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Predicting 3-month risk for adolescent suicide attempts among pediatric emergency department patients

Cheryl A. King,[1] Jacqueline Grupp-Phelan,[2] David Brent,[3] J. Michael Dean,[4] Michael Webb,[4] Jeffrey A. Bridge,[5] Anthony Spirito,[6] Lauren S. Chernick,[7] E. Melinda Mahabee-Gittens,[8] Rakesh D. Mistry,[9] Margaret Rea,[10] Allison Keller,[11] Alexander Rogers,[12] Rohit Shenoi,[13] Mary Cwik,[14] Danielle R. Busby,[1] T. Charles Casper,[4] and the Pediatric Emergency Care Applied Research Network

[1]Department of Psychiatry, University of Michigan, Ann Arbor, MI; [2]Department of Emergency Medicine, University of California, San Francisco, San Francisco, CA; [3]Department of Psychiatry, University of Pittsburgh, Pittsburgh, PA; [4]Department of Pediatrics, University of Utah, Salt Lake City, UT; [5]Departments of Pediatrics, Psychiatry and Behavioral Health, Ohio State University College of Medicine, Columbus, OH; [6]Department of Psychiatry and Human Behavior, Brown University, Providence, RI; [7]Department of Emergency Medicine, Columbia University, New York, NY; [8]Department of Pediatrics, University of Cincinnati, Cincinnati, OH; [9]Departments of Pediatrics and Emergency Medicine, University of Colorado School of Medicine, Aurora, CO; [10]Medical Center, University of California Davis School of Medicine, Sacramento, CA; [11]Department of Pediatric Emergency Medicine, University of Utah, Salt Lake City, UT; [12]Departments of Emergency Medicine and Pediatrics, University of Michigan, Ann Arbor, MI; [13]Department of Pediatrics, Baylor College of Medicine, Houston, TX; [14]Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

Background: The incidence of adolescent suicide is rising in the United States, yet we have limited information regarding short-term prediction of suicide attempts. Our aim was to identify predictors of suicide attempts within 3-months of an emergency department (ED) visit. **Methods:** Adolescents, ages 12–17, seeking health care at 13 pediatric EDs (Pediatric Emergency Care Applied Research Network) and one Indian Health Service Hospital in the United States were consecutively recruited. Among 10,664 approached patients, 6,448 (60%) were enrolled and completed a suicide risk survey. A subset of participants (n = 2,897) was assigned to a 3-month telephone follow-up, and 2,104 participants completed this follow-up (73% retention). Our primary outcome was a suicide attempt between the ED visit and 3-month follow-up. **Results:** One hundred four adolescents (4.9%) made a suicide attempt between enrollment and 3-month follow-up. A large number of baseline predictors of suicide attempt were identified in bivariate analyses. The final multivariable model for the full sample included the presence of suicidal ideation during the past week, lifetime severity of suicidal ideation, lifetime history of suicidal behavior, and school connectedness. For the subgroup of adolescents who did *not* report recent suicidal ideation at baseline, the final model included only lifetime severity of suicidal ideation and social connectedness. Among males, the final model included only lifetime severity of suicidal ideation and past week suicidal ideation. For females, the final model included past week suicidal ideation, lifetime severity of suicidal ideation, number of past-year nonsuicidal self-injury (NSSI) incidents, and social connectedness. **Conclusions:** Results indicate that the key risk factors for adolescent suicide attempts differ for subgroups of adolescents defined by sex and whether or not they report recent suicidal thoughts. Results also point to the importance of school and social connectedness as protective factors against suicide attempts. **Keywords:** Suicide risk; adolescence; suicide attempt; social connectedness; emergency department.

Introduction

Suicide rates among adolescents in the United States continue to rise (Centers for Disease Control and Prevention, 2019), despite a downturn in the incidence worldwide (World Health Organization, 2017). Moreover, 5.1% of male and 9.3% of female high school students in the United States report a suicide attempt (SA) in the past year (Kann et al., 2018).

Risk factors for adolescent SAs span demographic, clinical, and social domains, meaning that the risk profiles for suicidal adolescents are multidimensional and heterogeneous. Female adolescents and adolescents who self-identify as LGBTQ are at increased risk (Kann et al., 2018; O'Brien, Putney, Hebert, Falk, & Aguinaldo, 2016). Previous history of SA and suicidal ideation (SI) (Nock et al., 2013), presence, persistence, and severity of SI (Czyz & King, 2015), and nonsuicidal self-injury (NSSI) (e.g. Asarnow et al., 2011) have all been reported to be predictors of suicide attempts. Similarly, psychiatric symptoms, such as depression and hopelessness, are consistent correlates and predictors of SA (King, Ewell Foster, & Rogalski, 2013), and symptoms of distress (e.g. anxiety and agitation) and impulse control (e.g. aggression, substance abuse) have emerged as the strongest predictors of attempts among adolescents who report ideation (Nock et al.,

2013). Sleep disturbance has been reported as an imminent risk factor for SA and death by suicide (e.g. Koyawala, Stevens, McBee-Strayer, Cannon, & Bridge, 2015).

