Suicide Risk and Protective Factors: A Network Approach

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Abstract

Suicide is a complex phenomenon, with numerous factors contributing to an individual's risk of suicide. To visualise and quantify complex interactions between variables, a novel approach called network analysis can be used. The aim of the present study was to explore how risk and protective factors for suicide interact with one another, and to determine which factors were most central to a network of these factors. Using an online survey, cross-sectional data was collected from a sample of 515 individuals who lived in New Zealand, Australia, the United Kingdom, and the United States of America, who were recruited through either social media or Prolific Academic. A network of 18 risk and protective factors for suicide was estimated using network analysis. In the network, suicidal ideation was strongly related to the suicide risk factors of feeling depressed, anxious, and hopeless, as well as substance use and perceived burdensomeness. In contrast, self-esteem, resilience, access to mental health services and a positive attitude towards these services were each protective against suicidal ideation. Factors which had the highest strength centrality were feeling depressed, feeling hopeless, perceived burdensomeness, self-esteem, and social support. The results of this research emphasise the importance of examining protective factors as well as risk factors when determining an individual's suicide risk.

Keywords: Network analysis, protective factors, risk factors, suicide

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Chapter One: Suicide

Suicide is a global concern, with 800,000 deaths estimated to occur worldwide each year (World Health Organization, 2018). Much higher rates of occurrence are seen for suicidal ideation, plans, and attempts. Recent statistics for the United States of America estimate that 9.8 million individuals had thoughts of suicide, 2.8 million had a suicide plan, and 1.3 million attempted suicide (National Institute of Mental Health, 2019). For each suicide death in this population, there were 33 attempted suicides (National Institute of Mental Health, 2019).

Prevalence of Suicide

High suicide rates are observed in many Western countries, including New Zealand, Australia, the United Kingdom, and the United States of America. In New Zealand in the year to June 2019 there were 685 suicide deaths, resulting in an overall suicide rate for New Zealand of 13.93 suicides per 100,000 people (Coronial Services of New Zealand, 2019). In Australia, people died by suicide at a rate of 12.2 per 100,000 during 2018, with a total of 3046 suicide deaths (Australian Bureau of Statistics, 2019). During the same period there were 6,507 suicides in the United Kingdom, equivalent to a rate of 11.12 suicides per 100,000 (Office for National Statistics, 2019). Suicide data for the United States of America also suggests a high suicide rate, with the National Institute of Mental Health (2019) reporting there were 47,173 suicide deaths in 2017, with an overall suicide rate of 14.0 per 100,000.

It is important to note that suicide rates may fluctuate within any given year due to changes in coronial rulings of the cause of death. For example, in Australia there are delays in the coronial reporting of a death as a suicide. As a result of this, after preliminary suicide statistics have been released for a given year, they are updated over the following two years to include coronial cases which were unresolved at the time of publishing the preliminary data (Life in Mind Australia, 2019). In England, Wales, and Northern Ireland, where coronial inquests can be lengthy, around half of the suicide deaths attributed to a given year actually occurred in the year previous, or possibly even earlier (Office for National Statistics, 2019), thus adding another dimension of difficulty in reporting, interpreting, and comparing annual suicide rates across countries. Furthermore, in New Zealand mortality statistics, the category of 'self-inflicted death of undetermined intent' may include a number of deaths which could be attributable to suicide, but which have been difficult to ascertain the intent (Rockett, Kapusta, & Coben, 2014). This is likely the case in other countries too, and thus the rates of suicide may in reality be slightly different to that which is reported by the coroner each year.

Cost of Suicide

There are large costs associated with suicide, including emotional and economic impacts. It is well-known that suicide has a profound impact on surviving family and friends. Parents who lose a child to suicide not only experience feelings of guilt or distress, but their relationships with their partner and surviving children are often changed as a result. Due to their overwhelming grief, bereaved parents may not be able to comfort or connect with one another or their surviving children (Jaques, 2000). As a result, siblings of the deceased may feel abandoned by their parents (Jaques, 2000), which may have repercussions in and of itself. Furthermore, following the suicide of a family member, the remaining members are at increased risk of suicide, with suicide-bereaved family members expressing high rates of suicidal ideation compared to those who have not experienced suicide bereavement (Jordan, 2008). Pitman et al. (2017) report that this may occur because suicide-bereaved individuals begin to perceive suicide as a tangible option to reduce their distress, and they become increasingly aware of any vulnerabilities to suicide that they shared with the deceased, such as mental illness. That said, family members may have similarities to the deceased, such as their genetics, socioeconomic status, or culture. These are risk factors for suicide, some of which will be discussed later in this thesis. Because of possessing similar risk factors, the suicide risk of suicide-bereaved family members could be higher than average, irrespective of whether suicide bereavement specifically has a causal effect on the suicide risk of family members.

