Predictors of suicidal ideation in older people. A decision-tree analysis.

Author/Contributor:

Handley, Tonelle; Hiles, Sarah; Inder, Kerry; Kay-Lambkin, Frances; Kelly, Brian; Attia, John

Predictors of suicidal ideation in older people. A decision-tree analysis

Authors: Tonelle E. Handley(GDipPsych)[1], Sarah A. Hiles(BPsych(Hons))[1], Kerry J. Inder(PhD)[1,2], Frances J. Kay-Lambkin(PhD)[1,3], Brian J. Kelly(PhD)[1,2], Terry J. Lewin(BComPsych(Hons))[1,2], Mark McEvoy(MMedSc(ClinEpi)[4], Roseanne Peel(MPH)[4], John R. Attia(PhD)[2,4]

1. Centre for Translational Neuroscience and Mental Health, University of Newcastle, Callaghan, Australia

2. Hunter Medical Research Institute, Locked Bag 1, Hunter Region Mail Centre, Newcastle, Australia

3. National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia

4. Centre for Clinical Epidemiology and Biostatistics, University of Newcastle, Newcastle, Australia

Corresponding author: Tonelle Handley

Centre for Translational Neuroscience and Mental Health, University of Newcastle,

22 Turton Rd, Waratah, NSW, 2298, Australia

Phone: +61 2 49854951; Fax: +61 2 40335692

Email: tonelle.handley@newcastle.edu.au

Key words: suicidal ideation; decision tree; older; CART; social support; psychological distress; physical functioning

Abstract

Objectives: Suicide among older adults is a major public health issue worldwide. While studies have identified psychological, physical and social contributors to suicidal thoughts in older adults, few have explored the specific interactions between these factors. This paper uses a novel statistical approach to explore predictors of suicidal ideation in a community-based sample of older adults.

Design: Prospective cohort study.

Participants and setting: Participants aged 55-85 were randomly selected from the Hunter Region, a large regional centre in New South Wales, Australia.

Measurements: Baseline psychological, physical and social factors, including psychological distress, physical functioning, and social support, were used to predict suicidal ideation at 5-year follow-up. Classification and Regression Tree (CART) modelling determined specific risk profiles for participants depending on their individual wellbeing in each of these key areas.

Results: Psychological distress was the strongest predictor, with 25% of people with high distress reporting suicidal ideation. Within high psychological distress, lower physical functioning significantly increased the likelihood of suicidal ideation, with high distress and low functioning being associated with ideation in 50% of cases. A substantial sub-group reported suicidal ideation in the absence of psychological distress; dissatisfaction with social support was the most important predictor among this group. The performance of the model was high (area under the curve 0.81).

Conclusions: Decision tree modelling enabled individualised "risk" profiles for suicidal ideation to be determined. While psychological factors are important for predicting suicidal ideation, both physical and social factors significantly improved the predictive ability of the

model. Assessing these factors may enhance identification of older people at risk of suicidal ideation.

Introduction

Suicide among older adults is a major public health issue worldwide, with a higher rate of completed suicides observed among the elderly than in any other age group[1]. There has been no decrease in this rate in recent years[2], and with the proportion of the world's population aged 65 years and over projected to triple by the year 2050[3], the social, emotional and economic costs of this phenomenon are expected to increase significantly in the future.

Older age is inevitably a time of loss and change; declines in physical health and functioning are among the most prominent occurrences, however, decreased opportunity and ability for social interactions is also notable[4]. Although evidence suggests that mental health improves with age[5,6], psychological conditions are often undiagnosed in older people[7] and may lead to considerable negative outcomes when they do occur.

The majority of existing research on suicidality in older samples utilises clinical rather than epidemiological samples[8], potentially limiting its applicability to the general population. Existing community-based research shows physical, social and psychological factors to be among the most important contributors to suicide vulnerability among older adults[9]. Although psychological factors have perhaps the strongest effect[10], social factors, including low perceived social support[11], limited social networks[12], and financial strain[13] increase the risk of suicidal behaviour even after controlling for the effects of mental illness. Existing research also indicates a significant role of physical illness, with both physical diagnoses and the associated symptoms and functional limitations contributing to suicidal thoughts and behaviours[14,15]. Despite the strong evidence suggesting a contribution of psychological, physical, and social factors to suicidality among older people, the independent roles of these variables, and their interactions, are not yet fully understood[16].

5

Suicidal ideation is among the biggest predictors of suicidal behaviours, significantly increasing the likelihood of eventual death by suicide[17,18]. While the prevalence of suicidal ideation among older adults is similar to the general population[19], it is more likely to result in a suicide death in older age groups[20]. Psychological autopsy studies show that emergency interventions for suicidal crises are less effective among older populations[20], suggesting that optimal suicide prevention may be best achieved by focusing on lower-end suicidality (e.g. suicidal ideation) with a view to prevent suicidal plans and behaviours.

The majority of older people receive mental health care in primary care settings[8] and typically seek consultations for general medical issues, rather than mental health concerns[21], even in the months prior to a suicide death[22]. Attempts to develop early interventions may therefore be best directed towards increasing general medical practitioners' ability to identify older people who may be at higher risk for suicidal thoughts in the future, regardless of their current psychological state or history of suicidality.

