A Comparison of Suicide Risk Scales in Predicting Repeat Suicide Attempt and Suicide: A Clinical Cohort Study

Åsa U. Lindh, MD, PhD[a,*]; Marie Dahlin, MD, PhD[a]; Karin Beckman, MD, PhD[a]; Lotta Strömsten, PhD[b]; Jussi Jokinen, MD, PhD[b]; Stefan Wiktorsson, PhD[c]; Ellinor Salander Renberg, PhD[b]; Margda Waern, MD, PhD[c]; and Bo Runeson, MD, PhD[a]

ABSTRACT

Objective: To compare the predictive accuracy of the Suicide Intent Scale (SIS), the Suicide Assessment Scale (SUAS), the Karolinska Interpersonal Violence Scale (KIVS), and the Columbia-Suicide Severity Rating Scale (C-SSRS) for suicide attempts and suicides within 3 and 12 months of an episode of self-harm.

Methods: This prospective multicenter cohort study included patients (N = 804) aged 18–95 years with a recent episode of self-harm assessed in psychiatric emergency settings from April 2012 to April 2016. Suicide attempts and suicides were identified in medical records and in the National Cause of Death Register. Receiver operating characteristic curves were constructed, and accuracy statistics were calculated. A sensitivity of at least 80% combined with a specificity of at least 50% were considered minimally acceptable.

Results: At least 1 suicide attempt was recorded for 216 participants during follow-up, and 19 participants died by suicide. The SUAS and C-SSRS were better than chance in classifying the 114 suicide attempts occurring within the first 3 months; a C-SSRS score ≥ 27 yielded a sensitivity/specificity of 79.8%/51.5% ($P < .001$). During 1-year follow-up, the SUAS and C-SSRS also performed better than chance, but no cutoff on either instrument gave a sensitivity/specificity of ≥ 80%/≥ 50%. The SIS was the only instrument that could classify suicides correctly. At 3 months, the area under the curve (AUC) was 0.94 (95% CI, 0.89–0.99), and a score ≥ 21 predicted suicide with a sensitivity/specificity of 100%/81.9%, based on only 4 suicides. At 1-year follow-up, the AUC was 0.74 (95% CI, 0.61–0.87), and a score ≥ 17 predicted suicide with a sensitivity/specificity of 72.2%/57.9%.

Conclusions: Instruments that predicted nonfatal repeat suicide attempts did not predict suicide and vice versa. With the possible exception of the prediction of suicide by the SIS in a short time frame, the specificity of these instruments was low, giving them a limited relevance in the prediction of suicidal behaviors.

J Clin Psychiatry 2019;80(6):18m12707

To cite: Lindh ÅU, Dahlin M, Beckman K, et al. A comparison of suicide risk scales in predicting repeat suicide attempt and suicide: a clinical cohort study. *J Clin Psychiatry.* 2019;80(6):18m12707.

To share: https://doi.org/10.4088/JCP.18m12707

[a]Centre for Psychiatry Research, Department of Clinical Neuroscience, Karolinska Institutet, & Stockholm Health Care Services, Stockholm County Council, St Görans Hospital, Stockholm, Sweden

[b]Department of Clinical Sciences, Division of Psychiatry, University of Umeå, Umeå, Sweden

[c]Department of Psychiatry and Neurochemistry, University of Göteborg, Göteborg, Sweden

**Corresponding author:* Åsa U. Lindh, MD, PhD, Vårdvägen 1, SE-112 81 Stockholm, Sweden (asa.lindh@ki.se).

During the past 50 years, rating scales have been constructed with the purpose of structuring information that could be of relevance in the prediction of suicide attempts or suicide. The American Psychiatric Association guideline for the assessment and treatment of patients with suicidal behavior[1] states that suicide assessment scales may be used as aids but not as substitutes for a thorough clinical evaluation. In Great Britain, the National Institute for Health and Care Excellence guidelines on long-term management of self-harm[2] classify the use of suicide risk assessment tools and scales to predict future suicide or repetition of self-harm as a "do not do" recommendation but state that they might be of help in structuring the risk assessment. Existing instruments have focused on different aspects of suicidality but have rarely been compared with each other in head-to-head designs. Exceptions include the recent work of Quinlivan et al (2017)[3] and Steeg et al (2018),[4] who compared the performance of the Manchester Self-Harm Rule, the ReACT Self-Harm Rule, the SAD PERSONS scale, the modified SAD PERSONS scale, the Barratt Impulsiveness Scale, and clinician and patient estimates of future risk of self-harm in 2 cohorts of patients with self-harm. None of the included instruments outperformed the clinician and patient estimates,[3] and all instruments failed to accurately predict both nonfatal and fatal outcomes.[4] Some of the most widely used assessment tools, such as the Suicide Intent Scale (SIS)[5] and the Columbia-Suicide Severity Rating Scale (C-SSRS),[6] have yet to be compared in a prospective clinical study.

In the present study, we compare 4 suicide risk assessment instruments in a Swedish cohort of psychiatric patients with a recent episode of self-harm: the SIS,[5] the Suicide Assessment Scale (SUAS),[7] the Karolinska Interpersonal Violence Scale (KIVS),[8] and the C-SSRS.[6] These instruments cover a wide range of phenomena relevant to suicide risk assessment. They are used in clinical settings in Sweden and to some extent are recommended in Swedish national guidelines[9,10] that suggest the use of such tools as a mere complement to clinical assessment. Our aim was to assess the predictive accuracy of the 4 rating scales for the outcomes of suicide attempt and suicide within 3 and 12 months of a self-harm episode and to evaluate if a sensitivity of at least 80% and a specificity of at least

Clinical Points

- Many suicide assessment scales have been developed, but the predictive properties of these instruments are seldom compared.
- In a clinical self-harm cohort, all examined scales had limited accuracy for the prediction of suicide and nonfatal repeat suicide attempt, and instruments that predicted the latter did not predict suicide.
- The examined scales should be used only as a complement to clinical assessment.

