Psychiatry Research 268 (2018) 317–322

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Characteristics of a suicide attempt predict who makes another attempt after hospital discharge: A decision-tree investigation☆

Joshua T. Jordan*, Dale E. McNiel

Department of Psychiatry, University of California, San Francisco, San Francisco, CA, USA

ARTICLE INFO

KeyWords:
Risk assessment
Risk management

ABSTRACT

The year following discharge from psychiatric hospitalization is a high-risk period for suicidal behavior, particularly among patients initially hospitalized after a suicide attempt. Demographic and clinical correlates have been identified; however, characteristics of the initial attempt may provide insight into risk for subsequent attempts as well. This investigation examined whether individual or a combination of suicide attempt characteristics predicted future attempts. Two hundred and eighteen psychiatric inpatients from the MacArthur Violence Risk Assessment Study with a recent suicide attempt were administered items from the Suicide Intent Scale and followed one year after discharge. Sixty-nine (31.65%) made a subsequent attempt. Data were analyzed by a stepwise logistic regression, followed by an iterative receiver operator curve (IROC) analysis, a recursive partitioning classification tree. The cross-validated IROC, but not logistic regression, predicted subsequent suicide attempts. Furthermore, the IROC found that participants who made definite plans and underwent extensive preparation were at highest risk for subsequent attempts. These findings suggest that suicide attempt characteristics preceding psychiatric hospitalization can help identify patients at elevated risk for another attempt post-discharge.

1. Introduction

Suicide is the tenth leading cause of death in the United States, and second among individuals between the ages of 15 and 24 (Drapeau and McIntosh, 2016). One of the most high-risk periods for suicide attempts and subsequent death by suicide is in the year following psychiatric hospitalization (Chung et al., 2017), and individuals who are initially hospitalized for suicidal ideation or behaviors appear to be at greatest risk for subsequent death by suicide (Chung et al., 2017). Identifying risk factors associated with post-discharge suicidal behavior is therefore important to suicide prevention during this period of elevated vulnerability.

A history of self-harm, male gender, recent social problems, major depression, and unplanned discharges have all been implicated as risk factors (Large et al., 2011) for death by suicide after discharge. No single or combination of clinical or sociodemographic characteristics strongly predict subsequent suicidal behaviors or attempts, however (Large et al., 2011). Other information may increase clinical accuracy; namely, characteristics of the attempt itself. Prior research has suggested that subjective intent to die can predict subsequent suicide attempts (Sapyta et al., 2013), that individuals using violent means are more likely to ultimately die by suicide (Runeson et al., 2010), and that perceived attempt effectiveness may have validity in predicting subsequent attempts as well (O'Connor et al., 2017).

The Suicide Intent Scale (SIS; Beck et al., 1974) has promise in detecting future suicide risk among individuals with a recent attempt. The SIS consists of 15 items, assessing objective evidence of intent to die (isolation, timing, precautions against discovery, not acting to get help, final acts in anticipation of death, active preparation, presence of a suicide note, not communicating intent) and self-reported expectations from the attempt (purpose of attempt, expectations of fatality, conception of method lethality, seriousness of the attempt, attitude toward living and dying, conception of medical rescuability, premeditation). Each item is rated ordinally from zero to two, with higher scores indicating greater severity. Total scores are derived by taking the sum of all the items. A comprehensive review of the SIS observed mixed evidence for the predictive validity of the total score in detecting risk for future suicide attempts (Freedenthal, 2008); however, some research using subscales from the SIS has found consistent group differences (Beck and Steer, 1989; Beck et al., 1989). One study found that four items discriminated between those who ultimately died by suicide and those who did not (Stefansson et al., 2012), which suggests that

☆ Previous presentation: Paper presented at the annual meeting of the American Association of Suicidology, Washington DC, April 2018.

* Corresponding author.
E-mail address: jtjordan@ucsf.edu (J.T. Jordan).

https://doi.org/10.1016/j.psychres.2018.07.040
Received 12 March 2018; Received in revised form 6 July 2018; Accepted 29 July 2018
Available online 31 July 2018
0165-1781/ © 2018 Elsevier B.V. All rights reserved.

some characteristics of an attempt may confer an increased risk for subsequent attempts better than others. We are unaware of investigations that have focused exclusively on individual characteristics from the SIS, or their interactions, in predicting future suicide risk. Identifying specific characteristics, or a combination of characteristics, could provide a more accurate assessment of risk for subsequent suicidal behavior after an initial attempt.

This paper describes a prospective study of 218 psychiatric patients who recently attempted suicide before hospitalization. We examined whether characteristics of the index suicide attempt, as measured by items from the SIS, predicted re-attempt in the year after hospital discharge. Because there were no a priori hypotheses, exploratory data-driven models were used. We evaluated whether a standard multivariate (additive) model could predict re-attempt status, and whether a recursive partitioning approach (Kraemer, 1992) could predict re-attempt status based on interactions between characteristics. Recursive partitioning was implemented because it examines contingent relationships among variables that may identify heterogeneous profiles of individuals at elevated risk that standard linear models cannot identify, and if the models have adequate diagnostic capabilities, it can produce empirically-derived decision trees that may inform and guide the clinical assessment and management of suicidal patients, which has already been applied to violence risk assessment (Monahan et al., 2000; Steadman et al., 2000).