Declines in physical and social functioning occur in the majority of older adults, yet only a small proportion display suicide vulnerability. Therefore, exploring these factors as independent predictors of suicidality through traditional analytical techniques such as linear or logistic regression may have limitations. Rather, it is more likely that a culmination or interaction of factors contributes to suicide risk in older adults, and specific risk factors may vary depending on an individual's circumstances. Establishing the situations in which physical, social and psychological factors contribute to suicide vulnerability is clinically useful. A decision tree approach allows for the exploration of how factors interact, and can be used to create profiles to predict an individual's level of risk for a given outcome. This

approach is frequently used in various areas of physical health, allowing non-specialists to identify an individual's risk for a range of diagnoses including cardiac arrest[23], cancer[24] and dengue fever[25]. In recent years, this technique has also been used as a tool for exploring psychological outcomes, including suicidal ideation[26] and attempts[27], in both community and clinical samples, with some evidence that this approach results in better predictive abilities than logistic regression[26,28].

The aim of the present analysis is to determine long-term risk profiles for suicidal ideation among a community sample of older adults using a decision tree approach, with a focus on the role of physical, social and psychological risk factors. It will explore both main effects and interaction between these factors, in order to establish the specific role of these constructs and to better guide early intervention efforts. While our approach is primarily exploratory, we hypothesise that significant interactions will be observed between physical, social and psychological risk factors. Hence, we predict that investigating interactions between these factors, alongside main effects, will result in a clearer understanding of the pathways that lead to suicidal ideation, enhancing the clinical utility of findings and the identification of people in need of intervention.

Methods

Participants

Participants were recruited as part of the Hunter Community Study (HCS), an observational study of healthy aging in the Hunter Region of New South Wales (NSW), Australia. Baseline recruitment occurred between 2004 and 2007, with participants selected randomly from the NSW state electoral roll. Data were collected via self-report postal surveys, which were mailed to participants' homes. The full survey methodology, including all measures used, has been published elsewhere[29]. A follow-up phase of all baseline respondents in the Hunter Community Study occurred between 2010 and 2011. Participants gave written informed consent to participate in a longitudinal study.

Measures

The present analysis utilises the following measures, collected in the baseline phase of the study:

Demographics: Single-item measures evaluated participants' current age, gender, marital status, employment status, and household income. Participants also reported whether they receive the age pension, a means tested government-provided income for Australians aged 65+ (these payments currently equate to $733.70 per single or $1,160.20 per couple each fortnight)[30].

Short-Form Health Survey[31]: The "physical functioning" subscale was included in the present analysis to investigate the extent to which individuals' ability to perform regular daily activities is affected by physical health conditions (such as bathing, climbing stairs or carrying groceries). Survey responses are re-coded according to standardised procedures[32],

whereby scores range from 0-100 with a mean of 50 and a standard deviation of 10. Higher scores reflect higher functioning, that is, fewer functional limitations. This subscale has excellent internal consistency and reliability (Cronbach's alpha 0.93).

Duke Social Support Index (DSSI)[33]: The 11-item DSSI was used to assess social networks and support. This abbreviated measure was developed for widespread use in older adult samples, and has been validated in community-based populations[34]. The index includes two subscales measuring a) social interaction (the size of an individual's social network and the frequency of their contact with friends and family), and b) the individual's overall satisfaction with their social support. Scores range from 4-12 for social interaction and 7-21 for social satisfaction, with higher scores reflecting higher support. The social interaction and social satisfaction subscales have high internal consistency in the Australian general population (Cronbach's alpha 0.80 & 0.58 respectively)[35].

Kessler-10 psychological distress scale (K10)[36]: The K10 assesses the frequency of 10 psychological symptoms during the previous four weeks. It is commonly used as an indicator of general mental health and wellbeing, and is frequently used both on an individual level (i.e. by medical practitioners) and to explore wellbeing on a population level. In the Australian population, K10 scores are significantly associated with the likelihood of meeting diagnostic criteria for affective and anxiety disorders, with a smaller effect also observed for substance use disorders[5,37]. Scores range from 10-50, with a higher score indicating greater distress, and can be grouped into four categories: "low" (10-15), "moderate" (16-21), "high" (22-29) and "very high" (30-50). The K10 has excellent internal consistency in general population samples (Cronbach's alpha 0.92).

Alcohol use: Participants reported their use of alcohol in the past three months, including how many days they consumed alcohol, and the number of drinks consumed each day. This information was used to classify them into non-drinkers (no alcohol in the past three months), low/moderate drinkers, or hazardous drinkers ($\geq$ 4 drinks per day for females or 6 drinks per day for males, at least 3 days per week).

Chronic illness: Self-reported chronic illnesses (yes/no) were categorised into six groups: arthritis (osteoarthritis, rheumatoid arthritis); respiratory conditions (asthma, bronchitis, emphysema); cardiovascular conditions (angina, heart attack, stroke, diabetes, atrial fibrillation) and risk factors (hypertension, high cholesterol); thyroid problems; and osteoporosis. A continuous variable representing participants' total number of chronic illnesses was also calculated.

Clinic measures: Following self-report survey completion, participants were asked to attend a clinic session where a series of objective measures of physical health were undertaken, using standardised protocols. These included systolic blood pressure (averaged over three measures), grip strength (using a dynamometer), body mass index, and lung function (forced expiratory volume, standardised for age and gender).

Suicidal ideation: A single-item measure of suicidal ideation was included in the follow-up survey only. Item 9 of the Patient Health Questionnaire-9 (PHQ-9)[38] was used to determine the frequency of thoughts of suicide during the previous two weeks. Response options included "not at all," "several days," "more than half the days" and "nearly every day." For the present analysis, responses were dichotomised into a "yes/no" variable, with responses of "several days" or greater classified as a "yes." Previous research supports the validity of self-

rated single-item measures of suicidal ideation within depression rating scales, suggesting that such measures have similar validity to longer, more specified scales[39].