Interpersonal factors such as low social connectedness also have been related to the likelihood of suicidal ideation and behavior (Czyz, Liu, & King, 2012; Gunn, Goldstein, & Gager, 2018). Bully victims and perpetrators have reported an increased incidence of SAs (Borowsky, Taliaferro, & McMorris, 2013), and physical and sexual abuse have been prospectively associated with SAs (Castellví et al., 2017). Interpersonal conflicts and losses, and legal/disciplinary problems are acute stressors associated with SAs and suicide (e.g. Gould, Fisher, Parides, Flory, & Shaffer, 1996).

Given this heterogeneity of suicide risk factors, it is challenging for healthcare providers to assess level of risk and for intervention and prevention specialists to identify potent and potentially modifiable targets for risk reduction. Moreover, extant research has focused on single risk factors (Franklin et al., 2017), despite the growing recognition of the multidimensional nature of suicidal risk and current clinical practice, which attempts to integrate available information about multiple risk factors. Consequently, further research that takes into account multiple risk factors is sorely needed.

The challenge of suicide risk assessment and identification of potent prevention targets is exacerbated for males and for adolescents who conceal or deny their suicidal thoughts. Adolescent females are more likely than males to report SI and behavior (Kann et al., 2018) and to obtain mental health services (Rhodes et al., 2012), yet the rate of suicide is much higher among adolescent males than females (Centers for Disease Control and Prevention, 2019). An improved understanding of the short-term risk factors for SAs among males may enable us to improve risk recognition and prevention. Similarly, although many of the most commonly used screening tools assess SI (e.g. Horowitz et al., 2012), recent SI is not a significant predictor of SAs for all subgroups of adolescents (e.g. King, Jiang, Czyz, & Kerr, 2014).

Our objective was to examine predictors of SAs during the 3-months following adolescents' ED visits in the Study One dataset of the Emergency Department Screening for Teens at Risk for Suicide (ED-STARS) Study. This large-scale study was implemented in collaboration with the Pediatric Emergency Care Applied Research Network (PECARN). Its primary aim was to develop the Computerized Adaptive Screen for Suicidal Youth (CASSY), a relatively brief suicide risk screen with the potential for widespread implementation in emergency departments (King et al., under review). Because our baseline assessment included a broad array of previously identified risk factors for SAs, this study also enabled us to examine predictors of SAs following ED visits using multivariable models.

We examined predictors in the total follow-up sample and in subsamples defined by sex and the presence of recent SI. We hypothesized that predictors of SAs would include indicators of SI and behavior (e.g. past week suicidal ideation, lifetime history of suicidal behavior) and, reflecting a different domain, one or more interpersonal risk factors (e.g. peer victimization, low social or school connectedness). We expect interpersonal factors to be important in light of longitudinal studies (e.g. Gunn et al., 2018) and theoretical formulations about the salience of interpersonal processes to suicidal risk (e.g. Durkheim, 1897; Joiner, 2005).

Methods
Participants

Adolescents (ages 12–17) were recruited from 13 EDs in PECARN (June 2015–July 2016) and the Whiteriver Indian Health Service (IHS) Hospital, which serves the White Mountain Apache Tribe (November 2015–April 2017). Among 10,664 approached adolescents, 6,448 (60.5%) completed a suicide risk survey. A subset of patients ($n = 2,897$ (43.6%) enriched for suicide risk (Figure 1 and Appendix S1) was randomly assigned to a 3-month telephone follow-up; 2,104 participants completed this follow-up (72% retention). The sample included 1,327 females (63.1%) and 777 males (36.9%) with a mean age of 15.1 years ($SD = 1.6$). Additional demographic information is in Appendix S2.

Procedure

At PECARN sites, adolescents were recruited during screening shifts that were randomly selected for each site from time periods when research coordinators were on site (primarily afternoons and evenings due to higher volume of adolescent patients). At the IHS Hospital, recruitment was ED-linked with a daily admission review and IRB permission to contact at home for recruitment. Exclusion criteria were as follows: previous study enrollment, ward of State, non-English speaking adolescents (non-English speaking parents enrolled), medically unstable, and severe cognitive impairment.

Adolescents completed a self-report survey assessing demographics and suicide risk factors in the ED (except for IHS site). Participants were included if adolescent and parent ($n = 1,799$, 85.5%), adolescent only ($n = 183$, 8.7%), or parent only ($n = 122$, 5.8%) follow-up interviews were conducted. Follow-up informant (parent or youth vs. both) was unrelated to participants' lifetime histories of suicidal ideation and behavior, and to the suicide attempt outcome. Participants with only youth or only parent follow-up interviews were, however, older than those with both interviews. ($p < .001$, Kruskal–Wallis test.). Written-informed parent/guardian consent and adolescent assent were obtained, in addition to IRB approval from all sites. Adolescents who turned 18 prior to follow-up were reconsented.

