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THE DEVELOPMENT OF A FUZZY LOGIC MODEL-BASED SUICIDE RISK ASSESSMENT TOOL

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Abstract

The purpose of the research was to develop a fuzzy logic model-based risk assessment tool and to determine the views of health professionals working in community mental health centers concerning this. A methodological method was employed in developing the fuzzy logic model-based risk assessment tool, and the qualitative research method was used to elicit attitudes toward it. In the first stage, the suicide risk assessment tool was developed. In second stage the health professionals used the suicide risk assessment tool for four weeks. Feedback regarding health professionals' opinions of the suicide risk assessment tool was then elicited handling a semi-structured reportage form, and data were investigate handling descriptive analysis. Health professionals reported powerful aspects making the suicide risk assessment tool a functional, practical, comprehensive, and highly applicable guideline. Participants also recommended the addition to the results screen of a chart showing the course of the suicide risk assessment, and that the reliability and validity of the tool be confirmed. In conclusion, health professionals expressed positive opinions regarding the scope of the suicide risk assessment tool and its measurement of that risk. Following confirmation of its reliability and validity, it may be useful for the fuzzy logic-based suicide risk assessment form to be integrated into and applied in the community health centers system.

Keywords: community mental health, fuzzy logic, suicide risk assessment, suicide

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1. Introduction

Around 800,000 people global lose their lives because of suicide every year (WHO, 2018). In 2018, 3161 individuals in Turkey died from suicide (TUIK, 2018). The World Health Organization 2013-2020 Mental Health Action Plan, adopted by the World Health Assembly in 2013, targeted a 10% decrease in national suicide levels by 2020 (WHO, 2013).

Retrospective and psychologic autopsy researches have shown that a detectable psychological disease is available in at least 90% of all completed suicides (Conwell et al., 1996). Half to two-thirds of psychiatric diagnoses involve mood disorders (Herrera, 2018). Other research findings concerning the relationship between suicide and mental disorders show that the highest suicide-related mortality rates occur in individuals diagnosed with substance misuse and eating disorders, and indicate moderate suicide levels for mood and personality disorders, and relatively low proportions for anxiety disorders (Harris & Barraclough, 1998). The risk of suicide also increases with the use of more than one substance (Borges et al., 2000), and in case of depression (Malone et al., 2000), eating disorders (Harris & Barraclough, 1997), and personality disorder (Soloff et al., 1994). The groups with the highest risk of suicide are those with borderline personality disorder (Black et al., 2004; Söderberg, 2001) and antisocial personality disorder (Black et al., 2004).

Community Mental Health Centers (CMHCs) in Turkey provide psychosocial support services, follow-up and treatment within the framework of a community-based mental health model for individuals with chronic mental disorders such as schizophrenia, other psychotic disorders and bipolar disorder (Turkish Ministry of Health, 2011). Twenty to fifty percent of schizophrenia patients attempt suicide (Lu et al., 2019). Individuals with bipolar disorder also frequently attempt suicide during depressive attacks (APA, 2003), and the risk of suicide increases still further in case of substance use disorder, anxiety disorder, eating disorder, and personality disorder accompanying bipolar disorder (Hansson et al., 2018). Due to their characteristics, it is particularly important to assess the suicide risks of the individuals being followed-up by CMHCs.

There is no method capable of completely accurately showing the risk of suicide. However, the probability of risk can be predicted by means of risk assessment. Health professionals should trust their own clinical experience in risk assessment, but must also confirm their assessments on the basis of evidence-based findings (Fawcett, 2006). Important factors determining suicidal behavior are interactions between suicide risk and protective factors (Goldsmith et al., 2002). Factors protecting against suicide include a sense of belonging (Joiner et al., 2006), a good cognitive level (Malone et al., 2000), useful and good developed coping capabilities and the fact that religious faiths disapprove of suicide (APA, 2003), being married and having children (Nock et al., 2008), powerful family bonds, and positive supportive relations between the patient and clinician (Samra, 2007).