Statistical analysis

Data analysis was conducted using SPSS (version 20; SPSS, Chicago, IL, USA) and JMP (version 9; SAS Institute Inc., Cary, NC, USA). Univariate analyses used baseline factors as predictors and follow-up suicidal ideation as the outcome. One-way ANOVA was used to explore continuous variables, and chi-square tests for categorical variables. Descriptive statistics are presented as mean ± standard deviation. Variables were entered into a partition modelling analysis in JMP to undertake Classification and Regression Trees (CART) analysis. A logistic regression was used to explore main effects.

Advantages of CART analysis: CART analysis is a non-parametric method designed to explore interaction effects between two or more factors with maximum statistical power. Additionally, CART analysis offers the advantage of easy interpretation, by providing a graphical representation of the hierarchy of predictor variables. This technique sequentially determines the variable that accounts for the greatest amount of variance in the outcome, and splits the sample based on the most useful cut-off score. This process is automated by the program; cut-off scores are determined by JMP based on the most discriminating points in relation to the outcome, and to the other variables in the model. The splitting procedure is then repeated for each resultant "node." This is an interactive process; to avoid over-fitting, the authors manually stopped splitting the tree when it was determined that further splits would not improve the overall model. This decision was made by assessing the folded (10-fold) and overall K-fold cross-validation, and the area under the curve (AUC) of the receiver operating characteristic (ROC) curve of the model (the AUC represents the overall

relationship between sensitivity and specificity). A minimum split size of five was imposed; that is, a split could not be generated unless a minimum of five participants were included in each resultant node.

Results

For the baseline phase of HCS, invitation letters were sent to 9784, 7575 people responded, 3877 agreed to participate and a total of 3253 actually participated (response rate 44.5%). Comparisons between responders and non-responders revealed no statistically significant difference for gender but a slightly younger age (66.3 years vs. 68.6 years, t=0.4, $p < .001$). The final sample provide a population profile reflecting that of the NSW state and national Australian profiles in terms of gender and marital status, but slightly younger in age[29].

Of the 3253 baseline participants, 2160 (66.4%) completed the follow-up survey. Between baseline and follow-up, 132 participants (4.0%) were known to be deceased, while 175 (5.4%) actively withdrew from the study (mostly due to nursing home placement, dementia or serious illness). The majority of other participants lost to follow-up were uncontactable (e.g. had changed address and could not be located) or did not return the postal survey. Participants who did not complete follow-up were older at baseline than those who completed follow-up (68.59±8.54 vs. 66.02±7.29, $F(1,3280) = 79.03$, $p < .001$). They were also more likely to be widowed (16.4% vs 10.4%, $\chi^2_{(3)} = 23.15$, $p < .001$), and had a greater number of chronic diseases (2.34±1.74 vs. 2.02±1.57, $F(1,3153) = 20.12$, $p <.001$) and a higher psychological distress score (15.23±5.92 vs. 14.29±5.23, $F(1,3145) = 27.33$, $p < .001$).

Table 1 displays baseline participant characteristics by follow-up suicidal ideation status. Overall, 95 participants (4.5%) reported suicidal ideation at 5-year follow-up. Participants reporting suicidal ideation at follow-up had a significantly lower household income than those with no suicidality, and were more likely to receive the age pension. Follow-up suicidal ideation was associated with significantly higher psychological distress and higher alcohol use at baseline. Similarly, participants with suicidal ideation at follow-up reported a

13

significantly higher number of chronic illnesses at baseline, were more likely to have a respiratory condition, and reported lower overall physical functioning. Suicidal ideation was more common among participants whose body mass index identified them as "obese" (≥30). Follow-up suicidal ideation was also associated with both lower social interaction and levels of satisfaction with social support at baseline.

Insert Table 1 near here

Results of the CART are shown in Figure 1. Tree growth was manually stopped after six splits, as it was determined that additional variables did not improve the overall model fit after this point (AUC 0.814; K-fold cross-validation 611.44 (folded), 593.84 (overall); see Figure 2). The strongest baseline predictor of follow-up suicidal ideation was K10 score, with 25% of participants with "high" or "very high" psychological distress (total score ≥21) reporting ideation. Within this group, there was a higher likelihood of suicidal ideation (50%) for those with a baseline SF-36 physical functioning score less than 40, and risk was further increased for those receiving the age pension. For participants with high distress and higher physical functioning, the risk of suicidal ideation was highest for those consuming alcohol at a hazardous level.

Insert Figures 1 and 2 near here

Two percent of respondents with a "low" or "moderate" K10 score at baseline indicated thoughts of suicide at follow-up. Among these participants, baseline satisfaction with social support was the strongest predictor. Participants whose satisfaction with social support was 18 or greater were particularly unlikely to report suicidal ideation, however the risk was

14

slightly elevated for those who reported "moderate" compared with "low" distress. No additional risk factors were identified for people who reported both low distress and lower social support; the odds of ideation in this group was approximately double that of the overall sample, and four times that of participants with high social support.

Although the primary goal of CART analysis is to identify potential individualised risk profiles, it is also possible to examine the utility of combining these profiles into aggregate risk indices. For example, the lower portion of Figure 1 illustrates the likely impact that reducing the number of sub-groups classified as being "at risk" has on sensitivity and specificity. In this instance, assigning respondents with low or moderate distress but higher satisfaction with social support (sub-groups A and B in Figure 1) to the low risk category appears to provide a reasonable trade-off between sensitivity and specificity (or, alternatively, only allocating sub-group A to low risk, if sensitivity is considered to be more important).