2. Methods

2.1. Participants and procedures

Data for the present investigation comes from the MacArthur Violence Risk Assessment Study (MVRAS), a longitudinal study of hospitalized psychiatric patients recruited while in one of three acute inpatient facilities in U.S. cities between 1992 and 1995 (Monahan et al., 2001). As previously reported, subjects were recruited if they were civilly admitted; between 18–40 years old; White or African American (or Hispanic in Worcester only); English-speaking; and have a chart diagnosis of a psychiatric disorder (Monahan et al., 2000). Subjects were initially evaluated while in the inpatient facilities and re-evaluated in the community once every ten weeks during the year after discharge. A description of how informed consent was obtained is provided elsewhere (Monahan et al., 2001). Because this study is a secondary analysis of a publically available, de-identified dataset, additional institutional review board approval was not necessary.

2.2. Psychiatric diagnosis and clinical assessment

Subjects were assessed by a master's or doctoral-level research clinician and administered the DSM-III-R checklist for Axis I psychiatric disorders (Hudziak et al., 1993) to confirm psychiatric diagnoses for study eligibility. The Structured Interview for DSM-III-R Personality Disorders (SIDP-R; Pfohl et al., 1989) was given at follow-up assessments to determine presence of a personality disorder.

Suicide attempt status was defined as a self-injurious act with intent to die, either explicitly stated or inferred through steps taken (O'Carroll et al., 1996). Explicit intent in the MVRAS was determined by answering "yes" to the question "Were you trying to kill yourself?"; inferred intent was determined based on items from the SIS as previously described (Sadeh and McNiel, 2013; Skeem et al., 2006). Inferring intent increased the total number of suicide attempters by 15% (Skeem et al., 2006).

Seven items from the SIS were administered. These included: acts in anticipation of death (responses include: none/thought about/made definite plans), premeditation (none/$<$3 h/$>$3 h), preparation (none/minimal to moderate/extensive), note (none/thought about/present), probability of intervention (intervention probable/intervention not likely/ intervention unlikely), isolation (somebody present/somebody nearby or in visual or vocal contact/no one nearby), and precautions against discovery (none/passive precautions/active precautions). Additional qualitative information was obtained for subjects who obtained scores of one or two on these items and was recorded in the database.

One additional attempt characteristic – lethality of the method used – was included in the analysis. This was coded as zero (non-lethal) or one (lethal) based on the criteria outlined by Bhaskaran et al. (2014), with drug/alcohol ingestion and laceration considered "non-lethal" and all other methods (e.g., firearm, vehicular, combination of methods) considered "lethal."

2.3. Statistical analysis

Suicide attempters who made a subsequent attempt in the year following psychiatric hospitalization were first compared to those who attempted at baseline only by univariate analyses (Mann-Whitney U tests for continuous variables and Pearson chi-square or Fisher's Exact Test for categorical variables). Stepwise logistic regression with forward elimination was first used to determine if a standard multivariate method could identify unique predictors of re-attempt status. Forward elimination was chosen for this analysis as the recursive partitioning model operates in a forward fashion. Variables were excluded from the model if $p > .05$.

An iterative receiver operator characteristic analysis (IROC) was used to evaluate whether interactions between characteristics of the index suicide attempt predicted subsequent attempt. The IROC was conducted via the ROC5 software; the software and supporting documentation are freely available (https://web.stanford.edu/~yesavage/ROC.html). IROC is a hypothesis-generating recursive partitioning technique that identifies predictors – and interactions between predictors – that best differentiates between groups (Kraemer, 1992). IROC identifies predictors through Cohen's κ, and tests for significance via a chi-square statistic. First, IROC rank orders all predictors via κ, which can be weighted to favor sensitivity or specificity. For binary data, IROC searches for the largest κ. For ordinal or continuous data, IROC evaluates κ (and its associated p-value) at all cut-points of the variable. After it identifies an optimal predictor, it divides the data based on this value. The IROC then looks for the next best predictor among these new groups. It continues this process until there are no more significant predictors (per a priori-defined p-values), or the sample size is deemed too small. This results in an empirically-derived decision tree (Main et al., 2017). This item-level approach has been adopted with success (Tiet et al., 2016, 2015). Given that the purpose of the analysis was exploratory, and due to the combination of our modest sample size and low base rate for re-attempts, we set the minimum sample size to $n < 10$. This threshold has been used in prior item-level IROC analyses (Tiet et al., 2015; Tiet et al., 2016). We set the threshold for statistical significance to $p < .05$, which was consistent with the logistic regression. Given the tendency of single decision trees to over-fit data, and that pruning is not a feature of IROC, we assessed the stability and significance of each identified contingent relationship by bootstrapping (Efron and Tibshirani, 1993) each significant Cohen's κ with 5000 replications. In brief, bootstrapping is a resampling method that takes a parameter of interest (in this case, Cohen's κ), samples (with replacement) from the original dataset a specified number of times (in this case, 5000 times), and re-estimates the parameter with each iteration. This in turn provides a robust estimate of the distribution of the parameter, which can be used to assess statistical significance. The 95% bootstrapped confidence intervals were examined to determine whether the split would be retained in the decision tree. Bootstrapped Cohen's κ 95% confidence intervals that contained zero were considered non-significant, and these branches (and subsequent nodes) were removed.