Measures

This study incorporated adolescent data from the baseline self-report survey (92 primary, 27 follow-up questions; details in Appendix S3). Due to ED space and time constraints, a concern for respondent burden, and a need to assess a wide range of risk factors to develop CASSY algorithms, brief, adapted versions of standardized scales were used for many risk factors, all of which had been previously associated with adolescent SAs.
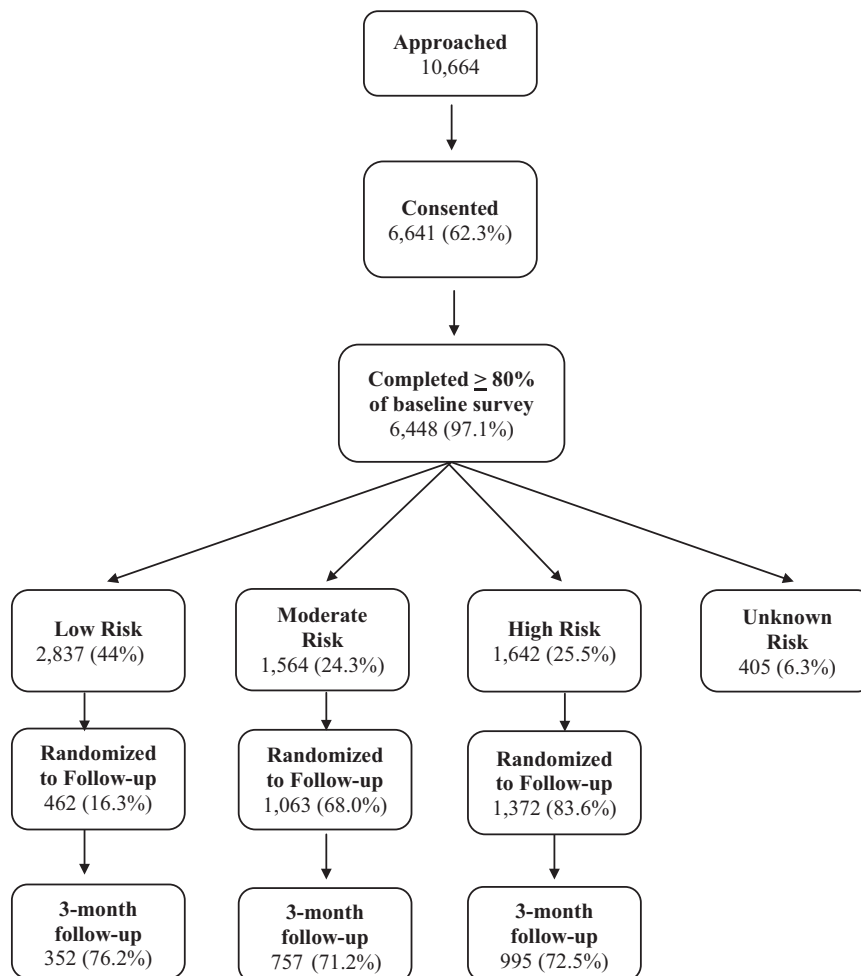
Figure 1 Participant flow. *Note.* High risk = suicidal ideation with intent/plan, history of suicide attempt, NSSI 5 or more times in past year, or homicidal ideation with intent/plan; Moderate risk = suicidal ideation, homicidal ideation (without plan/intent), or two or more other suicide risk factors (see Supplement for details). Low risk = does not meet criteria for high or moderate risk.

An adapted Columbia-Suicide Severity Rating Scale (C-SSRS; Posner et al., 2008) was used to assess history of SAs at baseline and SAs between baseline and 3-month follow-up. SA was defined as a positive response to either of two questions: 'In the past 3 months, have you made a suicide attempt?' 'In the past 3 months, have you tried to harm yourself because you were at least partly trying to end your life?' Past week SI was assessed with question #3 from the Ask Suicide-Screening Questions (ASQ; Horowitz et al., 2012): 'In the past week, have you been having thoughts about killing yourself?' In defining subgroups of adolescents who did and did not report recent SI, we removed participants who selected 'unknown' or did not respond to the question.

Additional suicide risk factors assessed at baseline included lifetime severity of SI and suicidal behavior, suicidal rumination, NSSI, depression, hopelessness, homicidal ideation, anxiety, agitation, sleep disturbance, adaptive functioning, alcohol and drug use, impulsivity, aggression, connectedness (family, school, social), peer victimization, physical and sexual abuse, negative life events, and identification as a sexual or gender minority.

Statistical analysis

Univariable associations between baseline demographic and clinical risk factors and SAs at 3-months were determined, and predictors with significant associations ($p < .1$) were candidates for inclusion in multivariable logistic regression models (Hosmer, Lemeshow, & Sturdivant, 2013). In stage one,

demographics and variables pertaining to suicidal thoughts, suicidal behaviors, and NSSI were added to the model in a stepwise fashion; the model with the lowest Akaike Information Criterion (AIC) was carried forward. Remaining candidates, including all other clinical risk factors examined (see Table 1), were considered using forward stepwise selection. In the final stage, variables were dropped using backward selection ($p > .05$), such that all variables were statistically significant in the final model.