The results of the logistic regression are shown in Table 2. Compared with participants with a household income of less than $20,000 per year, those earning $20,000-$39,999 had approximately half the odds of reporting suicidal ideation at follow-up, while those earning over $70,000 had their odds reduced by approximately 75%. Higher baseline psychological distress was associated with increased odds of reporting follow-up suicidal ideation, while satisfaction with social support was a significant protective factor. Compared to low or moderate drinkers, hazardous drinkers were approximately three times more likely to report suicidal ideation. The overall fit of this model was high (AUC 0.86).

Insert Table 2 near here

Discussion

In the present analysis approximately 5% of participants reported suicidal ideation, similar to existing research both in Australia[10] and internationally[40] for older persons. The univariate analysis found a range of associations between baseline factors and follow-up suicidal ideation, including physical and psychological health, social support and financial status. These results reflect those of previous cross-sectional studies[10,11,14,40], suggesting the possibility of a temporal relationship and supporting the utility of these factors from a public health perspective. As suicidal ideation was not measured at baseline, we could not confirm a temporal or causal relationship in the present analysis, however our findings indicate this is an important direction for future research. Previous research in other samples has found a significant predictive effect of both psychological distress and subjective social support after controlling for baseline suicidal ideation, providing support for our findings[41].

The CART analysis indicated that baseline psychological distress was the most important predictor of follow-up suicidal ideation, with the percentage reporting suicidal ideation in the "high" distress group ten times that of participants with low distress (25.3% vs. 2.4%). This reflects previous research in general adult samples which suggests that psychological distress is an important correlate of suicidal ideation both cross-sectionally[42] and longitudinally[41]; the present study suggests that this remains in samples of exclusively older individuals. As the K10 is widely recommended and easily implemented, the abilities of this measure to identify suicidal thoughts are positive, suggesting a high level of feasibility for non-specialists to implement this tool as a screening instrument.

Among participants with elevated baseline psychological distress, limitations in physical functioning further increased the likelihood of suicidal ideation. As this factor was not

significant in the regression, our results suggest that the effects of physical limitations are additive to those of psychological symptoms, rather than independent. Neither the number of chronic illnesses nor the type of illness was significant in our model. It is important to note that this analysis did not include factors such as disease state or severity, which may be important to include in future research. Regardless, these findings have important implications, suggesting that the likelihood of suicidal ideation may increase with the normal physical declines of aging, which may occur in the absence of actual physical illness. Such limitations in mobility are associated with significant loss of independence among older people[43], which has been identified as a key concern in this age group[44].These findings emphasise the importance of a holistic approach to wellbeing among older adults; as the interaction of physical and psychological health had a significant impact on the likelihood of suicidal ideation, an integrated approach to screening for and treating both of these factors may be necessary for the risk of ideation to decline.

The likelihood of suicidal ideation was further increased among participants in receipt of the age pension. Receipt of the age pension is more common among people with long-term disabilities, lower education, and people who do not own their home[45].This variable may be a proxy for other factors, such as subjective financial hardship or feelings of dependence. While this is a relatively crude measure, it had a substantial effect in our model, almost tripling the odds of reporting suicidal ideation. Many health services (including medical practitioners and pharmacists) record patients' pensioner status, and hence have easy access to this information. As physical and functional declines are associated with a greater use of health services, taking note of this additional factor among older patients with functional limitations is an easy and informative approach for healthcare workers to greatly improve their ability to identify people in potential need of intervention.

For participants with high distress and higher physical functioning, hazardous alcohol use was a significant risk factor for suicidal ideation. Hazardous alcohol use is generally underestimated in older adults, in part due to their less frequent help-seeking behaviours for alcohol-related disorders. Thus, screening for alcohol use problems among older patients is recommended. Treatments including cognitive-behaviour therapy and self-help groups have effectively reduced alcohol use and prevented relapse for older adults, and may similarly decrease the risk of developing thoughts of suicide[46].

Approximately half of participants with suicidal ideation did not have elevated psychological distress. This may be of particular clinical importance, as psychological distress is frequently used as a screener for psychiatric diagnoses, and low scores are generally considered as an indicator of no need for clinical intervention. Previous research has found that suicidal ideation may occur in the absence of a depressive illness[47], and our results support a recommendation of additional screening even among those with low distress. Specifically, assessing satisfaction with social support was shown to significantly increase the ability to identify the likelihood of thoughts of suicide among people with low/moderate psychological symptoms.

The relationship between suicidal ideation and social support among the elderly is particularly important in light of the aging population and the limited available resources providing social support to older individuals; in this respect, low social support among older people may be conceptualised as a major public health problem[40]. International research has shown that community-based social support and welfare programs for older people significantly decrease the rate of suicide[48]. In Australia, community-based programs exist to

provide support to older adults in areas such as meal preparation, transport and home maintenance; incorporating a social support aspect into these available services may be both financially and practically feasible, and provide significant public health benefits for older residents.

Although few factors were significant in the logistic regression, these independent effects may have important implications. The hazardous use of alcohol almost tripled the odds of future suicidal ideation, while each one-point increase in psychological distress was also significant; although this was a small effect of 14% per point, the magnitude increases dramatically across the 40-point K10 scale. Significant protective factors were also observed, with a household income of over $70,000 being associated with a 75% decrease in the odds of future ideation, while each one-point increase in satisfaction with social support decreased the odds of ideation by 22%; across the 14-point scale, this effect is substantial.

At an individual clinician level, knowledge of the independent role of these factors may assist them to better estimate the likelihood that a given patient will experience suicidal ideation in future. Broader intervention programs are also likely to benefit from improved knowledge; however, given the relatively low prevalence of suicidal ideation in the community, and the sensitivity/specificity profiles illustrated in Figure 1, it may be more appropriate for intervention programs to simultaneously target several of the outcomes linked to this set of risk factors, including depression, alcohol use, social isolation, suicidal thoughts and behaviours.

