



Predicting future suicidal events in adolescents using the Concise Health Risk Tracking Self-Report (CHRT-SR)



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ABSTRACT

Background: Several self-report rating scales have been developed to assess suicidal ideation, yet most have limited utility in predicting future suicide attempts. This is particularly critical in adolescence, where suicide is the second leading cause of death. This study evaluated the Concise Health Risk Tracking Self-Report (CHRT-SR) as a prospective predictor of suicide attempts and events in high-risk adolescents enrolled in a suicide-prevention intensive outpatient program (IOP).

Methods: Data were collected by retrospective chart review of adolescents treated in IOP for youth with severe suicidality. At baseline, youth completed the 14-item CHRT-SR (CHRT-SR₁₄), which assesses suicide risk based on 3 subscales: Propensity, Impulsivity, and Suicidal Thoughts. Two outcomes were assessed: actual suicide attempts and suicidal events (suicide attempt, inpatient hospitalization, or emergency department visit) during the IOP.

Results: Of the 251 adolescents who completed the baseline CHRT-SR₁₄, 26 had a suicidal event during IOP (mean time in IOP: 5.4 ± 2.3 weeks), of whom 14 had an actual suicide attempt. Youth with any suicidal event had higher scores than those without an event on the CHRT-SR₁₄ Total (p = .005), Propensity (p = .008), and Suicidal Thoughts (p = .001) scales at baseline. Youth who made a suicide attempt had significantly higher scores than those without an event for the Total Score, Propensity, and Suicidal Thoughts subscales. CHRT-SR₁₄ Total Score of 28 had a sensitivity of 85.7% and specificity of 56.5% in predicting suicide attempts. A score of 22 predicted suicidal events, with a sensitivity of 80.8% and specificity of 40.9%. CHRT-SR₇ Total Score of 12 predicted suicide attempts, with a sensitivity of 85.7% and specificity of 53.4%.

Conclusions: The CHRT-SR₁₄ self-report predicts suicide attempts and events with at least 80% sensitivity and acceptable specificity in adolescents at high-risk for suicide.

1. Introduction

Adolescent suicidal behavior is common, with around one million

youth attempting suicide each year in the United States (Nock et al., 2013). Almost 5000 adolescents in the U.S. die by suicide annually; suicide has risen to the 2nd leading cause of death among 15-24-year-

Abbreviations: CHRT-SR, Concise Health Risk Tracking Self-Report; CHRT-SR₇, CHRT 7-Item; CHRT-SR₁₂, CHRT 12-Item; CHRT-SR₁₄, CHRT 14-Item; IOP, Intensive Outpatient Program; NLR, Negative Likelihood Ratio; NPV, Negative Predictive Value; PHQ-9, Patient Health Questionnaire; PLR, Positive Likelihood Ratio; PPV, Positive Predictive Value; QIDS-A-SR, Quick Inventory of Depressive Symptomatology-Adolescent Self-Report

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olds (Centers for Disease Control, 2016; Curtin et al., 2016). Risk factors for suicide and suicide attempts include a combination of genetic vulnerability, psychiatric disorders, life adversity, and familial, societal, and cultural factors (Hawton, Saunders and O'Connor, 2012). Given increased risk for suicide in youth with mental illness, particularly depression, the U.S. Preventive Services Task Force recommends that all primary care doctors, including pediatricians and family physicians, should routinely screen adolescents for depression, and provide recommendations or referrals for treatment for depression if needed (Siu and Force, 2016).

Regardless of age, identifying individuals who will make a suicide attempt remains a challenge. Runeson and colleagues conducted a systematic review of 21 studies (20 in psychiatric settings and one in primary care) that examined fifteen rating scales to evaluate whether these rating scales could predict suicide attempts. Most studies included only adults, although several also included adolescents. *They set a clinically acceptable threshold of at least 80% sensitivity with at least a 50% specificity for evaluation of the scale. No measure met this threshold* (Runeson et al., 2017). Madan and colleagues also report on the sensitivity and specificity of several measures, including the Columbia Suicide Severity Rating Scale (C-SSRS), Patient Health Questionnaire (PHQ-9), Beck Hopelessness Scale, and Suicide Cognitions Scale in 1075 adults admitted to a psychiatric hospital. Similar to Runeson and colleagues' findings, none of the suicide measures met the threshold for reliability in predicting future suicide attempts (Madan et al., 2016). Thus, prediction of future suicidal behavior remains problematic across the lifespan, but is particularly germane in adolescents where suicide is a leading cause of death.