50% could be obtained for any rating scale. These figures were suggested as minimally acceptable accuracy statistics in a recent review[11] of suicide risk assessment instruments. In addition to cutoffs identified by our own data, we also determined scale accuracy at cutoffs previously suggested by other authors.

METHODS

Sample

This study was carried out at 3 university hospitals in Stockholm, Gothenburg, and Umeå, Sweden. In Stockholm and Umeå, patients were included at the psychiatric emergency departments (EDs), serving catchment areas of 2.2 million and 150,000 persons, respectively. The psychiatric EDs are staffed with psychiatrists, residents in psychiatry, and nurses; are open 24 hours a day, 7 days a week; and accommodate referrals from other caregivers as well as persons arriving by ambulance, with the police, or on their own initiative. In Gothenburg, patients were included via a psychiatric consultation team at the accident and emergency department of a hospital serving a catchment area of 400,000 persons. The consultation team operates on weekdays and is staffed with a psychiatrist and several mental health professionals. Patients who had a psychiatric assessment in conjunction with an episode of self-harm from April 2012 to April 2016 were asked to participate. Both nonsuicidal self-injuries, ie, deliberate self-injuries without intent to die,[12] and suicide attempts, ie, potentially self-injurious behavior for which there is evidence that the person wanted to die as a result,[13] were included in the sample and in the analyses of this study. Participants had to be capable of taking part in an interview in Swedish and had to have a Swedish personal identity number. The latter was required for follow-up in medical records and national registers. Exclusion criteria were symptoms interfering with verbal communication (eg, confusion, severe psychotic symptoms, cognitive impairment, aggressiveness, intoxication). If the patient was admitted to hospital and such symptoms abated within a few days, they were eligible for inclusion. The research interview was performed within 7 days of the index self-harm event in 94% of the cases. All participants were aged 18 to 95 years. With 804 of 1,134 eligible patients accepting to take part in the interview, the participation rate was 71%. A flowchart of the study is provided in Supplementary Figure 1. Two-thirds of the participants were women. A majority of the participants, 93%, were admitted to inpatient care after the index event with a median stay of 9 days (range, 1–238 days).

Data Collection at Baseline

Interviews were performed by mental health staff (psychiatrist, psychologist, and psychiatric nurse). In addition to the rating scales, we also gathered demographic information and data on previous psychiatric symptoms and treatment at the interview and from the medical record.

Rating Scales

A description of the specific items covered by the respective instruments is provided in Supplementary Tables 1–4.

The SIS evaluates objective and subjective circumstances of a recent suicide attempt assumed to reflect degree of suicidal intent.[5,14] A cutoff score ≥ 16 was found to be predictive of suicide in a cohort of patients who had attempted suicide followed for 15–20 years.[15] Studies with shorter follow-up times either present cutoffs for subgroups (eg, participants above a certain age) or present results in terms of odds ratios or differences in mean or median scores between those who die by suicide during follow-up and those who survive.[16]

The SUAS assesses worst-point intensity of suicide-related psychiatric symptoms for the past 30 days.[7] It was developed to be sensitive to change in suicidality over time. In a recent review[17] of the evidence for suicide risk assessment instruments, it was noted that there were too few studies to assess the diagnostic accuracy of the SUAS. Two studies have evaluated the predictive ability of the SUAS in patients who had attempted suicide, one[18] finding that a total score ≥ 39 predicted suicide and the other[19] that a total score > 30 predicted fatal or nonfatal repeat attempt.

The KIVS was constructed as a short alternative to more extensive instruments assessing use of and exposure to interpersonal violence in childhood and adulthood.[8] Two studies[8,20] employing partially overlapping clinical cohorts of patients who had attempted suicide found positive correlations between high scores and future suicide. The KIVS has also been evaluated in a subset of the cohort used in the present study, with high scores predicting repetition of suicide attempt within 6 months.[21] A KIVS score ≥ 6 was predictive of suicide in a cohort of patients who had attempted suicide with a follow-up time of 15–20 years.[20]

The C-SSRS was constructed for classification of suicidal ideation and behaviors.[6] It has been used in a large number of clinical trials to detect suicide-related adverse events. Its predictive abilities have been evaluated in studies focusing primarily on nonfatal suicidal behaviors.[6,22–25] The predictive ability of the C-SSRS was examined in the present cohort in a 6-month follow-up study.[26] Intensity, but not severity, of suicidal ideation as well as the total score predicted nonfatal and fatal suicide attempts. In a psychiatric inpatient population, a total score ≥ 23 was predictive of suicidal behavior during a 6-month follow-up.[25]

Outcomes

Information on suicide attempts occurring within 3 and 12 months of the index episode was retrieved from the medical records. Events described as potentially self-injurious behavior with nonfatal outcome, with evidence that the person had some wish to die as a result of the act, were registered as suicide attempts.[13] The National Cause of Death Register[27] was used to identify suicide deaths (*ICD-10* codes X60–X84 and Y10–Y34).

Statistical Analyses

Data analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 24.0 (IBM Corp; Armonk, New York; 2016) and R version 3.3.1 (R Foundation for Statistical Computing; Vienna, Austria; 2016). In all tests, *P* values below .05 were considered statistically significant. Ratings for patients with and without the outcomes were compared using the Mann-Whitney *U* test. The χ^2 test was used to test differences in proportions. Receiver operating characteristic curves were constructed, and the area under the curve (AUC) was assessed for the total score of all instruments as predictor of the outcomes of suicide attempt and suicide at 3 months and 1 year from the index episode. The 3-month interval was chosen based on the need for guidance in risk assessment during this clinically relevant period.[28,29]

Accuracy statistics (sensitivity, specificity, positive and negative predictive value) were calculated for instruments that had an AUC larger than 0.50. These statistics were based on the cutoffs that maximized the sum of sensitivity and specificity. For each outcome, sensitivity and specificity of the instruments were compared using the χ^2 test. Predefined cutoffs identified in the literature were also examined.