This study has several limitations. As we measured suicidal ideation at follow-up only, we cannot determine whether our findings relate to the development of suicidal thoughts, or

whether the factors we identified may be markers of persistent or fluctuating suicidal ideation. It is also likely that baseline ideation would account for a considerable amount of variance in ideation at follow-up. Similarly, as we measured only thoughts of suicide, rather than suicidal behaviours, we cannot confirm whether the identified risk factors may be useful to predict future suicide attempts, or simply thoughts. This analysis included objective measures of financial and relationship status, however it is possible that subjective aspects, such as perceived financial hardship, recent relationship breakdown, or other interpersonal traumas, may have an important relationship with the outcome. It is likely that general health and wellbeing may have contributed to participants' completion of follow-up. People who did not complete the second survey reported both a higher number of chronic diseases and higher distress at baseline, suggesting that the final sample may not represent the general population, and that the effects of physical and psychological health on suicidal ideation may have been underestimated in this analysis.

The study also has some significant strengths. The performance of the decision tree is high, with an AUC of 0.81, which is indicative of the potential clinical significance and transferability of the results. Given that we used cross-fold validation to arrive at these estimates (in which part of the sample is dropped and the model re-run), it is unlikely that this represents overfitting and overestimation of the AUC. Nevertheless, it would be important to assess the performance of this model in an independent population. The decision tree identified several factors that were not significant in the logistic regression, enabling a greater understanding of risk factors that may have an additive, rather than independent, effect on suicidal ideation. The decision tree also has the advantage of enabling risk stratification based on a number of factors simultaneously and of equating this to an absolute risk of disease, as compared to the regression models which yield only relative measures.

The present analysis allowed us to explore profiles of older individuals who report suicidal ideation, identifying unique risk factors for specific sub-groups. By monitoring these factors in older patients, the ability for health professionals to distinguish individuals who may be at risk of suicidal ideation in the coming years, despite their current state, is increased. Consequently, the opportunity for early interventions in this group may be improved.

References

1. O'Connel H, Chin A-V, Cunningham C, et al: Recent developments: suicide in older people. BMJ 2004; 329: 895-899.

2. Shah A, Bhat R, MacKenzie S, et al: Elderly suicide rates: cross-national comparisons of trends over a 10-year period. Int Psychogeriatr 2008; 20: 673-686.

3. World Health Organization: Global health and aging. NIH Publication no. 11-7737. 2011; (http://www.nlm.nih.gov/medlineplus/internationalhealth.html). Accessed 11 February 2013.

4. Antonucci T, Akiyama H, Takahashi K: Attachment and close relationships across the lifespan. Attach Hum Dev 2004; 6: 353-370.

5. Slade T, Grove R, Burgess P: Kessler Psychological Distress Scale: Normative Data from the 2007 Australian National Survey of Mental Health and Wellbeing. Aust NZ J Publ Heal 2011; 45: 308-316.

6. Inder KJ, Lewin TJ, Kelly BJ: Factors impacting on the well-being of older residents in rural communities. Perspect Public Heal 2012; 132: 182-191.

7. Serby M, Yu M: Overview: depression in the elderly. Mt Sinai J Med 2003; 70: 38-44.

8. Pearson JL, Brown GK: Suicide prevention in late life: directions for science and practice. Clin Psychol Rev 2000; 20: 685-705.

9. Conwell Y, Thompson C: Suicidal behavior in elders. Psychiatr Clin North Am 2008; 31: 333-356.

10. Almeida OP, Draper B, Snowdon J, et al: Factors associated with suicidal thoughts in a large community study of older adults. Brit J Psychiat 2012; 201: 466-472.

11. Rowe JL, Conwell Y, Schulberg HC, et al: Social support and suicidal ideation in older adults using home healthcare services. Am J Geriatr Psychiatry 2006; 14: 758-766.

12. Beautrais AL: A case control study of suicide and attempted suicide in older adults. Suicide Life-Threat Behav 2002; 32: 1-9.

13. Gilman SE, Bruce ML, Ten Have T, et al: Social inequalities in depression and suicidal ideation among older primary care patients. Soc Psych Psych Epid 2013; 48: 59-69.

14. Waern M, Rubernowitz E, Runeson B, et al: Burden of illness and suicide in elderly people: case-control study. BMJ 2002; 324.

15. Tsoh J, Chiu HFK, Duberstein PR, et al: Attempted suicide in elderly Chinese persons. A multi-group, controlled study. Am J Geriatr Psychiatry 2005; 13: 562-571.

16. Conwell Y, Duberstein PR, Caine ED: Risk factors for suicide in later life. Biol Psychiatry 2002; 52: 193-204.

17. Brown GK, Beck AT, Steer RA, et al: Risk factors for suicide in psychiatric outpatients: a 20-year prospective study. J Consult Clin Psych 2000;68: 371-377.

18. Nock MK, Borges G, Bromet EJ, et al. Suicide and suicidal behaviour. Epidemiol Rev 2008; 30: 133-154.

19. Pfaff JJ, Almeida OP: Detecting suicidal ideation in older patients: identifying risk factors within the general practice setting. Brit J Gen Practice 2005; 55: 269-273.

20. Conwell Y, Duberstein PR, Cox C et al: Age differences in behaviors leading to completed suicide. Am J Geriatr Psychiatry 1998; 6: 122-126.