The Concise Health Risk Tracking© Self Report (CHRT-SR), a self-report that focuses on the past week, was designed to assess the severity of current suicide risk. The CHRT-SR assesses both suicidal ideation and other current clinical factors associated with suicide attempts. The original scale included 12 items (CHRT-SR₁₂) to assess helplessness, pessimism, perceived lack of social support, despair, and suicidal thoughts (Ostacher et al., 2015; Sanchez et al., 2018; Trivedi et al., 2011). Two additional items to assess impulsivity were later added (CHRT-SR₁₄) (Mayes et al., 2018; Reilly-Harrington et al., 2016; Sanchez et al., 2018). The CHRT-SR₁₂ has established reliability and validity in adults (Ostacher et al., 2015; Trivedi et al., 2011; Villegas et al., 2017), and the CHRT-SR₁₄ has established reliability and validity in both adults and adolescents (Mayes et al., 2018; Reilly-Harrington et al., 2016). A shortened 7-item version (CHRT-SR₇) was also validated in depressed and bipolar adult samples (Ostacher et al., 2015; Reilly-Harrington et al., 2016; Trivedi et al., 2011; Villegas et al., 2017). The scale has excellent internal reliability (Cronbach's coefficient alpha from .77 to .90) in depressed and bipolar adult populations (Ostacher et al., 2015; Reilly-Harrington et al., 2016; Trivedi et al., 2011; Villegas et al., 2017) and in suicidal adolescents (Cronbach's coefficient alpha of .91) (Mayes et al., 2018). The CHRT-SR₁₄ total score predicted suicide-related serious adverse events in 482 adults with bipolar disorder treated in a 6-month randomized clinical trial comparing lithium and quetiapine (Reilly-Harrington et al., 2016).

This report evaluated whether the CHRT-SR₁₄ could predict future suicide events and attempts in a sample of adolescents determined to be at high risk for an attempt who were treated in a suicide-prevention intensive outpatient program (IOP). We addressed the following questions: 1) Does CHRT-SR₁₄ predict suicidal events (i.e. attempts, hospitalizations, emergency department visits, etc.) and attempts? 2) What scores provide acceptable sensitivity and specificity? We also report on the performance of the previously published shorter versions, the CHRT₇ and the CHRT SR₁₂, which we extracted from the 14-item version used in this study.

2. Methods

Data were derived from a retrospective chart review of adolescents

with severe suicidal ideation and behaviors enrolled in a clinical IOP in a large not-for-profit children's hospital. The study was approved by the Institutional Review Board (IRB) at the University of Texas Southwestern Medical Center at Dallas; the IRB waived the requirement to obtain informed consent.

2.1. Participants

Participants included adolescents (ages 12–18 years) who were enrolled in the IOP. The IOP was specifically for treatment of youth with a recent suicide attempt or severe worsening of suicidal ideation warranting emergency services. Youth could be referred to IOP from within the hospital (emergency department, inpatient psychiatric unit, inpatient medical floor, day treatment psychiatric clinic, or outpatient psychiatric clinic) or community providers, and were typically evaluated for IOP within a few days after the suicidal event (attempt or worsening of ideation) or within a few days of discharge from inpatient hospitalization. Entry into IOP was based on the clinical judgment of licensed psychologists, therapists, or post-doctoral fellows. Youth who required other levels of care (inpatient hospitalization, day treatment, or outpatient care) were provided with referrals for treatment. Data for this report are from youth enrolled in the IOP program over a 2-year period between January 1, 2014, and December 31, 2015. IOP consisted of 3 h of group therapy twice weekly, with a focus on reducing risk factors associated with suicidal behaviors through cognitive behavioral therapy (CBT) and dialectical behavior therapy (DBT) treatment components. Length of treatment in IOP is based on individual need, but generally is 4–8 weeks in duration. Additional information on the IOP and sample have been previously published (Mayes et al., 2018).

2.2. Measures

Prior to and following treatment, youth completed the CHRT-SR₁₄ and the Quick Inventory of Depressive Symptomatology – Adolescent (QIDS-A-SR) (Moore et al., 2007). Responses on the CHRT-SR₁₄ range from 0 (strongly disagree) to 4 (strongly agree), with a total score ranging from 0 to 56. The CHRT-SR₁₄ has three subscales: Propensity (items 1–9), Impulsivity (items 10–11), and Suicidal Thoughts (items 12–14). The Propensity subscale can be further broken into the measurement of Pessimism (items 1–2), Helplessness (items 3–4), Social Support (items 5–6), and Despair (items 7–9) (Mayes et al., 2018; Sanchez et al., 2018). The licensed clinician also assessed current and lifetime suicidal ideation and suicidal behaviors through the C-SSRS (Posner et al., 2011).

The outcomes for these analyses were “suicidal events” and “suicide attempts” that occurred after baseline but prior to completion or discharge from the IOP. *Suicidal event* was defined as a suicide attempt, or emergency department visit or inpatient hospitalization due to worsening suicidal ideation. *Suicide attempt* was defined as a non-fatal, self-directed, potentially injurious behavior with an intent to die as a result of the behavior, which may or may not result in injury. Thus, all suicide attempts were included in the “suicidal events” category. Time to the attempt or event was calculated from the initial evaluation for IOP. Evaluation of whether the youth made a suicide attempt or had a suicidal event was determined through clinical evaluation and assessment using the C-SSRS by the clinician, as well as medical record review. For events that were questionable, a consensus among the clinician and at least two of the authors (TLM, BDK, JLH, GJE) was used to determine whether the event was categorized as an attempt or event.

