ORIGINAL ARTICLE

Suicide and Life-Threatening BEHAVIOR

Understanding suicidality in Pacific adolescents in New Zealand using network analysis

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Abstract

Introduction: Pacific adolescents in New Zealand (NZ) are three to four times more likely than NZ European adolescents to report suicide attempts and have higher rates of suicidal plans. Suicidal thoughts, plans, and attempts, termed suicidality in this study, result from a complex dynamic interplay of factors, which emerging methodologies like network analysis aim to capture.

Methods: This study used cross-sectional network analysis to model the relationships between suicidality, self-harm, and individual depression symptoms, whilst conditioning on a multi-dimensional set of variables relevant to suicidality. A series of network models were fitted to data from a community sample of New Zealand-born Pacific adolescents ($n = 550$; 51% male; Mean age (SD) = 17 (0.35)).

Results: Self-harm and the depression symptom measuring pessimism had the strongest associations with suicidality, followed by symptoms related to having a negative self-image about looks and sadness. Nonsymptom risk factors for self-harm and suicidality differed markedly.

Conclusions: Depression symptoms varied widely in terms of their contribution to suicidality, highlighting the valuable information gained from analysing depression at the symptom-item level. Reducing the sources of pessimism and building self-esteem presented as potential targets for alleviating suicidality amongst Pacific adolescents in New Zealand. Suicide prevention strategies need to include risk factors for self-harm.

KEYWORDS

adolescents, network analysis, pessimism, psychopathology, self-harm, suicidality

INTRODUCTION

According to the World Health Organization, suicide is the fourth leading cause of death among 15–19-year-olds (World Health Organization, 2020). This problem is particularly acute in New Zealand (NZ), which had the highest teen (aged 15–19) suicide rate in the Organisation for Economic Co-operation and Development (OECD), in a 2017 report (OECD, 2017). A recent investigation into youth mental health in NZ referred to adolescents as experiencing a rising "pandemic of psychological distress" (Menzies et al., 2020, p2).

Suicidal thoughts, plans, and attempts are consistent predictors of future suicide attempts (Coppersmith et al., 2017; Franklin et al., 2017; Goldston et al., 1999), and suicidal thoughts and attempts have been found to predict suicide death (Beghi et al., 2013; Bilsen, 2018; Chan et al., 2016; Franklin et al., 2017; Hubers et al., 2018). Therefore, a better understanding of suicidal thoughts, plans and attempts, defined in this study as suicidality, is the prerequisite of any effective suicide prevention strategy. Indeed, Jobes and Joiner (2019) believe more interventions should be directed at suicide ideation as an intervention target, independently of suicide attempts. Reinherz et al. (2006) found those with suicide ideation in adolescence were around 12 times more likely to have attempted suicide by the time they were 30, compared to those without suicide ideation. Although the overwhelming majority of those who think about, plan or attempt suicide do not usually die by suicide, adolescent suicidality is associated with many behaviors that significantly impact health and quality of life, such as substance abuse, aggression, irritability, and higher school dropout rates (Bousono et al., 2017; Daniel et al., 2006; Miotto et al., 2003; Orri et al., 2019).

THE PACIFIC POPULATION IN NEW ZEALAND

The Pacific population in NZ comprises those whose heritage traces back to various Pacific islands, with the largest groups from Samoa (48%), Tonga (22%), and the Cook Islands (21%), and also includes Niue (8%), Fiji (5%), Tokelau (2%), Tuvalu Islands (1.2%), and Kiribati (0.8%) (Statistics New Zealand, 2018). Overall, around 8% of the NZ population identify as being of Pacific origin. The Pacific population in NZ is highly urbanized, with around two thirds living in the Auckland region, and youthful, with a median age of 23 years compared with 38 years for the NZ national average (Statistics New Zealand, 2018). Pacific people in NZ are generally more religious than New Zealanders overall, with 23% of Pacific New Zealanders stating they have no religion, compared to the national average of 48%. Pacific New Zealanders maintain strong cultural roots with their Pacific homelands, and although each island community has its own distinct characteristics, Pacific people share several cultural values, including spirituality, collectivism, importance of family, and behaving respectfully, particularly toward elders and people in positions of authority (Ministry for Pacific Peoples, 2022). They add a vibrance and cultural richness to New Zealand in many ways, including but not limited to their contributions to music and art, and their celebrations of pan-Pacific culture through the festivals Polyfest, which also celebrates Māori culture, and Pasifika Festival. Unfortunately, they experience socio-economic deprivation at above average levels; for example, they are over-represented in the Auckland's poorest suburbs (Ministry of Health, 2021) and a recent survey found that 37% of Pacific children live in severe to moderate food insecure households compared to 19% for NZ children overall (Ministry of Health, 2019). Pacific adolescents in NZ are vulnerable to suicidality, particularly suicide attempts, and are around three to four times more likely to report attempted suicide than NZ European adolescents[1] (Fa'alili-Fidow et al., 2016;

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[1]Māori adolescents in New Zealand are also more likely to report attempted suicide compared to NZ Europeans (Fleming, T., Tiatia-Seath, J., Peiris-John, R., Sutcliffe, K., Archer, D., Bavin, L., Crengle, S., & Clark, T. (2020). Youth19 Rangatahi Smart Survey, initial findings: Hauora hinengaro/emotional and mental health. *The Youth19 Research Group, The University of Auckland and Victoria University of Wellington, New Zealand.*, ibid). While this is of concern, Māori adolescents are not the focus of this research.

Fleming et al., 2020). They also have higher rates of reported suicide plans (Fortune et al., 2010) and are much less likely to access professional medical help (Helu et al., 2009).

RISK FACTORS FOR SUICIDALITY

As with other mental disorders, suicidality appears to result from the complex and dynamic interplay of factors from across many life domains, rather than as the result of a single stressor (Fonseca-Pedrero et al., 2022). Findings from published studies are often contradictory, and it has been suggested that conflicting results could be the result of indirect associations and comorbidity (Goldston, 2004). However, depression and deliberate self-harm have been consistently associated with adolescent suicidality in both cross-sectional and longitudinal research (Coppersmith et al., 2017; Franklin et al., 2017; Galaif et al., 2007; Goldston et al., 1999; Macalli et al., 2021), including in a large meta-analysis (Gillies et al., 2018). Furthermore, the association strengthens as incidences of self-harm increase (Gillies et al., 2018). Other factors commonly found to be associated with adolescent suicidality include psychological disorders and problems, such as anxiety and hopelessness (e.g., Ayub, 2009; Elledge et al., 2021; Macalli et al., 2021); low self-esteem (e.g., Fonseca-Pedrero et al., 2020), health risk behaviors (such as substance use and sexual activity) (e.g., Hallfors et al., 2004; Kuroki, 2015), behavioral issues (such as impulsivity and delinquency) (e.g., Fonseca-Pedrero et al., 2022; Hawton et al., 2012), low socio-economic status (e.g., Navarro et al., 2021), bullying (e.g., Fonseca-Pedrero et al., 2022), a lack of connectedness with family, friends, school, and peers (e.g., Consoli et al., 2013; Whitlock et al., 2014), pain (Hinze et al., 2019), and poor self-rated health (Nkansah-Amankra et al., 2010). Teevale et al. (2016) found that risk factors for suicide attempts among Pacific adolescents in NZ were being female, food insecurity, poor family connections and monitoring, life dissatisfaction, having a religious affiliation, and having a family member or friend attempt or die by suicide. Conversely, higher levels of family monitoring were found to be protective (Teevale et al., 2016). Another study, using data from Pacific adolescents presenting at hospital after a suicide attempt, found that family or relationship stress were major precipitants for suicide attempts among Pacific adolescents in New Zealand (Aoelua, 2019).