21. Australian Institute of Health and Welfare: Older Australians at a glance (4th edition). 2007; Cat. no. AGE 52. Canberra: AIHW.

22. Tadros G, Salib E: Elderly suicide in primary care. Int J Geriatr Psychiatry 2007; 22: 750-756.

23. Bleasdale R, Campbell P, Edmunds E, et al: Cardiac arrest survivors and implantable defibrillator recipients: implementation of the recommendations contained in standard

5 of the cardiac national service framework. South East Wales Cardiac Network 2011; (http://www.wales.nhs.uk/sites3/docmetadata.cfm?orgid=490&id=143065). Accessed 11 February 2013.

24. Vlahou A, Schorge JO, Gregory BW, et al: Diagnosis of ovarian cancer using decision tree classification of mass spectral data. J Biomed Biotechnol 2003; 2003: 308-314.

25. Tanner L, Schreiber M, Low JGH, et al: Decision tree algorithms predict the diagnosis and outcome of dengue fever in the early phase of illness. PLOS Neglect Trop D 2008; 2: e196.

26. Batterham PJ, Christensen H: Longitudinal risk profiling for suicidal thoughts and behaviours in a community cohort using decision trees. J Affect Disord 2012; 142: 306-314.

27. Mann JJ, Ellis SP, Waternaux CM, et al: Classification trees distinguish suicide attempters in major psychiatric disorders: a model of clinical decision making. J Clin Psychiat 2008; 69: 23-31.

28. Batterham PJ, Christensen H, Mackinnon AJ: Modifiable risk factors predicting major depressive disorder at four year follow-up: a decision tree approach. BMC Psychiatry 2009; 9.

29. McEvoy M, Smith W, D'Este C, et al: Cohort profile: the Hunter Community Study. Int J Epidemiol 2010; 39: 1452-1463.

30. Department of Human Services: Age pension. April 10, 2013. Available at: http://www.humanservices.gov.au/customer/services/centrelink/age-pension. Accessed April 18, 2013.

31. Ware JE, Sherbourne CD: The MOS 36-item short form health survey (SF-36): conceptual framework and item selection. Med Care 1992; 30: 473–83.

32. Ware JE, Kosinski M, Keller SD: SF-36 Physical and Mental Health Summary Scales: a user's manual. 1994; Health Assessment Lab, New England Medical Centre: Boston.

33. Koenig HG, Westlund R, George LK, et al: Abbreviating the Duke Social Support Index for use in chronically ill elderly individuals. Psychosomatics 1993; 34: 61–69.

34. Goodger B, Byles J, Higganbotham N: Assessment of a short scale to measure social support among older people. Aust NZ J Publ Heal 1999; 23: 260-265.

35. Powers JR, Goodger B, Byles JE: Assessment of the abbreviated Duke Social Support Index in a cohort of older Australian women. Australas J Ageing 2004; 23: 71-76.

36. Kessler RC, Andrews G, Colpe LJ, et al: Short screening scales to monitor population prevalences and trends in nonspecific psychological distress. Psychol Med 2002; 32: 959–976.

37. Andrews G, Slade T: Interpreting scores on the Kessler Psychological Distress Scale (K10). Aust NZ J of Publ Heal 2001; 25: 494-497.

38. Kroenke K, Spitzer RL, Williams JBW: The PHQ-9. J Gen Intern Med 2001; 16: 606–613.

39. Desseilles M, Perroud N, Guillaume S, et al. Is it valid to measure suicidal ideation by depression rating scales? J Affect Disord 2012; 136: 398-404.

40. Awata S, Seki T, Koizumi Y, et al: Factors associated with suicidal ideation in an elderly urban Japanese population: A community-based, cross-sectional study. Psychiatry Clin Neurosci 2005; 59: 327-336.

41. Handley TE, Inder KJ, Kelly BJ, et al: You've got to have friends: the predictive value of social integration and support in suicidal ideation among rural communities. Soc Psych Psych Epid 2012; 47: 1281-1290.

42. Chamberlain P, Goldney R, Delfabbro P, et al: Suicidal ideation. The clinical utility of the K10. Crisis 2009; 30: 39-42.

43. Hirvensalo MH, Cohen-Mansfield J, Rind S, et al: Assessment of impairments that limit exercise and use of impairment information to generate an exercise. J Aging Phys Activ 2007; 15: 459-479.
44. Quine S, Morrell S: Fear of loss of independence and nursing home admission in older Australians. Health Soc Care Comm 2007; 15: 212-220.
45. Chalmers J, Norris K: Early retirement: does it lead to dependency on income support? Sydney, NSW, Social Policy Research Centre, 2001.
46. Barrick C, Conners GJ. Relapse prevention and maintaining abstinence in older adults with alcohol-use disorders. Drugs Aging 2002; 19: 583-594.
47. Handley TE, Inder KJ, Kay-Lambkin FJ, et al. Contributors to suicidality in rural communities: beyond the effects of depression. BMC Psychiatry 2012; 12: 105.
48. Oyama H, Wantanabe N, Ono Y, et al. Community-based suicide prevention through group activity for the elderly successfully reduced the high suicide rate for females. Psychiatry Clin Neurosci 2005; 59: 337-344.