Factors reported to involve a high risk of suicide include suicidal ideations, preparatory actions, stressful life events and cognitive/emotional conditions (Rudd et al., 2006), extensive suicidal behaviors and objective signs of suicidal attainment (such as specific planning, access to lethal means, and the occasion to set these into action) (Walsh et al., 2015), stressful life events (Konkan et al., 2014), admission to and discharge from hospital (Goldacre et al., 1993; Harris & Barraclough, 1997), important physical diseases (Erlangsen et al., 2005), chronic painful diseases impairing functioning and external appearance, diseases rendering the individual dependent on others or affecting the ability to see and hear, and chronic diseases (Chehil & Kutcher, 2012), hopelessness (Qiu et al., 2017), and social isolation.

The risk of suicide is generally assessed using scales, but these may be limited in terms of the extent to which the assessment logic actually reflects human ways of thinking, the inclusion in the assessment process of health professionals' knowledge and experience and these being supported with proven data, and taking into account factors protecting the individual against suicide. The use of existing suicide risk assessment scales is for this reason insufficient in terms of health professionals confirming their own clinical experience with evidence-based information. A single numerical value obtained from scales may also result in important risk-related situations being missed. A risk evaluation and suicide risk assessment appears in the official CMHC directive, but no structured objective measurement tool is employed, and risk assessment relies more on the individual's worker's own knowledge and experience.

One of the most appropriate procedures for assessing non-linear, multi-dimensional, complex, and imprecise subjects such as suicide is fuzzy logic (Chattopadhyay et al., 2010). This was invented in 1965 by Lotfi A. Zadeh under the name of fuzzy logic or the fuzzy setting theory (Zadeh, 1965). The greatest advantage of fuzzy logic is that it very closely matches human reasoning. In the classic set theory, also known as binary logic, an element either belongs to a set, or else does not. However, there are several conditions in which an element's membership of a set is uncertain or indefinite. These are frequently seen in the sphere of health (Phuong & Kreinovich, 2001). When classic logic is used in suicide risk assessment, binary results are elicited for the risk of suicide, in the form of low or high, or present or absent. The production of the absolute results regarding the risk of suicide can result in health professionals missing risky or borderline situations. In fuzzy logic theory, an element may have various degrees of membership or may belong to more than one set. The degree of membership of elements in a fuzzy set ranges between 0 and 1, and these values show partial membership of a set (Zadeh, 1965). For instance, when an individual's suicide risk is assessed using fuzzy logic, risk status may be present in a low risk group with one particular degree of membership and at the same time in a high risk group with another particular degree of membership. In this way, health professionals can see the extent of the individual's membership of different groups, and can at the same time include their own knowledge and experimentation in the suicide risk assessment process. There is no tool and/or scale assessing the risk of suicide using the fuzzy logic method in Turkey. In international terms, the UK Galatean Risk and Safety Tool (GRIST)

program is based on the fuzzy logic model (Buckingham, 2002).

If effective suicide risk assessment is not performed, the individual may experience various risks, ranging from mild damage to potentially fatal situations. This makes accurate risk assessment essential. The fuzzy logic-based suicide risk assessment tool developed in the scope of the present research is practical and user-friendly and may be expected to contribute to suicide risk assessment depending on health professionals' knowledge and experience. The aim of this study to develop a fuzzy logic model-based suicide risk assessment tool and to establish the views of health professionals working in CMHCs regarding that tool.

2. Materials and Methods

Approval for the research was granted by the Üsküdar University Non-Interventional Research Ethical Committee (No. B.08.6.YÖK.2.ÜS.0.05.0.06/2017/327).

Type of research: A methodological design was employed in the development of a fuzzy logic model-based suicide risk assessment tool, and a qualitative method was used to collect opinions concerning the tool developed.

Application: Application was performed in two phases. In the first phase, a fuzzy logic model-based suicide risk assessment tool was developed, while in the second, user views concerning the tool were elicited.

Stage 1: The development of a fuzzy logic model-based suicide risk assessment tool

The procedures performed during the development of the fuzzy logic model-based suicide risk assessment tool are listed, in order, below.

1. Determination of suicide risk factors: Evidence-based study findings in systematic reviews and meta-analyses were examined in order to identify factors increasing and protecting against the risk of suicide. Fourteen risk areas and eight protective factors were identified (Franklin, 2017; Harris & Barraclough, 1997; Ribeiro et al., 2016; Runeson et al., 2017).