For both the stepwise logistic regression and IROC, participants were classified as re-attempters if their predicted probability exceeded the sample base rate of re-attempting in the year following discharge.

Furthermore, to estimate generalizability of the models to outside samples, we used leave-one-out cross validation. This approach works well for cross-validation when there is a relatively small sample size (Molinaro et al., 2005) and with small sample sizes is preferable to split-sample validation. Missing data was handled in the stepwise regression with list-wise deletion. In the event that the models had differing sample sizes, the logistic regression equation was applied to the sample used in the IROC.

Demographic and clinical information were also included in both the stepwise logistic regression and IROC analyses, in addition to the aforementioned suicide attempt characteristics. Demographic information included age, education (less than vs. ≥12 years), gender (male vs. female), race (White vs. non-White), marital status (married vs. not married), and employment status (employed vs. unemployed). Clinical characteristics included depressive disorders (major depression or dysthymia), a psychotic disorder (schizophrenia, schizoaffective, or delusional disorder), bipolar disorder, substance use disorder (alcohol abuse/dependence, and/or drug abuse/dependence), and presence of a personality disorder.

3. Results

Of the 1,136 patients in the parent study at baseline, two hundred and fifty (51% male, 77% white) reported a recent suicide attempt within the two months preceding the index hospitalization (Sadeh and McNiel, 2013). Of these 250 participants, 87.2% (218/250) had at least one follow-up assessment and were included in the present study. Participants who completed at least one follow-up assessment were significantly more likely to have a depressive disorder than those who did not (Odds Ratio [OR] = 2.89, $x^2[1] = 7.92$, $p = .005$, 95% Confidence Interval [CI] = 1.24–6.61). No other clinical or demographic characteristics distinguished between participants who completed follow-up assessments and those who did not.

Among these 218 participants, 132 (60.55%) had data at all five follow-up assessments; 42 (19.27%) had data at four assessments; 20 (9.17%) had data at only three assessments; 18 (8.26%) had data at only two assessments; and six (2.75%) had data at only one follow-up assessment. Furthermore, 69 (31.51%) made a subsequent suicide attempt in the year following their initial attempt (76.81% within the first 30 weeks).

Demographic and clinical characteristics of single versus repeat attempters can be found in **Table 1**. There were no significant differences between single and repeat attempters on any characteristics at baseline. There was less than three percent missing data on the majority of items; however, only 82% (N = 179) of participants were administered “Acts in Anticipation” and 90% (N = 197) of participants were administered the SIDP-R. Participants were more likely to have “Acts in Anticipation” missing if they were female (OR = 2.66, $x^2[1] = 7.03$, $p = .008$, 95% CI = 1.21–6.12) and if they had ≥12 years of education (OR = 2.64, $x^2[1] = 4.47$, $p = .035$, 95% CI = 1.01–8.10). Participants were more likely to have the SIDP-R missing if they had a substance and/or alcohol use disorder (OR = 3.22, $x^2[1] = 4.56$, $p = .033$, 95% CI = 1.00–13.59).

The stepwise logistic regression had a total sample size of N = 154 due to missing data, and the IROC had a total sample size of N = 175 due to missing data. Thus, the logistic regression equation identified by the stepwise model was applied to the sample used in the IROC to make the two methods comparable. Therefore, the sample size for the below results are based on the 175 participants used in the IROC.

3.1. Stepwise logistic regression

The stepwise logistic regression found that absence of a depressive disorder was associated with a subsequent suicide attempt, as was Acts in Anticipation (see Table 2). These predictors were significant and had the same directionality in both the original sample and the IROC sample. The overall model had an Area Under the Curve (AUC) of 0.63 (95% Confidence Interval [CI] = 0.55–0.71), sensitivity of 55.77%, specificity of 69.11%, positive predictive value (PPV) of 43.28%, and negative predictive value (NPV) of 78.70%. The cross-validated model had an AUC of 0.43 (95% CI = 0.34–0.58), with sensitivity = 61.54%, specificity = 56.91%, PPV = 37.65%, NPV = 77.78%. The cross-validated model, based on the AUC, suggests that the linear model may not have utility as a predictive tool.

Table 1
Demographic and clinical characteristics of the sample.