2.3. Statistical analyses

Demographic and clinical variables were compared between those with and without an event and those with and without an attempt using t-tests for continuous variables or chi-square tests for categorical

variables. Unadjusted univariate logistic regression models were used to predict presence versus absence of an event, an attempt versus no event, and an event but not an attempt versus no event during IOP with the following predictors: CHRT-SR₁₄ Total, CHRT-SR₁₄ Propensity (and Pessimism, Helplessness, Social Support, and Despair subscales), CHRT-SR₁₄ Impulsivity, and CHRT-SR₁₄ Suicidal Thoughts. These logistic regression models were repeated with the addition of gender and lifetime history of a suicide attempt as covariates; however, because these covariates had a negligible effect on the outcomes, we report only the unadjusted results.

An ROC analysis was done to establish thresholds to predict those who will have an event or attempt during IOP using the CHRT-SR₁₄ Total Score, and the Propensity, Impulsivity, and Suicidal Thoughts subscale scores. Similar ROC analyses were conducted on the 12-item and 7-item CHRT-SR (CHRT-SR₁₂ and CHRT-SR₇, respectively), each derived from the 14-item scale. The R package ‘optimal cutpoints’ was used to establish these optimal cut-offs using various criteria: sensitivity of at least 80%, 85%, 90%, and 95%. Since a false negative (FN) (i.e., to predict a subject will NOT have an event when the subject will have an event) is more costly than a false positive (FP) (i.e. to predict a subject will have an event when the subject will NOT have an event), high sensitivity and negative predictive value (NPV) are desirable. We defined the ROC criteria to achieve a minimum level of sensitivity (greater than 80%, 85%, 90%, or 95%). The performance of the cut points was assessed by the following measures: sensitivity, specificity, positive predictive value (PPV), NPV, positive likelihood ratio (PLR), and negative likelihood ratio (NLR). Finally, PLR and NLR were calculated using the following formula (Rush, 2015):

$$\text{Positive LR} = \text{sensitivity}/(1-\text{specificity})$$

$$\text{Negative LR} = (1-\text{sensitivity})/\text{specificity}$$

3. Results

Altogether, 306 youth were evaluated for the IOP program, and 271 were enrolled. Eight of these youth enrolled in IOP twice; only their first enrollment data were included. Of the 263 unique adolescents enrolled in IOP, 251 provided sufficient information to be included in the analyses (Fig. 1). Table 1 provides details about the baseline demographic and clinical characteristics of the sample. Most patients (94%) had a diagnosis of depressive disorder (major depressive disorder, dysthymia, or depression NOS) based on clinical interview. The remaining patients (n = 15) either had another mood disorder, anxiety disorder, or both. Approximately 39% (n = 97) had comorbid mood disorder and anxiety. Mean length of time in IOP was 5.4 ± 2.3 weeks.

Following enrollment, 26 (10.4%) had a suicidal event, of which 14 (5.6%) made a suicide attempt; the remaining 12 (4.8%) either sought emergency services or inpatient hospitalization (or both). There were no deaths by suicide. Of note, as part of the clinical program, patients were contacted at one- and six-months after discharge, and there were no deaths during the course of that follow-up period, either. Mean time to the event was 22.9 ± 13.0 days, and 19/26 (73%) of the events occurred within 30 days of enrollment in IOP. Adolescents with an event during IOP were significantly younger than those without an event (14.4 ± 1.3 vs. 15.0 ± 1.4 ; $p = .040$). Youth with a suicide attempt had more lifetime suicide attempts than those with no attempt (2.4 ± 4.1 vs. 1.4 ± 1.6 ; $p = .036$). No other demographic or clinical characteristics differentiated those with and without an event and those with and without an attempt (Table 1).

3.1. Predictive validity

At baseline, those with any suicidal event scored higher than those without an event on the CHRT-SR₁₄ for Total Score (31.1 ± 14.5 vs. 24.0 ± 11.7 ; $p = .005$), Propensity (19.9 ± 9.7 vs. 15.3 ± 8.2 ;

$p = .008$), and Suicidal Thoughts (6.7 ± 4.2 vs. 4.3 ± 3.5 ; $p = .001$), but not on Impulsivity (4.5 ± 2.3 vs. 4.4 ± 2.3 ; $p = .831$). Youth with a suicide attempt had higher scores than those without an event for Total Score (35.4 ± 14.0 ; $p < .001$), Propensity (22.6 ± 9.5 ; $p < .001$), and Suicidal Thoughts (7.3 ± 3.5 ; $p < .001$).