Another group who are impacted by suicide are mental health professionals. Many practitioners have experienced losing a client due to suicide, with one Australian report finding nearly a third of psychologists have had this experience (Finlayson & Simmonds, 2018). An earlier Australian report found similar statistics, with 39% of surveyed psychologists having been bereaved by a client suicide, and 76% having worked with a client who had attempted suicide (Trimble, Jackson, & Harvey, 2000). Client suicide can affect mental health professionals in several ways. Finlayson and Simmonds (2018) report that shock, distress, and guilt are among some of the most common emotional reactions experienced by psychologists following a client's suicide, particularly when the suicide was not considered to be predictable. Psychologists also report being impacted professionally, often doubting their competence, and becoming highly focused on suicide risk factors among other clients (Finlayson & Simmonds, 2018).

In addition to the emotional cost associated with suicide, there are also significant economic costs. Some such economic costs include the loss of productivity in the workforce due to suicide deaths, and the cost of the services that are utilised such as accident and emergency services, or victim support services (O'Dea & Tucker, 2005). For example, in the United States of America, suicide accounted for 24% of work-related costs from fatal injuries in 2017, resulting in an economic loss of approximately USD50.8 billion (National Institute of Mental Health, 2019). In New Zealand, O'Dea and Tucker (2005) estimated the economic cost associated with the 460 suicide deaths that occurred in 2002 to be a total of NZD206.2 million, with NZD201.5 million coming from lost production, while the remaining included service-related costs, such as police, coroners, and Victim Support. Due to economic growth (Statistics New Zealand, 2019) and an increase in the number of suicide deaths annually (Coronial Services of New Zealand, 2019), presumably the economic cost of suicide in New Zealand at present is higher than this. Furthermore, these figures do not account for costs relating to the subsequent mental health of suicide-bereaved family members.

As described above, one person's suicide can have an impact on the lives of many others, and even has impacts as far reaching as a country's economy. Researching suicide and its causes is therefore in the interests of every individual, not just those experiencing suicidality first hand.

Static Risk Factors for Suicide

Much of the research concerning suicide to date has explored the risk factors which are associated with suicidal ideation, attempts, and death. Every individual has a baseline risk for suicide, which is largely dependent on static risk factors. These are variables that are historical or relate to demographic information (Sinclair, 2017). Static risk factors for suicide include variables such as gender, ethnicity, age, marital status, sexual orientation, familial history of suicide, personal history of self-harm or suicide attempts, and history of abuse or neglect. People within specific subgroups die by suicide at a higher rate than others, and thus those groups have a high baseline risk of suicide. Research supporting the contribution of these static variables to suicide risk will be discussed below.

Gender. Higher rates of suicidal ideation and behaviour are seen among females compared to males, yet globally males die by suicide at higher rates than females (Schrijvers, Bollen, & Sabbe, 2012). In New Zealand, hospital presentations for intentional self-harm and suicide attempts are more than twice as high for females than for males (Ministry of Health, 2016), but the ratio of male to female suicide deaths is 2.7:1 (Coronial Services of New Zealand, 2019). This suggests that although females attempt suicide more often, males die by suicide at a higher rate. Similar ratios of male suicide deaths to female suicide deaths are seen in other countries, with a ratio of 3.2:1 observed in Australia, 3:1 in the United Kingdom, and 3.7:1 in the United States of America (Australian Bureau of Statistics, 2019; National Institute of Mental Health, 2019; Office for National Statistics, 2019). There are a number of proposed explanations for this, namely that males more often use lethal methods of suicide, such as hanging or shooting, compared to females, and that females are more willing to seek help for suicidal ideation and behaviour than males are (Krysinka, 2014).

Ethnicity. Worldwide there are differences in the suicide rates of various ethnic groups within countries. For example, in New Zealand, Māori people have the highest suicide rate, followed by European, Pacific Islander, and Asian peoples (Coronial Services of New Zealand, 2019). Table 1 shows the suicide rates of these ethnic groups for the year to June 2019.

Table 1

Suicide Rates per Ethnic Group in New Zealand

Ethnicity	Suicide Rate per 100,000
Māori	28.23
European	13.46
Pacific Islander	11.49
Asian	7.63

Source: Coronial Services of New Zealand (2019).