Variable	Baseline attempt only (n = 149)	Follow-up attempt (n = 69)	df	x^2	p
Age Group			2	1.82	0.402
18–20	16 (10.74)	4 (5.80)			
21–30	65 (43.62)	35 (50.72)			
31–40	68 (45.64)	30 (43.48)			
Gender					
Male	79 (53.02)	30 (43.48)	1	1.72	0.190
Ethnicity					
White	112 (75.17)	55 (79.71)	1	0.54	0.461
Marital status					
Married	17 (11.41)	9 (13.04)	1	0.12	0.729
Employment					
Employed	97 (65.10)	39 (56.52)	1	1.48	0.224
Education					
≥ 12 Years	103 (69.13)	51 (73.19)	1	0.521	0.471
Psychiatric diagnosis					
Psychotic disorder	15 (10.01)	5 (7.25)			0.502[a]
Depressive disorder	118 (79.19)	49 (71.01)	1	1.76	0.185
Bipolar disorder	17 (11.41)	9 (13.04)	1	0.12	0.729
Personality disorder[b]	99 (73.33)	53 (85.48)	1	3.56	0.059
Alcohol/Substance use disorder	92 (61.74)	37 (53.62)	1	1.29	0.256

Note. Frequencies and percentages presented.
[a] Fisher's exact test;
[b] n = 135 for baseline only and n = 62 for follow-up attempters.

Table 2
Significant variables from stepwise logistic regression predicting suicide attempt in the year after hospital discharge.

Variable	Odds ratio	|z|	p-value	95% CI
Acts in anticipation	1.66	2.15	0.032	1.05 to 2.62
Depression diagnosis	0.46	2.02	0.044	0.22 to 0.98

Note. Forward elimination, with exclusion at p-values of >0.05.

3.2. Iterative receiver operator characteristic analysis

Results of the IROC analyses can be found in Fig. 1, and diagnostic information can be found in Table 3. The IROC identified six subgroups, which did not differ in the number of follow-up observations ($x^2[5] = 2.24$, $p = .816$). All identified significant contingent relationships were significant via bootstrapping; therefore, no nodes were removed. The overall AUC was 0.72 (95% CI = 0.64–0.80), with sensitivity of 76.90%, specificity of 56.90%, PPV = 43.00%, and NPV = 85.40%, and the cross-validated model had an AUC of 0.62 (95% CI = 0.52–0.72), with sensitivity of 78.85%, specificity of 45.53%, PPV = 37.96%, and NPV = 83.58%.

3.2.1. Attempters with definite plans

The strongest predictor among all variables was a score of two on the item “acts in anticipation of death” (“none” or “thought about” versus “made definite plans”). Qualitative clinical notes from the interviewers revealed that participants with ratings of “thought about” communicated their wishes to die in some capacity, and participants with “definite plans” engaged in activities preparing for after their

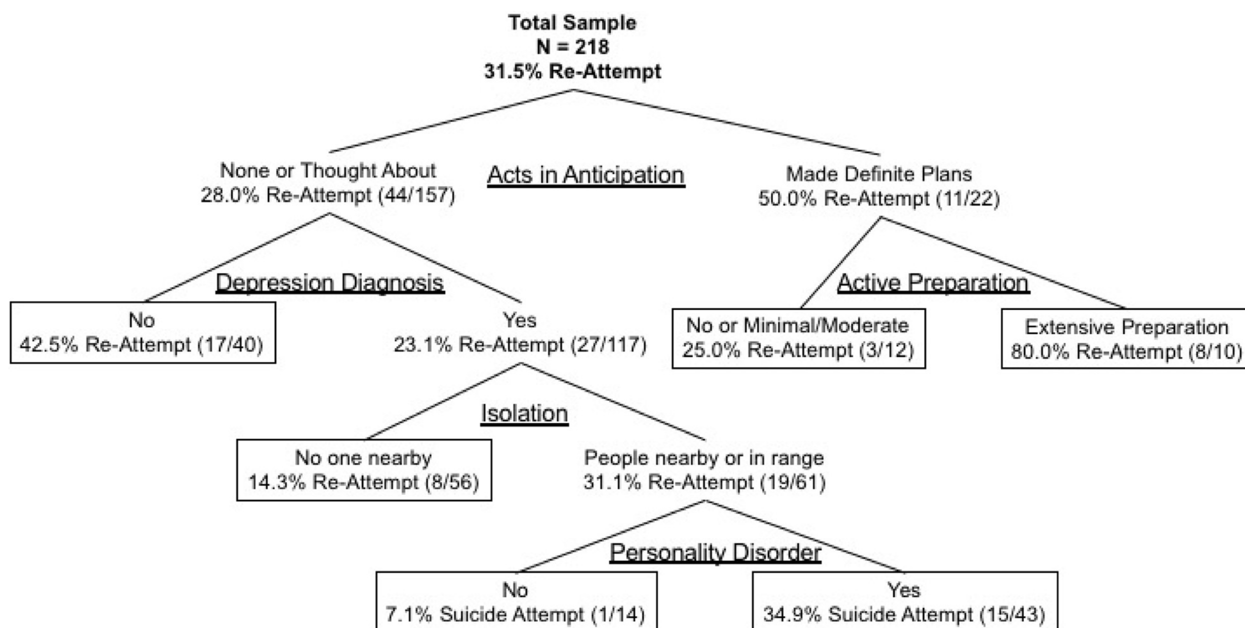

Fig. 1. Iterative receiver operator decision tree predicting suicide attempt in the year after hospital discharge.
Note. Boxes indicate terminal nodes.