Ethics Approval

Ethical approval was obtained from the Gothenburg Regional Ethics Committee (589-10, T034-12). Written informed consent was obtained from all participants.

RESULTS

Baseline characteristics are described in Table 1. Complete ratings on all scales were obtained from 746 participants (93%). Participants with missing data on any of the instruments were not included in the comparison. Participants with or without complete ratings did not differ with regard to age, sex, type of self-harm at index, and prevalence of the outcomes (Supplementary Table 5). The range of values as well as mean and median values on all rating scales are shown in Supplementary Table 6 together with measures of interrater reliability and internal consistency.

One-year follow-up data were available in medical records for 775 participants (96%). For the remainder (n = 29, 4%), there were no or very few record entries. The most common reason for this was that the participant had moved from the catchment area.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N = 804)[a]

Characteristic	Value
Age, median (interquartile range), y	33 (23–50)
Women	541 (67)
Men	263 (33)
Current occupation	
Work/student	325 (40)
Unemployed/sick leave/disability pension	395 (49)
Retired	84 (10)
Living alone	424 (53)
Current mental health treatment[b]	573 (71)
Inpatient care in past 3 months	231 (29)
Previous suicide attempt	544 (68)
Previous non-suicidal self-injury	421 (52)
Psychiatric hospitalization at index[c]	750 (93)
Suicide attempt at index[d]	
Overall	666 (83)
Poisoning	470 (71[e])
Hanging and other violent methods[f]	151 (23[e])
Cutting	117 (18[e])
Nonsuicidal self-injury at index[d]	
Overall	138 (17)
Cutting	95 (69[g])
Poisoning	37 (27[g])
Other	21 (15[g])
Clinical diagnosis at index, primary, or secondary position[h]	
Anxiety disorder (F40–F48)	320 (40)
Mood disorder (F30–F39)	295 (37)
Substance use disorder (F10–F19)	172 (21)
Personality disorder (F60)	170 (21)

[a]Values shown as n (%) unless otherwise noted.
[b]Having an ongoing contact with primary or psychiatric care with treatment for a psychiatric condition.
[c]Defined as at least 1 night's admission to inpatient care.
[d]More than 1 method allowed.
[e]Percentage of overall number of participants (666) with suicide attempt at index.
[f]Vehicular impact, jumping from height, drowning, gassing, firearm.
[g]Percentage of overall number of participants (n = 138) with nonsuicidal self-injury at index.
[h]According to *ICD-10*.

Suicide attempts were recorded for 114 persons (14%) within the first 3 months after the index episode. During the 1-year follow-up, a total number of 216 persons (27% of the cohort, 152 women [28%] and 64 men [24%], *P* = .26) made at least 1 suicide attempt.

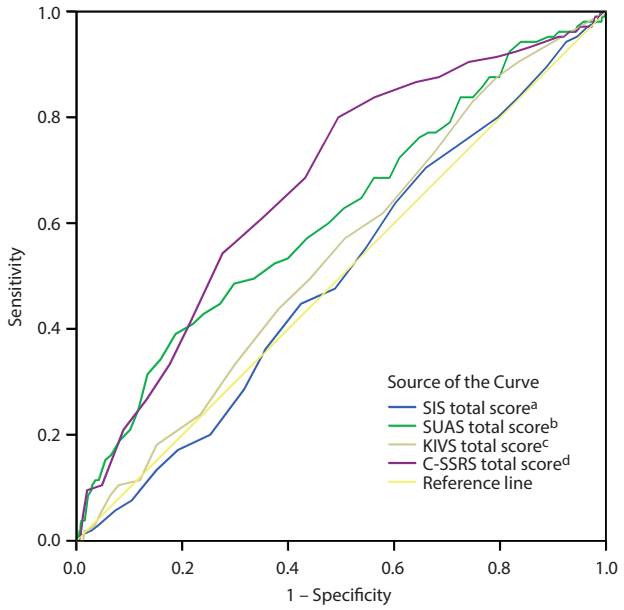
Five participants (0.6%) died by suicide within the first 3 months of follow-up. Four had complete ratings on all instruments and were included in the comparison. Nineteen participants (2.4% of the cohort) died by suicide during the first year after the index episode. Of these, 12 were men and 7 were women; thus, 4.6% of all men and 1.3% of all women died by suicide during the first year (*P* = .004). Hanging (n = 8) and self-poisoning (n = 6) were the most common methods. Eleven participants (1.4% of the cohort) died of natural causes during the first year of follow-up.

Performance of the Rating Scales

Raw numbers for each presented cutoff and corresponding outcome are presented in Supplementary Tables 7 and 8.

