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Individuals at High Risk for Suicide Are Categorically Distinct From Those at Low Risk

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Although suicide risk is often thought of as existing on a graded continuum, its latent structure (i.e., whether it is categorical or dimensional) has not been empirically determined. Knowledge about the latent structure of suicide risk holds implications for suicide risk assessments, targeted suicide interventions, and suicide research. Our objectives were to determine whether suicide risk can best be understood as a categorical (i.e., taxonic) or dimensional entity, and to validate the nature of any obtained taxon. We conducted taxometric analyses of cross-sectional, baseline data from 16 independent studies funded by the Military Suicide Research Consortium. Participants ($N = 1,773$) primarily consisted of military personnel, and most had a history of suicidal behavior. The Comparison Curve Fit Index values for MAMBAC (.85), MAXEIG (.77), and L-Mode (.62) all strongly supported categorical (i.e., taxonic) structure for suicide risk. Follow-up analyses comparing the taxon and complement groups revealed substantially larger effect sizes for the variables most conceptually similar to suicide risk compared with variables indicating general distress. Pending replication and establishment of the predictive validity of the taxon, our results suggest the need for a fundamental shift in suicide risk assessment, treatment, and research. Specifically, suicide risk assessments could be shortened without sacrificing validity, the most potent suicide interventions could be allocated to individuals in the high-risk group, and research should generally be conducted on individuals in the high-risk group.

Keywords: taxometrics, suicide, suicide risk, military personnel

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Despite decades of research focused on understanding and preventing suicide, suicide rates in the United States continue to rise among civilians (Caine, 2013) and military personnel (Berman et al., 2010). Even basic understanding of what constitutes or defines suicidal entities varies immensely (Silverman, Berman, Sanddal, O'Carroll, & Joiner, 2007). Although suicide risk is often thought of as existing on a graded continuum, its latent structure has not been empirically determined. Unlike clearly dimensional psychopathology, serious suicide risk may be better conceptualized as analogous to a diagnosis: either present or absent. To be clear, the determination that suicide risk is categorical would not necessarily imply long-term temporal stability, as there are numerous categorical entities (e.g., being pregnant, having the flu) that are impermanent and, in some cases, amenable to treatment. In the current study, we empirically addressed whether suicide risk should be understood as a categorical entity (i.e., one that is qualitatively discrete from nonpathological functioning). The answer to this question holds implications for risk assessments, targeted interventions, and research on suicide risk.

To prevent suicide at the individual level, clinicians must identify those at greatest risk and provide effective interventions. This strategy may be particularly relevant among military personnel who are routinely screened for mental health symptoms. Systematic reviews (e.g., Haney et al., 2012) and a recent meta-analysis (Large, Sharma, Cannon, Ryan, & Nielssen, 2011) suggest that existing risk assessment tools have limited predictive validity for identifying those most likely to make a suicide attempt. Understanding the underlying structure of suicide risk could aid in the

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development of more efficient risk assessments and inform clinical decision-making on the basis of these risk assessments in many ways. First, knowledge about the underlying structure of suicide risk would inform the development of risk assessments suited to its structure. Specifically, categorical constructs require items designed to discriminate at the boundary between group members, whereas dimensional constructs require items designed to discriminate across the range of a continuum (Ruscio & Ruscio, 2002). Second, a categorical structure for suicide risk would imply that distinctions between low- and high-risk groups are nonarbitrary; therefore, clinicians could make evidence-based decisions about which individuals require various types of interventions. Third, a categorical structure for suicide risk would imply that research should generally be conducted on people in the high-risk group. It is possible that much of the existing literature, in which samples tend to be composed of relatively few individuals at high risk for suicide, is not informative for those at categorically elevated risk for suicide. This could explain the limited progress in developing effective assessments and interventions.

One approach to determining the latent structure of a construct is using the taxometric method pioneered by Meehl (1973, pp. 200–224). This compilation of data-analytic tools allows researchers to empirically investigate the categorical (i.e., taxonic) versus dimensional structure of a construct. The validity and robustness of the taxometric approach has been well documented (Ruscio & Kaczetow, 2009; Waller & Meehl, 1998), and results of taxometric analyses can be used to inform assessment and intervention approaches (Waller & Meehl, 1998). Although other data analytic tools are available to examine the latent structure of psychological constructs (e.g., finite mixture modeling; FMM), simulation work (McGrath & Walters, 2012) suggests that taxometric analysis has a high degree of accuracy when distinguishing between categorical and dimensional structures and can therefore serve as a useful first step prior to investigating more complex models of latent structure.

In the only published taxometric study relevant to the latent structure of suicidal behavior, Liu, Jones, and Spirito (2015) concluded that suicide ideation is a dimensional construct. However, this study has a number of inherent limitations. First, the small sample ($N = 334$) was limited to depressed adolescents. Second, no external validity analyses were performed. Third, and perhaps most important, although suicide ideation (i.e., current suicidal thoughts) is one facet of suicide risk (i.e., propensity for future suicidal behavior), only a small proportion of individuals who experience suicide ideation make suicide attempts (ten Have et al., 2009).

Although no published taxometric studies of suicide risk exist, a number of cluster analyses and latent class analyses (LCAs) have identified two (Witte, Timmons, Fink, Smith, & Joiner, 2009), three (Kurz et al., 1987; Thompson, Kuruwita, & Foster, 2009), and four (Jiang, Perry, & Hesser, 2010) groups that differ in suicide risk level. Of these studies, only two (Kurz et al., 1987; Thompson et al., 2009) used a longitudinal design with future suicide attempts as an outcome. Both studies found evidence of three groups, but two of the three groups were indistinguishable in likelihood of a future suicide attempt. This may indicate that although three distinct groups can be identified statistically, distinguishing between two high- versus low-risk groups may be what is most important when predicting future suicide attempts. Alternatively, the identification of three, as opposed to two, groups in these studies may have been an artifact of the statistical methods used, as cluster analysis and LCA can overestimate the number of groups (Ruscio, Haslam, & Ruscio, 2006). It is also worth noting that the existing literature includes only civilians; thus, research in military samples is warranted.