Table 2 reports the predictive validity of the total and each subscale score in identifying youth with any suicidal event or attempt. A one-point increase in the CHRT-SR₁₄ Total Score was associated with a 5.3% increased likelihood of any suicidal event and a 9.7% increase in the likelihood of a suicide attempt. A one-point increase in the CHRT-SR₁₄ Propensity score was associated with a 7.2% increase in the likelihood of any suicidal event and a 12.8% increase in the likelihood of a suicide attempt. A one-point increase in the CHRT-SR₁₄ Suicidal Thoughts score was associated with a 20.2% increase in the likelihood of any event and a 28.3% increase in the likelihood of a suicide attempt. Impulsivity did not predict suicidal events or suicide attempts. Of note, lack of Social Support led to even greater risk for a suicide attempt: for every one-point increase in the CHRT-SR₁₄ Perceived Lack of Social Support score, there was a 44.1% increase in the likelihood of a suicide attempt.

3.2. ROC curve analysis

We examined the CHRT-SR₁₄ to identify cut-off scores that could be used clinically to identify youth at risk of any suicidal event or a suicide attempt. Tables 3a and 4a provide the sensitivity, specificity, PPV, NPV, PLR, and NLR for optimal cut-off scores for any suicidal event and suicide attempts, respectively. In predicting suicidal events, the CHRT-SR₁₄ Total Score of 22 and Propensity subscale of 14 provided the highest specificity (40.9% and 39.1%, respectively at a sensitivity > 80% [80.8% for each measure]). This specificity level did not meet our threshold of 50%. At a sensitivity > 80% for any event, specificity was relatively low for the Impulsivity subscale cut-off of 2 (11.1%) and Suicidal Thoughts subscale cut-off of 3 (35.8%) (Table 3a). PPV was below 15% for the Total Score and for all subscales, which means that even someone who meets the cut-off is unlikely to have an event. The NPV, on the other hand, was high (above 91%) implying that someone who does not meet the cut-off is highly unlikely to have an event. We also examined the sensitivity and specificity of the Total Scores for the CHRT-SR₁₂ (Table 3b) and CHRT-SR₇ (Table 3c), which showed a similar balance between sensitivity and specificity as the 14-item scale.

For suicide attempts (Table 4a), the CHRT-SR₁₄ Total Score cut-off of 28 met the threshold of > 80% sensitivity (85.7%) and > 50% specificity (56.5%). The Suicidal Thoughts cut-off of 4 and Propensity cut-off of 16 provided a specificity slightly below the threshold of > 50% (46.6% and 48.9%, respectively) with a sensitivity of 85.7% for both measures. For the CHRT-SR₁₂ Total Score cut-off of 20, a specificity of 85.7% was also associated with a sensitivity just below 50% (48.9%) (Table 4b). However, the CHRT-SR₇ Total Score cut-off of 12 performed as well as the 14-item scale cut-off of 28 (sensitivity 85.7%, specificity 53.4%) (Table 4c). All cut-off scores for the various levels of sensitivity and specificity were higher for predicting suicide attempts than suicidal events. Also, PPVs were lower for attempts (below 11%) than for any event and NPVs were higher for attempts (above 96%) than for any event.

4. Discussion

In this study of 251 adolescents at risk for suicide enrolled in an IOP, 5.6% (n = 14) made an attempt and 10.4% (n = 26) had a suicidal event (attempt, emergency department visit, or inpatient hospitalization). The CHRT-SR₁₄ Total Score, Propensity, and Suicidal Thoughts factors predicted future attempts and events during the IOP. In general, the scale showed greater predictive validity for predicting future suicide attempts than the more inclusive “suicidal events” outcome. For every one-point increase on the CHRT-SR₁₄ Total Score, there was a