In many countries, indigenous populations are over-represented in suicide statistics compared to their non-indigenous counterparts. This is the case in New Zealand, Australia, Canada, and the United States of America (Clifford, Doran, & Tsey, 2013), among other countries. There are numerous proposed reasons for this difference, such as the impact of colonisation on indigenous populations, and subsequent loss of culture and land, as well as intergenerational trauma and racism (Clifford et al., 2013). An example of the difference in suicide rates in indigenous and non-indigenous populations is clearly shown in New Zealand suicide rates. Māori, the indigenous people of New Zealand, die by suicide at an elevated rate compared to non-indigenous ethnicities in New Zealand, with the Māori suicide rate more than twice that of the European suicide rate (Coronial Services of New Zealand, 2019).

In other countries the opposite relationship between indigenous status and suicide is true, with non-indigenous populations having a higher suicide rate than indigenous ones. This is the case in South Africa, for example, where White South Africans die by suicide at a higher rate than indigenous Black South Africans (Flisher, Liang, Laubscher, & Lombard, 2016). In a systematic review of research comparing the suicide rates of indigenous and non-indigenous populations, non-indigenous populations in Fiji, Papua New Guinea, and Israel also had higher suicide rates than the indigenous populations of these countries (Pollock, Naicker, Loro, Mulay, & Colman, 2018). Clearly, whether or not a group is indigenous is not the only variable driving ethnic differences in suicide rates.

Age. There are a two main age groups which are typically at increased risk of suicide. Table 2 shows the most recent suicide rates per age bracket in New Zealand. The age groups which have the highest suicide rates are those aged 15 to 24 years and 45 to 59 years (Coronial Services of New Zealand, 2019). The United Kingdom report some similarities, with individuals aged 45 to 49 having the highest suicide rate of 18.1 per 100,000 (Office for National Statistics, 2019). New Zealand suicide rates show an additional steep increase for individuals older than 90 years, but this is likely to be due to small population numbers. For example, the most recent statistics show that seven individuals aged 90 or older died by suicide (Coronial Services of New Zealand, 2019), resulting in a high suicide rate, as can be seen in the table below.

Table 2

Suicide Rates per Age Bracket in New Zealand

Age Bracket	Suicide Rate per 100,000
10 to 14	3.41
15 to 19	23.14
20 to 24	26.87
25 to 29	20.85
30 to 34	18.71
35 to 39	14.46
40 to 45	15.60
45 to 49	18.12
50 to 54	20.11
55 to 59	17.07
60 to 64	11.82
65 to 69	8.72
70 to 74	11.27
75 to 79	6.99
80 to 84	6.49
85 to 89	8.90
Over 90	21.72

Source: Coronial Services of New Zealand (2019).

Marital status. People who are unmarried have a higher risk of suicide than people who are married, irrespective of whether unmarried individuals are single, divorced, or widowed. In a meta-analysis by Kyung-Sook, Sangsoo, Sangjin, and Yeong-Jeon (2018), all unmarried relationship statuses had a positive association with risk of suicide, such that they showed significantly higher suicide risk compared to people who were married. Those who were divorced has the highest suicide risk, followed by single people and those who had been widowed (Kyung-Sook et al., 2018). In the United States of America, people who have divorced are estimated to die by suicide at a rate that is three to four times higher than those who are married (Stack, 1990). However, it must be noted that the United States of America has one of the highest divorce rates out of OECD countries (OECD, 2019), and thus the association between divorce and suicide may differ in other countries where the divorce rates are low.

Sexual orientation. Suicide risk is higher for sexual minorities, such as lesbian, gay, and bisexual persons, compared to heterosexual persons. These sexual minorities attempt suicide at a higher rate, particularly among youth and individuals who are male (Miranda-Mendizabal et al., 2017). In a New Zealand cohort study by Fergusson, Horwood, Ridder, and Beautrais (2005), logistic regression analysis showed that homosexual individuals had attempted suicide between the ages of 21 and 25 years at a significantly higher rate than heterosexual individuals of that age. This difference may in part be because sexual minorities experience greater levels of stigma, discrimination, and marginalisation, which are in turn associated with increased likelihood of a suicide attempt (Miranda-Mendizabal et al., 2017). Furthermore, significantly higher rates of mental health problems such as depression, anxiety, and substance abuse are seen in homosexual populations (Fergusson et al., 2005), which may contribute to suicide risk for these individuals.

Though there have been numerous studies examining the relationship between sexual orientation and non-fatal suicide attempts, fatal suicidal behaviour among sexual minority groups has not been well-explored. As such there is not as strong evidence for the role of sexual orientation as a risk factor for suicide death. The few psychological autopsy studies that have investigated whether there is a difference in the suicide rates of sexual minorities compared to heterosexual individuals have reported that there is no difference in the suicide rates of these populations (Plöderl et al., 2013). However, such studies have been fraught with methodological problems, including the way in which the sexual orientation of the deceased has been determined (see Plöderl et al., 2013 for further discussion).