THE NETWORK APPROACH TO PSYCHOPATHOLOGY

Networks are a highly visual and versatile graphical tool, consisting of nodes and edges, suitable for displaying and investigating complex interactions among groups of variables that operate like systems (Barabási, 2012). For example, using network analysis, relationships among the explanatory variables can be identified as well as, direct and indirect associations with variables of interest (De Beurs et al., 2019). The use of network analysis in the field of psychology has gained traction over the last 10 years, inspired by the development of the network approach to psychopathology (Borsboom, 2017; Borsboom & Cramer, 2013) and advances in the development of statistical models and software (Epskamp, 2020; Haslbeck & Waldorp, 2020; Williams & Mulder, 2020). In psychological networks, nodes represent the study variables and edges the pairwise conditional relationships between them (Borsboom et al., 2021). According to the network approach to psychopathology, the symptoms and their interactions constitute the mental disorder, rather than being the manifestations of a common, underlying cause (Borsboom, 2017). The impact of symptoms on mental disorders is very heterogeneous (Fried et al., 2014; Gossage et al., 2022; Lux & Kendler, 2010). In a study on the effect of individual depression symptoms on psychosocial impairment, for example, Fried and Nesse (2014) found that the relative importance of symptoms (as measured by contribution of variance explained) on impairment ranged from 20.9% for Sad mood to 0.7% for Hypersomnia. Consequently, summing symptom scores to create a single latent construct leads to a loss of potentially valuable information and insight that could be used to aid the design of interventions (Borsboom & Cramer, 2013; Fried & Nesse, 2015).

The present study used network analysis to gain a deeper understanding of how individual depression symptoms and self-harm contributed to suicidality in a sample of Pacific NZ adolescents, while allowing for the impact of a wide range of multidimensional variables (variables related to family, school, health, socio-economic factors, risky behaviors, church, Pacific identity, resilience, behavioral problems, internet use, and peer relationships) found to be associated with suicidality in previous research (see Risk factors for Suicidality).

Network models have been shown to differ among races and ethnicities (Christian et al., 2021; Kim et al., 2021; Wasil et al., 2020). For example, in a study using network analysis to investigate depression symptoms and substance use among Indian adolescents, Wasil et al. (2020) found that the symptom relating to "Feeling like a failure" had a much more central role than in another similar study with U.S. adolescents (Mullarkey et al., 2019), where "Self-hatred" occupied a more central position. Wasil et al. (2020) proposed that it was the more collectivist culture in Indian society coupled with family pressure to achieve that was

driving this difference. Kim et al. (2021), in a study of depression symptom networks among Korean children and adolescents, also believed that the more collectivist culture in South Asian countries was resulting in symptoms relating to school difficulties being more central in their network compared to the study by Mullarkey et al. (2019). Therefore, if network analysis is to fulfill its potential as an aid to clinical decision making, these decisions need to be based on culturally and ethnically relevant networks.

The key contributions of this work are twofold. Primarily, it is the first time that network analysis has been used to investigate suicidality in Pacific adolescents, inside or outside NZ, to date. Secondly, to date this is the first study to use network analysis to investigate the impact of self-harm and individual depression symptoms on adolescent suicidality, while conditioning on such a diverse set of variables, variables covering almost every aspect of an adolescent's life. Including a wide range of relevant variables reduces the risk that an association between two variables is really the result of both variables being associated with a third variable, that is absent from the network (Jones et al., 2017). This study is exploratory in nature and not associated with a formal hypothesis.

METHODS

Sample

The present study used data collected during the 17-year wave of the Pacific Island Families (PIF) Study, between 2017 and 2018, when the participants turned 17. The PIF study is an ongoing longitudinal study of a birth cohort of 1398 Pacific children born at a South Auckland hospital in NZ in the year 2000 (Paterson et al., 2008). Eligibility criteria for the PIF Study included having at least one parent who identified as being of a Pacific ethnicity and was a permanent resident of NZ. The PIF Study has been guided by the Pacific People's Advisory Group and approved by Auckland University of Technology Ethics Committee (AUTEC) (references 17/26 and 19/364 apply). To date, data have been collected at regular intervals from 6 weeks to 20 years of age.

Of the 632 participants who took part in the 17-year wave of the PIF Study, 82 participants were excluded due to having missing data for more than 30% of items on the psychometric inventories used, leaving a final sample of 550 participants. Data were imputed on the remaining missing data points using a multiple imputation method missForest (Stekhoven & Bühlmann, 2012) (Refer Table S1 for more details of participant characteristics

pre and post data imputation, and Appendix S1 for more information on missing data analysis and the imputation strategy).

Measures

This study used a binary measure of *Suicidality*[2] based on the self-report answers to three questions:

1. "Have you seriously thought about killing yourself (attempting suicide)?"
2. "Have you made a plan to kill yourself (attempt suicide)?"
3. "Have you tried to kill yourself (attempted suicide)?"

Possible responses were "Not at all", "Not in the last 12 months", "Once or twice", or "Three or more times". If the responses to all three questions were "Not at all" or "Not in the last 12 months", then participants were coded as 0 for *Suicidality*; all other responses were coded as 1. The restriction to the last 12 months was to keep the time frame consistent with the question relating to *Self-harm*, and the collapsing of the levels "Once or twice" with "Three or more times" was due to small cell counts in the final level ("Three or more times").

Self-harm was measured as a separate construct to *Suicidality*, as definitions of what constitutes self-harm has a cultural contextual. For Pacific people in New Zealand, it may include harm to mental or spiritual self, as well as deliberate harm to the physical self (Dash et al., 2017). It was assessed with a single question: "During the last 12 months, have you deliberately hurt yourself or done anything you knew might have harmed you (but not kill you)? Answers were grouped into 3 levels: Level 1 = No, Level 2 = Once, and Level 3 = Two times or more.

Depression was assessed using the shorter version of the Children's Depression Inventory (CDI:S) (Kovacs & Preiss, 1992) and analyzed in terms of individual symptoms. The CDI:S is a ten-item, reliable depression scale suitable for youths aged 7 to 17 years (Klein et al., 2005). Participants were asked to score each item from 1 to 3 to reflect how they felt about the item over the last two weeks. After reverse scoring positively worded items, higher symptom scores denoted higher symptom severity. Depression symptoms were modeled as continuous.

