only available on some of these factors. Specifically, several studies have suggested that treatment effects observed in research studies decrease as treatments are implemented in practice.[17,18] This may in part be due to bias toward publishing positive effects in psychotherapy trials.[19,20] Other studies have observed that without the incentives and attention of researchers, fewer people may agree to participate in an intervention.[16] Subanalyses were conducted to see how outcomes might change if reach of the intervention is reduced to 80% of people, if there was a 30% decrease in effectiveness of the intervention, or both.

Results

Table 1 presents the input parameters that were used in the model related to health outcomes. Table 2 presents

Table 1. Model input parameter values for health outcome model

Parameter	Values used in model	Source
Populations	Defines populations that might benefit from the intervention being evaluated	
Adults (aged 18–64 years) with past-year suicide, and an ED visit linked to suicide attempt	390,359	NEISS 2010
Rates of key events		
Proportion who attempt suicide and survive in year following attempt	15% in the first year following attempt, cumulative risk at the end of 5 years=25%	Owens et al. 2002[11]
Proportion who die of suicide attempt in year following attempt	2% in the first year following attempt, cumulative risk at the end of 5 years=3%	Owens et al. 2002[11]
Other causes death rate	Rate varies by age, average rate=0.0073	CDC Website Kochanek et al. 2011[12]
Intervention-related parameters		
Effectiveness of intervention (RR)	RR=0.68 (95% CI=0.56, 0.83)	AHRQ-EPC Task Force report 2012 O'Connor et al. 2013[1]
Decay rate of intervention effectiveness	100% in Year 1, decays to zero effect by 5 years	ACE suicide review
Hospital and ED-based clinicians are able to refer directly to PST	No delay in linking patients to services	ACE suicide review
No dose effect of intervention	Anyone receiving any intervention benefits at indicated efficacy	ACE suicide review
Uptake of intervention	Main analysis=100%, subanalysis=80% Uptake refers to the number of people who are likely to accept the intervention	Group discussion

ACE, Assessing Cost Effectiveness of Prevention; AHRQ-EPC, Agency for Healthcare Research and Quality Evidence-Based Practice Center; ED, emergency department; NEISS, National Electronic Injury Surveillance System; PST, psychotherapeutic intervention; RR, relative risk

the results of the model for health outcomes, under optimal conditions. The model estimated that over 1 year, implementing evidence-based psychotherapeutic interventions would decrease the number of suicide attempts by 18,737. If the intervention was offered over 5 years, the intervention would reduce the number of attempts by 109,306. Over 1 year, the model estimated that this would result in about 2,498 fewer deaths from

Table 2. Health outcomes for psychotherapeutic interventions in ED setting, adults aged 18–64 years

Type of outcome	Estimated suicide attempts and suicide deaths averted	Actual suicide attempts seen in the ED: NEISS 2010	Estimated % of total attempts averted	Actual suicide deaths: WISQARS 2010	Estimated % of total suicide deaths averted
Optimal implementation					
Nonfatal suicide attempts averted in 1 year	18,737	390,359	5		
Nonfatal suicide attempts averted in 5 years	109,306	1,951,795	6		
Suicide deaths averted in 1 year	2,498			31,354	8
Suicide deaths averted in 5 years	13,928			156,770	9

ED, emergency department; NEISS, National Electronic Injury Surveillance System; WISQARS, Web-Based Injury Statistics Query and Reporting System

Table 3. Subanalyses of health outcome estimates

Type of outcome	Estimated suicide attempts and suicide deaths averted	Suicide attempts seen in the ED: NEISS 2010	Estimated % of total attempts averted	All suicide deaths, ages 18–64 years: WISQARS 2010	Estimated % of total suicide deaths averted
80% reach (full effectiveness)					
Nonfatal suicide attempts averted in 1 year	14,990	390,359	4		
Nonfatal suicide attempts averted in 5 years	84,447	1,951,795	4		
Suicide deaths averted in 1 year	1,999			31,354	6
Suicide deaths averted in 5 years	11,146			156,770	7
100% reach (30% reduction in effectiveness)					
Nonfatal suicide attempts averted in 1 year	7,026	390,359	2		
Nonfatal suicide attempts averted in 5 years	44,122	1,951,795	2		
Suicide deaths averted in 1 year	937			31,354	3
Suicide deaths averted in 5 years	5,884			156,770	4
80% reach (30% reduction in effectiveness)					
Nonfatal suicide attempts averted in 1 year	5,621	390,359	1		
Nonfatal suicide attempts averted in 5 years	35,301	1,951,795	2		
Suicide deaths averted in 1 year	749			31,354	2
Suicide deaths averted in 5 years	4,704			156,770	3

ED, emergency department; NEISS, National Electronic Injury Surveillance System; WISQARS, Web-based Injury Statistics Query and Reporting System

suicide, and over 5 years about 13,928 fewer suicide deaths.