To account for the oversampling of higher risk groups for follow-up, a weight equal to the inverse of the sampling probability of each of the three risk groups was applied in analyses. For categorical variables, the reference level was 'No', 'None', or equivalent, when possible. White and non-Hispanic were used as reference populations. When model separation became an issue due to low counts, categories of predictor variables were combined. For each final model, we calculated the predictive performance of the model as the area under the curve (AUC), with a 95% confidence interval (CI). As a sensitivity analysis, we conducted a 10-fold cross-validation of the final model for the full sample. Statistical analyses were performed using SAS software version 9.4 (SAS Institute Inc, 2013).

Results
Retention

Retention was greater for males than females (76.0% vs. 70.8%; $p = .003$) and varied by race ($p < .001$)

Table 1 Univariable relations between baseline variables and suicide attempt/death[a]

	Suicide attempt/death			Unadjusted, weighted[c] Odds ratio
	Yes (N = 104)	No (N = 2,000)	p Value[b]	
Demographics				
Gender: Female	84 (80.8%)	1243 (62.2%)	<.001	3.4 (1.8, 6.6)
Race				
American Indian or Alaska Native	2 (1.9%)	55 (2.8%)	.710	0.7 (0.1, 4.0)
Asian/Native Hawaiian/Pacific Islander	2 (1.9%)	30 (1.5%)		1.0 (0.2, 6.9)
Black or African American	22 (21.2%)	464 (23.2%)		0.8 (0.4, 1.6)
White	64 (61.5%)	1058 (52.9%)		
Multiracial	6 (5.8%)	126 (6.3%)		0.9 (0.3, 2.7)
Unknown/unavailable	8 (7.7%)	267 (13.4%)		0.4 (0.2, 1.2)
Ethnicity				
Latinx	18 (17.3%)	439 (22.0%)	.256	0.7 (0.3, 1.4)
Not Latinx	70 (67.3%)	1329 (66.5%)		
Unknown/unavailable	16 (15.4%)	232 (11.6%)		1.5 (0.7, 3.0)
Childs grade in school				
5th – 8th grade	37 (36.6%)	673 (34.9%)	.939	
9th – High school graduate	64 (63.4%)	1247 (64.6%)		1.1 (0.6, 1.9)
Child does not attend school	0 (0.0%)	9 (0.5%)		N/A
Mother/Stepmother education				
High school graduate or less	27 (26.7%)	559 (29.0%)	.695	
Some college/technical training	28 (27.7%)	553 (28.7%)		1.1 (0.5, 2.2)
College graduate/professional	41 (40.6%)	769 (39.9%)		1.1 (0.6, 2.1)
Don't know/Not applicable	5 (5.0%)	47 (2.4%)		2.2 (0.6, 8.1)
Father/Stepfather education				
High school graduate or less	32 (32.0%)	761 (39.6%)	.374	
Some college/technical training	29 (29.0%)	376 (19.6%)		1.7 (0.9, 3.4)
College graduate/professional training	27 (27.0%)	599 (31.2%)		1.1 (0.5, 2.1)
Don't know/Not applicable	12 (12.0%)	184 (9.6%)		1.5 (0.6, 3.7)
Family public assistance	51 (51.0%)	859 (44.8%)	.389	1.3 (0.7, 2.1)
Suicidal ideation/Behavior/NSSI				
Suicidal ideation – past week: ASQ #3				
Yes	69 (66.3%)	348 (17.4%)	<.001	22.0 (12.0, 40.2)
No	27 (26.0%)	1503 (75.3%)		
No response	8 (7.7%)	145 (7.3%)		5.9 (2.1, 17.0)
Suicide ideation severity – lifetime: C-SSRS; mean (SD)	4.1 (1.28)	1.9 (1.98)	<.001	2.2 (1.8, 2.6)
NSSI # methods (YRBS); mean (SD)	2.4 (2.34)	0.8 (1.50)	<.001	1.6 (1.5, 1.8)
NSSI # incidents (YRBS)				
0 times	24 (23.1%)	1354 (67.9%)	<.001	
1–2 times	27 (26.0%)	312 (15.6%)		9.7 (4.6, 20.2)
3–4 times	14 (13.5%)	107 (5.4%)		15.2 (6.1, 37.9)
5 or more times	39 (37.5%)	222 (11.1%)		21.1 (10.5, 42.3)
Suicide attempts/behavior – lifetime				
None	13 (13.0%)	1243 (63.1%)	<.001	
Aborted/interrupted attempt only	12 (12.0%)	199 (10.1%)		11.8 (4.2, 33.4)
1 Previous suicide attempt	12 (12.0%)	152 (7.7%)		15.5 (5.5, 43.9)
Multiple previous attempts	63 (63.0%)	377 (19.1%)		32.8 (15.1, 71.1)
Self-harm thoughts (PHQ, #9)				
Not at all	26 (25.0%)	1447 (72.7%)	<.001	
Several days	20 (19.2%)	275 (13.8%)		8.0 (3.6, 17.5)
More than half the days	20 (19.2%)	113 (5.7%)		20.0 (9.0, 44.8)
Nearly every day	38 (36.5%)	156 (7.8%)		27.0 (13.5, 54.0)
Suicidal thoughts – duration: C-SSRS				
Never had suicidal thoughts	4 (3.9%)	876 (44.3%)	<.001	
A few seconds or minutes	6 (5.8%)	362 (18.3%)		8.2 (1.6, 41.8)
Less than 1 hr/some of the time	19 (18.4%)	330 (16.7%)		29.5 (7.4, 117.7)
1–4 hr/a lot of time	32 (31.1%)	205 (10.4%)		83.3 (22.0, 316.0)
4–8 hr/most of day	19 (18.4%)	100 (5.1%)		103.0 (25.4, 417.3)
More than 8 hr/continuous	23 (22.3%)	105 (5.3%)		118.6 (30.0, 469.4)
How likely…act on suicidal thoughts?				
No suicidal thoughts/not at all likely	22 (21.4%)	1411 (70.9%)	<.001	
Slightly possible	29 (28.2%)	345 (17.3%)		10.9 (5.2, 22.9)
Somewhat likely	23 (22.3%)	158 (7.9%)		19.3 (8.7, 42.9)
Almost for sure will act on them	29 (28.2%)	77 (3.9%)		49.5 (22.5, 108.9)
Suicidal rumination: mean (SD)	7.2 (2.66)	2.9 (3.20)	<.001	1.6 (1.4, 1.7)