The socio-demographic variables of *Gender*, *Ethnicity*, and socio-economic deprivation were included in the

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[2]When variables from this study are referred to in the text, they are denoted by capital first letter and italics, for example *Suicidality*, to differentiate them from general use of such terms and constructs.

study. The level of socio-economic deprivation was assessed with a self-reported measure of food insecurity, *Money for food* (Ramsey et al., 2012), where participants were asked how often their parents or guardians ever worried about having enough money to buy food. Due to the nature of the cohort, all participants were very close in age ($M = 17.0$, SD = 0.35); therefore, age was not included as a variable. All these socio-economic variables were modeled as categorical.

The following variables were measured using psychometric inventories: *Relationship with mother*, *Relationship with father*, *Relationship with friends*, *Impulsivity*, *Delinquency*, *Negative peer influence*, *Gang involvement*, *Resilience*, and Pacific identity, which was measured with the following subscales: *Cultural Efficacy* (*CE*), *Group Membership Evaluation* (*GME*), *Religious Centrality and Embeddedness* (*RCE*), and *Pacific Connectedness and Belonging* (*PCB*). All these variables were modeled as continuous, with higher scores denoting a higher endorsement of the construct, apart from *Gang involvement*, which was binary, with a score of 1 corresponding to a "Yes" for *Gang involvement*. Confirmatory Factor Analysis (CFA) was performed on the items making up each inventory, using the R package Lavaan (Rosseel, 2012), to check whether they supported a single factor solution or a set of subscales. (Refer Table S2 for details of the psychometric inventories used and the results of the CFA.)

Other variables used in the analysis included *Church attendance*, *Binge drinking*, *Smoke cigarettes, Take drugs*, (for example, party pills, smoke marijuana), *Had sex, Hours online, Online bullying—victim, Online bullying—perpetrator, Attend school, Part of school*[3], *Get along with teachers,*[3] Body mass index (*BMI*), *Health, Energy levels*, and *Self-assessed weight*. All these variables were modeled as categorical, apart from *BMI*, which was continuous. Weight and height measurements, used to calculate *BMI*, were taken by the study assessors, otherwise all data were self-reported by the adolescents but in the presence of trained Pacific assessors.

Refer Table S3 for more details of the study variables.

Statistical analysis

Statistical analysis was completed using statistical software R (R Core Team, 2020) augmented by various R packages, with alpha = 0.05 being the statistical significance threshold, where relevant.

Missing data

The Kolmogorov–Smirnov (KS) test was used to compare the distributions of continuous variables, pre and post imputation (Abayomi et al., 2008) and Pearson's chi-square test of homogeneity for categorical variables (Reis et al., 1999).

Bivariate tests

Bivariate associations with *Suicidality* were investigated using the two sample Wilcoxon Rank Sum test for the continuous variables (which all had moderate to severe skewed distributions) (Appendix S2 for histograms of the continuous variables), and Pearson's chi-square test for categorical variables. Multiple testing was adjusted using the Holm-Bonferroni method (Holm, 1979).

Network estimation and visualization

Cross-sectional network analysis was used to identify conditional, pairwise associations among the study variables. As the data contained categorical, ordinal, and continuous numeric variables, mixed graphical models were used to estimate the networks using the R package *mgm*, which is suitable for the network modeling of data of different types (Haslbeck & Waldorp, 2020). If two nodes shared an edge there existed a statistical relationship between them, conditional on all other variables in the network. "Conditional on all other variables" in this context means that an edge between two variables cannot be explained away by any of the other variables included in the network.[4] If they did not share an edge, they were conditionally independent. The mgm-package uses neighborhood nodewise regression to estimate parameters, which are then combined into an edge weight (w), an absolute value that quantifies the strength of an association (Appendix S3 for more details about how the parameters are estimated and combined into edge weights). To control for spurious edges, mgm uses least absolute shrinkage and selection operator (LASSO) (Tibshirani, 1996); small edge weights are shrunk to zero via a penalty parameter lambda, and non-zero estimates are shown by the presence of an edge. In this study lambda was selected using 10-fold cross validation (CV) (Haslbeck & Waldorp, 2020).

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[3]For those students that had left school, questions about school were asked in the past tense, for example, 'How well did you get along with your teachers when you were at school?' and the answers combined with those students that were still at school.

[4]For example, if we have a chain graph A-B-C, then A and C are marginally dependent through B. However, when conditioning on all other variables (here only B), then A and C are conditionally (on B) independent. For more information on conditional independence see Dawid, A. P. (1979). Conditional independence in statistical theory. Journal of the Royal Statistical Society: Series B (Methodological), 41(1), 1–15.

The network models were visualized using the R package qgraph (Epskamp et al., 2012). Blue edges depicted positive associations, red edges negative ones, and gray edges showed that the nature of the association could not be displayed in the network graph (because it involved a categorical variable with three levels or more) but could be discerned with post hoc investigation. Odds ratios were used to estimate the characteristics of the association between *Suicidality* and *Self-harm*, as is common with binary and categorical variables (Szumilas, 2010). Node placement was controlled using Fruchterman-Reingold algorithm, which aims to place highly connected nodes at the center of the network (Kobourov, 2012).

Before fitting the networks, continuous variables were transformed using a nonparanormal (npn) transformation (Liu et al., 2009), as their distributions were skewed (Appendix S2), using the R package Huge (Zhao et al., 2012). Therefore, the associations shown in the networks involving continuous variables relate to the transformed data. Goldbricker function in the R package networktools (Jones, 2020) was used to test for redundant nodes; these are nodes that are too topologically similar to each other, which can interfere with network estimation accuracy (Appendix S3 for more details on how goldbricker identifies redundant nodes).

Nodewise predictability

Nodewise predictability was computed using methods available in the mgm package (Haslbeck & Waldorp, 2018). Predictability captures how well a given node can be predicted by its neighbors. For continuous variables, nodewise predictability was measured using R-squared, and for categorical variables it was measured both in terms of classification accuracy for the whole model, which includes the intercept model, and the additional accuracy over and above the intercept model, that is attributable to neighboring nodes[5] (refer Appendix S3 for more details of what these measures represent).

Network reliability

Pairwise edge reliability was assessed by calculating edge inclusion probabilities derived from 200 non-parametric

bootstrap samples (Haslbeck & Waldorp, 2020). A high inclusion probability of a given edge across bootstrap samples provides evidence for this edge being present in the population (Fried et al., 2020; Haslbeck & Waldorp, 2020). In addition to inclusion probabilities we also summarized the bootstrapped sampling distributions by calculating quantiles, which allow one to get a more detailed picture of the accuracy of the parameter estimates. However, bootstrap quantiles from LASSO estimates cannot be interpreted in the same way as a traditional confidence interval (CI) where a zero in the CI indicates that the true estimate is not different to zero, because LASSO estimates are biased toward zero (Bühlmann et al., 2014; Burger et al., 2020; Epskamp et al., 2018). Therefore, probability inclusion rates were used to discern the robustness of a pairwise association. The width of a bootstrap quantile, however, can be used to give a measure of parameter accuracy (Epskamp et al., 2018).