2. The collection of specialist opinions to determine the effect levels of risk factors: Specialist opinions were elicited in order to determine the effect levels of factors increasing or protecting against the risk of suicide. Views were collected from 19 specialists working in psychiatric clinics (nine physicians, four nurses, two social services experts, and four psychologists). These specialists had been working in psychiatric clinics for between 10 and 42 years. They were asked to score each factor reducing or increasing the risk of suicide between '0 and 1' with 1% sensitivity. These numerical values were transferred onto Excel, and mean values were determined (Table 1).

Table 1. Mean scores awarded by specialists for suicide risk factors

Suicide risk indicators	Mean value
History of suicide attempts	
History of more than one suicide attempts	0.88
History of one suicide attempt	0.65
No history of attempted suicide	0.12
Current thinking regarding suicide	
Presence of clear and constant intent to commit suicide	0.81
Occasional suicidal ideation	0.64
No suicidal ideation	0.10
Suicide plan	
Presence of a suicide plan	0.87
No suicide plan	0.20
Impairment of thought content	
Presence of intensive delusions/hallucinations (containing the instruction to commit suicide) in the current period	0.85
Absence of intensive delusions/hallucinations (containing the instruction to commit suicide) in the current period	0.19
Other diagnoses accompanying schizophrenia and bipolar disorder	
Schizoaffective disorder	0.55
Substance abuse	0.61
Depression	0.64
Personality disorders	
Cluster A disorders (Paranoid personality disorder, schizotypal personality disorder, schizoid personality disorder)	0.10
Cluster B disorders (Borderline personality disorder, antisocial personality disorder)	0.70
Anxiety disorders	0.31
Eating disorders	0.28
Postpartum psychosis	0.63
Life-threatening chronic disease causing pain and function impairment	0.50
Drug therapy adherence	
No drug therapy adherence	0.61
Occasional drug therapy adherence	0.46
Adheres to drug therapy	0.20
Time since discharge from the psychiatric ward	
Between one day and one month after discharge	0.46
After the first month following discharge	0.37
No condition requiring admission to the psychiatric ward for an extended period	0.14
Stressful life events (the 'stressful life events' list can be used if the specialist so requires)	
Presence of perceived highly stressful life event/events/ in the previous month	0.64
Presence of perceived moderately stressful life event/events/ in the previous month	0.42
Presence of perceived mildly stressful life event/events/ in the previous month	0.20
Family history of suicide	
Death of a member of the family due to suicide	0.80

Hopelessness (the 'hopelessness scale' can be used if the specialist so requires)	
Feelings of hopelessness, helplessness and weakness, a pessimist aspect perspective toward life	0.70
Uncertain, negative future plans	0.54
Having some plans and hopes for the future	0.16
Beck Depression Inventory score	
Scoring 17 or more on the Beck Depression Inventory	0.61
Scoring under 17 on the Beck Depression Inventory	0.24
Emotional state	
Emotional turmoil (anxiety, agitation, anger).	0.53
Emotional fluctuations	0.50
Low level anxiety	0.18
Distress level	
Scoring 0-3 on the distress thermometer	0.17
Scoring 4-6 on the distress thermometer	0.34
Scoring 7-10 on the distress thermometer	0.56
Psychological health	
Scoring above average on the brief resilience scale (12 or more)	0.16
Scoring below average on the brief resilience scale (less than 12)	0.39
Protective factors	
Being married (with a positive relationship)	0.30
Having children	0.31
Having a good cognitive level	0.26
Holding spiritual/religious beliefs (disapproving of suicide)	0.31
Having strong family ties	0.26
Having strong ties with friends or neighbors	0.26
Having a job or occupation	0.26
A positive relationship between the patient and counselor	0.29

4. Calculating the risk of suicide with a fuzzy logic model: An Excel file based on probability density function was prepared to calculate Gaussian distribution for the calculation of suicide risk with a fuzzy logic model. The model functions through the formula:

When the risk assessment tool items increasing the risk of suicide are completed, the maximum possible score is 9.41 and the minimum score is 2.16. Risk levels are assessed as low, moderate or high. The high risk rate rises the closer scores approach to 9.41, the moderate risk rate the closer they approach to 5.78, and the low risk rate the closer they approach to 2.16. Factors protecting the individual against suicide on the risk assessment tool are evaluated separately from the fuzzy logic model. The software produces a result by adding the effect levels of each protective factor. The maximum possible score from the factors protecting the individual against suicide is 2.25, and the minimum possible score is 0.26. Higher scores indicate a greater level of protection against suicide. After determining an individual's suicide risk level, health professionals can form an opinion concerning suicide risk status in the light of their clinical knowledge

and experience and of the score obtained from protective factors.