(continued)

Table 1 (continued)

	Suicide attempt/death			Unadjusted, weighted[c]
	Yes (N = 104)	No (N = 2,000)	p Value[b]	Odds ratio
Other risk factors				
Hopelessness item: MFQ				
Not true	18 (17.3%)	1178 (58.9%)	<.001	
Sometimes	49 (47.1%)	613 (30.7%)		9.2 (4.5, 19.0)
True	37 (35.6%)	209 (10.5%)		24.2 (11.3, 52.0)
Depression: PHQ-9; mean (SD)	15.5 (7.34)	8.5 (7.04)	<.001	1.2 (1.1, 1.2)
Alcohol use: AUDIT-C score; mean (SD)	0.5 (1.53)	0.3 (1.12)	.047	1.2 (1.0, 1.4)
Cannabis use: DUS (adapted)	20 (19.2%)	187 (9.4%)	<.001	3.5 (1.8, 6.8)
Homicidal thoughts	15 (14.6%)	140 (7.0%)	<.001	3.9 (1.8, 8.4)
Agitation: BAM; mean (SD)	13.9 (5.23)	9.3 (5.72)	<.001	1.2 (1.1, 1.3)
Anxiety: SCARED-C; mean (SD)	4.5 (2.18)	3.0 (2.37)	<.001	1.4 (1.3, 1.5)
Sleep disturbance: PROMIS; mean (SD)	13.5 (3.89)	11.6 (4.18)	<.001	1.2 (1.1, 1.3)
Physical abuse – family	24 (23.3%)	296 (14.9%)	.001	2.8 (1.5, 5.3)
Sexual abuse	36 (36.0%)	310 (15.7%)	<.001	5.2 (3.0, 9.1)
Gender minority	13 (12.5%)	125 (6.3%)	.009	2.9 (1.3, 6.5)
Sexual minority	61 (58.7%)	580 (29.0%)	<.001	6.1 (3.6, 10.3)
Functional impairment (PHQ, #10)	82 (79.6%)	1016 (50.9%)	<.001	7.1 (3.7, 13.5)
Family connectedness; mean (SD)	6.5 (1.71)	7.6 (1.84)	<.001	0.6 (0.6, 0.7)
Social connectedness scale: mean (SD)	6.4 (2.45)	7.7 (2.10)	<.001	0.7 (0.6, 0.8)
School connectedness scale: mean (SD)	5.2 (2.04)	6.8 (2.09)	<.001	0.6 (0.6, 0.7)
Impulsive aggression screen: mean(SD)	0.7 (0.93)	0.4 (0.81)	<.001	1.7 (1.3, 2.2)
Impulsivity: UPPS Subscale; mean(SD)	2.9 (0.72)	2.5 (0.88)	<.001	2.4 (1.8, 3.3)
Peer victimization; mean (SD)	4.1 (2.41)	3.2 (1.80)	<.001	1.3 (1.2, 1.5)
Peer bullying perpetration; mean (SD)	2.6 (1.49)	2.3 (0.97)	.002	1.3 (1.1, 1.6)
Physical fighting: YRBS				
0 times	68 (66.0%)	1391 (69.6%)	.016	
1 time	11 (10.7%)	279 (14.0%)		1.1 (0.5, 2.5)
2 or 3 times	11 (10.7%)	208 (10.4%)		1.4 (0.6, 3.4)
4 or more times	13 (12.6%)	121 (6.1%)		3.8 (1.7, 8.6)
Negative life events: mean (SD)	0.6 (0.72)	0.4 (0.60)	<.001	2.3 (1.6, 3.2)

[a]Missing participant data varies across measures from low (PROMIS, $n = 1$; YRBS fighting and negative life events, $n = 2$; PHQ-9, $n = 3$; past week suicidal ideation, $n = 4$; C-SSRS Severity Score, $n = 5$) to high (father education, $n = 84$; public assistance, $n = 86$).
[b]All p-values come from Wald Chi-squared tests.
[c]To account for the oversampling of higher risk groups for follow-up, a weight equal to the inverse of the sampling probability of each of the three risk groups was applied in analyses.

and ethnicity ($p < .001$), with higher retention rates for Whites (75.1%) and multiracial youth (79.5%) than other races (range from 61.3–72.6%), and for non-Latinx than Latinx ethnicity (75.6% vs. 68.5%). Higher parental education was also associated with greater retention (p's < .001). The retention rates for mothers and fathers, respectively, were as follows: high school or less (67.9%, 68.1%), some college/technical (73.8%, 73.2%), college graduate (77.6%, 81.7%), unknown/not applicable (65.0%, 70.0%).