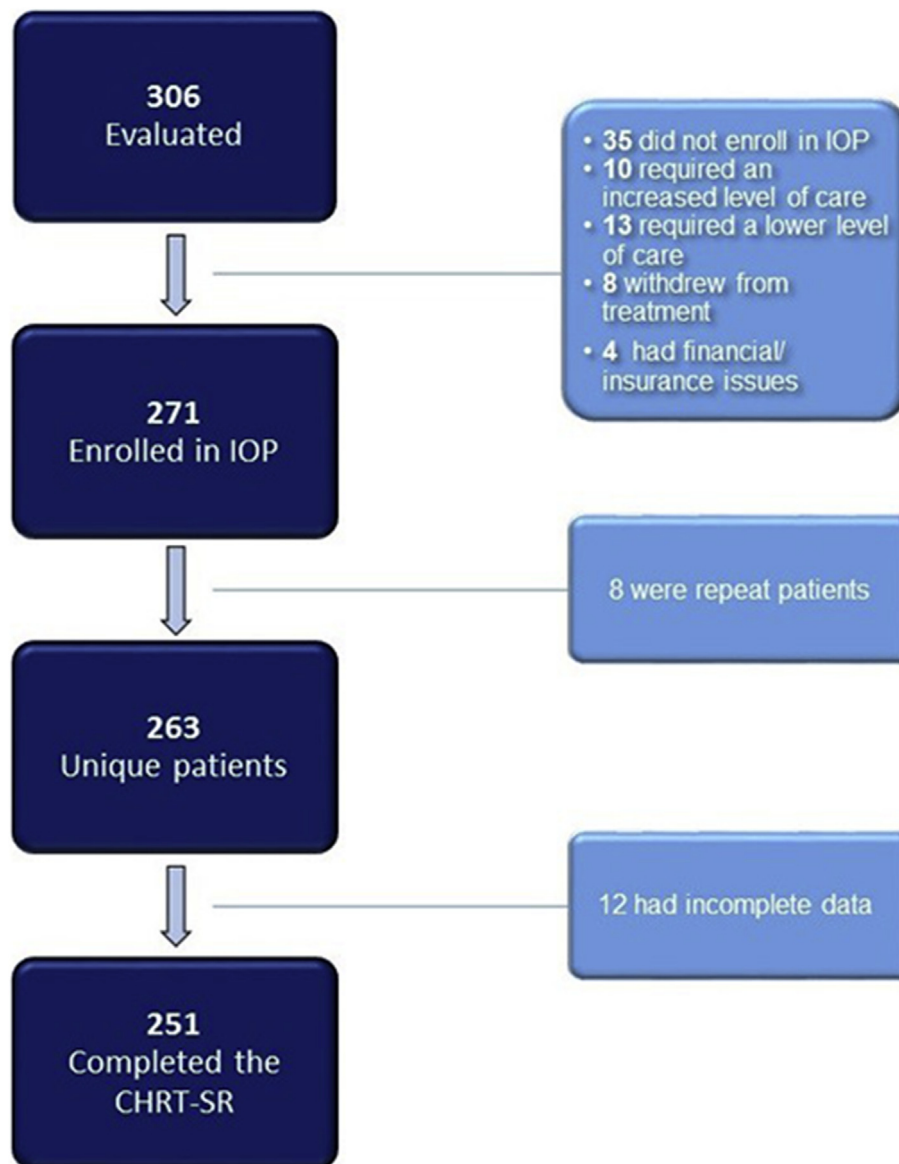


Fig. 1. CONSORT Diagram.

9.7% increase in the likelihood of a suicide attempt. For predicting attempts, a CHRT-SR₁₄ Total Score of 28 had a sensitivity of 85.7% and specificity of 56.5%. For predicting events, a CHRT-SR₁₄ of 22 had a sensitivity of 80.8% and specificity of 40.9%. The CHRT-SR₇ also performed well in predicting suicide attempts, with a Total Score cut-off of 12 providing sensitivity of 85.7% and specificity of 53.4%.

These findings are consistent with Reilly-Harrington and colleagues, who found that the CHRT-SR₁₄ predicted suicide-related adverse events in adults with bipolar disorder. Specifically, the hazard of having a suicide-related serious adverse event was increased by 76% for every 10-point increase on the baseline CHRT-SR₁₄ total score (Reilly-Harrington et al., 2016). As noted, in a prior review of a variety of measures to predict future suicide attempts, Runeson did not identify any measure that met their pre-defined threshold of > 80% sensitivity and > 50% specificity (Runeson et al., 2017). In this sample, the CHRT-SR₁₄ and the CHRT-SR₇ Total Scores predicted future suicide attempts at this threshold. The CHRT-SR₁₂, as well as the Propensity and Suicidal Thoughts factors, were just short of reaching this threshold based on the specificity outcomes.

These results on the CHRT-SR represent one of the first reports that meet the criteria outlined by Runeson and colleagues and are in

contrast to prior studies, none of which have identified adequate methods for predicting future suicide attempts with acceptable sensitivity and specificity (Runeson et al., 2017). The sensitivity and specificity analyses on the CHRT-SR (all versions) in this sample provide acceptable cut-off scores for predicting suicide attempts.

While the CHRT-SR is not intended to be a substitute for clinical assessment, it may be a useful measure to help triage individuals toward clinical assessment when identified as high risk. For this reason, the report provides multiple cut-off score options for minimum sensitivities of at least 80%, which should be selected at the provider's discretion. The lower the score selected, the greater the sensitivity, but, as expected, the higher the rate of false positives. By selecting a threshold of > 80% sensitivity and > 50% specificity, for example, a CHRT-SR₁₄ Total Score of 28 would accurately identify 85.7% of youth who will make a future attempt. To increase sensitivity by reducing the cut-off score to 23 would allow about 92.8% of youth to be identified, but at the cost of more false positives. Providers can select the most appropriate level of sensitivity and specificity desired given the clinical circumstances.

This study has several limitations. First, the sample is one at high risk for future suicide attempts, and it is restricted to adolescents

Table 1
Demographic and clinical characteristics.