In sum, increased knowledge about the latent structure of suicide risk could have critical implications for clinical assessment, intervention, and research. In the current study, we used taxometric analysis to test the competing hypotheses that suicide risk has a categorical versus a dimensional latent structure in a sample of predominantly military personnel. On the basis of preliminary evidence from studies using other methods (Kurz et al., 1987; Thompson et al., 2009), as well as the fact that suicide-related variables tend to exhibit extreme skew that suggests a categorical structure (Meehl, 1999), we predicted suicide risk would have a categorical latent structure. If a taxon (i.e., categorical structure) emerged, we planned to conduct follow-up external validation analyses to describe its nature.

Method

Participants and Procedures

Participants considered for inclusion in this study were 2,422 men and women recruited from 16 independent studies funded by the Military Suicide Research Consortium (MSRC; see online supplemental Table S1 for each site's recruitment procedures). Some participants ($n = 649$) were excluded from the taxometric analyses due to incomplete data, resulting in a final sample of $N =$ 1,773 participants. As shown in online supplemental Tables S2 (full sample) and S3 (military participants), fairly minor differences emerged between included and excluded participants on some demographic variables. Additionally, Table S4 demonstrates that for some of the taxometric indicators, the included participants had greater symptom severity.

The final sample consisted of primarily male (77.4%; $n =$ 1,362) participants, whose average age was 34.77 ($SD = 14.33$). The sample was predominantly non-Hispanic (91.5%; $n = 1{,}457$) and White (68.1%; $n = 1{,}190$). The majority of participants had a military affiliation (93.2%; $n = 1{,}636$). Each primary study site obtained Institutional Review Board (IRB) approval to collect the initial data, and the authors of the current study obtained IRB approval to conduct secondary data analyses with de-identified data.

Measures: Taxometric Indicators

All participants completed the 57-item Common Data Elements (CDE) assessment, a compilation of items that assess suicidality and related constructs created by the MSRC. Many of the items were taken from existing measures, with additional items designed by MSRC staff. To ensure appropriate coverage of the suicide risk construct, we identified indicators for our taxometric analysis by consulting best practice guidelines for variables that should be considered in a suicide risk assessment (e.g., Fowler, 2012; Joiner, Walker, Rudd, & Jobes, 1999) as well as the empirical literature. First, we assessed two components of current suicide ideation supported by an extensive factor analytic literature (Pettit et al., 2009): (a) current suicidal desire and ideation; (b) current specific planning for a suicide attempt. Second, we assessed lifetime worst-point suicidal planning and behavior, which has been found to be even more predictive of suicide than current planning (Joiner et al., 2003). Third, we assessed lifetime number of suicide attempts, because such a history is associated with increased risk for suicide (Christiansen & Jensen, 2007). Fourth, we assessed objective lethality of past suicide attempts, which has also been associated with increased risk for suicide (Gibb, Beuatrais, & Fergusson, 2005). Finally, we assessed insomnia, given recent findings (Pigeon, Pinquart, & Conner, 2012) demonstrating that insomnia is predictive of suicide. These indicators and their psychometric properties are presented in Table 1, and are described in more detail below.

Current suicidal desire and ideation. This was a composite variable consisting of seven items from the CDE and reflects current thoughts about suicide that do not involve specific plans to make an attempt. These items were drawn from the Depression Symptom Index—Suicidality subscale (DSI-SS; Joiner, Pfaff, & Acres, 2002), the Suicidal Behaviors Questionnaire—Revised (SBQ-R; Osman et al., 2001), and the Beck Scale for Suicide Ideation (BSS; Beck, Steer, & Ranieri, 1988); see Table 1 for specific items that were utilized from each of these measures. Because these items use different scales, they were each transformed into *z*-scores before being summed to form a composite indicator. Internal consistency was good for this measure ($\alpha = .91$). Given that it is not informative to provide mean and standard deviation for the standardized composite variable, we calculated the mean and standard deviation for the three items drawn from the DSI-SS to characterize the magnitude of current suicidal ideation in this sample. These three items are on a scale from 0 to 3; the maximum score is therefore 9. In our sample, scores ranged from 0 to 9 ($M = 1.50$, $SD = 2.03$).

Current specific planning for a suicide attempt. This domain was assessed with a single CDE item that was drawn from the DSI-SS, which has 4 response options (Joiner et al., 2002). Respondents select from the following response options: *I am not having thoughts about suicide* (n = 1,152; 65.0%), *I am having thoughts about suicide but have not formulated any plans* (n = 323; 18.2%), *I am having thoughts about suicide and am considering possible ways of doing it* (n = 191; 10.8%), and *I am having thoughts about suicide and have formulated a definite plan* (n = 107; 6.0%).

Lifetime worst-point suicidal planning and behavior. This CDE item was drawn from the SBQ-R (Osman et al., 2001) and had six response options to the question *Have you ever thought about or attempted to kill yourself?:* (1) *Never* (n = 670; 37.8%); (2) *It was just a brief passing thought* (n = 289; 16.3%); (3) *I have had a plan at least once to kill myself, but did not try to do it* (n = 195; 11.0%); (4) *I have had a plan at least once to kill myself and really wanted to die* (n = 177; 10.0%); (5) *I have attempted to kill myself, but did not want to die* (n = 139; 7.8%); and (6) *I have attempted to kill myself, and really hoped to die* (n = 303; 17.1%).

Lifetime number of suicide attempts. Participants were asked how many times in their lifetime they had made an attempt to kill themselves with at least some intent to die. Because of substantial skew on this variable, all participants with six or more lifetime suicide attempts were recoded to have a score of 6. The frequency of suicide attempts in this sample was as follows: 0 attempts (n = 1,119; 63.1%), 1 attempt (n = 288; 16.2%), 2 attempts (n = 141; 8.0%), 3 attempts (n = 76; 4.3%), 4 attempts (n = 48; 2.7%), 5 attempts (n = 21; 1.2%); 6 or more attempts (n = 80; 4.5%).

Objective lethality of most serious suicide attempt. As part of the CDE, all participants who had ever attempted suicide were asked to provide a written narrative describing the details of the plan and method used for their most lethal suicide attempt. They also were asked to indicate the level of medical attention required for this suicide attempt (0 = *no medical attention,* 1 = *primary care doctor or nurse visit,* 2 = *emergency room visit,* 3 = *hospital admission to a general medical floor,* 4 = *hospital admission to an intensive care unit*). Two doctoral students in clinical psychology used this information to rate the objective lethality of the suicide attempt using a 0–11 rating scheme that was adapted from the Lethality of Suicide Attempt Rating Scale-II (LSARS-II; Berman, Shepherd, & Silverman, 2003). Participants who had no history of suicide attempt received a score of 0. Additionally, raters were instructed to give participants a score of 0 if the narrative description indicated that a suicide attempt had not actually occurred (e.g., the individual described a suicide plan that was not enacted). Agreement between the two raters regarding whether a suicide attempt had occurred was adequate (Cohen's $\kappa = .85$), and disagreements were resolved by a third rater, who is a licensed clinical psychologist with extensive clinical and research experience with suicidal populations.