RESULTS

Overall, 17.1% of the analysis sample reported *Suicidality*. This variable broke down as follows: suicidal thoughts 16.0%, suicide plans 9.8%, and suicide attempts 5.5% (there was overlap between these categories and so they do not sum to 17.1%). *Suicidality* primarily consisted of those having suicidal thoughts (94.2%). The majority of those reporting *Suicidality* were female (64%). Around 21% of the analysis sample reported self-harming once or more in the last 12 months, with females making up 62% of these.

See Table 1 for the summary characteristics of the analysis sample. There were no differences between the original sample ($N = 632$) and the analysis sample ($n = 550$), based on the results of the KS test and Pearson's chi-square test (Table S1).

Distribution of variables conditioned on suicidality

In the bivariate analyses, after adjusting for multiple testing, *Suicidality* was significantly associated with *Self-harm* (self-harmed once or more), *Gender* (female), *Smoke cigarettes* (yes), *Take drugs* (yes), *Part of school* (no); significantly lower mean scores for *Relationship with mother*, *Relationship with father*, *Relationship with friends*, and *GME* (*Group Membership and Belonging*); and higher mean scores for *Negative peer pressure*, *Impulsivity*, and all depression symptoms (Table S3 for details of total distributions and distributions conditioned on *Suicidality*, including p-values, for all study variables).

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[5]Predictability of a node by neighboring nodes is the same as the predictability of a node by all nodes in the network. This is because all nodes that are not in the neighborhood of given node have a zero-weight associated to them (Haslbeck, J. and L.J. Waldorp, How well do network models predict observations? On the importance of predictability in network models. Behavior Research Methods, 2018. 50(2): p. 853–861).

TABLE 1 Participant summary characteristics.

Variables (*variable name*)	Analysis sample[a] n = 550
Demographics	*n* (%)
Gender[b]	
Female	270 (49.1%)
Male	280 (50.9%)
Ethnicity	
Samoan	263 (47.8%)
Tongan	129 (23.5%)
Cook Islands Māori	80 (14.5%)
Other Pacific Island[c]	35 (6.4%)
Other[d]	43 (7.8%)
How often parents worry about having enough money for food (*Money for food*)[e]	
Never	162 (29.5%)
Sometimes	228 (41.4%)
Often	82 (14.9%)
All the time	78 (14.2%)
Do you still attend school (*Attend school*)	
Yes	483 (87.9%)
No	67 (12.1%)
Depression, Suicidality and Self-harm	
Suicidality	
In the last 12 months have you thought about, made plans or attempted suicide?	
Yes	94 (17.1%)
No	456 (82.9%)
Self-harm	
During the last 12 months, have you deliberately hurt yourself or done anything you knew might have harmed you (but not kill you)?	
Yes—twice or more	64 (11.6%)
Yes—once	53 (9.6%)
No	433 (78.8%)
Depression symptoms[f]	Mean (SD)
Negativity towards looks	1.49 (0.64)
Irritability	1.46 (0.65)
Pessimism	1.33 (0.50)
Loneliness	1.25 (0.50)
Sadness	1.21 (0.45)
Self-criticism	1.20 (0.42)
Crying	1.17 (0.43)
Self-hatred	1.15 (0.39)
Feels unloved	1.13 (0.35)
Lack of friendship	1.13 (0.39)

TABLE 1 (Continued)

[a]The sample after removal of those participants with more than 30% missing data for items on the psychometric inventories.

[b]The gender data used in this study were self-identified and collected in the 14-year wave as no gender data were collected in the 17-year wave. Participants were given the options of male, female or pass/don't know. The response of "pass/don't know" was treated as missing data as cell counts for this response were very small.

[c]This group was made up of those who identified as Tokelauan, Niuean, or Fijian.

[d]This group was made up of those who identified as Pākehā (European New Zealanders), Māori or multiple Pacific groups equally.

[e]The level of socio-economic deprivation was assessed with a self-reported measure of food security, *Money for food*.

[f]The range for all depression symptom scores was from 1 to 3.

Network estimation

In a network comprising depression symptoms, *Suicidality*, and *Self-harm*, Goldbricker identified *Self-harm* and *Suicidality* as too topologically similar and recommended the removal of *Self-harm*. However, as *Self-harm* was theoretically important to the study, depression symptom networks were fitted with and without *Self-harm*. When all other non-symptom variables were added to the network, Goldbricker detected *PCB* as too topologically similar to both *CE and GME*, and *Relationship with father* with *Relationship with mother*, but not *Self-harm* with *Suicidality*. Goldbricker recommended the removal of *PCB* and *Relationship with father*. To monitor the effect that removing *PCB* and *Relationship with father* would have on findings, networks were fitted with and without those variables. Therefore, in total, four networks were estimated:

1. Network A—all depression symptoms and *Suicidality*
2. Network B—all depression symptoms, *Self-harm*, and *Suicidality*
3. Network C—all depression symptoms, *Self-harm*, *Suicidality*, and all other non-symptom variables except for *PCB* and *Relationship with father*
4. Network D—all depression symptoms, *Self-harm*, *Suicidality*, and all other non-symptom variables

Details of edge weights, inclusion probabilities, and bootstrap quantiles for the variables associated with *Suicidality* for all networks are reported in Table 2. Tables of predictability statistics and weighted adjacency matrices for all networks are available in (Tables S4 and S5 (Network A), Tables S6 and S7 (Network B), Tables S8 and S9 (Network C), and Tables S10 and S11 (Network D)).

TABLE 2 Edge weights, Inclusion probabilities, and Bootstrapped 95% quantiles for pairwise associations with Suicidality.

Network index	Variables associated with *suicidality*	Edge weight	Nature of association	Inclusion probabilities[c]	Bootstrapped 5%, 95% quantiles
Network A	*Pessimism*	0.30	+ve	99%	0.12, 0.42
	Negativity towards looks	0.19	+ve	94%	0, 0.32
	Sadness	0.17	+ve	94%	0, 0.32
	Loneliness	0.12	+ve	80%	0, 0.25
	Lack of friendship	0.12	+ve	68%	0, 0.32
	Crying	0.10	+ve	73%	0, 0.24
	Self-hatred	0.09	+ve	62%	0, 0.24
	Irritability	0.08	+ve	58%	0, 0.22
	Feels unloved	0.06	+ve	61%	0, 0.23
Network B	*Self-harm*	0.61	na[b]	100%	0.41, 0.84
	Pessimism	0.31	+ve	99%	0.13, 0.46
	Negativity towards looks	0.16	+ve	68%	0, 0.29
	Sadness	0.14	+ve	61%	0, 0.29
	Irritability	0.10	+ve	54%	0, 0.24
Network C	*Self-harm*	0.51	na[b]	100%	0.36, 0.82
	Pessimism	0.24	+ve	87%	0, 0.41
	Take drugs	0.13	+ve	54%	0, 0.53
	Sadness	0.11	+ve	45%	0, 0.31
	Negativity towards looks	0.10	+ve	44%	0, 0.26
	Part of school	0.12	−ve	31%	−0.60, 0
	Relationship with mother	0.09	−ve	34%	−0.25, 0
	Hours online[a]	0	na[b]	66%	0, 0.27
	Money for food[a]	0	na[b]	65%	0, 0.30

[a]These edges were not present in the network but recovered in the bootstrap resamples.