Family history of suicide. Individuals who have experienced a family member dying by suicide are at high risk of suicide themselves. In a Swedish study by Runeson and Asberg (2003), the suicide rate for individuals with a family history of suicide was twice as high as it was for individuals without this family history. This risk factor could be genetic, due to a shared environmental effect (Brent & Mann, 2005), or a combination of both. Evidence supporting the genetic heritability of suicide comes from adoption studies. One of the classic studies examining this, by Schulsinger, Kety, Rosenthal, and Wender (1979), reported a high rate of suicide among biological relatives of an adopted person who died by suicide, but not among their adopted relatives, suggesting there may be a genetic component involved. However, recent cross-sectional research by Pitman, Osborn, Rantell, and King (2016) suggests that suicide bereavement may increase an individual's risk of attempting suicide, irrespective of whether the deceased is a blood relative or not. This was tested by adding an interaction term (blood relative versus not a blood relative) to multivariable regression models estimating the strength of the associations between suicide bereavement and outcome variables such as depression and non-suicidal self-injury (Pitman et al., 2016). The addition of this interaction term did not change the associations estimated in these models, such that suicide bereavement was associated with increased risk of suicide attempt, regardless of the blood relationship to the deceased (Pitman et al., 2016).

History of self-harm or suicide attempts. An individual with a personal history of self-harm is at risk for future suicidal behaviour. Chan et al. (2016) conducted a systematic review and meta-analysis of cohort studies, and found that previous self-harm was significantly associated with an increased risk of suicide. Ribeiro et al. (2016) found a similar relationship in their meta-analysis of longitudinal studies about self-harm and suicide, reporting a significantly higher risk of suicide attempt for individuals with a history of self-harm. Previous suicide attempts are also predictive of future attempts, with Gibb, Beautrais, and Fergusson (2005) finding that 28.1% of individuals who had attempted suicide previously went on to attempt again, while a further 4.6% died by suicide. A high level of risk is also associated with having both a history of self-harm and history of suicide attempt. Adolescents who had self-harmed and attempted suicide expressed higher levels of suicidal ideation, and fewer reasons for living (Muehlenkamp & Gutierrez, 2007), further supporting the involvement of these factors in suicide risk.

History of abuse or neglect. Childhood maltreatment, such as abuse or neglect, is associated with future risk of suicidal behaviour. A meta-analysis by Liu et al. (2017) found a significant positive association of childhood abuse with suicide attempts, and a similar result for childhood neglect. Regardless of the type of abuse (e.g., physical, sexual, or emotional) or neglect, those who have this experience as a child or adolescent are at high risk of future suicide attempt (Castellvi et al., 2017), and these attempts often occur at a younger age than those who have not experienced childhood maltreatment (Hoertel et al., 2015).

Dynamic Risk Factors for Suicide

Dynamic risk factors are those that are situational, changing over time (Sinclair, 2017). They are variables that alter an individual's baseline level of risk, resulting in an increased (or decreased) risk for suicide. They can further be distinguished into acute or stable dynamic risk factors. Acute factors are those that can change rapidly, while stable factors remain unchanged for a long period of time but in principle are still amenable to change (Hanson & Harris, 2000). Dynamic risk factors for suicide include socioeconomic deprivation, rural-urban status, substance abuse, mental health problems, being bullied, hopelessness, impulsivity, perceived burdensomeness, access to means, physical health and disability, exposure to suicide in the media, and stressful life events. As dynamic risk factors can be altered, targeting such variables in suicide prevention methods may be effective in reducing risk, with lower levels of dynamic risk factors generally being associated with lower levels of suicidality. Research supporting the implication of dynamic risk factors in suicidality will be discussed below.

Socioeconomic deprivation. People who live in areas of high socioeconomic deprivation are typically at higher risk of suicide than people who live in areas of low deprivation. In 2012, people living in the most deprived areas of New Zealand died by suicide at a rate of 13.8 per 100,000, while those living in the least deprived areas had a suicide rate of 6.6 per 100,000 (Ministry of Social Development, 2016). Socioeconomic deprivation was measured in the Ministry of Social Development (2016) report using the NZDep2006 Index of Deprivation, which combined census data at the time such as income, employment, qualifications, owning a home, and access to a private vehicle (Salmond, Crampton, & Atkinson, 2007). A recent systematic review of studies based in Europe examining the association between socioeconomic disadvantage and suicidal behaviour found a significant relationship between these variables, such that those living in areas of higher socioeconomic disadvantage experienced more suicidal behaviour (Cairns, Graham, & Bambra, 2017). Living in areas of high socioeconomic deprivation may increase suicide risk in several ways. For example, people living in these areas may experience difficulty in accessing mental health services or other services that would assist with living, due to lack of available finances, or they may experience less social integration, which factors such as steady employment offer (Denney, Rogers, Krueger, & Wadsworth, 2009).