Table 1
Taxometric Indicators and Properties (N = 1,773)

CDE Items	Indicator name and composition	Validity using Cohen's *d* (95% CI)	Skew	Kurtosis
1, 3, 4, 6, 8, 19, 20	Current suicidal ideation and desire (items 1, 3, & 4 from DSI-SS, items 2 & 4 from SBQ-R, and items 1 & 2 from BSS)	2.37 (1.66, 1.89)	0.90	−0.18
2	Current specific planning for suicide attempt (item 2 from DSI-SS)	1.80 (1.68, 1.91)	1.42	0.85
5	Lifetime worst point suicidal planning and behavior (item 1 from SBQ-R)	2.70 (2.57, 2.83)	0.55	−1.22
13	Lifetime number of suicide attempts (0, 1, 2, 3, 4, 5, 6+)	1.71 (1.23, 1.44)	2.04	3.46
15, 16	Objective lethality of most serious suicide attempt (original items from CDE)	1.77 (1.60, 1.89)	1.64	1.67
52–56	Current insomnia (items 1–4, & 7 from ISI)	1.34 (2.24, 2.49)	−0.02	−1.11

Note. CDE = Common Data Elements; DSI-SS = Depression Symptom Index-Suicidality Subscale; SBQ-R = Suicidal Behaviors Questionnaire-Revised; BSS = Beck Scale for Suicide Ideation; ISI = Insomnia Severity Index. Higher scores indicate more concerning levels of suicide-relevant variables.

For individuals who made a suicide attempt, each attempt was rated on a 1 (*death is an impossible result*) to 11 (*death is almost a certainty*) scale; for each scale point, descriptive anchors for the rating were provided. Because the LSARS-II was designed to be on an interval scale, the raters were instructed to use decimal values if a participant's response appeared to fall between two anchor points. We averaged the raters' responses to obtain a final lethality rating score. Interrater agreement was good; the intraclass correlation for average measures, using absolute agreement (McGraw & Wong, 1996), was .84. Among those with a suicide attempt that was coded by the raters (i.e., those with a nonzero score; $n = 546$), the averaged scores ranged from 1.0 ($n = 4$; 0.7%) to 11.0 ($n = 15$; 2.7%), with a mean of 5.18 ($SD = 2.47$).

Insomnia. The CDE contained five of the seven items from the Insomnia Severity Index (Bastien, Vallières, & Morin, 2001). These items assess the severity of current sleep problems and interference with daily functioning on a 0 to 4 scale. The maximum score on this measure is 20; in our sample, scores ranged from 0 to 20 ($M = 8.77$, $SD = 5.78$). Internal consistency was good ($\alpha = .89$).

Measures: Follow-Up External Validity Variables

Although all participants were administered the CDE, administration of other measures varied across recruitment sites. As such, some variables that were used in follow-up external validity analyses were only available for a subset of participants included in our taxometric analyses. Detailed descriptions of these measures can be found below. The available *N* for each variable and descriptive statistics can be found in Table 2 for the continuous variables and in text for the ordinal variables.

Scale for Suicide Ideation (SSI; Beck, Kovacs, & Weissman, 1979). The SSI is a 19-item, clinician-rated scale presented in a semistructured interview format to assess current suicide ideation. The measure contains 19 items, which are rated on a 3-point scale with higher scores indicating greater severity of suicide ideation. Because items 1 and 2 were part of the CDE and were therefore used in the taxometric analysis, the total score used in follow-up analyses excluded these items. Internal consistency was acceptable ($\alpha = .77$).

Beck Suicide Scale (BSS; Beck et al., 1988). The BSS is the self-report version of the SSI. The first 19 items assess suicide ideation and intent over the past week. The total score of those items, excluding items 1 and 2, which were used in primary taxometric analyses, was used in follow-up analyses. Internal consistency was good ($\alpha = .95$). BSS item 20 was excluded from follow-up analyses, given its similarity to the number of lifetime attempts indicator that was used in the primary taxometric analyses. BSS item 21 (i.e., intent to die during last suicide attempt) was examined as an ordinal variable in follow-up analyses, as it had three response options. This item was only administered to those who had a past suicide attempt and completed the BSS ($n = 327$). Responses to BSS item 21 were as follows: *My wish to die during the last suicide attempt was low* ($n = 67$; 20.5%), *My wish to die during the last suicide attempt was moderate* ($n = 127$; 38.8%), and *My wish to die during the last suicide attempt was high* ($n = 133$; 40.7%).

Interpersonal Needs Questionnaire—Revised (INQ-R; Van Orden, Witte, Gordon, Bender, & Joiner, 2008). The INQ-R is a 15-item, self-report scale used to measure thwarted belongingness (nine items) and perceived burdensomeness (six items). Items are rated on a 7-point scale, with higher scores indicating higher levels of these constructs. Total scores for each construct were used in follow-up analyses. Internal consistency for the belongingness ($\alpha = .94$) and burdensomeness ($\alpha = .93$) subscales was good.

Beck Hopelessness Scale (BHS; Beck, Weissman, Lester, & Trexler, 1974). The BHS assesses hopeless cognitions with 20 true–false items. The total score on this measure was used in follow-up analyses. Internal consistency was good ($\alpha = .90$).

Posttraumatic Checklist—Military Version (PCL-M; Weathers, Huska, & Keane, 1991). The PCL-M assesses for symptoms of PTSD during the past month, using a 5-point scale. Select items from the PCL-M were included in the CDE assessing the following symptom clusters: reexperiencing (four items), avoidance (two items), and hypervigilance (two items). Total scores for each of the symptom clusters were used in follow-up analyses. Internal consistency for each cluster of items was adequate (α's = .86–.93).