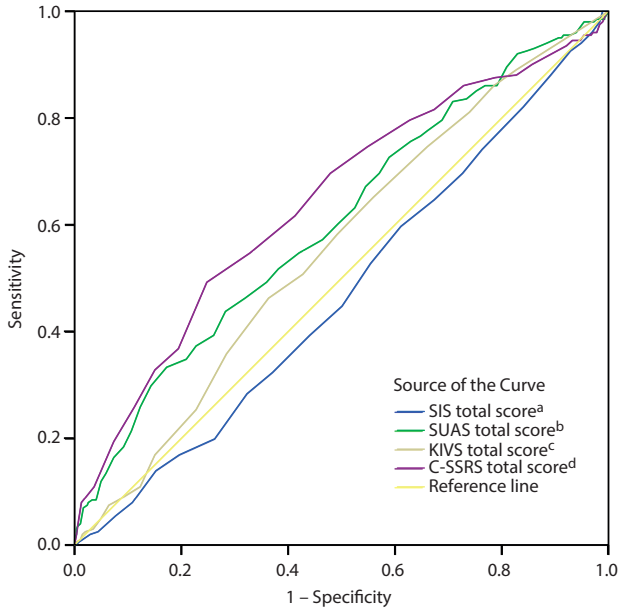
The SIS did not perform better than chance in predicting suicide attempts (Figures 1 and 2), but the total score was a significant predictor of suicide at both 3 and 12 months (Supplementary Figure 2, Figure 3, Table 2) with positive

Figure 1. Total Scores on the SIS, SUAS, KIVS, and C-SSRS as Predictors of Suicide Attempt During 3-Month Follow-Up



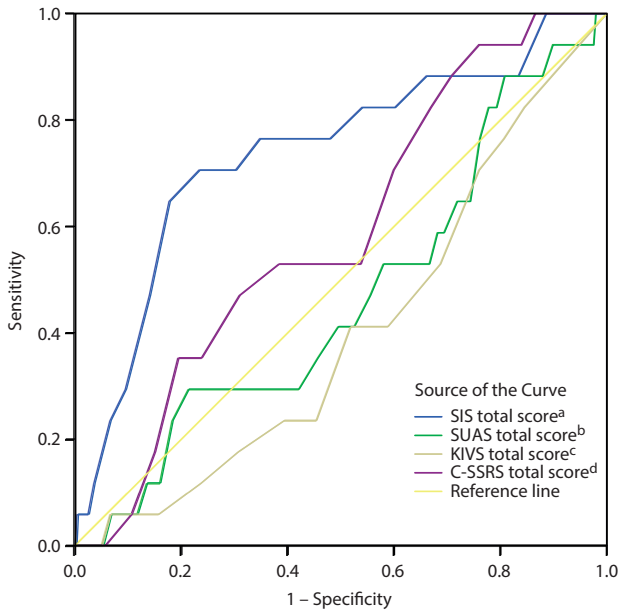
[a]SIS: AUC = 0.50; 95% CI, 0.44–0.56; $P = .981$.
[b]SUAS: AUC = 0.61; 95% CI, 0.55–0.68; $P < .001$.
[c]KIVS: AUC = 0.54; 95% CI, 0.48–0.60; $P = .179$.
[d]C-SSRS: AUC = 0.67; 95% CI, 0.62–0.73; $P < .001$.
Abbreviations: AUC = area under the curve, C-SSRS = Columbia-Suicide Severity Rating Scale, KIVS = Karolinska Interpersonal Violence Scale, SIS = Suicide Intent Scale, SUAS = Suicide Assessment Scale.

Figure 2. Total Scores on the SIS, SUAS, KIVS, and C-SSRS as Predictors of Suicide Attempt During 1-Year Follow-Up



[a]SIS: AUC = 0.47; 95% CI, 0.43–0.52; $P = .238$.
[b]SUAS: AUC = 0.60; 95% CI, 0.56–0.65; $P < .001$.
[c]KIVS: AUC = 0.56; 95% CI, 0.51–0.60; $P = .019$.
[d]C-SSRS: AUC = 0.64; 95% CI, 0.60–0.69; $P < .001$.
Abbreviations: AUC = area under the curve, C-SSRS = Columbia-Suicide Severity Rating Scale, KIVS = Karolinska Interpersonal Violence Scale, SIS = Suicide Intent Scale, SUAS = Suicide Assessment Scale.

Figure 3. Total Scores on the SIS, SUAS, KIVS, and C-SSRS as Predictors of Suicide During 1-Year Follow-Up



[a]SIS: AUC = 0.74; 95% CI, 0.61–0.87; $P = .001$.
[b]SUAS: AUC = 0.47; 95% CI, 0.33–0.60; $P = .633$.
[c]KIVS: AUC = 0.40; 95% CI, 0.29–0.53; $P = .168$.
[d]C-SSRS: AUC = 0.59; 95% CI, 0.47–0.71; $P = .214$.
Abbreviations: AUC = area under the curve, C-SSRS = Columbia-Suicide Severity Rating Scale, KIVS = Karolinska Interpersonal Violence Scale, SIS = Suicide Intent Scale, SUAS = Suicide Assessment Scale.

predictive values (PPVs) of 2.8% and 3.9%, respectively. Testing the cutoff ≥ 16 as suggested by Stefansson et al[15] yielded a 12-month PPV of 3.5%.

SUAS total score was a significant predictor of suicide attempts at both 3 and 12 months (Figures 1 and 2) with PPVs of 17.4% and 30.2%, respectively. However, no single cutoff gave a combination of sensitivity ≥ 80% and specificity ≥ 50% (Table 2). The SUAS could not predict suicide during the follow-up (Supplementary Figure 2, Figure 3).

The KIVS was a significant predictor of suicide attempts at 12 months (PPV = 30.3%) but not at 3 months (Figures 1 and 2, Table 2). It could not classify the outcome of suicide correctly; performance at the suggested cutoff (≥ 6) was no better than chance (Table 2).

The C-SSRS was a significant predictor of suicide attempts at 3 and 12 months with PPVs of 21.4% and 33.6%, respectively (Figures 1–2, Table 2). Suicides during follow-up were not correctly classified by the C-SSRS (Supplementary Figure 2, Figure 3).