Table 3
Diagnostic information from iterative receiver operator decision tree.

Rule	Sens	Spec	PPV	NPV	κ (95% BCI)
Made definite plans	20.0%	91.1%	50.0%	72.0%	0.13 (0.05–0.31)*
Made definite plans + actively prepared	72.7%	81.8%	80.0%	75.0%	0.55 (0.17–0.82)*
No plans + no depression	38.6%	79.7%	42.5%	76.9%	0.19 (0.03–0.35)*
No plans + depression + not isolated	70.4%	53.3%	31.2%	85.7%	0.17 (0.02–0.31)*
No plans + depression + not isolated + personality disorder	93.8%	31.7%	34.9%	92.9%	0.17 (0.04–0.33)*

Note.
* $p < .05$; Sens = Sensitivity; Spec = Specificity; PPV = Positive predictive value; NPV = Negative predictive value; κ= Kappa; BCI = Bootstrapped confidence intervals.

death (e.g., preparing a will, paying for their funeral).

Among those with definite plans, participants were further divided based on a score of two on "active preparation". Examination of the interviewers' clinical notes indicated that participants with ratings of "extensive" ensured they had adequate means for their attempt; participants with ratings of "minimal to moderate" ingested substances.

3.2.2. *Attempters without definite plans*

Among participants who did not or had only thought about wrapping up affairs prior to their attempt, the IROC divided these participants based on whether they met criteria for a depressive disorder. Participants that did not meet criteria for a depressive disorder were more likely to make a subsequent attempt than those who did.

For participants without definite plans prior to their index attempt and a depressive disorder, risk was further stratified depending on whether or not they had made their attempt in isolation. A score of zero ("somebody present") or one ("somebody nearby or in visual or vocal contact") was associated with increased risk for subsequent suicide attempt relative to participants who made their attempt in isolation. Within this subgroup, participants who made their attempt with others near or within range of them were significantly more likely to make a subsequent attempt if they met criteria for a personality disorder.

4. Discussion

This prospective study examined whether characteristics of a suicide attempt before psychiatric hospitalization predict a subsequent suicide attempt in the year after discharge. The current study confirms that characteristics of an index attempt can identify subgroups at high risk of making another attempt, and can be used with other clinical information to inform risk assessment. It additionally identified a high-risk subgroup: individuals who made definite plans and took additional steps to prepare for their index attempt were highly likely to make another attempt after their discharge.

The association between plans, preparation and suicide risk is consistent with previous research. The "resolved plans and preparation" subscale from the Scale for Suicide Ideation (SSI; Beck et al., 1979) has been found to predict future death by suicide (Joiner et al., 2003). Other studies have found that this subscale is associated with single and multiple suicide attempts (Gibb et al., 2009; Joiner et al., 1997; Minnix et al., 2007), and because of this has become a critical component of empirically-derived risk assessment for suicidality (Joiner et al., 1999). The present findings provide further evidence that resolved plans and preparations place individuals at greater risk for suicidal behavior.

The Interpersonal Theory of Suicide (IPTS) posits that individuals acquire the capability to enact lethal or nearly lethal suicide attempts through previous suicidal behaviors (Joiner, 2005). Moreover, it has been proposed that the mental rehearsal of suicidal acts increases suicide capability (Selby et al., 2007; Van Orden et al., 2010), and that practical factors, such as having a knowledge of and or/access to lethal means also increases one's capacity for suicide (Klonsky and May, 2015). It may be that the additional acts of planning and preparation taken by individuals prior to their attempt desensitized them to the extent that it facilitated an easier transition to future suicidal behavior. Furthermore, given that these patients appeared to approach their attempt in a manner that assumed probable death, they may be less future-oriented than other attempt survivors, which is associated with suicide risk (Chang et al., 2013; Hirsch et al., 2007, 2006), and they may be disappointed that they survived their attempt given their level of effort – which is associated with subsequent suicide (Bhaskaran

et al., 2014; Henriques et al., 2005). Ultimately, these patients represent a high-risk group that requires more intensive services after their discharge from psychiatric hospitalization.

This study also highlights the utility of alternative statistical approaches to identify individuals at heightened risk for adverse outcomes such as suicide. Traditionally, suicide research has focused predominantly on standard multivariate methods such as logistic regression to identify predictors of suicide risk. Although powerful, traditional linear models examine how a linear combination of variables predict an outcome, and identifies homogeneous outcomes with heterogeneous risk predictors; recursive partitioning methods such as IROC, however, elucidate interactions between predictors, thereby identifying homogeneous outcomes and risk predictors (Kiernan et al., 2001). For example, in the present study, the logistic regression identified acts in anticipation of death and absence of depression as predictors of re-attempt status, but was unable to identify which and how individuals in particular are affected by those predictors.