Table 2
Descriptive Statistics for Continuous Variables Used in Follow-Up External Validity Analyses

Variable	*N*	*M*	*SD*	Range	Skew	Kurtosis
Scale for Suicide Ideation[a]	307	16.94	6.83	1–32	−0.25	−0.63
Beck Suicide Scale[a]	1,228	3.49	6.53	0–32	1.83	2.36
INQ Perceived Burdensomeness	997	12.14	8.63	4–42	1.33	0.77
INQ Thwarted Belongingness	996	26.73	15.03	6–63	0.45	−1.01
Beck Hopelessness Scale	244	7.20	5.40	0–20	0.50	−0.88
PCL-M Hypervigilance	1,632	5.04	2.82	1–10	0.42	−1.19
PCL-M Reexperiencing	1,011	10.01	5.28	4–20	0.37	−1.19
PCL-M Avoidance	1,011	5.27	2.92	1–10	0.28	−1.36
Intent/Lethality During Recent Attempt[b]	570	5.36	2.22	0–8	−0.66	−0.39
BDI-II[c]	158	15.97	12.64	0–52	0.81	−0.04
Fearlessness about Death	880	17.46	6.29	0–28	−0.19	−0.53

Note. INQ = Interpersonal Needs Questionnaire; PCL-M = PTSD Checklist—Military Version; BDI-II = Beck Depression Inventory-II.
[a] Excludes items 1 and 2, which were included as indicators for the taxometric analysis. [b] Only includes participants who have made a previous suicide attempt. [c] Excludes item 9, which is an index of suicidal ideation.

Intent and lethality during most recent suicide attempt. Four self-report items created by the developers of the CDE were used to measure levels of intent (e.g., *At the time, to what extent did you intend to die?*) and lethality (e.g., *How certain were you that what you had done would be fatal?*) during the most recent suicide attempt. These items were each rated on a three-point scale and combined to form a total score, with higher scores indicating greater intent/lethality. Only individuals with a history of suicide attempt provided responses to these items. Internal consistency was good ($\alpha = .82$).

Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a 21-item self-report questionnaire that assesses depressive symptoms over the past two weeks. Rated on a 4-point scale, higher scores indicate greater severity of symptoms. The total score from this measure was used in follow-up analyses, excluding item 9, which was examined separately as an ordinal indicator of suicide ideation in follow-up analyses. Internal consistency was good ($\alpha = .95$). For the 158 participants who completed the BDI-II, responses to item 9 were as follows: *I do not have any thoughts of killing myself* (n = 116; 73.4%); *I have thoughts of killing myself, but I would not carry them out* (n = 38; 24.1%); and *I would like to kill myself* (n = 4; 2.5%).

Fearlessness About Death (FAD; Ribeiro et al., 2014). The FAD is a 7-item self-report measure rated on a 5-point Likert scale, with higher scores indicating greater fearlessness about death. The total score from this measure was used in follow-up analyses. Internal consistency was adequate ($\alpha = .78$).

Lifetime nonsuicidal self-injury. A self-report item created by the developers of the CDE was used to assess frequency of lifetime nonsuicidal self-injury (i.e., *How many times in your lifetime have you purposefully hurt yourself* without *wanting to die?*). Due to substantial skew, responses were recoded into a 7-point scale, and this item was modeled as an ordinal variable in follow-up analyses. Of the 1,666 participants who completed this item, responses were as follows: *zero* (n = 1,221; 73.3%), *one* (n = 123; 7.4%); *two* (n = 60; 3.6%); *three* (n = 45; 2.7%); *four* (n = 23; 1.4%); *five through 10* (n = 75; 4.5%); *11 or more* (n = 119; 7.1%).

Family history of suicide. A self-report item created by the developers of the CDE was used to assess family history of suicide. Participants were asked whether they had known anyone who had died by suicide, and if so, what their relationship was to that person. For the 1,678 participants who completed this item, responses were coded on the following ordinal scale, indicating the level of genetic relatedness: 0 = *no suicide deaths or only non-biological relatives* (n = 1,466; 87.4%), 1 = *third-degree relatives* (n = 82; 4.9%), 2 = *second-degree relatives* (n = 68; 4.1%), and 3 = *first-degree relatives* (n = 62; 3.7%). This item was modeled as an ordinal variable in follow-up analyses.

Data Analytic Strategy

Taxometric analyses. The taxometric analyses were conducted using the R computing environment and Ruscio's source code (Ruscio, 2014). Taxometric analyses are performed using listwise deletion; therefore, all potential participants who were missing data on any of the indicators were excluded from all analyses. The three taxometric procedures used to analyze our data were Mean Above Minus Below A Cut (MAMBAC; Meehl & Yonce, 1994), MAXimum EIGenvalue (MAXEIG; Waller & Meehl, 1998), and Latent Mode factor analysis (L-Mode; Waller & Meehl, 1998). We used the default settings put in place by Ruscio (2014) for each taxometric analysis (e.g., the number of cuts, number of replications, etc.) on the basis of findings from Monte Carlo research on how best to implement each procedure (Ruscio, Ruscio, & Carney, 2011).

Relative model fit was primarily assessed using the comparison curve fit index (CCFI; Ruscio, 2007). A CCFI less than .45 indicates a better fit for a dimensional structure, a CCFI of .45 to .55 indicates ambiguous results, and a CCFI greater than .55 indicates a better fit for a categorical (i.e., taxonic) structure (Walters & Ruscio, 2013). Ruscio, Walters, Marcus, & Kaczetow (2010) recommend averaging CCFI values across taxometric procedures. Research confirms the utility of the CCFI in assessing the relative fit between one's data and the results for parallel analyses of artificial categorical and dimensional comparison data that reproduce the distributions and correlations observed in the empirical data (Ruscio, Ruscio, & Meron, 2007; Ruscio et al., 2010).

Relative model fit was also evaluated in a secondary manner by two independent raters who visually inspected the graphical output panels for each taxometric method used (see Figure 1). They rated each averaged curve produced from this study's data as categorical, dimensional, or ambiguous on the basis of whether it most closely resembled the comparison categorical data plot, most closely resembled the comparison dimensional data plot, or equally well resembled both sets of comparison data plots. Each rater was reliably trained to rate plots (Cohen's $\kappa = .73$ on training plots), but was blind to the hypothesis of this study.