Table 1. Baseline characteristics by follow-up suicidal ideation status (univariate)

	Suicidal ideation n = 95 Mean (SD)	No suicidal ideation n = 2065 Mean (SD)	df	p
Demographics:				
Age	65.85 (7.69)	65.84 (7.19)	1, 2144	.987
Gender				
Male	50.5 (48)	47.3 (977)	1	.540
Female	49.5 (47)	52.7 (1088)		
Marital status, % (n)				
Married/de facto	68.8 (64)	76.9 (1546)	2	.112
Divorced/separated/never married	20.4 (19)	13.1 (263)		
Widowed	10.8 (10)	10.0 (202)		
Employment status, % (n)				
Employed/unemployed	40.9 (38)	50.7 (1015)	1	.064
Retired	59.1 (55)	49.3 (987)		
Household income, % (n)				
Less than $20,000	48.3 (42)	29.5 (495)	3	<.001
$20,000-$39,999	26.4 (23)	31.8 (608)		
$40,000-$69,999	19.5 (17)	23.3 (445)		
$70,000+	5.7 (5)	19.0 (364)		
Age pension				
Yes	35.6 (32)	18.2 (359)	1	<.001
No	64.4 (58)	81.2 (1617)		
Psychological health:				
K10 psychological distress	22.06 (7.79)	13.85 (4.64)	1, 2111	<.001
Alcohol use, % (n)				
Non-drinker	21.5 (17)	21.1 (383)	2	<.001
Low/moderate use	53.2 (42)	68.6 (1246)		
Hazardous use	25.3 (20)	10.3 (188)		
Self-reported physical health:				
Number of chronic illnesses	2.39 (1.84)	1.99 (1.55)	1, 2075	.017
Musculoskeletal condition, % (n)	44.6 (41)	33.4 (663)	1	.027
Respiratory condition, % (n)	32.6 (30)	21.7 (30)	1	.014
Cardiovascular condition, % (n)	30.3 (27)	27.8 (542)	1	.607
Cardiovascular risk factor, % (n)	67.4 (60)	63.8 (1242)	1	.486
Thyroid problem, % (n)	10.9 (10)	208 (10.5)	1	.906
SF-36 physical functioning	59.03 (27.64)	76.35 (22.39)	1, 2095	<.001
Clinic measures:				
Body mass index, % (n)				
Normal weight	17.3 (13)	21.4 (396)	2	.006
Overweight	33.3 (25)	46.7 (866)		
Obese	49.3 (37)	31.9 (591)		
Grip strength	31.6 (11.1)	33.4 (10.4)	1, 1967	.135
Systolic blood pressure	137.6 (18.5)	136.1 (27.4)	1, 1963	.637
Lung function	0.86 (0.20)	0.90 (0.16)	1, 1777	.117
Social support:				
Social interaction	12.67 (4.55)	15.02 (4.53)	1, 2118	<.001
Satisfaction with social support	16.84 (3.43)	19.45 (2.13)	1, 2113	<.001

Note: K10, Kessler-10; SF-36, Short Form Health Survey – 36 item version; continuous variables have been analysed by one-way ANOVA, categorical variables have been analysed by chi-square.
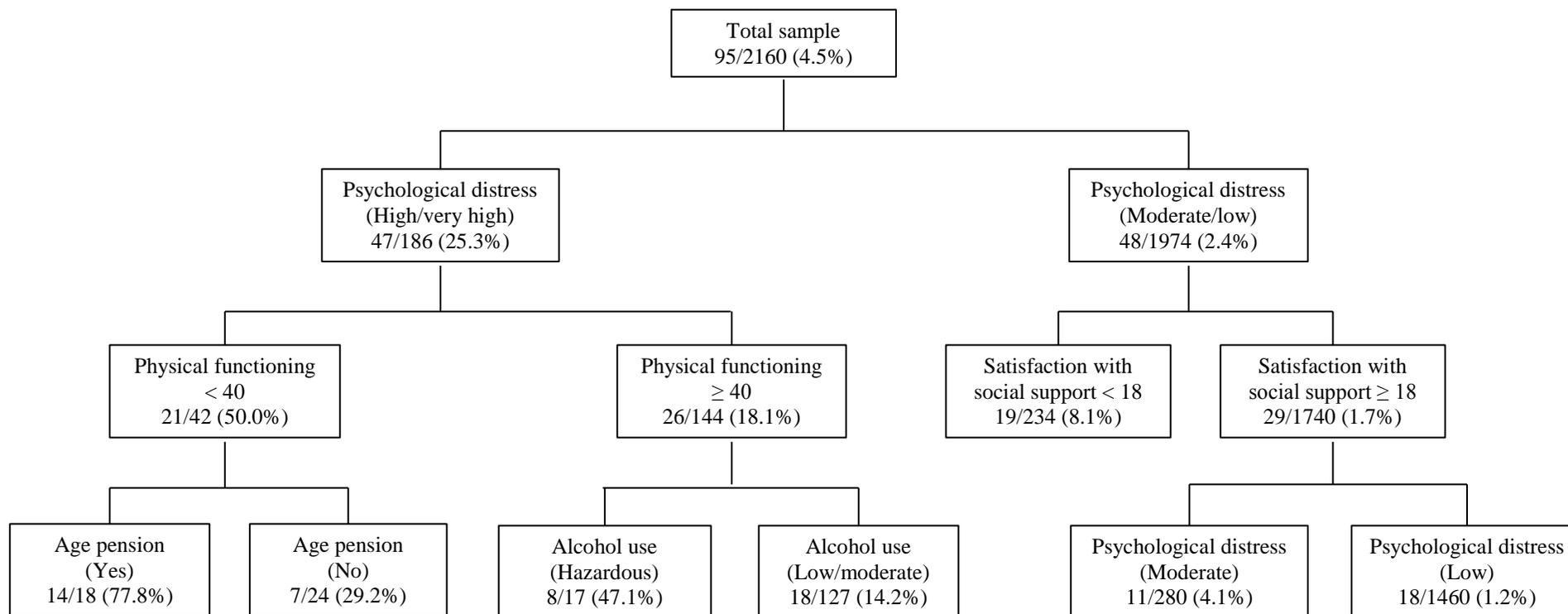
Figure 1. Decision tree demonstrating risk profiles for suicidal ideation.