[b]The sign for categorical variables with more than two levels cannot be shown visually in the network graph, but more information about the nature of the association was extracted from post hoc testing (see section Network C (Depression symptoms, Self-harm, other non-symptom variables (except Relationship with father and PCB), and Suicidality)).

[c]Inclusion probabilities and bootstrapped quantiles were estimated with 200 resamples of data from the relevant network.

Network A (depression symptoms and suicidality)

In Network A, the strongest and most reliable association with *Suicidality* was *Pessimism* (w = 0.30, Inclusion probability 99%, Bootstrapped 95% quantiles [0.12, 0.42]), followed by *Negativity towards looks* (w = 0.19, Inclusion probability 94%, Bootstrapped 95% quantiles [0, 0.32]), *Sadness* (w = 0.17, Inclusion probability 94%, Bootstrapped 95% quantiles [0, 0.32]), and *Loneliness* (w = 0.12, Inclusion probability 80%, Bootstrapped 95% quantiles [0, 0.25]). These symptoms were positively associated with *Suicidality*, meaning they were potential risk indicators for *Suicidality*. *Suicidality* was directly associated with all other depression symptoms, except for *Self-criticism*, but with inclusion probabilities of less than 80%. *Suicidality* had a whole model predictability of 0.85 (intercept model = 0.83). See Figure 1 for the network graph.

Network B (depression symptoms, self-harm, and suicidality)

In Network B, the strongest and most reliable association with *Suicidality* was *Self-harm* (w = 0.61, Inclusion probability 100%; Bootstrapped 95% quantiles [0.41, 0.84]), followed by *Pessimism* (w = 0.31, Inclusion probability 99%; Bootstrapped 95% quantiles [0.13, 0.46]). *Suicidality* was also associated with *Negativity towards looks*, *Sadness*, and *Irritability*, but with inclusion probabilities of less than 70%. All these symptoms were potential risk indicators for *Suicidality*. *Suicidality* had a whole model predictability of 0.86 (intercept model = 0.83). See Figure 2 for the network graph.

The odds of reporting *Suicidality* increased as incidences of *Self-harm* increased, with an odds ratio (OR) of 3.3 for those in level 2 of *Self-harm* (self-harmed once), rising to 5.8 for those in level 3 (self-harmed twice or
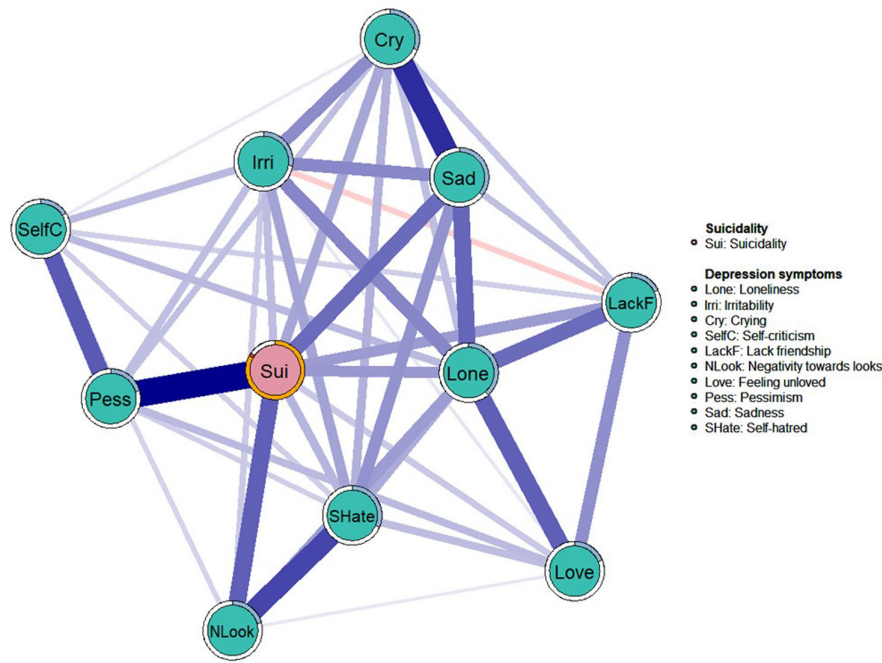
FIGURE 1 Network A, showing pairwise associations between depression symptoms and *Suicidality*, n = 550. Wider and more color-saturated edges depict stronger associations and the color the nature of the association between two nodes: blue represents a positive association and red a negative association. The predictability of each node is shown by the shaded pie segment. This is light blue for continuous variables (depression symptoms) and displays the value of R-squared; and for the categorical variable (*Suicidality*), the yellow part of the segment represents the proportion of correct classification of the intercept model, the red part the improvement beyond this proportion attributable to neighboring nodes, and the sum of both segments represents the proportion of correct classification of the whole model.

more), compared to the reference level (level 1) of no self-harming, all relevant to the last 12 months.

The strongest and most reliable associations with *Self-harm* (apart from *Suicidality*) were *Sadness* (w = 0.10, Inclusion probability 91%; Bootstrapped 95% quantiles [0, 0.26]), and *Negativity towards looks* (w = 0.10, Inclusion probability 87%; Bootstrapped 95% quantiles [0, 0.26]); and with *Pessimism* (apart from *Suicidality*) were *Self-criticism* (w = 0.19, Inclusion probability 99.5%; Bootstrapped 95% quantiles [0.11, 0.25]), and *Feeling unloved* (w = 0.08, Inclusion probability 81%; Bootstrapped 95% quantiles [0, 0.15]).

Network C (depression symptoms, self-harm, other non-symptom variables (except relationship with father and PCB), and suicidality)

In Network C, the strongest and most reliable association with *Suicidality* was *Self-harm* (w = 0.51, Inclusion probability 100%, Bootstrapped 95% quantiles [0.36, 0.82]), followed by *Pessimism* (w = 0.24, Inclusion probability 87%, Bootstrapped 95% quantiles [0, 0.41]). *Suicidality* was

also positively associated with *Negativity towards looks, Sadness* and *Take drugs*; and negatively with *Relationship with mother* and *Part of school*, but these associations were much less reliable, with inclusion probabilities of 54% or less. Based on the results of the bootstrapped resamples, *Suicidality* was associated with *Hours online* and *Money for food*, with inclusion probabilities of 66% and 65%, respectively. *Suicidality* had a whole model predictability of 0.87 (intercept model = 0.83). See Figure 3 for the network graph.