Descriptive statistics: suicidal thoughts, suicide attempts, and NSSI

At baseline, 1,090 adolescents (51.9%) reported a lifetime history of SI and 815 adolescents (39.4%) reported a lifetime history of suicidal behavior, including actual, aborted, and interrupted attempts. The mean number of lifetime SAs reported was 1.67 ($SD = 6.91$; Median = 0). Regarding number of past-year NSSI incidents, 1378 adolescents (65.7%) reported none, 339 adolescents (16.2%) reported 1–2, 121 (5.8%) reported 3–4, and 261 (12.4%)

reported 5 or more (data missing, $n = 5$). A SA between ED visit and 3-month follow-up was reported for 104 adolescents (4.9%; 84 females, 6.3%; 20 males, 2.6%). There was one suicide death, which was included as a SA in analyses.

Spearman's correlations among risk factors are reported in Tables S1–S4. As examples of the strength of correlations, lifetime severity of SI was highly positively correlated with lifetime history of suicidal behavior (.70, $p < .001$) and moderately positively correlated with number of NSSI incidents during the past 12 months (.53, $p < .001$). Social and school connectedness were moderately positively correlated (.47, $p < .001$).

Site differences were identified in suicide risk predictors and outcomes. This information is provided in Tables S5–S9.

Predictors of suicide attempt during 3 months following ED visit

Univariable associations with suicide attempts. - Sex, sexual, and gender minority status, and all of

the examined psychosocial and clinical characteristics predicted SAs at 3-month follow-up (see Table 1).

Multivariable regression models. The final multivariable model for the total sample included past week SI (yes/no), lifetime severity of SI, history of suicidal behavior, and school connectedness (AUC = 0.86, 95% CI: 0.82–0.89; Table 2). In the sensitivity analysis, the ORs, (CIs), and AUCs fitted from each of the 10 subsamples (each approximately 90% of full cohort) were similar, with a median AUC of 0.87 and IQR 0.84–0.90.

To examine replicability of this model across sites, we examined a model including site and the interaction between site and the final model risk score (fitted logit values for each patient). The interaction was nonsignificant (p = .55), suggesting that the relationship between the predicted risk and SA outcome does not differ by site. Site was also unrelated to SA risk (p = .70) after taking into account risk factors.

For adolescents *without* past week SI at baseline, the final model included lifetime SI severity and social connectedness (AUC = 0.84, 95% CI: 0.78-0.90; Table 3). For adolescents *with* recent SI at baseline, the final model included family public assistance, suicidal rumination (repetitive thoughts), and social connectedness (AUC = 0.69, 95% CI: 0.62–0.76; Table 3).

For male adolescents, the final model included past week SI and lifetime SI severity (AUC = 0.89, 95% CI: 0.85–0.94; Table 4). For female adolescents, the model included past week SI, number of NSSI incidents during the past 12 months, and social connectedness (AUC = 0.84, 95% CI: 0.81–0.87).

Discussion

In this prospective study of adolescent ED patients, we identified baseline predictors of SAs across a 3-month period of follow-up using multivariable models for the entire sample, and for subsamples defined by sex and the presence or absence of recent suicidal thoughts. These subgroups included two particularly vulnerable groups: adolescent males who receive fewer mental health services (Rhodes et al., 2012) and have a much higher rate of suicide than adolescent females (Centers for Disease Control and Prevention, 2019), and adolescents who do not report recent suicidal thoughts, which challenges risk recognition.

Study results replicate the importance of previously identified suicide risk factors. Every clinical risk factor included in our baseline suicide risk survey was associated significantly with the likelihood of a SA between the baseline ED visit and 3-month follow-up. Concordant with hypotheses, past week SI, lifetime severity of SI, lifetime history of suicidal behavior, and an interpersonal factor, school connectedness, emerged as the key predictors of attempts for the total sample. Moreover, emphasizing the importance of connectedness to our understanding of risk, either school or social connectedness emerged as a key predictor for three of the four subgroups of adolescents studied. Contrary to hypotheses, however, the model for males included only two factors: recent SI and lifetime severity of SI.