If a categorical solution emerged, this would indicate two distinct groups in the sample, hereafter referred to as taxon and complement groups. The estimated base rates for the taxon group would be derived from the averaged curves for the MAMBAC and MAXEIG procedures to compute an overall base rate estimate for our sample (Ruscio et al., 2010). Waller and Meehl (1998) suggest averaging the base rate estimates for L-Mode when they are both close to .50; however, empirical guidelines on which base rate to use when at least one of the base rates varies notably from .50 have yet to be determined.

Follow-up external validity analyses. In the event that a categorical structure emerged in our main taxometric analyses, two follow-up examinations would be conducted. First, we would conduct external validity analyses using Mplus version 7.2 (Muthén & Muthén, 2012). For continuous external validity variables, we estimated linear regression models with these variables as outcomes and the binary taxon variable (i.e., taxon vs. complement) as a predictor. For ordinal external validity variables, we ran ordinal regressions with the binary taxon variable as the predictor.

To handle missing data for the external validity analyses, we used full information maximum likelihood (FIML) and included each taxometric indicator, for which we had complete data for all participants, as auxiliary variables in a saturated correlates model to improve the accuracy of parameter estimates (Collins, Schafer, & Kam, 2001; Enders, 2010; Graham, 2003). As emphasized by Enders (2010), auxiliary variables are not the same thing as covariates and as such do not affect the interpretation of parameter estimates. The proportion of pairwise present data ranged from 9% to 94%. Because the proportion of missing data for some variables exceeded the proportion of missing data that has been investigated in simulation studies for our approach to missing data (Collins et

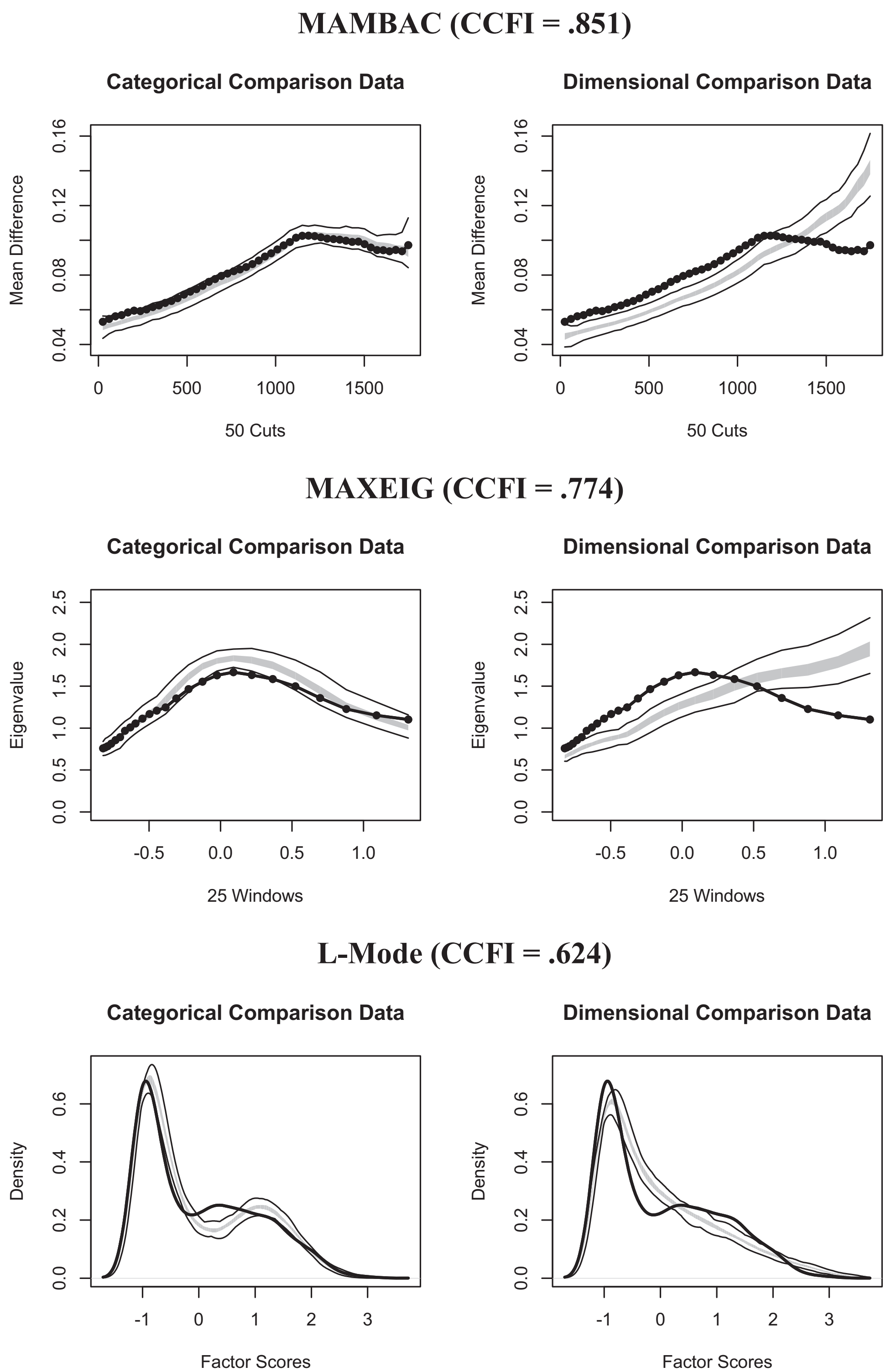

Figure 1. Results for each taxometric procedure. Dark lines show curves for empirical data and lighter lines show the minimum and maximum values for parallel analyses of 100 samples of comparison data. Shaded regions contain the middle 50% of values for parallel analyses of comparison data. CCFI = Comparison Curve Fit Index; MAMBAC = Mean Above Minus Below A Cut; MAXEIG = MAXimum EIGenvalue; L-Mode = Latent Mode.

al., 2001), we also ran all analyses using listwise deletion and found a very similar pattern of results (see supplemental Table S5). We were unable to use FIML to handle missing data for the analyses with ordinal variables as outcomes, as this is not possible in Mplus. Thus, we used listwise deletion for these variables.