Although within many countries socioeconomic status is related to suicide risk, this is not true across countries. Countries with lower gross domestic product do not have consistently higher rates of suicide compared to countries with higher gross domestic product. A mixed effect model of suicide rates and gross domestic product per capita among 56 countries by Blasco-Fontecilla et al. (2012) showed that many developing Latin-American, Caribbean, and South-East Asian countries experienced a significant increase in suicide rates as their gross domestic product per capita increased, as did high income Asian countries like Japan. The opposite relationship was found in both developing and high income European regions, such that there was a significant decrease in suicide rates as gross domestic product per capita increased (Blasco-Fontecilla et al., 2012). These results suggest that a good economic status for a country as a whole does not always result in fewer suicides, with different relationships between gross domestic product and suicide rates seen across countries.

Rural-urban status. People who live in remote or rural areas die by suicide at a higher rate than people who live in urban areas (Ferguson et al., 2005). In rural Maryland counties in the United States of America for example, Nestadt, Triplett, Fowler, and Mojtabai (2017) found suicide rates to be higher than they were in urban counties. Several factors are postulated to influence the difference seen in these rates. People who live rurally tend to have access to more lethal means of suicide like guns and poisons (Ferguson et al., 2005) and therefore they are more likely to die when they attempt suicide. Furthermore, mental health services in rural areas often have limited availability (Ferguson et al., 2005) and are difficult to access, so individuals living in rural areas utilise mental health services at a lower level than urban dwelling individuals do (Judd, Cooper, Fraser, & Davis, 2006). This reduces their likelihood of receiving an intervention for suicidal thoughts or behaviour, and subsequently their risk of suicide is higher. As the area in which a person lives, whether rural or urban, can in principle be changed, this factor is considered dynamic. However, in many circumstances it may be difficult to change where a person lives, and therefore rural-urban status is considered to be a relatively stable dynamic risk factor for suicide.

Substance abuse. People who use substances are at high risk of suicide, dying by suicide at a higher rate than the general population in numerous countries, including New Zealand, Australia, the United Kingdom, and the United States of America (Flensborg-Madsen et al., 2009; Poorolajal, Haghtalab, Farhadi, & Darvishi, 2016). Individuals who have a substance use disorder are also at high risk for suicide (Yuodelis-Flores & Ries, 2015), as are individuals who have alcohol use disorder. A multiple regression analysis by Flensborg-Madsen et al. (2009) found participants with an alcohol use disorder to be at a significantly higher risk of suicide. Furthermore, the Australian Bureau of Statistics (2019) reported that 29.4% of individuals who died by suicide in Australia during 2018 had a drug or alcohol use disorder.

Current alcohol intoxication is an acute dynamic risk factor for suicide, with large proportions of people who have attempted suicide or died by suicide found to have alcohol in their blood (Cherpitel, Borges, & Wilcox, 2004; Conner et al., 2013). In Australia, 21.5% of people who died by suicide in 2018 were found to have alcohol or other drugs in their blood at the time of suicide (Australian Bureau of Statistics, 2019). Intoxication may lead to high suicide risk through increased psychological distress, aggression, and impulsivity, and it may also inhibit thought processes which would usually generate alternative ways of coping with distress (Hufford, 2001).

Mental health problems. Having a mental health problem puts an individual at higher risk of suicide. Compared to the general population, risk for suicide among those with mental health problems such as borderline personality disorder and schizophrenia is more than ten-fold (Chesney, Goodwin, & Fazel, 2014). Increased risk of suicide is associated with several other disorders, including depression and anxiety (Chesney et al., 2014; Kanwar et al., 2013), both of which are very common worldwide. The associations of depression and anxiety with suicide are described in more detail below.

Major depressive disorder. Depression is very common, affecting an estimated 300 million people worldwide in 2015 (World Health Organisation, 2018). The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders [DSM-5] describes the criteria for a diagnosis of major depressive disorder, one of which is recurrent suicidal ideation or a suicide attempt (American Psychiatric Association, 2013). Although not everyone with depression will attempt suicide or experience suicidal ideation, having this disorder puts an individual at higher risk. The Australian Bureau of Statistics (2019) found that 43.9% of individuals who died by suicide in Australia during 2018 had a mood disorder such as depression. Furthermore, Brådvik, Mattisson, Bogren, and Nettelbladt (2008) conducted a multivariate regression analysis of longitudinal cohort data which showed a significantly higher suicide risk for participants with depression.