Lifetime severity of SI was found to be a key predictor for the overall sample, and three of the four subgroups of adolescents examined. This finding is consistent with previous studies indicating that adolescents who develop a suicide plan are more likely to make an attempt than ideators without a plan (Nock et al., 2013), that intensity of SI predicts SAs (Peters, Mereish, Solomon, Spirito, & Yen, 2018), and that 'worst ever' SI is as strong a predictor of suicide risk as current ideation (Beck, Brown, Steer, Dahlsgaard, & Grisham, 1999). Similarly, the importance of lifetime history of suicidal behavior is consistent with studies showing that increased risk for subsequent self-harm and death by suicide persists for years after initially seeking health care for self-harm (Finkelstein et al., 2015).

Table 2 Multivariable models for prediction of suicide attempt in total sample

Baseline characteristic	Suicide attempt/death over 3-month follow-up		OR (95% CI)	p
	Yes N = 98 (%)	No N = 1,964 (%)		
Suicidal Ideation – past week (ASQ Item #3)				
No	27 (27.6)	1489 (75.8)		.005
Yes	64 (65.3)	335 (17.1)	3.25 (1.56, 6.77)	
No response	7 (7.1%)	140 (7.1)	1.37 (0.42, 4.46)	
Suicide ideation severity – lifetime: C-SSRS: q1, median, q3	3,5,5	0,1,4	1.35 (1.03, 1.76)	.031
Lifetime history of suicidal behavior				
None	13 (13.3)	1241 (63.2)		.033
Aborted or interrupted attempt only	11 (11.2)	198 (10.1)	2.59 (0.75, 8.97)	
One suicide attempt	11 (11.2)	152 (7.7)	2.48 (0.66, 9.36)	
Multiple attempts	63 (64.3)	373 (19.0)	4.69 (1.56, 14.07)	
School connectedness: q1, median, q3	3,5,7	6, 7, 8	0.84 (0.73, 0.96)	.011

Lower levels of school connectedness indicate worse school connectedness.

Table 3 Multivariable model for prediction of suicide attempts among adolescents who did and did not report recent suicidal ideation in emergency department

	Suicide attempt/death over 3-month Follow-Up			
	Yes (%)	No (%)	OR (95% CI)	p
Adolescents without recent suicidal ideation	$N = 27$	$N = 1,496$		
Lifetime suicide ideation severity: q1 median q3	2,4,5	0,0,2	2.02 (1.51, 2.69)	<.001
Social connectedness q1, median, q3	5,7,9	7,8,10	0.76 (0.60, 0.96)	.019
Adolescents with recent suicidal ideation	$N = 67$	$N = 329$		
Family public assistance				.002
No	28 (41.8)	204 (62.0)		
Yes	39 (58.2)	125 (38.0)	2.39 (1.38, 4.13)	
Suicidal rumination: q1, median, q3	7,9,10	6,7,9	1.22 (1.06, 1.39)	.004
Social connectedness: q1, median, q3	4,6,9	5,8,9	0.88 (0.79, 0.98)	.023

Lower connectedness scores indicate worse connectedness.

Table 4 Multivariable models for prediction of suicide attempts among male and female adolescents

	Suicide attempt/death over 3-month Follow-Up			
	Yes (%)	No (%)	OR (95% CI)	p
Males	$N = 20$	$N = 754$		
Suicidal ideation – past week (ASQ Item #3)				.020
No	5 (25.0)	660 (87.5)		
Yes	15 (75.0)	94 (12.5)	9.33 (1.42, 61.57)	
Lifetime suicidal ideation severity score: q1, median, q3	3,4,5	0,0,3	1.69 (1.04, 2.74)	.034
Females	$N = 84$	$N = 1,234$		
Suicidal ideation – past week (ASQ Item #3)				.010
No	30 (35.7)	982 (79.6)		
Yes	54 (64.3)	252 (20.4)	2.48 (1.24, 4.96)	
NSSI past 12 months				.025
0 times	15 (17.9)	770 (62.4)		
1–2 times	25 (29.8)	202 (16.4)	3.93 (1.61, 9.58)	
3–4 times	10 (11.9)	81 (6.6)	2.10 (0.66, 6.64)	
5 or more times	34 (40.5)	181 (14.7)	2.80 (1.11, 7.11)	
Lifetime suicidal ideation severity score: q1,median, q3	4,5,5	0,2,4	1.53 (1.20, 1.95)	<.001
Social connectedness: n (q1 median q3)	4, 6, 8	6, 8, 10	0.83 (0.73, 0.93)	.001

Lower connectedness scores indicate worse connectedness.

School or social connectedness emerged as a key predictor for several subgroups of adolescents, which is consistent with a growing body of research (Gunn et al., 2018) indicating that higher levels of school connectedness were associated with less suicidal behavior in general school samples, high-risk adolescents, and sexual minority adolescents (Marraccini & Brier, 2017). Social connections may have long-term consequences for mortality as well as morbidity. A 14-year follow-up of adolescent hospitalized for SI and behavior found that those assigned to an intervention to mobilize social support from adults had reduced self-injury mortality (King et al., 2019). Therefore, social and school connectedness are likely to be an important target for risk assessment and preventive intervention.