Second, we compared the predictive power of taxon membership versus nonmembership to that of participants' continuous scores on the indicators used in the taxometric analyses, as suggested by Lenzenweger (2004). According to Cohen (1983), when continuous variables are artificially dichotomized at their means, a certain amount of information is lost, such that the variance accounted for by a dichotomized variable is expected to be no more than 63.7% of the variance accounted for by the continuous variable. Thus, we considered whether a similar amount of information was lost when using the dichotomous taxon group membership variable as a predictor variable versus the continuous taxometric indicator summed score variable. Because there is no exact analogue of R^2 when outcome variables are ordinal, we did not conduct these analyses with the ordinal validity variables.

Results

Indicator Selection

Cohen's *d* was used to assess the validity of the scores for all six indicators to be used in the taxometric analyses as a measure of the separation between the preliminary taxon and complement groups. Indicator validity scores ranged from $d = 1.34–2.70$ ($M = 1.95$, $SD = 0.49$; see Table 1); all surpassed the threshold suggested by Meehl (1995). Correlations among indicators were within acceptable limits. Specifically, they were considerably higher in the full sample (mean $r = .51$) than within the putative taxon (mean $r = .08$) or complement (mean $r = .29$) groups. Intercorrelations between all taxometric indicators can be found in supplemental Table S6.

Taxometric Analyses

The comparison CCFI values for MAMBAC (.85), MAXEIG (.77), and L-Mode (.62) all supported categorical (i.e., taxonic) structure, as did the mean CCFI (.75)[1,2]. In addition, the graph for each procedure was judged by two independent raters as more congruent with the graph for the categorical than the dimensional comparison data (see Figure 1).

The estimated taxon base rates derived from the averaged curves for the MAMBAC and MAXEIG procedures were .35 and .37, respectively. The base rates were .47 and .89 for LMode. There are no empirically based guidelines for averaging LMode base rates when they deviate notably from .50; however, Ruscio and Walters (2009) suggested that when LMode estimates are highly inconsistent but other taxometric approaches (e.g., MAMBAC and MAXEIG) provide convergent base rate estimates, it is reasonable to use the base rate estimates from the other taxometric methods. Thus, we used an overall base rate estimate derived from MAMBAC and MAXEIG (i.e., .36) to assign participants to the taxon ($n = 638$) or complement group ($n = 1,135$) on the basis of total indicator scores (Ruscio, 2009).

Sample Composition Analyses

Prior to conducting external validity analyses, we wanted to rule out two alternative explanations for our categorical results. First, we wanted to rule out the possibility that our taxon simply represented individuals with a history of suicide attempts. Thus, we examined the prevalence of suicide attempts in both the complement and taxon groups. Given that 16% of the complement group reported at least one previous suicide attempt, and 26% of the taxon group had no history of suicide attempt, our identified taxon does not appear to have emerged solely on the basis of past suicide attempts.

Second, we wanted to rule out the possibility that our taxon arose spuriously as a function of specific study recruitment strategies. In contrast to this idea, each of the 16 study sites contributed participants to both the taxon and complement groups, with a contribution rate by study ranging from 0.5% to 84.9% (see Table S1 for the percentage of each sample that was included in the taxon group). Nevertheless, because each of the independent studies pooled in our dataset contributed significantly different percentages of suicidal participants to our identified taxon group, and because sample composition has been shown to impact the validity of results using taxometric methods (Ruscio et al., 2006), we performed follow-up taxometric analyses on just the subset of participants ($n = 975$) that came from 11 studies that recruited participants on the basis of past or current suicidal behavior. These studies had contributed more than 25% of their sample to our identified taxon group and are indicated with an asterisk in online supplemental Table S1. Even when the analyses were limited to these selected samples, the categorical findings remained. Specifically, the mean CCFI was .58 (MAMBAC CCFI = .77, MAXEIG CCFI = .56, LMode CCFI = .42).[3] As would be expected in a subsample recruited on the basis of past or current suicidal behavior, the base rate estimates for the taxon were higher in this set of analyses compared to our original analyses (MAMBAC = .54, MAXEIG = .58; because L-Mode yielded CCFI $<$ .50, it was not used to estimate the taxon base rate). Thus, our finding of a categorical structure for suicide risk does not appear to be spurious or to have resulted from a sample composition artifact.

External Validity Analyses

Follow-up analyses were conducted to further explore the nature of the taxon. As shown in Table 3, taxon and complement groups differed significantly on each continuous outcome variable; β values represent group differences in *SD* units. The largest effect sizes were for the variables most conceptually similar to suicide risk (i.e., current suicide ideation, perceived burdensomeness, thwarted belongingness). Effect sizes for many other variables

[1] Because there was some redundancy between the number of past attempts and objective lethality indicators, we reran the taxometric analysis without the objective lethality indicator. Results remained very consistent (MAMBAC CCFI = .85, MAXEIG CCFI = .71, LMode CCFI = .82); mean CCFI = .79.

[2] CCFIs were computed using a supplied base rate of .36 based upon the results described in the next paragraph.

[3] CCFIs were computed using a supplied base rate of .56 based upon the results described in the next sentence.

Table 3
Results From Separate Regression Analyses With Taxon Membership Predicting Continuous Variables

Variable	*N*	Unst. *B* (*SE*)	β (95% CI)	*p*	R^2
Scale for Suicide Ideation[a]	1,773	11.58 (.85)	1.43 (1.31, 1.54)	<.001	.47
Beck Suicide Scale[a]	1,773	10.35 (.43)	1.48 (1.41, 1.56)	<.001	.51
INQ Perceived Burdensomeness	1,773	11.32 (.57)	1.31 (1.20, 1.42)	<.001	.40
INQ Thwarted Belongingness	1,773	18.36 (.80)	1.25 (1.16, 1.34)	<.001	.36
Beck Hopelessness Scale	1,773	5.91 (.61)	1.08 (.89, 1.27)	<.001	.27
PCL-M Hypervigilance	1,773	2.68 (.14)	.95 (.86, 1.03)	<.001	.21
PCL-M Reexperiencing	1,773	3.94 (.31)	.72 (.62, .83)	<.001	.12
PCL-M Avoidance	1,773	2.10 (.17)	.70 (.59, .80)	<.001	.11
Intent/Lethality During Recent Attempt[b]	654	1.50 (.22)	.68 (.49, .86)	<.001	.09
BDI-II[c]	1,773	5.54 (2.05)	.43 (.12, .75)	.007	.04
Fearlessness About Death	1,773	1.85 (.49)	.29 (.14, .44)	<.001	.02

Note. INQ = Interpersonal Needs Questionnaire; PCL-M = Posttraumatic Checklist—Military Version; BDI-II = Beck Depression Inventory-II. Taxon membership was coded 0 = complement and 1 = taxon. β signifies the difference between groups in *SD* units for the outcome variable.
[a] Excludes items 1 and 2, which were included as indicators for the taxometric analysis. [b] Only includes participants who have made a previous suicide attempt. [c] Excludes item 9, which was examined separately.