Table 3 presents the results of our subanalyses exploring how outcomes might change if circumstances were less than optimal. The first subanalysis explored how estimates change if reach (agreement to participate in the intervention) dropped from 100% to 80%. Under this assumption, the model estimated that over 1 year about 14,490 attempts would be averted, and over 5 years, 84,447 attempts would be averted. Over 1 year, the intervention would avert about 1,999 deaths from suicide, and over 5 years, 11,146 suicide deaths would be averted. The second subanalysis explored how estimates change if the effectiveness of intervention were reduced by 30%. Under this assumption, the model estimated that over 1 year, the number of suicide attempts averted would be 7,026, and over 5 years, 44,122 attempts would be averted. Over 1 year, the intervention would avert about 937 suicide deaths, and over 5 years, 5,884 suicide deaths. The final subanalysis explored how estimates change if reach were reduced to 80% and effectiveness reduced 30%. Under these assumptions, the model estimated that over 1 year, 5,621 attempts would be averted, and over 5 years, 35,301 attempts would be averted. Over 1 year, 749 deaths from suicide would be averted, and over 5 years, 4,704 suicide deaths would be averted.

Discussion

The purpose of this paper is to illustrate how information from a health outcome model might aid in setting priorities related to suicide prevention. It is not intended to be a definitive model of health outcomes from suicide prevention, but rather to provide a first step in identifying gaps in available research that if filled could improve future models. Because this paper is primarily intended to provide an example of what types of information a health outcome model could provide, it does not provide some information that could be important for decision makers. For instance, comprehensive assessment of statistical precision is not investigated. In addition, the model was simple and thus may not include all relevant factors.

The model was limited by lack of data on several epidemiologic parameters related to suicidal behavior. More data on the relationship among suicide ideation, suicide attempt, and completed suicide would allow for a more accurate model. In particular, information about

accumulation of risk across multiple attempts is needed. Models were also limited by the lack of availability of data on subgroups (e.g., women, racial/ethnic subgroups).

The models were also limited by currently available research on the effectiveness of psychotherapeutic interventions for suicide attempts. In particular, more information on the impact of psychotherapeutic interventions on preventing death from suicide death is needed. Many of the studies in recent systematic reviews[1,8] had small samples; some focused on subsamples (e.g., women only); and a number of different types and amounts of psychotherapy were tested.

Understanding the impact of these factors could improve future models. For instance, women attempt suicide more frequently than men, and interventions to prevent reattempt may be more successful in women. These limitations suggest caution in interpretation of the effectiveness of these interventions. However, it is also important to consider that some of these factors, such as small samples, are in part due to the nature of the problem under consideration and thus may be difficult to resolve.

Additional information on intervention effectiveness could also improve models. For example, if a person has received a psychotherapeutic intervention and comes to an ED with a new attempt, will repeating the intervention have additional effect? Could psychotherapeutic interventions work for persons presenting at other clinical settings (e.g., outpatient mental health, substance abuse programs)?

The models focused on two key outcomes identified by the RPTF: suicide attempts and suicide deaths. However, these outcomes do not fully capture the benefits associated with the psychotherapeutic interventions. For instance, O'Connor et al.[1] reported that psychotherapeutic suicide prevention interventions also reduce depression symptoms. Further, some research has indicated that persons who attempt suicide die of other causes (e.g., accidents, illnesses) at a higher rate,[21] and prevention programs might also alter this risk. In addition, suicide attempts and suicide death have significant consequences for family and friends, and these may have important and lasting health implications for these people. Thus, the current results include only partial representation of the potential benefits of these interventions.

The model was also limited by lack of information about implementation. It is unknown what the likely participation rate for psychotherapeutic interventions would be in typical ED settings. A related concern is the assumption that the intervention will be equally effective as in research studies.[16–18] The modeling approach attempted to address these issues by conducting subanalyses to see how results changed if some factors were less optimal. However, there could be a variety of reasons why health outcomes might be different in real-world settings, including lack of appropriate training and supervision of intervention staff or lack of funding for the intervention. Systematic discussion of such factors might also aid in setting priorities for suicide prevention.

The model also did not consider the costs associated with providing an intervention. Cost is important because most health policy decisions are made within a context of constrained budgets. Use of cost information in decision making has been described by several expert groups[22,23] and is used in public health policy decisions in a number of contexts.[8,24–26] One recent example is the Assessing Cost Effectiveness of Prevention (ACE) Australia project (sph.uq.edu.au/bodce-ace-prevention). The ACE project used decision analytic modeling to evaluate the relative costs and health outcomes associated with alternative prevention strategies across the health system.[25–27]

Cost information is likely important from both the system and the patient perspective. Most research studies pay for the cost of the research treatment; thus, patient financial costs are typically minimal. However, in practice, most people would pay copayments, or if uninsured, the entire cost of the treatment. This could be a significant barrier to optimal implementation. From the health systems perspective, implementation of universal psychotherapeutic interventions for suicide prevention would require significant investment. This investment might reduce some future health care costs, (e.g., hospitalizations due to future attempts), but few studies document any types of costs related to suicide prevention interventions to date.

Conclusions

Achieving the goal of reducing suicide deaths and attempts by 20% within 5 years[4] requires information on the likely impact of different approaches in order to prioritize where to focus implementation efforts. Further research developing more sophisticated models of the impact of suicide prevention interventions could aid this effort. Inclusion of more complex understanding of suicidal behavior, longer time frames, and inclusion of outcomes that capture the full benefits and costs of interventions would be helpful next steps.

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