Adolescents who do not report *recent* SI, who comprised nearly one-third of the youth who made SAs in this study, can be challenging to identify in EDs and other settings where the focus is on current risk. In this subgroup, lifetime severity of SI and social connectedness were the primary risk indicators. The accuracy of prediction in this 'hidden' subgroup provides particularly strong support for the need for suicide risk screening in the pediatric ED. Surprisingly, the accuracy of prediction for this subgroup (AUC = 0.84) was higher than the accuracy of prediction for the subgroup of adolescents who reported recent suicidal ideation (AUC = 0.69). This may be due to the inconsistency of adolescents' reports of SI across study measures, which will be the focus of a future study.

NSSI only emerged as a primary risk factor for females. It is unknown whether or not this relates to the different types of NSSI reported by females (Sornberger, Heath, Toste, & McLouth, 2012), social influences, and interpersonal challenges associated with engagement in NSSI (Victor & Klonsky, 2018), or females' higher likelihood of experiencing suicidal thoughts and engaging in suicidal behavior (Kann et al., 2018). The more limited statistical power for adolescent males, due to fewer SA outcomes, may

also be important as NSSI was a predictor of SAs among males in univariable analyses.

The prediction model AUCs for the full sample, the sample of adolescents who did not report recent SI at baseline, and the subsamples of males and females each ranged between 0.84 and 0.89, which can be considered excellent classification accuracy (Hosmer et al., 2013), and contrasts with the disappointing performance of previous single risk factor approaches to suicide risk prediction (Franklin et al., 2017). Although the heterogeneity of suicide risk factors and the low base rates of SAs and suicide are challenges to risk stratification (Belsher et al., 2019), findings suggest that a multivariable prediction model can be useful for the short-term prediction of adolescent SAs. However, of equal or greater importance, these models identify potentially important targets for clinical risk evaluation and prevention. Screening tools for risk recognition can be developed using prediction algorithms developed from large data sources (Belsher et al., 2019). We used this strategy in developing the CASSY, which is being validated in a new sample.

Results should be considered within the context of study limitations. We used brief and adapted scales to assess most suicide risk factors to reduce respondent burden and facilitate patient flow in EDs. Although each of the baseline clinical risk factors we assessed was found to be a significant univariable predictor of SAs, the use of brief scales may have reduced the reliability of measurement and our ability to fully capture each construct. Furthermore, this study was conducted primarily in pediatric EDs of academic health systems, which are not representative of the range of EDs in the United States. In addition, we had lower levels of retention for adolescents from racial and ethnic minority groups, females, and adolescents whose parents had less education. Although we considered weighting the sample for nonresponse, we chose to prioritize adjusting for the oversampling of higher risk groups because we had specific information pertinent to the oversampling and did not want to apply multiple weights to relatively small subgroups. Moreover, for the most part, these variables were not predictive of SA, and therefore our predictive models are most likely not biased due to nonresponse. Finally, despite the relatively large size of this study, the relatively low number of youth with SAs limited our statistical power for identifying multiple predictors, especially within critical subgroups such as males, for whom the number of attempts was smaller than for females. While in this study, our focus was on identifying key risk factors, in future reports we will describe how we also used study data to develop and validate an adaptive screening tool.

In summary, in this short-term prospective study of predictors of SAs in a large and diverse sample of adolescents recruited from pediatrics EDs, we found that past week SI, lifetime severity of SI, lifetime history of suicidal behavior, and connectedness were critical risk and protective factors. We also documented variation in key risk factors across important subgroups, including adolescent males and adolescents who did not report recent SI. The risk and protective factors identified may be important to assess clinical risk evaluations and can serve as important targets for intervention and prevention strategies.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Appendix S1. Baseline criteria for assignment to low, moderate, and high-risk groups.
Appendix S2. Study participants – additional demographic information.
Appendix S3. Study measures.
Table S1. Spearman's correlations among categorical suicide risk variables.
Table S2. Spearman's correlations among categorical suicide risk variables and social variables.
Table S3. Spearman's correlations among categorical suicide risk factors and other clinical risk variables.
Table S4. Spearman's correlations among clinical risk variables and social variables.
Table S5. Baseline suicidal ideation and 3-month suicide attempt outcomes by site.
Table S6. Baseline history of suicidal ideation and suicidal behavior by site.
Table S7. Baseline school and social connectedness by site.
Table S8. Baseline Nonsuicidal self-injury (NSSI) by site.
Table S9. Public assistance (i.e. food stamps, Medicaid) by site.

Acknowledgements

Correspondence

Cheryl King, Department of Psychiatry, University of Michigan, Rachel Upjohn Building, 4250 Plymouth Road, Ann Arbor, MI 48109-2700, USA; Email: kingca@umich.edu

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Key points

- A wide range of single demographic, psychiatric, and social risk factors for adolescent suicide attempts during a 6 month period or longer have been identified.
- This multi-site, prospective study of 2,104 adolescent emergency department patients examined predictors of short-term (3-month) risk for suicide attempts. Using multivariable models, we identified predictors in the total sample and in critically important subgroups. Study findings highlight the importance of adolescents' social and school connectedness and provide new information regarding predictors of attempts for subgroups of males, females, and adolescents who do not report suicidal thoughts.
- Results regarding predictors of suicide attempts can inform the recognition of adolescents at risk and possible targets for prevention and intervention.

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