	Total Sample (n = 251)	No Event (n = 225)	Any Event (n = 26)	Suicide Attempt (n = 14)	Event but NOT Attempt (n = 12)
Age	14.9 ± 1.4	15.0 ± 1.4	14.4 ± 1.3 ^a	14.4 ± 1.4	14.4 ± 1.1
Gender (Female)	81.3% (204)	81.8% (184)	76.9% (20)	71.4% (10)	83.3% (10)
Ethnicity					
Hispanic	9.6% (24)	9.3% (21)	11.5% (3)	0	25.0% (3)
Non-Hispanic	89.2% (224)	89.3% (201)	88.5% (23)	100.00% (14)	75.0% (9)
Unknown	1.2% (3)	1.3% (3)	0	0	0
Race					
Caucasian	85.3% (214)	84.0% (189)	96.2% (25)	100.00% (14)	91.7% (11)
African American	8.0% (20)	8.4% (19)	3.8% (1)	0	8.3% (1)
Asian	2.0% (5)	2.2% (5)	0	0	0
More than one race	0.4% (1)	0.4% (1)	0	0	0
Unknown	4.4% (11)	4.9% (11)	0	0	0
Suicide Attempt Led to IOP	56.2% (141)	56.9% (128)	50.0% (13)	64.3% (9)	33.3% (4)
Severe Worsening of Ideation Led to IOP	43.8% (110)	43.1% (97)	50.0% (13)	35.7% (5)	66.7% (8)
Number of Lifetime Suicide Attempts					
0	1.4 ± 1.8 28.7% (72)	1.4 ± 1.6 27.6% (62)	1.7 ± 3.2 38.5% (10)	2.4 ± 4.1 ^b 28.6% (4)	0.8 ± 1.2 50.0% (6)
1	42.2% (106)	43.6% (98)	30.8% (8)	28.6% (4)	33.3% (4)
2	12.7% (32)	13.3% (30)	7.7% (2)	7.1% (1)	8.3% (1)
3+	16.3% (41)	15.6% (35)	23.8% (6)	35.7% (14)	8.3% (1)
Non-Suicidal Self-Injury (NSSI)					
Any History of NSSI	75.6% (189)	75.0% (168)	80.8% (21)	92.9% (13)	66.7% (8)
Ongoing/Active NSSI	45.4% (114)	44.0% (99)	57.7% (15)	64.3% (9)	50.0% (6)
Baseline QIDS-A Self Report Total Score	13.4 ± 5.9	13.2 ± 5.7	14.9 ± 7.4	16.3 ± 6.4	13.0 ± 8.6

Abbreviations: IOP: Intensive outpatient program; QIDS-A: Quick Inventory of Depressive Symptomatology – Adolescents (QIDS-A).

^a Any event vs. No event p < .04.

^b Suicide attempt vs. No event p < .05.

Table 2
Predictive validity of the CHRT-SR₁₄.

Measure	No Event (n = 225)		Any Event (n = 26)		Suicide Attempt (n = 14)			Event but NOT Attempt (n = 12)		
	Baseline M ± SD	Baseline M ± SD	OR	OR 95% CI	Baseline M ± SD	OR	OR 95% CI	Baseline M ± SD	OR	OR 95% CI
Total Score	24.00 ± 11.72	31.08 ± 14.47	1.055**	1.015, 1.096	35.43 ± 14.01	1.107***	1.044, 1.173	26.00 ± 13.85	1.007	.956, 1.060
Propensity	15.28 ± 8.20	19.88 ± 9.70	1.073*	1.017, 1.133	22.64 ± 9.52	1.136**	1.049, 1.229	16.67 ± 9.26	1.010	.937, 1.089
Pessimism	3.06 ± 2.16	4.04 ± 2.09	1.227*	1.012, 1.488	4.57 ± 2.03	1.393*	1.074, 1.806	3.42 ± 2.07	1.039	.788, 1.372
Helplessness	3.95 ± 2.42	4.65 ± 2.77	1.131	.949, 1.349	5.36 ± 2.53	1.329*	1.024, 1.724	3.83 ± 2.92	.958	.748, 1.226
Social Support	2.23 ± 1.98	3.46 ± 2.73	1.294**	1.080, 1.549	4.14 ± 2.98	1.462**	1.159, 1.845	2.67 ± 2.27	1.103	.829, 1.468
Despair	6.01 ± 3.26	7.73 ± 3.83	1.192*	1.032, 1.378	8.57 ± 3.46	1.387**	1.108, 1.737	6.75 ± 4.16	1.038	.858, 1.256
Impulsivity	4.44 ± 2.27	4.54 ± 2.30	1.022	.850, 1.228	5.50 ± 2.31	1.257	.953, 1.659	3.42 ± 1.78	.824	.633, 1.073
Suicidal Thoughts	4.27 ± 3.46	6.65 ± 4.20	1.214**	1.072, 1.375	7.29 ± 3.47	1.357**	1.124, 1.637	5.92 ± 4.98	1.107	.936, 1.309

*p < .05 **p < .01 ***p < .001.