Differences in Predictive Accuracy Between the Rating Scales

The sensitivity of the C-SSRS was higher than that of the SUAS in predicting suicide attempts during the 3-month follow-up (Table 2). There was no significant difference regarding specificity. Regarding suicide attempts during the 12-month follow-up, the SUAS had the highest sensitivity and the lowest specificity compared to both the C-SSRS and

Table 2. Accuracy Statistics of the Evaluated Instruments[a]

	Optimal Cutoff Scores in the Present Sample						
	Suicide Attempt, 3 mo		Suicide Attempt, 12 mo			Suicide, 3 mo	Suicide, 12 mo
Variable	SUAS ≥ 47	C-SSRS ≥ 27	SUAS ≥ 37	KIVS ≥ 6	C-SSRS ≥ 26	SIS ≥ 21	SIS ≥ 17
Sensitivity	60.2* (50.2–69.3)	79.8† (71.1–86.5)	83.4*‡ (77.4–88.1)	58.5†* (51.4–65.2)	74.9†‡ (68.4–80.4)	100 (39.6–100)	72.2 (46.4–89.3)
Specificity	53.0 (49.1–56.9)	51.5 (47.6–55.2)	29.4*‡ (25.7–33.4)	51.1† (47.0–55.3)	45.8† (41.8–50.0)	81.9 (78.9–84.5)	57.9 (54.3–61.4)
PPV	17.4 (13.6–21.7)	21.4 (17.7–25.7)	30.2 (26.4–34.2)	30.3 (25.8–35.1)	33.6 (29.4–38.1)	2.8 (0.9–7.5)	3.9 (2.2–6.8)
NPV	89.0 (85.4–91.9)	93.9 (90.9–96.0)	82.9 (76.8–87.7)	77.2 (72.6–81.3)	83.3 (78.7–87.1)	100 (99.2–100)	98.9 (97.2–99.6)

	Cutoff Scores Suggested From Previous Studies					
	Suicide Attempt, 3 mo	Suicide Attempts, 12 mo		Suicide, 12 mo		
	SUAS > 30	SUAS > 30	C-SSRS ≥ 23	SIS ≥ 16	SUAS ≥ 39	KIVS ≥ 6
Sensitivity	94.7 (87.8–97.7)	92.2 (87.4–95.3)	86.0 (80.5–90.2)	72.2 (46.4–89.3)	61.1 (36.1–81.7)	47.4 (25.2–70.5)
Specificity	16.4 (13.7–19.5)	17.5* (14.4–20.9)	28.3† (24.7–32.1)	52.1† (48.4–55.7)	30.7§‡ (27.5–34.2)	48.5 (44.9–52.1)*
PPV	15.6 (13.0–18.7)	29.0 (25.6–32.7)	30.5 (26.9–34.4)	3.5 (1.9–6.0)	2.1 (1.1–3.8)	2.3 (1.1–4.4)
NPV	94.7 (88.4–97.8)	86.0 (77.9–91.5)	84.7 (78.7–89.3)	98.7 (96.9–99.5)	97.0 (93.8–98.7)	97.4 (95.0–98.7)

[a]All values shown as % (95% CI).
*$P < .05$ vs C-SSRS.
†$P < .05$ vs SUAS.
‡$P < .05$ vs KIVS.
§$P < .05$ vs SIS.
Abbreviations: C-SSRS = Columbia-Suicide Severity Rating Scale, KIVS = Karolinska Interpersonal Violence Scale, NPV = negative predictive value, PPV = positive predictive value, SIS = Suicide Intent Scale, SUAS = Suicide Assessment Scale.

the KIVS. The C-SSRS had higher sensitivity than the KIVS, with similar specificity. When testing the cutoffs suggested from other samples on the suicide outcome during 12-month follow-up, there were no significant differences in sensitivity between the SIS, SUAS, and KIVS. The SUAS had a lower specificity than the SIS and KIVS, which were similar in this aspect.

DISCUSSION

In this prospective cohort study of a population with a high risk of future suicidal behavior, all 4 risk assessment instruments performed with limited accuracy. The best figures for prediction were found for the shorter, clinically more relevant time interval: For the C-SSRS, a near-acceptable combination of sensitivity and specificity could be obtained in predicting suicide attempts within 3 months, giving a PPV 1.5 times the prevalence of this outcome. For the SIS, we could obtain a good combination of sensitivity and specificity for suicide at 3 months. These results, however, apply to the data-driven cutoffs. Regarding the performance of the SIS, the result is based on only 4 suicides, implying limited generalizability. The 1-year suicide rate was somewhat higher than observed in other studies,[30,31] which might be a reflection of the high percentage of admitted participants in the present study.

A review[16] covering 30 years of research on the SIS revealed primarily negative findings for the prediction of suicide attempt, and our results support this finding. Evidence is mixed regarding the scale's accuracy in predicting suicide, with most studies[15,32–34] reporting a positive correlation not seen in other samples.[35–37] Negative studies on this topic have generally had smaller samples or shorter follow-up times than positive studies. The present study is among the largest using a psychiatric, mainly inpatient sample and has among the shortest follow-up times.

Regarding predicting suicide attempt with the SUAS, our results are similar to previous findings.[19] We could not confirm the remarkably high specificity for suicide previously demonstrated by Niméus et al.[18] One important difference between the studies concerns the rating scale itself, since we used a modified version with a fully verbalized scale.[38] The use of fully verbalized rating scales has been shown to increase test-retest reliability and validity.[39] Psychiatric illness is an important risk factor for suicide,[40] but our findings could indicate that symptom severity (independent of diagnosis) as measured with the SUAS is not specific enough in evaluating suicide risk.

The KIVS was somewhat better than chance in classifying the suicide attempts during the 1-year follow-up, a finding in line with that from a subset of this sample.[21] It did not classify suicides correctly. Previous studies[8,20] with positive results on suicide prediction have had follow-up periods of 4–20 years and thus higher prevalence of suicides, making comparisons with our sample less relevant.