Anxiety disorders. Another highly prevalent type of disorders are anxiety disorders, which affected an estimated 264 million people worldwide in 2015 (World Health Organization, 2017). Anxiety disorders are often implicated in suicide, with 17.6% of individuals who died by suicide in Australia during 2018 having an anxiety and other stress-related disorder (Australian Bureau of Statistics, 2019). In a meta-analysis of studies examining the relationship between anxiety disorders and suicide, it was found that individuals with an anxiety disorder were significantly more likely to experience suicidal ideation, to attempt suicide, and to die by suicide than individuals without an anxiety disorder (Kanwar et al., 2013). This was the case for all subtypes of anxiety except for obsessive-compulsive disorder (Kanwar et al., 2013).

Being bullied. Another dynamic risk factor for suicide is being bullied, whether it be through physical, verbal, emotional, or cyber bullying. Both perpetrators and victims of bullying are at higher risk of suicide, but victims of bullying are the most at risk of the two (Hinduja & Patchin, 2010). People who have experienced bullying have higher levels of suicidal ideation, and they attempt suicide at a higher rate than those that have not experienced bullying (Hinduja & Patchin, 2010; Holt et al., 2015). An Australian study found that adults who had been victims of bullying as children were significantly more likely to experience suicidal ideation as an adult, with odds ratios estimating participants were three times more likely to experience suicidal ideation if they had been bullied as a child (Roeger, Allison, Korossy-Horwood, Eckert, & Goldney, 2010). This suggests that a history of being bullied may be implicated in some suicides.

Hopelessness. Hopelessness is often cited as a risk factor for suicide, being associated with future suicidal ideation, attempt, and death (Beck, Steer, Kovacs, & Garrison, 1985; Kuo, Gallo, & Eaton, 2004). Longitudinal research by Kuo, Gallo, and Eaton (2004) utilised bivariate analyses and found that individuals in the United States of America who reported hopelessness at the beginning of the study were significantly more likely to have died by suicide during the 13-year follow-up period than those who did not feel hopeless. More specifically, participants reporting hopelessness at the baseline of this study were more than eleven times more likely to have died by suicide (Kuo et al., 2004). Others have found hopelessness, as measured by the Beck Hopelessness Scale, to be a risk factor for suicidal ideation, but not for suicide attempts (Qiu, Klonsky, & Klein, 2017).

Impulsivity. Impulsivity in relation to a suicide attempt can be defined in several ways, including lack of preparation or contemplation before attempt, and impulsivity as a reason for the attempt (May & Klonsky, 2015). There is little agreement on the definition of impulsivity in studies examining the relationship between impulsivity and suicide attempts (Rimkeviciene, O'Gorman, & De Leo, 2015). However, irrespective of the length of time spent on preparation and contemplation prior to a suicide attempt, many individuals tend to explain their own attempt as impulsive (May & Klonsky, 2015). Impulsive attempts often use low lethality methods and occur in close proximity to negative life events, while planned attempts are often of higher lethality and are also associated with higher levels of hopelessness (Connor, 2011).

Perceived burdensomeness. The study of perceived burdensomeness as a risk factor for suicide is a relatively modern occurrence. Several studies have found perceived burdensomeness to be positively associated with suicide attempts (Bell et al., 2018; Joiner et al., 2002). For example, using binary logistic hierarchical regression, Bell et al. (2018) estimated that perceived burdensomeness was significantly associated with a history of suicide attempts among a sample of 114 military veterans with depression. Perceived burdensomeness has also been posited as a key factor in theories of suicidal behaviour in recent times (see the Modern Theories of Suicide Development subsection of this chapter for further discussion), further implicating its potential contribution to suicide risk.

Access to means. Having access to the means to attempt suicide, such as a firearm, motor vehicle, or rope, puts an individual at increased acute risk for attempting. Easy access to a particular method influences an individual's decision about which method to use

(Sarchiapone, Mandelli, Iosue, Andrisano, & Roy, 2011). Therefore, minimising access to the most lethal methods may result in a reduced likelihood of death. Examples of this in action include the restriction of deadly pesticides in rural areas to reduce suicide by poisoning; the construction of barriers to reduce the likelihood of suicide by jumping; and the reduced pack size of many prescription medications to reduce suicide by medication overdose (Sarchiapone et al., 2011). When the method of suicide is common, lethal, and easily accessible, restricting access to it tends to be effective in reducing suicide risk (Sarchiapone et al., 2011).

Physical health and disability. Being in poor physical health due to some types of illness or injury puts an individual at high risk of suicide. Research supports the association of suicide risk with cancer (Quan, Arboleda-Florez, Fick, Stuart, & Love, 2002), lung disease, ulcers, and AIDS (Goodwin, Marusic, & Hoven, 2003). Having a physical disability also puts an individual at high risk of suicide, with the lifetime rate of suicidal ideation more than two times higher among individuals with a physical disability than for able-bodied individuals (Russell, Turner, & Joiner, 2009).