Abbreviations: M: Mean; SD: Standard Deviation; OR: Odds Ratio.

receiving treatment specifically for suicidal ideation and behaviors. To be eligible for the treatment, youth had to have a recent history of a suicidal event (suicide attempt or emergency evaluation or inpatient hospitalization due to suicidality). It is not clear whether the cut-off scores would be similar in a general adolescent population. Second, the data are based on a clinical sample using clinical assessments from a retrospective chart review, rather than a prospective assessment of suicidal events. In addition, analyses of the CHRT-SR were conducted post-hoc. Further, these analyses are limited to predicting future suicidal behaviors during the course of the treatment that could last for up to 12 weeks (typically 4–8 weeks). Because some patients did not complete IOP, we do not have complete data on all patients. Of the 251 enrolled, 46 did not complete treatment; of those 46, 34 (73.9%) did

not have an event before they left the IOP, and 41 (89.1%) did not have an attempt before leaving IOP. It is possible that these patients could have had an event or attempt after leaving IOP, which could affect the results. Finally, the performance of the cut-off scores has not yet been validated in another sample.

5. Conclusion

Results provide support for the CHRT-SR (especially CHRT-SR₁₄ and CHRT-SR₇) as a tool to identify potential risk for suicide attempts in adolescents at high risk for suicidal behavior. Although CHRT-SR is not intended to be a substitute for clinical assessment, it may be a useful measure in identifying high-risk individuals in need of further clinical

Table 3a
Optimal cut-offs for predicting any suicidal event – CHRT-SR₁₄^b.

Cut-off ^a	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₁₄ Total Score (Items 1–14)						
22	80.8%	40.9%	13.6%	94.8%	1.37	0.47
14	88.5%	23.1%	11.7%	94.5%	1.15	0.50
10	92.3%	12.9%	10.9%	93.5%	1.06	0.60
CHRT-SR ₁₄ Propensity (Items 1–9)						
14	80.8%	39.1%	13.3%	94.6%	1.33	0.49
10	88.5%	24.4%	11.9%	94.8%	1.17	0.47
5	92.3%	12.9%	10.9%	93.5%	1.06	0.60
CHRT-SR ₁₄ Impulsivity (Items 10–11)						
2	92.3%	11.1%	10.7%	92.6%	1.04	0.69
1	96.8%	9.9%	12.1%	96.0%	1.07	0.32
CHRT-SR ₁₄ Suicidal Thoughts (Items 12–14)						
3	84.6%	35.8%	13.2%	95.3%	1.32	0.43

^a Subject predicted to have an event if CHRT-SR score is greater than or equal to cut-off. Abbreviations: PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

^b The 14-item CHRT-SR (CHRT-SR₁₄) includes Propensity (items 1–9), Impulsivity (items 10–11), and Suicidal Thoughts (items 12–14).

Table 3b
Optimal cut-offs for predicting any suicidal event – CHRT-SR₁₂^b.

Cut-off ^a	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₁₂ Total Score (Items 1–9, 12–14)						
18	80.8%	43.6%	14.2%	95.1%	1.43	0.44
10	88.5%	20.4%	11.4%	93.9%	1.11	0.56
5	92.3%	12.0%	10.8%	93.1%	1.05	0.64

^a Subject predicted to have an event if CHRT-SR score is greater than or equal to cut-off. Abbreviations: PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

^b The 12-item CHRT-SR (CHRT-SR₁₂, derived from the 14-item scale) includes Propensity (items 1–9) and Suicidal Thoughts (items 12–14).

Table 3c
Optimal cut-offs for predicting any suicidal event – CHRT-SR₇^b.

Cut-off ^a	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₇ Total Score (Items 3–6, 12–14)						
8	80.8%	37.6%	13.0%	94.4%	1.29	0.51
3	88.5%	13.7%	10.6%	91.2%	1.02	0.84

^a Subject predicted to have an event if CHRT-SR score is greater than or equal to cut-off; Abbreviations: PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

^b The 7-item CHRT-SR (CHRT-SR₇, derived from the 14-item scale) includes four of the Propensity items (items 3–6) and Suicidal Thoughts (items 12–14).

assessment.

CRedit authorship contribution statement

Taryn L. Mayes: Conceptualization, Data curation, Investigation, Methodology, Project administration, Writing - original draft. **Michael Killian:** Formal analysis, Writing - review & editing. **A. John Rush:** Writing - review & editing. **Graham J. Emslie:** Investigation, Project administration, Resources, Writing - review & editing. **Thomas Carmody:** Formal analysis, Writing - review & editing. **Betsy D.**

Table 4a
Optimal cut-offs for predicting a suicide attempt – CHRT-SR₁₄^a.