5. Conversion of the fuzzy logic model-based suicide risk assessment tool into an online format: The suicide risk assessment tool was converted into an online format in order to enhance various facilitating features, such as ease of access, maintenance of confidentiality, and remote access (www.ufalt.net).

Stage 2: Determination of the views of health professionals working in CMHCs concerning the fuzzy logic model-based suicide risk assessment tool

Sample: The research sample consisted of health professionals working in two CMHCs affiliated to the Istanbul Provincial Health Directorate and one affiliated to the Karaman Provincial Health Directorate. A social services specialist, two nurses and two psychologists were working in the first CMHC, and a psychiatrist, two nurses, a psychologist, a social services specialist and an ergotherapist in the second, and a psychiatrist, two nurses, a psychologist, and a social services specialist in the third. Fifteen health professionals in CMHCs agreeing to take part in the study were enrolled.

Date Collection Tool: Health professionals' opinions were elicited using a semi-structured reportage form developed by the authors. This consisted of two parts. The first section contained eight questions designed to elicit characteristics such as health professionals' age, sex, work experience, and receipt of occupational and risk assessment training. The second section contained one question regarding how health professionals' use of the suicide risk assessment tool affected their evaluations, and two others concerning the powerful aspects of the tool and those requiring further development.

Application: Health professionals in the three CMHCs were informed about the suicide risk assessment tool developed, which was made available for their use. They used the suicide risk assessment tool for four weeks. Feedback concerning their opinions of the tool was obtained through a semi-structured reportage form. Interviews were held face to face with each health professional, in their own offices, and lasted between 15 and 35 min. The interviews were also recorded.

Data Reliability and Validity: The principles of credibility, transmissibility, consistency and confirmability in qualitative inquiry were employed in the establishment of data reliability and validity (Yıldırım & Şimşek, 2013).

Data Evaluation: The study data were subjected to descriptive evaluation. This involves data being summarized and interpreted according to previously determined themes (Yıldırım & Şimşek, 2013).

3. Results

Fifteen health professionals were interviewed in the scope of the research. The nurses participating in the research were numbered from N1 to N6, the psychiatric specialists were numbered PS1 and PS2, the psychologists were numbered from P1 to P3, the social services specialists were numbered from SS1 to SS3, and the ergotherapist

was coded ERG. The health professionals enrolled in the research and some of their characteristics are shown in Table 2.

Table 2. Characteristics of the health professionals who provided views concerning the suicide risk assessment tool

Participants	Age	Sex	Occupation	Education level	Length of time worked in the CMHC	Length of time worked in other psychiatri	Receipt of risk assessment training
PS1	38	Male	Psychiatrist	Postgraduate	3 Years	13 Years	No
PS2	31	Male	Psychiatrist	Postgraduate	1 Year	10 Years	No
N1	36	Female	Nurse	Postgraduate	6 Years	4 Years	Yes
N2	39	Female	Nurse	Postgraduate	2 Years	11 Years	Yes
N3	35	Female	Nurse		6 Years	5 Years	Yes
N4	45	Female	Nurse	Bachelor's	6 Years	8 Years	No
N5	40	Female	Nurse	Bachelor's	5 Years	5 Years	Yes
N6	38	Female	Nurse	Postgraduate	5 Years	5 Years	Yes
P1	26	Female	Psychologist	Postgraduate	1 Year	10 Years	No
P2	27	Female	Psychologist	Postgraduate	1 Year	11 Years	No
P3	33	Male	Psychologist	Bachelor's	5 Months	11 Years	Yes
SSS1	25	Female	Social services specialist	Bachelor's	4 Months	12 Years	No
SSS2	28	Male	Social services specialist	Bachelor's	2 Years	12 Years	Yes
SSS3	26	Male	Social services specialist	Bachelor's	1 Year	15 Years	No
ERG	25	Female	Ergotherapist	Bachelor's	1 Year	9 Years	No

The data obtained from the interviews were subjected to descriptive analysis, and themes and subthemes were identified. Themes refer to powerful aspects of the tool and those requiring development, while subthemes refer to scope, applicability, and suicide risk measurement.