The C-SSRS gives particular weight to the severity and intensity of suicidal ideation, phenomena that have been shown to predict nonfatal suicidal behaviors rather than suicides.[6,22–25] The results for suicide attempt were similar to those of Madan and coworkers,[25] although the outcome

in that study included also aborted and interrupted attempts as well as preparations for suicide attempt. Further, participants in that study were not selected on the basis of a recent attempt, which was the case in the present study. The C-SSRS total score was not better than chance in classifying suicide. No previous results on suicide as an outcome are available for comparison.

A finding common to all instruments and outcomes (with the possible exception of prediction of suicide with the SIS at 3 months) was that a high sensitivity was paired with a low specificity. With rare conditions such as suicide, the PPV is driven by the specificity of the test,[41] and it is a common finding in suicide research that an acceptable sensitivity often is paired with a specificity below 50%, resulting in a low PPV. A highly sensitive instrument with low specificity could still be of some use in a clinical setting where it is sufficient to identify patients who need a more thorough evaluation.

An important consideration is that the rating scales were tested in a real-world clinical setting. As in all studies involving patients at risk of serious outcomes, study participants were treated according to their clinical needs.[42] No other study design would be ethically acceptable. It was thus expected that all patients who were assessed as suicidal by their doctors would receive some form of active treatment; doing so would be expected to influence both studied outcomes and thus the predictive ability of the assessment instruments examined in our study. This influence might be particularly relevant for the SUAS, as the reduction of symptom severity is a common treatment goal. With regard to the KIVS, experience of interpersonal violence, both as victim and as perpetrator, is a well-established risk factor for suicide,[43,44] and there is some evidence that this effect could be mediated by an increased risk of depression and substance use disorder.[45,46] Treatment given during the relatively short time following the index attempt could lessen the influence of previous experiences of violence, but this could still be a significant risk factor in a longer time perspective.

This study has some notable strengths. The sample size is large enough to allow separate evaluation of fatal and nonfatal outcomes. Due to the use of the Cause of Death Register that has full national coverage, all deaths could be identified and classified. The follow-up time is fairly short and clinically relevant. There are also some important limitations. Participants were recruited at psychiatric emergency services, and most were admitted to hospital. It follows that the results cannot be generalized to other self-harm populations. Only suicide attempts noted in medical records could be captured with our approach. We lack information on possible suicide attempts for the 29 participants with no entries in the medical record during follow-up.

CONCLUSIONS

Although acceptable accuracy statistics could be obtained for the data-driven cutoffs for the SIS in predicting suicide and the C-SSRS in predicting suicide attempts, none of the instruments evaluated in this study was specific enough for prediction of suicidal behavior in a psychiatric context. Thus, our findings support the existing guidelines concerning the use of suicide risk assessment instruments. These instruments may still be of use in the education of physicians under training and inexperienced staff members and as a way of structuring the clinical assessment.

Submitted: December 19, 2018; accepted September 9, 2019.

Published online: November 19, 2019.

Author contributions: Drs Lindh and Runeson designed the study with input from Drs Dahlin, Beckman, Jokinen, Renberg, and Waern. Dr Lindh extracted, processed and analyzed the data. All authors interpreted the results and Dr Lindh wrote the first draft. All the authors contributed to subsequent drafts and have approved the final version of the manuscript.

Potential conflicts of interest: The authors report no financial or other relationship relevant to the subject of this article.

Funding/support: The study was financed by grants from the Swedish Research Council 521-2011-299, the Bror Gadelius Foundation, and the Swedish state under the agreement between the Swedish government and the county councils (Region Västra Götaland ALFGBG 147361, ALFGBG-715841, Stockholm County Council ALF 20120225, ALF 20150290, and Västerbotten County Council ALFVLL-225251, ALFVLL-549931).

Role of the sponsor: The supporters had no role in the design, analysis, interpretation, or publication of this study.

Supplementary material: Available at PSYCHIATRIST.COM.

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CLINICAL PSYCHIATRY
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Supplementary Material

Article Title: A Comparison of Suicide Risk Scales in Predicting Repeat Suicide Attempt and Suicide: A Clinical Cohort Study

Author(s): Åsa U. Lindh, MD, PhD; Marie Dahlin, MD, PhD; Karin Beckman, MD, PhD; Lotta Strömsten, PhD; Jussi Jokinen, MD, PhD; Stefan Wiktorsson, PhD; Ellinor Salander Renberg, PhD; Margda Waern, MD, PhD; and Bo Runeson, MD, PhD

DOI Number: https://doi.org/10.4088/JCP.18m12707

List of Supplementary Material for the article

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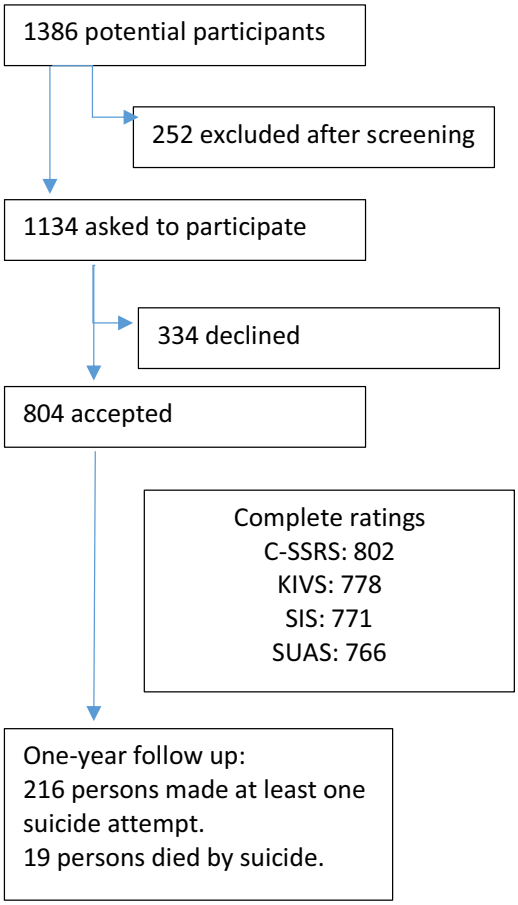
Supplementary Figure 1.