Exposure to suicide in the media. There is support both for and against an effect of exposure to media on suicide risk. Some research suggests there is an increased risk of suicide contagion among those exposed to media stories about suicide (Gould, Jamieson, & Romer, 2003). For example, a time series analysis showed that in the months following the suicide of Robin Williams in August 2014, when there were many news reports about his suicide, the number of suicides in the United States of America increased by 9.9% compared to the number that were forecast to occur (Fink, Santaella-Tenorio, & Keyes, 2018). Many of these suicides involved the same method as Robin Williams' suicide, such that there was a significant increase in that particular method compared to what was forecast (Fink et al., 2018). Though the increase in suicides cannot be definitely attributed to the high number of media reports about the suicide of Robin Williams, Fink et al.'s (2018) study demonstrates a positive association between these variables. Because of the association between media about suicide and increased suicide rates, the World Health Organization (2008) has guidelines for media reports about suicide, with suggestions to avoid language which sensationalises suicide, and to avoid describing the method used in the suicide. Thematic analysis of a sample of 63 news articles about the suicide of Robin Williams revealed that 27% romanticised the suicide, and 46% explicitly detailed the method of suicide, thus failing to meet such guidelines (Carmichael & Whitley, 2019), potentially contributing to the subsequent increase in the number of suicides following Robin Williams' death.

Despite speculation about the impact of *fictional* media about suicide, recent research does not support its association with suicide. In a meta-analysis of studies on the impact of fictional media about suicide on suicidal behaviour or ideation, Ferguson (2018) found an overall effect size of close to zero, which was not statistically significant. As such, the results did not support a relationship between fictional media about suicide and subsequent suicidal behaviour or ideation (Ferguson, 2018).

Stressful life events. A stressful life event such as an interpersonal loss, unemployment, financial difficulty, or legal problem often precedes a suicide attempt (Beautrais, 2003), thus an individual's acute risk of suicide is higher following such events. A review of psychological autopsy studies suggests that nearly all individuals who have died by suicide have experienced a stressful life even in the preceding year (Foster, 2011). Beautrais, Joyce, and Mulder (1997) found that young people experienced numerous stressful life events prior to attempting suicide, with most of these stressful events relating to interpersonal, work, financial, and legal problems.

Protective Factors for Suicide

Much of the literature about suicide focuses on risk factors. However, it is important to acknowledge that there are also protective factors for suicide, which increase an individual's ability to cope and may reduce likelihood of suicide (Chehil & Kutcher, 2012). Protective factors for suicide have not been researched as prolifically as risk factors have been, often not receiving the same theoretical attention (De Beurs et al., 2019), and yet in many cases protective factors are used to inform the development of suicide prevention programmes and strengths-based interventions for individuals (Chehil & Kutcher, 2012). Factors which are protective against suicide include social support, self-esteem, sense of belonging, stable employment, problem solving skills, resilience, and access to mental health services as well as a positive attitude towards them.

Social support. Social support may protect against suicide in numerous ways. Kleiman and Liu (2013) describe that having social support can result in less frequent suicidal ideation, and that it can be particularly protective against suicide during stressful life events – a time where suicide risk would usually be heightened. Other research suggests that social support may protect against suicide by moderating the relationship between a particular risk factor and suicide. For example, social support moderates the relationship between impulsivity and suicide, with one study finding that if a person had high impulsivity (putting them at high risk of suicide), and also had high levels of social support, then their overall risk of suicide was low (Kleiman, Riskind, Schaefer, & Weingarden, 2012). Additionally, social support may significantly increase the intensity of other protective factors such as self-esteem (Kleiman & Riskind, 2013), providing a further protective effect against suicide

Self-esteem. People without suicidal ideation report higher levels of self-esteem than people who have thoughts of suicide or who have attempted suicide in the past (Teismann et al., 2019). This aligns with other research on suicide risk which reports low self-esteem can put a person at increased risk of suicidal ideation and attempt (Fergusson, Beautrais, & Horwood, 2003). For example, in their logistic regression, Wild, Flisher, and Lombard (2004) found that adolescents with low self-esteem to be significantly more likely to experience suicidal ideation, and to attempt suicide.

Sense of belonging. Many popular theories of suicide posit a connection between suicide and feeling as though one does not belong or is not connected to others. One such theory is Joiner's (2005) interpersonal psychological theory of suicide (see the Modern Theories of Suicide Development subsection of this chapter for further discussion). However, research evidence for this association has thus far been weak. For example, a systematic review by Hatcher and Stubbersfield (2013) found low levels of sense of belonging to have only a weak relationship with suicidality, though the authors state that this finding could simply be due to poor conceptualisation and measurement of sense of belonging in their study.