As with Network B, the OR for reporting *Suicidality* rose as incidences of *Self-harm* rose. It was 2.4, for those in level 2 of *Self-harm*, rising to 4.0 for those in level 3, compared to the reference level (level 1).

The strongest and most reliable associations with *Self-harm*, apart from *Suicidality*, were *Gender* (w = 0.19, Inclusion probability 94%; bootstrapped 95% quantiles [0, 0.47]); *Negative peer pressure* (w = 0.18, Inclusion probability 89%; bootstrapped 95% quantiles [0, 0.32]); and *Bullied online—victim* (w = 0.15, Inclusion probability 81%; bootstrapped 95% quantiles [0, 0.59]); and with *Pessimism* were *Self-criticism* (w = 0.17, Inclusion probability 99%; bootstrapped 95% quantiles [0.12, 0.26]) and *Binge drinking* (w = 0.12, Inclusion probability 87%; bootstrapped 95% quantiles [0, 0.27]).
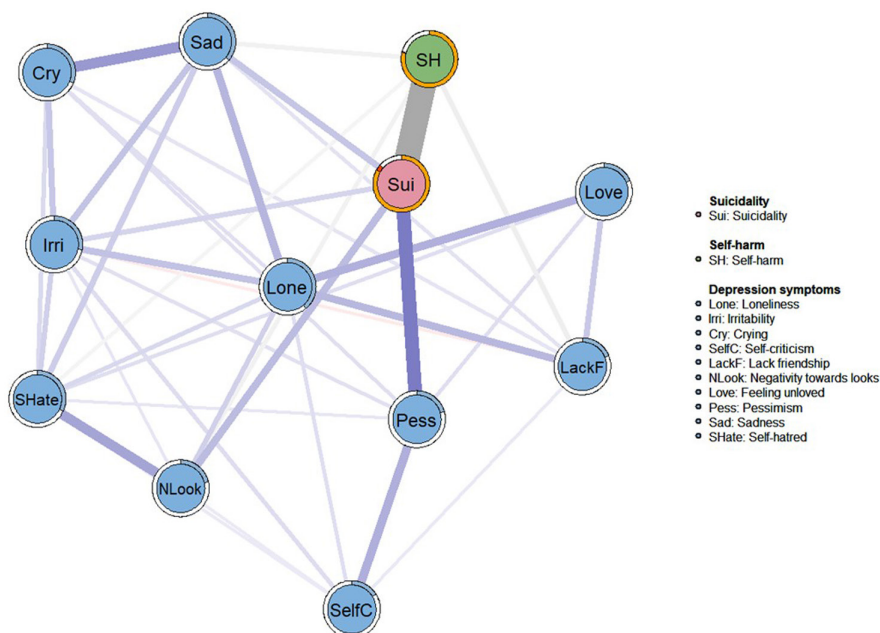
FIGURE 2 Network B, showing pairwise associations between depression symptoms, *Self-harm*, and *Suicidality*, *n* = 550. Wider and more color-saturated edges depict stronger associations and the color the nature of the association between two nodes: blue represents a positive association, red a negative association, and gray means the nature of the association cannot be displayed in the network graph but is discoverable from post hoc investigation. The predictability of each node is shown by the shaded pie segment. This is light blue for continuous variables (depression symptoms) and displays the value of R-squared; and for the categorical variables (*Suicidality* and *Self-harm*), the yellow part of the segment represents the proportion of correct classification of the intercept model, the red part the improvement beyond this proportion attributable to neighboring nodes, and the sum of both segments represents the proportion of correct classification of the whole model.

Network D (depression symptoms, self-harm, all non-symptom variables, and suicidality)

In Network D, the associations with *Suicidality* were identical to those in Network C, apart from very small changes in edge weights.

DISCUSSION

The present study used network analysis to gain a deeper understanding of how individual depression symptoms and self-harm contributed to suicidality in a sample of Pacific NZ adolescents, while allowing for the impact of a range of other variables found to be associated with suicidality in previous research. Key results of the study were the differences in the contribution of individual depression symptoms to *Suicidality*, and the strength of the association with *Pessimism*. Other noteworthy findings were the consistent associations between *Suicidality* and *Negativity towards looks* and *Sadness*, and the differences in the non-symptom potential risk indicators for *Suicidality* compared to *Self-harm*.

Pessimism was the strongest and most reliable risk indicator for *Suicidality*, other than *Self-harm*, across all networks. Pessimism, as measured by a single item on a depression inventory as in this study, has been found to be associated with adolescent suicide ideation in two recent network analyses (Gijzen et al., 2021; Núñez et al., 2018). Of note was the association between suicide ideation and pessimism being weaker in the Gijzen et al. (2021) study compared to both the present study and the one by Núñez et al. (2018). Complementarily, optimism, as measured by Life Orientation Test-Revised (LOT-R) (Scheier et al., 1994), has been found to be protective against suicidality (Yi et al., 2021).