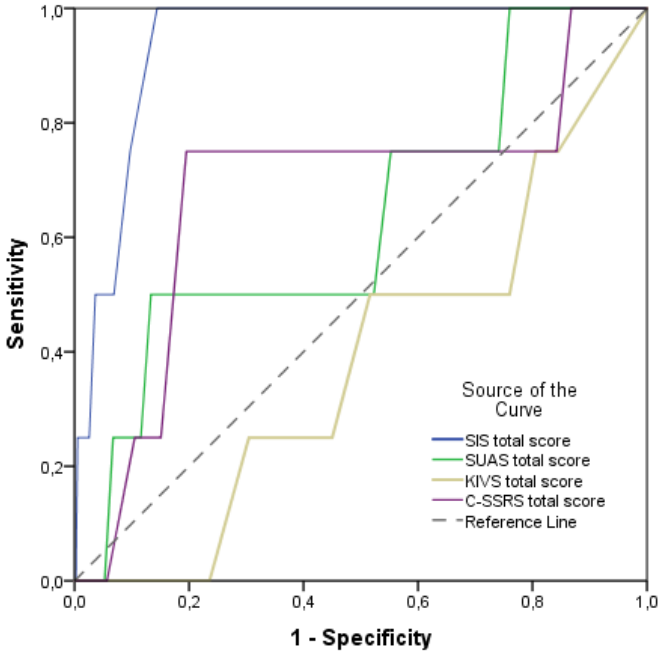
Flowchart of the study including number of complete ratings per instrument.



Abbreviations: C-SSRS: Columbia-Suicide Severity Rating Scale. KIVS: Karolinska Interpersonal Violence Scale. SIS: Suicide Intent Scale. SUAS: Suicide Assessment Scale.

Supplementary Figure 2.

Total sums of SIS, SUAS, KIVS and C-SSRS as predictors of suicide during 3 month follow-up.



SIS: AUC=0.94, 95% CI: 0.89 – 0.99, *p* = .002

SUAS: AUC= 0.63, 95% CI: 0.35 – 0.91, *p* = .36

KIVS: AUC=0.39, 95% CI: 0.13 – 0.64, *p* = .43

C-SSRS: AUC=0.68, 95% CI: 0.37 – 0.99, *p* = .22

Abbreviations: AUC=Area under the curve, CI=confidence interval, C-SSRS=Columbia-Suicide Severity Rating Scale, KIVS=Karolinska Interpersonal Violence Scale, SIS=Suicide Intent Scale, SUAS=Suicide Assessment Scale.

Supplementary Table 1.
The items of the Suicide Intent Scale.

The objective items		The subjective items	
Isolation	Final acts in anticipation of death	Alleged purpose of attempt	Attitude toward living/dying
Timing	Active preparation for attempt	Expectation of fatality	Conception of medical reversibility
Precautions against discovery	Suicide note	Conception of lethality of method	Degree of premeditation
Acting to get help during/after attempt	Overt communication of suicidal intent	Seriousness of attempt	

All items scored 0–2.

Supplementary Table 2.
The items of the Suicide Assessment Scale.

Sadness, despondency	Resourcefulness (difficulties in problem-solving)	Impulsivity	Suicidal thoughts
Hostility	Perceived loss of control	Low self-esteem	Purpose of suicide
Lack of energy	Physical tension	Hopelessness	Wish to die
Hypersensitivity	Anxiety	Inability to feel emotions	Lack of reason for living
Emotional withdrawal	Somatic concern	Poor frustration tolerance	Suicidal actions

All items scored 0–4

Supplementary Table 3.
The Items of the Karolinska Interpersonal Violence Scale.

Item score	Expression of violence, 6–14 years	Expression of violence, ≥15 years	Exposure to violence, 6–14 years	Exposure to violence, ≥15 years
1	Occasional fights, did not cause worry	Occasionally slapped a child. Occasionally shoved an adult.	Occasional slaps.	Threatened or exposed to low-level violence once
2	Often been in fights.	Hit a child on occasion. Fought when drunk.	Bullied for short period. Occasional corporal punishment	Beaten by partner. Threatened with object
3	Often started fights. Hit someone who had surrendered.	Hit partner or other adult when sober. Frequent fighting when drunk.	Often bullied. Hit by parent	Robbed, frequently beaten by partner. Threatened with weapon
4	Initiated bullying. Often hit others with fists or object	Instance of sexual assault. Repeated battering of child/partner.	Bullied throughout childhood. Beaten by schoolmates. Regularly beaten by parent. Sexual abuse	Raped. Battered.
5	Caused serious physical injury. Violent behaviour led to intervention from social services.	Caused severe bodily harm or death. Repeated sexual assault.	Repeated exposure to violence and/or sexual abuse that led to bodily harm	Repeatedly raped or battered, seriously injured

Supplementary Table 4.
The items of the Columbia-Suicide Severity Rating Scale

Ideation severity, 0–5	**Ideation intensity, scored for most severe suicidal thoughts, 0–25**	**Behaviours***	**Medical severity of actual suicide attempt, 0-5****
No suicidal ideation		Actual suicide attempt	No or very minor injury
Wish to be dead	Frequency, 1–5	Interrupted suicide attempt	Minor injury
Thoughts of suicide	Duration, 1–5	Aborted suicide attempt	Moderate injury, medical attention needed
Thoughts of suicide with specific method, no intent to act	Controllability, 0–5 where 0=does not attempt to control thoughts	Non-suicidal self-injury	Moderately severe injury, medical hospitalization required
Thoughts of suicide, with specific method and some intent to act	Deterrents, 0–5 where 0=does not apply	Preparations for suicide attempt	Severe injury, medical intensive care required
Thoughts of suicide, specific method, plan and intent.	Reasons for ideation, 0–5 where 0=does not apply		Death