Cut-off*	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₁₄ Total Score (Items 1–14)						
28	85.7%	56.5%	10.4%	98.5%	1.97	0.25
23	92.8%	43.4%	8.8%	99.0%	1.64	0.17
CHRT-SR ₁₄ Propensity (Items 1–9)						
16	85.7%	48.9%	9.0%	98.3%	1.68	0.29
15	92.8%	44.3%	9.0%	99.0%	1.67	0.16
CHRT-SR ₁₄ Impulsivity (Items 10–11)						
4	85.7%	33.6%	7.0%	97.6%	1.29	0.43
2	92.8%	10.9%	5.8%	96.3%	1.04	0.66
CHRT-SR ₁₄ Suicidal Thoughts (Items 12–14)						
4	85.7%	46.6%	8.6%	98.2%	1.60	0.31
3	92.8%	35.3%	7.8%	98.8%	1.44	0.20

^a The 14-item CHRT-SR (CHRT-SR₁₄) includes Propensity (items 1–9), Impulsivity (items 10–11), and Suicidal Thoughts (items 12–14).

Table 4b
Optimal cut-offs for predicting a suicide attempt – CHRT-SR₁₂^a.

Cut-off*	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₁₂ Total Score (Items 1–9, 12–14)						
20	85.7%	48.9%	9.0%	98.3%	1.68	0.29
18	92.8%	43.0%	8.8%	99.0%	1.63	0.17

^a The 12-item CHRT-SR (CHRT-SR₁₂, derived from the 14-item scale) includes Propensity (items 1–9) and Suicidal Thoughts (items 12–14).

Table 4c
Optimal cut-offs for predicting a suicide attempt – CHRT-SR₇^a.

Cut-off*	Sensitivity	Specificity	PPV	NPV	PLR	NLR
CHRT-SR ₇ Total Score (Items 3–6, 12–14)						
12	85.7%	53.4%	9.8%	98.4%	1.84	0.27
7	92.8%	30.2%	7.3%	98.6%	1.33	0.24

* Subject predicted to have an event if CHRT-SR score is greater than or equal to cut-off. Abbreviations: PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

^a The 7-item CHRT-SR (CHRT-SR₇, derived from the 14-item scale) includes four of the Propensity items (items 3–6) and Suicidal Thoughts (items 12–14).

Kennard: Investigation, Project administration, Resources, Writing - review & editing. **Manish K. Jha:** Methodology, Writing - review & editing. **Jessica King:** Data curation, Writing - review & editing. **Jennifer L. Hughes:** Writing - review & editing. **Madhukar H. Trivedi:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Resources, Writing - original draft.

Declaration of competing interest

Dr. Rush has received consulting fees from Akili, Brain Resource Inc., Compass Inc., Curbstone Consultant LLC, Emmes Corp., Johnson and Johnson (Janssen), Liva-Nova, Mind Linc, Otsuka-US, Sunovion; speaking fees from Liva-Nova; and royalties from Guilford Press and the University of Texas Southwestern Medical Center, Dallas, TX (for the Inventory of Depressive Symptoms and its derivatives). He is also named co-inventor on two patents: U.S. Patent No. 7,795,033: Methods to Predict the Outcome of Treatment with Antidepressant Medication,

Inventors: McMahon FJ, Laje G, Manji H, Rush AJ, Paddock S, Wilson AS; and U.S. Patent No. 7,906,283: Methods to Identify Patients at Risk of Developing Adverse Events During Treatment with Antidepressant Medication, Inventors: McMahon FJ, Laje G, Manji H, Rush AJ, Paddock S. **Dr. Emslie** has received research/grant from Duke University, Forest Research Institute, and Janssen Research & Development. **Dr. Emslie** is a consultant for Assurex Health Inc., Lundbeck, Neuronics Inc., Otsuka, and Pfizer Inc. **Dr. Kennard** is currently serving on the Board of Trustees for the Jerry M. Lewis, M.D. Mental Health Research Foundation. **Dr. Kennard** receives royalties from Guilford Press, Inc. **Dr. Jha** has received research funding from Acadia Pharmaceuticals and Janssen Research & Development, and honoraria for CME presentations from North American Center for Continuing Medical Education and Global Medical Education. **Dr. Hughes** receives royalties from Guilford Press. **Dr. Trivedi** has received research funding from NIMH, NIDA, and Patient-Centered Outcomes Research Institute (PCORI), Cancer Prevention Research Institute of Texas (CPRIT); has served as a consultant for Allergan, Alto Neuroscience Inc, Applied Clinical Intelligence LLC, Axsome Therapeutics, Boehringer Ingelheim, Engage Health Media, GreenLight VitalSign6 Inc, Janssen, Lundbeck Research USA, Merck Sharp & Dohme Corp., Navitor Pharmaceutical Inc, Otsuka, Perception Neuroscience, Pharmerit International, SAGE Therapeutics, Signant Health; and has received editorial compensation from American Psychiatric Association (Deputy Editor for American Journal of Psychiatry), Oxford University Press; **Dr. Carmody** owns stock in Vertex Pharmaceuticals and CRISPR Therapeutics; **Ms. Mayes** and **Drs. Killian**, and **King**, have no financial relationships with commercial interests.

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