(e.g., depression) were smaller and had nonoverlapping confidence intervals with the variables most conceptually similar to suicide risk, indicating that our taxon group is unlikely to represent a group experiencing general distress. Results were similar when listwise deletion, as opposed to full information maximum likelihood, was used to handle missing data (see online supplemental Table S5). As shown in Table 4, the taxon and complement groups differed significantly from one another on all of the ordinal variables as well.

The clinical and research utility of group membership was assessed by comparing the R^2 from regression analyses with dichotomous taxon membership as a predictor of the R^2 obtained when a continuous composite variable that represents participants' total score from all the indicators used in the taxometric analysis was used as a predictor (Meehl, 1995). This statistical approach was used to provide converging evidence for the categorical structure we identified in taxometric analyses. Specifically, if a construct with a truly continuous structure is artificially dichotomized, important information is lost and the relationship between that variable and other variables is attenuated in a predictable way (Cohen, 1983). In contrast, if a construct with a truly categorical underlying structure is dichotomized, we would not expect the same degree of attenuation. In Table 5, we provide the upper-bound expected R^2 for each variable when using a dichotomous predictor, which represents the R^2 for the continuous predictor times 63.7% (i.e., the information expected to be lost by artificially dichotomizing a variable; Cohen, 1983). As shown in Table 5, the R^2 was fairly similar for the dichotomized taxon variable versus the continuous composite variable. Additionally, for the variables that are most relevant for the construct of suicide risk, the amount of information lost was smaller than would be expected. This pattern provides indirect evidence that the structure of suicide risk is categorical and suggests that group membership status represents an equally valid but more efficient way of understanding suicide risk than a continuous score from a relatively long assessment measure. Results for these analyses using listwise deletion can be found in online supplemental Table S7.

Discussion

We examined the latent structure of suicide risk using taxometric analyses in a sample of predominantly military personnel. We found consistent, robust evidence that people who show particularly high levels of suicide risk represent a taxon; that is, they are *categorically* distinct from those at lower risk. Additionally, external validity analyses revealed that participants in the high-risk group had more concerning scores on external measures of suicidality than members of the low-risk group. Larger differences were

Table 4
Follow-Up Validity Analyses for Ordinal Variables

Variable	*N*	Unst. *B* (*SE*)	*p*	OR (95% CI)
Current Suicidal Thoughts or Wishes (BDI-II Item 9)	158	1.93 (.40)	<.001	6.89 (3.15, 15.08)
Lifetime Non-Suicidal Self-Injury	1,666	1.29 (.11)	<.001	3.62 (2.91, 4.52)
Wish to Die During Last Suicide Attempt (BSS 21)[a]	291	1.01 (.25)	<.001	2.73 (1.66, 4.49)
Family History of Suicide	1,678	0.48 (.15)	<.001	1.61 (1.21, 2.15)

Note. BDI-II = Beck Depression Inventory, Second Edition; BSS = Beck Suicide Scale.
[a] Only includes individuals with a previous suicide attempt who were administered the BSS. Lifetime non-suicidal self-injury was coded on the following scale: 0, 1, 2, 3, 4, 5 through 10, and 11 or more. Family history of suicide was coded on the following scale: 0 = no one / non-biological relative, 1 = third-degree relative, 2 = second-degree relative, 3 = first-degree relative.

Table 5
R^2 for Continuous Composite Indicator Versus Taxon Group Variable for the Continuous External Validity Variables (N = 1,773)

Variable	Continuous Composite Indicator R^2	Taxon R^2	Expected R^2 for dichotomization (Continuous R^2 × 63.7%)
Scale for Suicide Ideation[a]	.57	.47	.36
Beck Suicide Scale[a]	.52	.51	.33
INQ Perceived Burdensomeness	.47	.40	.30
INQ Thwarted Belongingness	.43	.36	.27
Beck Hopelessness Scale	.29	.27	.18
PCL-M Hypervigilance	.27	.21	.17
PCL-M Reexperiencing	.16	.12	.10
PCL-M Avoidance	.14	.11	.09
Intent/Lethality During Recent Attempt[b]	.18	.09	.11
Beck Depression Inventory-II[c]	.12	.04	.08
Fearlessness About Death	.03	.02	.02

Note. INQ = Interpersonal Needs Questionnaire; PCL-M = Posttraumatic Checklist—Military Version.
[a] Excludes items 1 and 2, which were included as indicators for the taxometric analysis. [b] Only includes participants who have made a previous suicide attempt. [c] Excludes item 9, which is an index of suicidal ideation.

found for indicators specific to current suicide risk than for measures of general distress. This pattern of results could imply that taxon members are those at highest risk for making a suicide attempt in the near future, although future empirical studies need to evaluate this possibility.

In addition, taxon group membership accounted for a similar amount of variance in the external validity variables as a continuous score of suicide risk. Thus, using a briefer measure of suicide risk in clinical and research settings could increase the efficiency with which assessments are conducted without sacrificing validity (Ruscio et al., 2011). Measure development of this nature is outside the scope of the current study; however, careful future measure development and validation research is needed to maximize the clinical utility of our results. Specifically, this type of research should be aimed at constructing a brief measure of suicide risk that differentiates taxon members from nonmembers. In this line of research, it may be useful to include the indicators that yielded the highest validity scores in our current study (e.g., current suicidal ideation and desire, lifetime worst point suicidal planning and behavior), in addition to others shown to be powerful in the literature (e.g., prior psychiatric hospitalization; Hjorthøj, Madsen, Agerbo, & Nordentoft, 2014). Furthermore, given that suicidal individuals may be motivated to conceal their level of risk, future researchers should investigate other variables (e.g., informant report, implicit measures of suicide risk) that could have improved clinical utility over the ones examined in the current study.