Theme 1. Powerful aspects: The health professionals participating in the research reported powerful aspects concerning the scope of the fuzzy logic model-based suicide risk assessment tool, its applicability, and suicide risk assessment status.

Subtheme 1. Scope: The participants declared that the number and content of the questions in the tool were sufficient to prevent questions being missed in the assessment and for the consideration of protective factors: "PS 1: In my opinion the scope is sufficient… I consider it ideal in terms of the number of questions… We must obtain maximum benefit with a minimum number of questions, particularly when interviewing cases of this type …". "N5: I think that the questions fully meet requirements…"

Subtheme 2. Applicability: Some health professionals reported that the applicability of the suicide risk assessment took was practical and facilitated suicide risk

evaluation. The participants who described the developed suicide risk assessment tool as practical ascribed this to its not being time-consuming in nature, its being simple and very easy to apply, its being based on information elicited when speaking to the patient, its being capable of application within the interview, its containing few areas requiring interpretation, and its being useful in case of uncertain assessments and highly practical. The fact that it could be easily completed by anyone with psychiatric training was also described as a powerful aspect of the tool:"P 1: …It is very simple. I mean it is very simple to apply. It is easy to apply it verbally… It did not take much time, and represents an excellent conversation in suicide assessment. It is something I can apply within the interview …" "SSS 4: …Our having such a form available may be something that will enhance the quality of our interviews with patients. I therefore consider it functional…"

The way the tool facilitated suicide risk assessment was an element emphasized by almost all participants: "PS1: It facilitates our work because the questions involve are basic parameters we need to know about the individual being assessed, whom we think may be a suicide risk. You have in all likelihood selected the most rational or valuable items from among these, and this facilitates our work in that sense. In other words it prevents us skipping any question and also considers protective factors right from the beginning, and that makes our job easier. It serves us as a guide." "SSS 1: The questions are definitely comprehensible. Patients definitely respond to these questions, because there is nothing that any patient cannot understand."

Other powerful aspects cited by health professionals include the easy accessibility of the suicide assessment risk tool due to its availability in an electronic environment, the fact it provides a numerical figure at the end of the assessment, that it permits more professional assessment, its enhancement of the task being performed, the fact it provides a common language, and the way it permits official documentation: "PS 1: It made things easier. I can make a more professional assessment. In addition, it also enhanced the quality of my assessments..." "P1:… The risk assessment tool provides results along the lines of a 10% low risk, a 50% moderate risk, and a 20% high risk. This enables us to say something about the risk and contributes to the analysis." "N5: I think this should be applied to all patients. Then we can proceed based on the results... There will still be situations that are missed. But at least it will have been applied. Then we will have documentation to say that 'We applied it, and there was no such ideation then.'

Subtheme 3. Suicide Risk Measurement Status: Health professionals reported that the assessment result they obtained using the suicide risk assessment tool was similar to that they estimated themselves, and that the tool provided clarity in case of uncertainty: "N4: The assessments are exactly what we think ourselves. For example, it provides immediate clarity about things we are uncertain of…"

One opinion to the effect that the suicide risk assessment tool is consistent and suited to evidential study was expressed as follows: "P2: … In my view, the system

is consistent internally and with its results. Of course, something more empirical would be needed to determine how useful this is. But I think the results are consistent and suitable for use …"

Theme 2: Aspects Requiring Development

Subtheme 1. Applicability: In terms of the applicability of the suicide risk assessment scale, some participants stated that the application of the tool could be enhanced if it were completed by a counselor well acquainted with the patient, if it were integrated into the system employed in CMHCs, and if graphics were added to the result screen: "P2: The risk assessment could easily be completed if the person applying the test is sufficiently acquainted with the patient…" "PS1: …if it were integrated into systems used in our daily procedures, for example, there is a program on the web containing the forms used in our CMHCs, and if it were integrated with that, then we could apply it very quickly…Graphics could be added to the results screen, and every graphic we produce could be given separately when we enter the patient's file. Let us assume that we apply this scale every two weeks, if there were a graphic showing the course, then that would be very useful very quickly."

4. Discussion

The views of health professionals in CMHCs regarding the fuzzy logic model-based suicide risk assessment tool are discussed below under the themes identified.