Given that suicide is the result of a complex series of interactions, and that the field is currently limited in its ability to predict suicide-related outcomes (Franklin et al., 2017), it stands to reason that recursive partitioning methods could substantially improve the assessment of suicide risk. Although some investigations of suicide risk have adopted this or similar approaches (e.g., Baca-Garcia et al., 2006; Delgado-Gomez et al., 2012; Delgado-Gomez et al., 2016; Ilgen et al., 2011; Handley et al., 2014; Kessler et al., 2005; Mann et al., 2008; Tiet et al., 2006; Walsh et al., 2017), they are not yet widely used.

There are some limitations to this study. There was a relatively small sample size, which may have prevented the identification of other high-risk subgroups and may limit the generalizability of our empirically-derived decision tree to other samples. Future research is needed to cross-validate our sample on external datasets, which would enhance generalizability. Moreover, single decision trees such as the one conducted in the present study have a tendency to over-fit the data, although we attempted to mitigate this through bootstrapping the identified contingent relationships. This sample was collected in the early 1990′s, and it is possible that these results may not generalize to the same extent to current psychiatric inpatients. Not all items of the SIS were administered, and other information (e.g., motivations for the attempt, reactions to the attempt, prior suicide history) was not available. Some baseline data was not missing at random; therefore, this may also limit the generalizability of our findings. Other psychiatric disorders marked by agitation or impulse control issues (e.g., posttraumatic stress disorder) are associated with an increased risk for suicide attempts (Nock et al., 2010) but were not assessed in the MVRAS. Future research is needed to replicate these findings in a larger, more current sample with more detailed information of the index attempt, and greater information regarding other psychiatric disorders.

The year following psychiatric hospitalization is one of the highest risk periods for death by suicide, particularly among those with a recent suicide attempt (Chung et al., 2017). The evaluation of an individual's steps taken prior to their attempt – specifically, whether they made definite plans and underwent extensive preparation for their attempt – may be a critical marker for future suicide attempts shortly after the patient is discharged. Similarly, if an individual makes few if any plans prior to their attempt and is not depressed, they may be at a greater risk for future suicide attempts in the following year. This information can help provide clinicians with a better sense of which patients may require a higher level of services once they are discharged back into the community.

Funding

None

Conflict of Interest

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.07.040.