*for actual, interrupted and aborted suicide attempts, both their occurrence (yes/no) and number of attempts are registered. Since the number of attempts can take on a wide range of values as participants may report hundreds of past attempts, we chose to trichotomize numbers of actual,

aborted and interrupted suicide attempts: 0 (no attempts), 1 (1-2 attempts) and 2 (three or more attempts) and applied these values when calculating the total score. Non-suicidal self injury and preparations are scored yes/no, without the number of events.

**if this item is scored zero, the potential lethality is scored 0–2.

Supplementary Table 5.

Comparison between participants with and without complete ratings on the suicide risk scales.

	Total number of participants: 804		
	Complete ratings, included in analysis n=746	Incomplete ratings, excluded from analysis n=58	*p*
Mean age, years	38.2	40.5	0.3
Sex, % women	67.6%	63.8%	0.6
Index attempt, % SA/NSSI	82.7%/17.3%	84.5%/15.5%	0.7
Suicide attempt during follow-up n (%)	201 (26.9%)	15 (25.9%)	0.9
Suicide during follow-up n (%)	17 (2.3%)	2 (3.4%)	0.6

Abbreviations: NSSI=non-suicidal self-injury, SA=suicide attempt. T-test was used to test difference in means. The χ^2-test was used to test differences in proportions.

Supplementary Table 6.

Baseline ratings on all instruments and measures of internal consistency and interrater reliability.

	SIS	**SUAS**	**KIVS**	**C-SSRS**
Valid ratings, *n*	771	766	778	802
Missing, *n*	33	38	26	2
Potential range	0 – 30	0 – 80	0 – 20	0 – 42
Actual range	1 – 30	3 – 75	0 – 20	1 – 42
Mean	15.0	44.5	6.1	25.8
Median	15.0	46.0	6.0	27.0
Percentiles 25	11	36	3	23
50	15	46	6	27
75	19	54	9	30
Cronbach α	0.78	0.87	0.64	0.55[a]
Intra-class coefficient; 95% CI	0.94; 0.85 – 0.9, *p* < .001	0.99; 0.97 – 1.00, *p*< .001	0.92, 0.82 – 0.97, *p*< .001	-
PABAK	-	-	-	0.63 – 0.95 for SI 0.70 - 0.90 for SB

[a]for items CS1 – 5 b, CS7 -11b, Cs12b, 14b, 15b, 17b, and 19b. Abbreviations: CI=confidence interval, C-SSRS=Columbia-Suicide Severity Rating Scale, KIVS=Karolinska Interpersonal Violence Scale, PABAK=prevalence-adjusted, bias-adjusted kappa, SB=suicidal behaviours, SI=suicidal ideation, SIS=Suicide Intent Scale, SUAS=Suicide Assessment Scale.

Supplementary Table 7.

Raw numbers for the optimal cut-offs in the present sample.

Optimal cut-offs in the present sample, suicide attempt												
Suicide attempt, 3 months	SUAS ≥47		C-SSRS ≥27		**Suicide attempt, 12 months**	SUAS ≥37		KIVS ≥6		C-SSRS ≥26	
	No attempt	Suicide attempt	No attempt	Suicide attempt		No attempt	Suicide attempt	No attempt	Suicide attempt	No attempt	Suicide attempt
Low risk	349	43	354	23	Low risk	165	34	292	86	269	54
High risk	309	65	334	91	High risk	396	171	279	121	318	161
Total	*658*	*108*	*688*	*114*	*Total*	*561*	*205*	*571*	*207*	*587*	*215*

Optimal cut-offs in the present sample, suicide					
Suicide, 3 months	SIS ≥21		**Suicide, 12 months**	SIS ≥17	
	Alive	Dead by suicide		Alive	Dead by suicide
Low risk	628	0	Low risk	436	5
High risk	139	4	High risk	317	13
Total	*767*	*4*	*Total*	*753*	*18*

Abbreviations: C-SSRS: Columbia-Suicide Severity Rating Scale. KIVS: Karolinska Interpersonal Violence Scale. SIS: Suicide Intent Scale. SUAS: Suicide Assessment Scale.

Supplementary Table 8.

Raw numbers for cut-offs suggested from previous studies.

Suggested cut-offs from previous studies, suicide attempt							
Suicide attempt, 3 months	SUAS >30		**Suicide attempt, 12 months**	SUAS >30		C-SSRS ≥23	
	No attempt	Suicide attempt		No attempt	Suicide attempt	No attempt	Suicide attempt
Low risk	108	6	Low risk	98	16	166	30
High risk	550	102	High risk	463	189	421	185
Total	*658*	*108*	*Total*	*561*	*205*	*587*	*215*
Suggested cut-offs from previous studies, suicide							
Suicide, 12 months	SIS ≥16		SUAS ≥39		KIVS ≥6		
	Alive	Dead by suicide	Alive	Dead by suicide	Alive	Dead by suicide	Alive
Low risk	392	5	230	7	368	10	392
High risk	361	13	518	11	391	9	361
Total	*753*	*18*	*748*	*18*	*759*	*19*	*753*

Abbreviations: C-SSRS: Columbia-Suicide Severity Rating Scale. KIVS: Karolinska Interpersonal Violence Scale. SIS: Suicide Intent Scale. SUAS: Suicide Assessment Scale.