Theme 1. Powerful aspects

Participants stated that the items in the suicide risk assessment tool can ensure that various questions that should be asked during assessment are not overlooked. They also considered that it contains questions that assess existing emotions, ideas and behaviors that can affect the individual's suicide risk while considering dynamic or state changes, that the tool can provide a common language. Participants also felt that the calculation of a number at the end of the analysis permits a more professional assessment, that the tool professionalizes application, is very simple and functional, and also permits official documentation. Reasons cited in studies for health professionals expressing positive views of risk assessment tools include the presence of questions that are very useful in evaluating previous psychological history and that might not otherwise come to mind (Buckingham, 2002), their facilitation of discussions about risk on the part of care providers (Muir-Cochrane et al., 2011), and their facilitation of professional decision-making (Holley et al., 2016). Causes for criticism of risk assessment tools include lack of attention to dynamic or state changes since they tend to focus on previous (static) risk factors, and their inability to consider individual factors concerning the patient (Doyle & Dolan, 2002), their being highly mechanical and behaviorally reductive, dehumanizing, and their failure to include professional intuition in the assessment process (Godin, 2004). We attribute the generally positive opinions of our suicide risk assessment tool on the part of participants to the questions evaluating both the individual's previous (static) and variable (dynamic) characteristics. We also think that participants approved the tool due to its providing information about risk group membership percentages as

a result of the fuzzy logic model employed, rather than providing definite values as in classic logic, thus including health professionals' views and experience in the decision-making process.

In terms of the applicability of the suicide risk assessment tool, the participants stated that it contained questions requiring consideration and professionalized application, was highly functional and easy to administer, and permitted official documentation. The provision of official documentation is also cited as the most important reason for positive attitudes toward the using of risk assessment tools on the part of health professionals in previous similar research (Godin, 2004; Muir-Cochrane et al., 2011; Woods, 2013). Some researches of attitudes toward risk assessment tools have reported that health professionals are undecided regarding the use of such tools, and that they may regard them as bureaucratic instruments of no value or purpose or else as psychiatric technology developed in order to reduce the role of clinical expertise (Gerace et al., 2013; Muir-Cochrane et al., 2011). Studies have also suggested that health professionals consider them to be useful guidelines capable of informing and guiding less able or less experienced applicators (Godin, 2004), and that they would employ a risk assessment tool if it was appropriate and user-friendly (Woods, 2013). We attribute the positive approach to the application of the risk assessment tool in the present study to the fuzzy logic model, an artificial intelligence program, very closely reflecting human thinking, and to participants being aware of the need for a suicide risk assessment tool.

While the result yielded by the tool was consistent with health professionals' own estimations of the individual's risk status, they also reported positive views concerning the fact that it additionally provided clarity in uncertain situations. More than one in four of the nurses participating in Holley, Chambers and Gillard's (2016) research believed that risk assessment tools were capable of predicting the probability of risk, but they also did not object to the statement that risk could not be predicted.

Theme 2. Aspects requiring development

The health professionals participating in this research also recommended that the suicide risk assessment tool be integrated with the CMHC system, and suggested that a graphic demonstrating the route of the patient's suicide risk assessment on the outcome monitor would also be useful. This finding shows that the participants in our study held positive opinions regarding the routine use of the suicide risk assessment tool. In contrast to these findings, one study involving community mental health nurses reported that some participants felt that the using of a standard risk assessment tool who a totally unnecessary bureaucratic imposition, while the majority felt that imposing the use of a standardized risk assessment tool would act as an obstacle to creativity in their work (Godin 2004). We think that the integration of our suicide assessment risk tool into the CMHC system will not create an additional workload since it will become part of existing practices. The addition to the results screen of a graphic demonstrating the route of the patient's suicide risk assessment will also be useful in terms of evaluating change in the patient's suicide risk.

Longitudinal researches are needed to define the effectiveness of the suicide risk assessment tool developed in this study in measuring suicide. The lack of data regarding the validity of the scale is the limitation of the study.

5. Conclusion

In conclusion, the health professionals in this research held positive views concerning the scope of the suicide risk assessment tool we developed. In the light of health professionals' views regarding the questions in the suicide risk assessment tool and their suggestions for how it might be improved, we may conclude that some aspects require further development.

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