References

Baca-Garcia, E., Perez-Rodriguez, M., Basurte-Villamor, I., Saiz-Ruiz, J., Leiva-Murillo, J., de Prado-Cumplido, M., Santiago-Mozos, R., Artes-Rodriguez, A., de Leon, J., 2006. Using data mining to explore complex clinical decisions: a study of hospitalization after a suicide attempt. J. Clin. Psychiatry 67, 1124–1133.
Beck, A., Steer, R., 1989. Clinical predictors of eventual suicide: a 5- to 10-year prospective study of suicide attempters. J. Affect. Disord. 17, 203–209.
Beck, A., Steer, R., Trexler, L., 1989. Alcohol abuse and eventual suicide: a 5- to 10-year prospective study of alcohol abusing suicide attempters. J. Stud. Alcohol Drugs 50, 202–209.
Beck, A.T., Kovacs, M., Weissman, A., 1979. Assessment of suicidal intention: the scale for suicide ideation. J. Consult. Clin. Psychol. 47, 343–352. https://doi.org/10.1037/0022-006X.47.2.343.
Beck, A.T., Schuyler, D., Herman, I., 1974. Development of suicidal intent scales. In: Beck, A.T., Resnik, H.L., Lettieri, D.J. (Eds.), The Prediction of Suicide. Charles Press Publishers, Oxford, England.
Bhaskaran, J., Wang, Y., Roos, L., Sareen, J., Skakum, K., Bolton, J.M., 2014. Method of suicide attempt and reaction to survival as predictors of repeat suicide attempters: a longitudinal analysis. J. Clin. Psychiatry 75, e802–e808.
Chang, E.C., Yu, E.A., Lee, J.Y., Hirsch, J.K., Kupfermann, Y., Kahle, E.R., 2013. An examination of optimism/pessimism and suicide risk in primary care patients: does belief in a changeable future make a difference. Cognit. Ther. Res. 37, 796–804.
Chung, D.T., Ryan, C.J., Hadzi-Pavlovic, D., Singh, S.P., Stanton, C., Large, M.M., 2017. Suicide rates after discharge from psychiatric facilities: A systematic review and meta-analysis. JAMA Psychiatry 74, 694–702.
Delgado-Gomez, D., Baca-Garcia, E., Aguado, D., Courtet, P., Lopez-Castroman, J., 2016. Computerized adaptive test vs. decision trees: development of a support decision system to identify suicidal behavior. J. Affect. Disord 206, 204–209.
Delgado-Gomez, D., Blasco-Fontecilla, H., Sukno, F., Ramos-Plasencia, M.S., Baca-Garcia, E., 2012. Suicide attempters classification: toward predictive models of suicidal behavior. Neurocomputing 92, 3–8.
Drapeau, C.W., McIntosh, J.L., 2016. In: U.S.A. Suicide 2015: Official Final Data. Washington, DC.
Efron, B., Tibshirani, R.J., 1993. An Introduction to the Bootstrap. Chapman & Hall, London, U.K.
Franklin, J.C., Ribeiro, J.D., Fox, K.R., Bentley, K.H., Kleiman, E.M., Huang, X., Musacchio, K.M., Jaroszewski, A.C., Chang, B.P., Nock, M.K., 2017. Risk factors for suicidal thoughts and behaviors: a meta-analysis of 50 years of research. Psychol. Bull. 143, 187–232. https://doi.org/10.1037/bul0000084.
Freedenthal, S., 2008. Assessing the wish to die: a 30-year review of suicide intent scale. Arch. Suicide Res. 12, 277–298. https://doi.org/10.1080/13811110802324698.
Gibb, B.E., Andover, M.S., Miller, I.W., 2009. Depressive characteristics of adult psychiatric inpatients with a history of multiple versus one or no suicide attempts. Depress. Anxiety 26, 568–574.
Handley, T.E., Hiles, S.A., Inder, K.J., Kay-Lambkin, F.J., Kelly, B.J., Lewin, T.J., McEvoy, M., Peel, R., Attia, J.R., 2014. Predictors of suicidal ideation in older people: a decision-tree analysis. Am. J. Geriatr. Psychiatry 22, 1325–1335.
Henriques, G., Wenzel, A., Brown, G.K., Beck, A.T., 2005. Suicide attempters' reaction to survival as a risk factor for eventual suicide. Am. J. Psychiatry 162, 2180–2182.
Hirsch, J.K., Duberstein, P.R., Conner, K.R., Heisel, M.J., Beckman, A., Franus, N., Conwell, Y., 2007. Future orientation moderates the relationship between functional status and suicide ideation in depressed adults. Depress. Anxiety 24, 196–201.
Hirsch, J.K., Duberstein, P.R., Conner, K.R., Heisel, M.J., Beckman, A., Franus, N., Conwell, Y., 2006. Future orientation and suicide ideation and attempts in depressed adults ages 50 and over. Am. J. Geriatr. Psychiatry 14, 752–757.
Hudziak, J., Helzer, J., Wetzel, M., Kessel, K., McGee, B., Janca, A., Przybeck, T., 1993. The use of the DSM-III-R checklist for initial diagnostic assessments. Compr. Psychiatry 34, 375–383.
Ilgen, M., Downing, K., Zivin, K., Hoggatt, K., Kim, H., Ganoczy, D., Austin, K., McCarthy, J., Patel, J., Valenstein, M., 2011. Identifying subgroups of patients with depression who are at high risk for suicide. J. Clin. Psychiatry 70, 1495–1500.
Joiner, T., 2005. Why people die by suicide. Harvard University Press, Cambridge, Massachusetts.
Joiner, T.E., Rudd, M.D., Rajab, M.H., 1997. The modified scale for suicidal ideation: factors of suicidality and their relation to clinical and diagnostic variables. J. Abnorm. Psychol. 106, 260–265.
Joiner, T.E., Steer, R.A., Brown, G., Beck, A.T., Pettit, J.W., Rudd, M.D., 2003. Worst-point suicidal plans: a dimension of suicidality predictive of past suicide attemtps and eventual death by suicide. Behav. Res. Ther. 41, 1469–1480.
Joiner, T.E., Walker, R.L., Rudd, M.D., Jobes, D.A., 1999. Scientizing and routinizing the assessment of suicidality in outpatient practice. Prof. Psychol. Res. Pract. 30, 447–453.