Understanding the latent structure of suicide risk also serves to clarify whether the purpose of assessment is to put people into risk-based groups or to detect their position along a risk dimension. Clinicians are likely familiar with categorizing participants into *low-risk* and *high-risk* groups, and our results suggested that this categorical approach is empirically defensible. That said, the way in which clinicians currently assign people to low- versus high-risk groups is highly variable and, oftentimes, not empirically informed. Pending further study, our results could help clinicians use the most sensitive and specific measures to accurately place clients into low- or high-risk groups.

Additionally, our results have implications for suicide intervention. Researchers have predicted that categorical entities will likely respond to treatment in an all-or-nothing fashion (Williamson, Gleaves, & Stewart, 2005), wherein change may be difficult to initiate, but once initiated, should be noticeable and complete. Of course, whether this prediction holds true regarding suicide risk is an empirical question, although there is evidence that suicidal crises tend to be relatively short-lived (Yip et al., 2012) and that most individuals who make very serious suicide attempts do not go on to die by suicide at a later point in time (Hawton, 2007). We should clarify, however, that resolution of a suicidal crisis does not necessarily indicate resolution of long-standing psychopathology or complex environmental stressors. Ultimately, with the development of risk assessments reflective of the categorical structure of suicide risk, clinicians could make evidence-based decisions about when to use various types of interventions for taxon members versus nonmembers. Moreover, allocating the most potent suicide interventions to the high-risk group may be the most efficient use of scarce resources. This type of intervention strategy may be particularly useful within a military context, where infrastructure exists to target military personnel at the highest risk for suicide.

The categorical structure of suicide risk may have even larger implications for how researchers study suicidality. To date, many research teams have examined suicide questions in samples of participants with low suicidality (e.g., unselected college students). Our results suggest that this approach is not ideal because people at particularly high risk for suicide appear to be *categorically* distinct from those who are not. Thus, identifying risk factors for suicide using samples with little to no endorsement of suicidality is an inadvisable approach when attempting to glean information about people who are actually at high risk for suicide. To be clear, we recognize the importance of examining population-level interventions when it comes to preventing suicide (see Knox, Conwell, & Caine, 2004) and are not arguing that these efforts necessarily be discontinued. Rather, we are advocating that studies examining risk factors for suicide be focused on individuals in the high-risk taxon so that finite resources can be devoted toward more frequent and detailed assessment, rather than collecting less intensive, less detailed data from a larger number of individuals, the vast majority of whom will never attempt suicide. Results from such studies could identify novel proximal, as opposed to distal, predictors of suicidal behavior, which would more clearly meet the needs of clinicians tasked with predicting likelihood of suicidal behavior over a matter of hours or days. Additionally, results from such studies could be informative for developing population-level interventions to target proximal risk factors for suicidal behavior.

When interpreting taxometric results, it is crucial to ensure that an identified taxon actually reflects the construct it was posited to reflect. As noted above, our external validity analyses provide strong support that the identified taxon reflects categorically high suicide risk. In addition, we were able to rule out other conceptualizations by looking at patterns of differences across groups. For instance, we did not simply identify a group of people who have previously attempted suicide (i.e., 16% of the complement group reported at least one previous suicide attempt, and over a quarter of the taxon group had no history of suicide attempt). In addition, each of the 16 study sites contributed participants to both groups; therefore, our taxon did not spuriously arise as a function of specific study site recruitment strategies (see Table S1) or problematic sample composition (see Sample Composition Analyses section).

Moreover, our results generally converge with those from studies using other methodological approaches to understand the latent structure of suicide risk, which have identified two suicide risk groups (Witte et al., 2009), or three risk groups wherein two of the groups were indistinguishable from one another based on risk of future suicide attempts (Kurz et al., 1987; Thompson et al., 2009). Also, a large, prospective, machine learning study showed that individuals who scored in the top 5% on 20 potent risk factors for suicide accounted for more than half of suicides in the sample (Kessler et al., 2015). Although this study was not designed to evaluate the latent structure of suicide risk, its results are consistent with the notion that there may be a group of individuals who have particularly high risk.

Several limitations of this study are worth noting. First, replication is essential. Next, additional assessments of discriminant validity could refine our understanding of the taxon. For instance, we were unable to determine whether this group specifically includes people who are at high risk for making a future suicide attempt versus those who simply have very high levels of current ideation; however, we believe the latter option is unlikely, given that Liu et al. (2015) found suicide ideation to be dimensional. On a related note, we are currently unable to assess the predictive validity of the identified taxon. It is critically important for longitudinal studies to examine whether taxon members go on to make serious suicide attempts and/or die by suicide. Longitudinal studies could also help to clarify whether taxon membership represents trait-like, longstanding vulnerability to suicidal behavior or whether it terminates at the conclusion of a suicidal crisis.

We also had a fair amount of missing data, and there was some evidence that the included participants had more severe suicidal symptoms than excluded participants. Thus, our use of listwise deletion for the taxometric analyses may be considered a limitation for the current study. That said, more optimal methods of handling missing data (i.e., multiple imputation, full information maximum likelihood) are currently unavailable for taxometric analyses. Furthermore, although we could have used single imputation to handle missing data, as reviewed by Enders (2010), there is no clear evidence that single imputation is superior to listwise deletion, and at least one prior study found that results from taxometric analyses using listwise deletion did not differ from analyses using single imputation of missing values (Walters, 2014). Thus, we feel that our use of listwise deletion in the current study is justifiable—a claim bolstered by the consistency of our taxometric results in the subsample selected for prior history of suicidal behavior, which also had lower missing data rates compared to the full sample (see supplemental Table S1). In addition, because the LMode base rate estimates in our analyses varied greatly, they could not be used when averaging base rates across methods. On a related note, the base rate estimates we obtained in our study are likely sample-specific, given our strategy of combining datasets collected in a number of different settings that may have been drawn from different populations. Finally, although taxometric analysis is a strong approach for examining the latent structure of constructs, it is not the only suitable method. For instance, FMM studies could add important information to the understanding of whether meaningful factors underlie the categories uncovered in the current study.

In summary, we found that people who are at high risk for suicide are categorically distinct from those who are not. Future researchers should attempt to replicate these findings in independent samples, examine the predictive validity of the high-risk taxon, and determine which assessment procedures are most sensitive and specific for identifying people who fall into the high-risk group. Given the potentially meaningful clinical implications of our results, there is an urgent need for these follow-up studies to be conducted.

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