Note: Each path in the tree, beginning in the topmost cell downwards, reflects a "profile" of participant characteristics, and the associated likelihood of suicidal ideation for participants who meet each criterion. In each cell, the numerator refers to the number of participants reporting suicidal ideation, while the denominator refers to the total number of participants in the cell. Percentages equate to the proportion of participants in each cell reporting suicidal ideation.
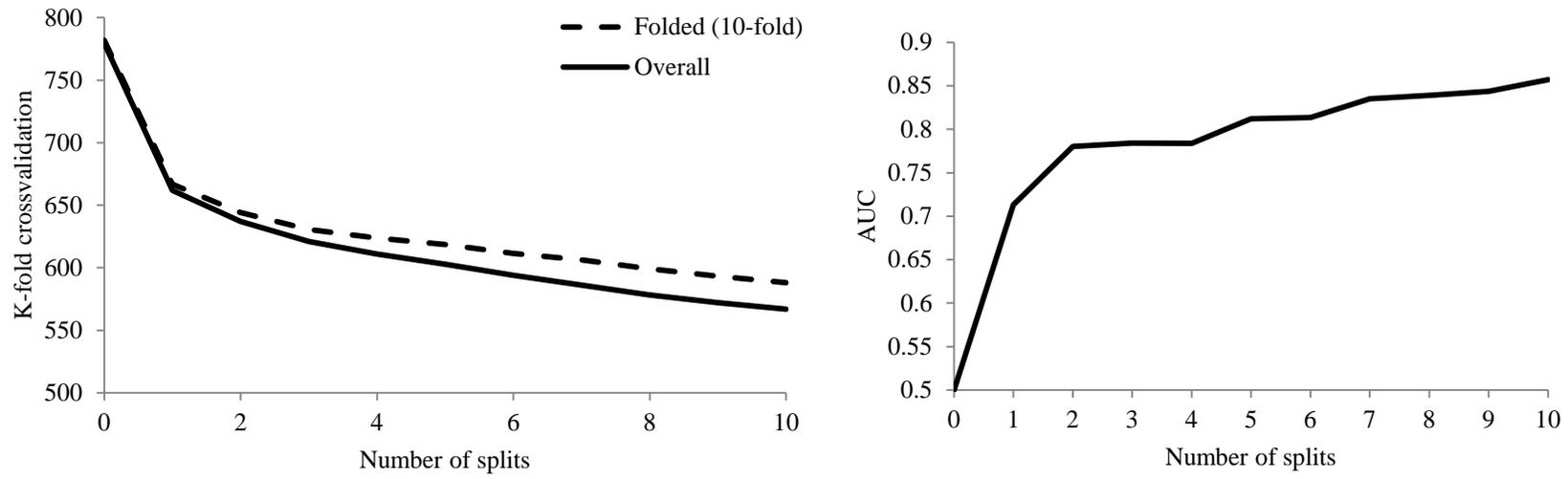
Figure 2. Overall model fit for decision tree as determined by a) K-fold cross-validation, and b) AUC

Table 2. Logistic regression using baseline characteristics to predict follow-up suicidal ideation

	AOR	95% CI	p
Demographics:			
Age	1.00	0.96-1.05	.905
Gender			
Male	1.00	-	
Female	0.85	0.36-2.01	.707
Marital status			
Married/de facto	1.00	-	
Divorced/separated/never married	0.85	0.37-1.95	.702
Widowed	1.07	0.55-2.07	.852
Employment status			
Retired	1.00	-	
Employed/unemployed	0.76	0.44-1.32	.335
Household income			
Less than $20,000	1.00	-	
$20,000-$39,999	0.52	0.28-0.96	.035
$40,000-$69,999	0.84	0.41-1.68	.614
$70,000+	0.25	0.09-0.75	.013
Age pension			
No	1.00	-	
Yes	1.54	0.90-2.65	.114
Psychological health:			
K10 psychological distress	1.14	1.10-1.18	<.001
Alcohol use			
Low/moderate use	1.00	-	
Non-drinker	1.00	0.54-1.86	.994
Hazardous use	2.88	1.49-5.54	.002
Self-reported physical health:			
Number of chronic illnesses	0.95	0.69-1.32	.778
Musculoskeletal condition	1.12	0.59-2.15	.724
Respiratory condition	1.32	0.69-2.74	.359
Cardiovascular condition	0.61	0.29-1.25	.172
Cardiovascular risk factor	0.91	0.47-1.76	.780
Thyroid problem	1.43	0.62-3.32	.402
SF-36 physical functioning	0.99	0.98-1.00	.132
Clinic measures:			
Body mass index			
Normal weight	1.00	-	
Overweight	0.74	0.36-1.55	.424
Obese	0.98	0.47-2.03	.953
Grip strength	0.99	0.96-1.04	.773
Systolic blood pressure	1.00	1.00-1.01	.426
Lung function	0.96	0.21-4.53	.962
Social support:			
Social interaction	0.87	0.74-1.03	.107
Satisfaction with social support	0.88	0.81-0.97	.008

Note: K10, Kessler-10; AOR, Adjusted Odds Ratio; SF-36, Short Form Health Survey – 36 item version; CI, Confidence Interval; reported p values are from Wald $\chi^2_{(1)}$ tests; overall logistic regression: Wald $\chi^2_{(26)} = 200.36$, $p < .001$.