In terms of clinical relevance, these findings suggest that negative expectations about the future should be regarded as an indicator of possible suicidality in Pacific adolescents in NZ. This could be vitally important in situations where adolescents may not feel able to admit to suicidal thoughts or behaviors but may feel more comfortable about reporting feeling pessimistic. Pessimism could also be a viable target for interventions. Focusing on the sources of pessimism and fostering optimism could help to reduce the severity or prevalence of suicidality and potentially suicide death among Pacific adolescents in NZ. Future
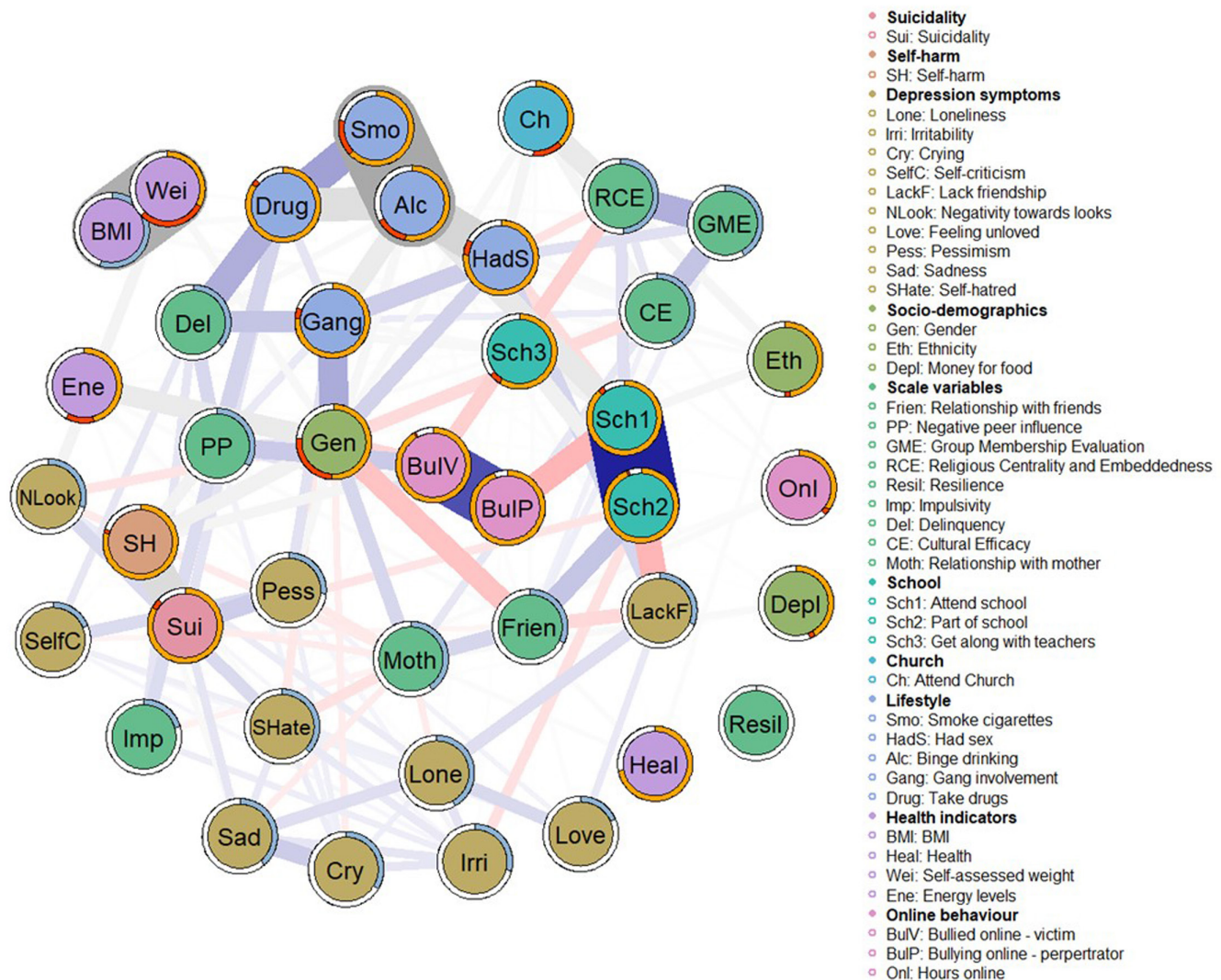
- Suicidality
  - Sui: Suicidality
- Self-harm
  - SH: Self-harm
- Depression symptoms
  - Lone: Loneliness
  - Irri: Irritability
  - Cry: Crying
  - SelfC: Self-criticism
  - LackF: Lack friendship
  - NLook: Negativity towards looks
  - Love: Feeling unloved
  - Pess: Pessimism
  - Sad: Sadness
  - SHate: Self-hatred
- Socio-demographics
  - Gen: Gender
  - Eth: Ethnicity
  - Depl: Money for food
- Scale variables
  - Frien: Relationship with friends
  - PP: Negative peer influence
  - GME: Group Membership Evaluation
  - RCE: Religious Centrality and Embeddedness
  - Resil: Resilience
  - Imp: Impulsivity
  - Del: Delinquency
  - CE: Cultural Efficacy
  - Moth: Relationship with mother
- School
  - Sch1: Attend school
  - Sch2: Part of school
  - Sch3: Get along with teachers
- Church
  - Ch: Attend Church
- Lifestyle
  - Smo: Smoke cigarettes
  - HadS: Had sex
  - Alc: Binge drinking
  - Gang: Gang involvement
  - Drug: Take drugs
- Health indicators
  - BMI: BMI
  - Heal: Health
  - Wei: Self-assessed weight
  - Ene: Energy levels
- Online behaviour
  - BulV: Bullied online - victim
  - BulP: Bullying online - perpetrator
  - Onl: Hours online

FIGURE 3 Network C showing the pairwise associations between depression symptoms, *Self-harm*, non-symptom variables (apart from *Relationship with father* and *PCB*), and *Suicidality* $n = 550$. Wider and more color-saturated edges depict stronger associations and the color the nature of the association between two nodes: blue represents a positive association, red a negative association, and gray means the nature of the association cannot be displayed in the network graph but is discoverable from post hoc investigation. The predictability of each node is shown by the shaded pie segment. This is light blue for continuous variables and displays the value of R-squared; and for the categorical variables, the yellow part of the segment represents the proportion of correct classification of the intercept model, the red part the improvement beyond this proportion attributable to neighboring nodes, and the sum of both segments represents the proportion of correct classification of the whole model.

research investigating the benefits of interventions aimed at reducing pessimism and promoting optimism, with the overall aim of alleviating suicidality, are warranted.

The symptoms *Sadness* and *Negativity towards looks* were the only other depression symptoms to be consistently associated with *Suicidality* across all networks, but these associations were typified by lower edge weights and reliability than for the association with *Pessimism*. It was not stipulated which aspects of looks were leading to this negativity. However, *Negativity towards looks* was strongly associated with *Self-assessed weight* and *Self-hatred* (see Figure 3), providing information about where the negative perceptions may be rooted and where interventions

should focus attention. Other research has found dissatisfaction with body image to be a risk factor for self-harm (Gomez-Castillo et al., 2022; Tie et al., 2022), and suicide ideation (Brausch & Muehlenkamp, 2007). Interventions that build self-esteem have been linked to more positivity around body image (O'Dea & Abraham, 2000). More research is needed to investigate how to mitigate these feelings of negativity towards one's appearance during adolescence, particularly against the backdrop of unrealistic body ideals constantly pushed on social media, which have an exacerbating effect (Gomez-Castillo et al., 2022; Marengo et al., 2018). Specific to Pacific adolescents in NZ, Teevale (2011) investigated whether a higher tolerance of

a larger body size among Pacific adolescents was presenting an obesity risk, as has been suggested in relation to Afro-American women (Kumanyika et al., 1993). In this research, Teevale (2011) found no support for this, where obese and healthy weight Pacific students in NZ correctly perceived their weight status, and desired healthy body sizes. The present study supports these findings, with higher levels of self-assessed weight being associated with higher BMIs. However, any attempt to tackle obesity among Pacific adolescents should be done in a socio-culturally specific manner, with reference to ethnic specific healthy weight ranges (Teevale, 2011).

Feeling sad goes to the root of the depressed state and is not an easy target for a treatment, but if the severity of other symptoms associated with sadness could be alleviated then those feelings might abate.

The differential impact of individual depression symptoms on *Suicidality* supports the view, put forward in much psychological network literature, that analyzing depression only in terms of a sum score of symptoms could obscure important information and hinder a fuller understanding of the mental disorder or problem being investigated (Fried et al., 2014; Fried & Nesse, 2015). This was also illustrated in an earlier prospective study by Beck et al. (1985), where the pessimism item on the Beck Depression Inventory (BDI), as well as high scores on the Hopelessness Scale, predicted suicide deaths more accurately than depression sum scores, among a sample of patients hospitalized with suicide ideation (Beck et al., 1985). Where it is necessary to use depression sum scores, such as to gain a measure of overall symptom severity, analysis could be conducted additionally at the symptom-item level, to safeguard against a potential loss of critical information. Alternatively, multiple psychological scales could be used to measure the same construct, as suggested by Fried and Nesse (2015). *Suicidality* was also associated with significantly higher severity scores for all depression symptoms in the bivariate analysis, as has been found elsewhere (Gijzen et al., 2021). These results also have implications for treating items in depression inventories related to suicidality as being equal with other symptom items, as occurs when items are summed to create a single variable. Future work could investigate whether symptom items related to suicidality should be weighted, when included in sum scores, to gain a more accurate measure of depression severity.