Kessler, R.C., Chiu, W.T., Demler, O., Merikangas, K.R., Walters, E.E., 2005. Prevalence, severity, and comorbidity of 12-month dsm-iv disorders in the national comorbidity survey replication. Arch. Gen. Psychiatry 62, 617–627. https://doi.org/10.1001/archpsyc.62.6.617.
Kiernan, M., Kraemer, H.C., Winkleby, M.A., King, A.C., Barr Taylor, C., 2001. Do logistic regression and signal detection identify different subgroups at risk? Implications for the design of tailored interventions. Psychol. Methods 6, 35–48.
Klonsky, E.D., May, A.M., 2015. The three-step theory (3ST): a new theory of suicide rooted in the "Ideation-to-Action" framework. Int. J. Cogn. Ther. 8, 114–129.
Kraemer, H.C., 1992. Evaluating Medical tests: Objective and Quantitative Guidelines, first ed. SAGE Publications.
Large, M., Sharma, S., Cannon, E., Ryan, C., Nielssen, O., 2011. Risk factors for suicide within a year of discharge from psychiatric hospital: a systematic meta-analysis. Aust. N. Z. J. Psychiatry2 45, 619–628.
Main, K.L., Soman, S., Pestilli, F., Furst, A., Noda, A., Hernandez, B., Kong, J., Cheng, J., Fairchild, J.K., Taylor, J., Yesavage, J., Wesson Ashford, J., Kraemer, H., Adamson, M.M., 2017. DTI measures identify mild and moderate TBI cases among patients with complex health problems: a receiver operating characteristic analysis of U.S. veterans. NeuroImage Clin. 16, 1–16.
Mann, J., Ellis, S., Waternaux, C., Liu, X., Oquendo, M., Malone, K., Brodsky, B., Haas, G., Currier, D., 2008. Classification trees distinguish suicide attempters in major psychiatric disorders: a model of clinical decision making. J. Clin. Psychiatry 69, 23–31.
Minnix, J.A., Romero, C., Joiner, T.E., Weinberg, E.F., 2007. Change in "resolved plans" and "suicidal ideation" factors of suicidality after participation in an intensive outpatient treatment program. J. Affect. Disord. 103, 63–68.
Molinaro, A.M., Simon, R., Pfeiffer, R.M., 2005. Prediction error estimation: A comparison of resampling methods. Bioinformatics 21, 3301–3307.
Monahan, J., Steadman, H.J., Robbins, P.C., Silver, E., Appelbaum, P.S., Grisso, T., Mulvey, E.P., Roth, L.H., 2000. Developing a clinically useful actuarial tool for assessing violence risk. Br. J. Psychiatry 176, 312–319.
Monahan, J., Steadman, H.J., Silver, E., Appelbaum, P.S., Robbins, P.C., Mulvey, E.P., Roth, L.H., Grisso, T., Banks, S., 2001. Rethinking risk assessment: The MacArthur study of mental disorders and violence. Oxford University Press.
Nock, M.K., Hwang, I., Sampson, N.A., Kessler, R.C., 2010. Mental disorders, comorbidity and suicidal behavior: results from the national comorbidity survey replication. Mol. Psychiatry 15, 868–876. https://doi.org/10.1038/mp.2009.29.
O'Carroll, P.W., Berman, A.L., Maris, R.W., Moscicki, E.K., Tanney, B.L., 1996. Beyond the tower of babel: a nomenclature for suicidology. Suicide Life Threat. Behav. 26, 237–252.
O'Connor, S., Comtois, K., Atkins, D., Kerbrat, A., 2017. Examining the impact of suicide attempt function and perceived effectiveness in predicting reattempt for emergency medicine patients. Behav. Ther. 48, 45–55.
Pfohl, B., Blum, N., Zimmerman, M., Stangl, D., 1989. Structured interview for DSM-III-R personality disorders. University of Iowa, Iowa City.
Runeson, B., Tidemalm, D., Dahlin, M., Lichtenstein, P., Langstrom, N., 2010. Method of attempted suicide as predictor of subsequent successful suicide: national long term cohort study. BMJ 341, c3222.
Sadeh, N., McNiel, D.E., 2013. Facets of anger, childhood sexual victimization, and gender as predictors of suicide attempts by psychiatric patients after hospital discharge. J. Abnorm. Psychol. 122, 879–890.
Sapyta, J., Goldston, D., Erkanli, A., Daniel, S., Heilbron, N., Mayfield, A., Treadway, S., 2013. Evaluating the predictive validity of suicidal intent and medical lethality in youth. J. Consult. Clin. Psychol. 80, 222–231.
Selby, E.A., Anestis, M.D., Joiner, T.E., 2007. Daydreaming about death: Violent daydreaming as a form of emotion dysregulation in suicidality. Behav. Modif. 31, 867–879.
Skeem, J.L., Silver, E., Aippelbaum, P.S., Tiemann, J., 2006. Suicide-related behavior after psychiatric hospital discharge: implications for risk assessment and management. Behav. Sci. Law 24, 731–746.
Steadman, H.J., Silver, E., Monahan, J., Appelbaum, P.S., Robbins, P.C., Mulvey, E.P., Grisso, T., Roth, L.H., Banks, S., 2000. A classification tree approach to the development of actuarial violence risk assessment tools. Law Hum. Behav. 24, 83–100.
Stefansson, J., Nordstrom, P., Jokinen, J., 2012. Suicide intent scale in the prediction of suicide. J. Affect. Disord. 136, 167–171.
Tiet, Q.Q., Finney, J.W., Moos, R.H., 2006. Recent sexual abuse, physical abuse, and suicide attempts among male veterans seeking psychiatric treatment. Psychiatr. Serv. 57, 107–113.
Tiet, Q.Q., Leyva, Y., Moos, R.H., Smith, B., 2016. Diagnostic accuracy of a two-item screen for drug use developed from the alcohol, smoking and substance involvement screening test (ASSIST). Drug Alcohol Depend. 164, 22–27.
Tiet, Q.Q., Leyva, Y.E., Moos, R.H., Frayne, S.M., Osterberg, L., Smith, B., 2015. Screen of drug use: diagnostic accuracy of a new brief tool for primary care. JAMA Intern. Med. 175, 1371–1377.
Van Orden, K.A., Witte, T.K., Cukrowicz, K.C., Braithwaite, S., Selby, E.A., Joiner, T.E., 2010. The interpersonal theory of suicide. Psychol. Rev 117, 575–600. https://doi.org/10.1037/a0018697.
Walsh, C.G., Ribeiro, J.D., Franklin, J.C., 2017. Predicting risk of suicide attempts over time through machine learning. Clin. Psychol. Sci. 5, 457–469.