Self-harm had the strongest and most reliable association with S*uicidality*, with the association strengthening for those who had self-harmed more than once, and these findings are consistent with the literature (Brunner et al., 2014; Coppersmith et al., 2017; Gillies et al., 2018). Teevale et al. (2016) found that over 70% of Pacific NZ adolescents who reported a suicide attempt, also reported self-harming. Self-harm and particularly repeated

instances of self-harm have been found to be ominous predicters of suicide deaths (Hawton et al., 2020; Zahl & Hawton, 2004), although in these studies, no differentiation was made between self-harm with or without suicidal intent. There is debate as to whether self-harm and suicidal behaviors are discrete entities (Burešová, 2016; Cha et al., 2018; Coppersmith et al., 2017) or different dimensions of the same phenomenon (Hawton et al., 2012; Kapur et al., 2013). Dash et al. (2017) found that what constitutes self-harm has a cultural context, and Pacific understandings of self-harm, within the NZ environment, also included committing harm to the mental and spiritual self and gradual forms of self-harm, such as excess alcohol intake, as well as inflicting intentional harm to the physical self (Dash et al., 2017). Based on the findings of Dash et al. (2017) and the fact that the self-harm measure used was not tightly defined, *Self-harm* and *Suicidality* were treated as separate variables in this study. However, the extent to which the *Self-harm* and *Suicidality* were measuring the same construct statistically, based on the similarity of network associations, was tested using the goldbricker package (Jones, 2020). Goldbricker identified *Self-harm* and *Suicidality* as possibly measuring the same construct in the network of depression symptoms (Network A). However, the risk profiles of *Suicidality* and *Self-harm* differed fundamentally when non-symptom variables were added to the networks (Networks C and D). The strongest and most reliable potential risk indicators for *Self-harm*, other than *Suicidality*, were being female, being a victim of online bullying, and being susceptible to negative peer pressure. All of these factors have been found to be risk factors for suicidal thoughts or behaviors in other studies (Cha et al., 2018; Hinduja & Patchin, 2010; Teevale et al., 2016), but they were not directly associated with *Suicidality* in this study, illustrating the complex interplay of factors involved in suicidality which methods such as network analysis aim to capture. The results from goldbricker do not prove that *Self-harm* and *Suicidality* are separate constructs, but they do suggest that identifying potential risk factors for self-harm, separately to suicidality, could be a valuable component of suicide prevention strategies, particularly where what constitutes self-harm could be open to cultural interpretations, such as with Pacific people, who may be defining self-harm quite differently to established western norms.

Non-symptom potential risk indicators for *Suicidality*, apart from *Self-harm*, were *Take drugs, Money for food*, and *Hours online*; and protective factors were *Relationship with mother* and *Part of school*. These potential risk indicators for *Suicidality* corroborate those in other studies (Consoli et al., 2013; Daniel et al., 2006; Kushal et al., 2021; Marchant et al., 2017; Rioux et al., 2021). Family and school environments have been found to be important factors for

building resilience against suicide attempts among Pacific youth in NZ (Teevale et al., 2016), and also protective against depression (Gossage et al., 2022). The collectivist nature of Pacific culture (Podsiadlowski & Fox, 2011) could be in part responsible for the importance of family and social relationships for good mental health for Pacific youth. These results provide support for involving family and school in treatment plans and prevention strategies for Pacific adolescents in NZ (Teevale et al., 2016), although the ability to build quality relationships could be a proxy for other factors, such as personality structure, schemas, and adaptiveness (Roelofs et al., 2011).

In this sample, the prevalence of 12-month suicide ideation (16.0%) and suicide attempts (5.5%) was higher than the average rates from a recent meta-analysis of adolescent samples from other countries (12-month suicide ideation: 14.2%; suicide attempt (4.5%) (Lim et al., 2019).

LIMITATIONS

A strength of this study was that as the sample was from a birth cohort, it is likely to be broadly representative of the selected population. One of the main limitations was its cross-sectional design, meaning causality could not be established. The study also did not test for moderators, and some variables, such as those measuring personality and schema, might have robust moderating effects in this model, which could be investigated in future research. It made no distinction between those adolescents who ideated, planned, or attempted suicide, due to small cell counts for those who planned or attempted suicide. Only a small fraction of those with suicide ideation will attempt suicide, and the characteristics of those who have ideated suicide compared to those who have attempted suicide has been shown to differ (Goldston, 2004; Kuroki, 2015). Future research could investigate these differences through longitudinal trajectories of suicide risk for Pacific adolescents and young adults to identify points of intervention that would reduce the risk of suicide ideation leading to suicide attempt and suicide death. The role of self-harm in this trajectory should also be investigated. The sample was representative in terms of national proportions of Pacific NZ youth, aged 15–19, for gender and in terms of Samoan and Tongan ethnic groups, however, those identifying as Cook Islands Māori or Other Pacific Island were underrepresented in this sample (Statistics New Zealand, 2018). The community sample was relatively homogeneous in terms of age, socio-economic status, and ethnicity, so findings may not generalize to other populations or clinical samples. Although the sample was relatively homogeneous, individuals within it will differ, so the findings are most relevant in terms of providing insight at the group level, rather than at the individual level. Not all known predictors of suicidality were able to be included, such as those measuring sexual and gender identity.

CONCLUSIONS

In this sample of Pacific adolescents in NZ, the largest contributors to *Suicidality* were *Pessimism* and *Self-harm*. Overall, the risks that individual depression symptoms presented for *Suicidality* varied enormously, supporting the view that analyzing psychopathological problems at the symptom-item level provides an in-depth insight that can valuably inform treatment approaches (Fried et al., 2014; Fried & Nesse, 2015; McNally, 2016). Measuring depression in terms of a single construct is still necessary for diagnostic and clinical trial purposes, but supplementing this with symptom level analysis, provides additional information that could complement case formulation and individualized treatment strategies (Macneil et al., 2012). The strongest and most reliable association with *Suicidality* was *Self-harm*, but the non-symptom potential risk indicators for *Self-harm* and *Suicidality* were fundamentally different. Screening for self-harm in psychological assessments, separate to suicidality, could be an important aspect of suicide prevention for Pacific adolescents in New Zealand.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

Under the conditions of ethical approval for the research described in this paper, the data cannot be publicly shared. Researchers should contact the corresponding author if they wish to ask questions or seek clarifications on the data.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.