Stable employment. Little attention has been paid to studying the impact of stable employment on suicide. One study in South Korea utilised logistic regression models to explore whether people who had stable employment were less likely to express suicidal ideation or to attempt suicide, and found a significant association between these factors (Min, Park, Hwang, & Min, 2015). This suggests that stable employment may provide some protection against suicide. Furthermore, Coope et al. (2015) found that employment related issues were implicated in 13% of the suicide deaths in their sample from England.

Problem solving skills. Having good problem solving skills may be protective against suicide. Recent research has examined the moderating effect of problem solving on the relationship between risk factors and suicide, finding active problem solving (i.e., taking steps to solve one's own problem) moderates the relationship between symptoms of depression and suicidal ideation (Quiñones, Jurska, Fener, & Miranda, 2015). Problem solving also moderates the relationship between stressful life events and suicidal ideation (Linda, Marroquín, & Miranda, 2012), resulting in lower suicide risk during these usually high risk periods. Furthermore, having poor problem solving confidence is associated with higher suicidal ideation (Abdollahi, Talib, Yaacob, & Ismail, 2015).

Resilience. Resilience is defined as having the capacity to overcome stress or adversity while functioning as one normally would (Sher, 2019). A review by Sher (2019) of current research about the impact of resilience on suicide describes resilience as having an overall protective effect. Cross-sectional research by Roy, Sarchiapone, and Carli (2007) explored the relationship between suicide attempts and resilience, as measured by the Connor-Davidson Resilience Scale. The authors found that participants who had previously attempted suicide had significantly lower resilience scores on this measure.

Access to mental health services and a positive attitude towards them. De Hert, McKenzie, and Peuskens (2001) found that having a negative attitude towards treatment such as medication was associated with a higher risk of suicide among people with schizophrenia. Their study also reported that the control group of people who had *not* attempted suicide were more likely to be accessing community-based care, suggesting this may be somewhat protective against suicide. Additionally, males, who as a group are at high risk of suicide, have poorer compliance with pharmacological treatment for depression than females, and tend to have fewer contacts with mental health services, further implicating attitude and access to treatment in suicide risk (Schrijvers et al., 2012). Particular types of psychological treatment, such as dialectical behaviour therapy, are effective at reducing future suicide attempts (McCauley et al., 2018). Thus, being able to access this treatment is likely protective against suicidal ideation and attempt.

Why Research the Risk and Protective Factors for Suicide?

Although we cannot definitively predict whether an individual will or will not attempt suicide, studying the risk and protective factors for suicide enables us to more accurately predict who *might*. Increasing the accuracy of predictions about who is most likely to attempt suicide may help mental health professionals direct resources to where they are most needed, ultimately improving suicide prevention methods, and thus preventing suicide.

By researching the risk and protective factors for suicide, useful therapeutic targets for suicide interventions may also be identified. The identification of static risk factors for suicide can be useful in determining whether an individual is likely to be at high risk, based on their history and demographics alone. Although these factors cannot be changed, sometimes supports can be put in place to assist an individual who, for example, has a family history of suicide, such as by directing them to support groups for the suicide-bereaved and providing psychotherapy if needed. This may somewhat ameliorate the stressful life circumstances they are experiencing and reduce their likelihood of attempting suicide, even though the risk factor has not been altered. Identification of dynamic risk factors for suicide is even more important for effective suicide prevention, because these factors are amenable to change, and therefore practitioners may be able to reduce an individual's suicide risk by altering some of these variables. For example, if an individual is at increased risk for suicide due to access to lethal means, plans could be put in place to reduce their access, thereby reducing their dynamic risk of suicide. Furthermore, knowledge of which protective factors an individual possesses provides practitioners with a focal point for strengths-based interventions, where an individual's own personal resources can be built upon to provide a protective effect against suicide.

Despite social and governmental investment in suicide prevention, annual suicide rates continue to increase in some countries, including New Zealand (Coronial Services of

New Zealand, 2019) and the United States of America (National Institute of Mental Health, 2019). In other countries, such as Australia, suicide rates remain largely unchanged despite efforts to improve services and implement new frameworks, as well as substantial investment from the government, businesses, and communities (Heffernan, Vale, & Atkinson, 2017). Heffernan et al. (2017) suggest that the general lack of improvement in suicide rates may be because suicide has an extremely complex aetiology. Though there is much known about the risk factors for suicide at present, this information has not yet resulted in the ability to accurately predict suicide every time, nor has it translated to a theory of suicide which can account for every case that occurs.

Modern Theories of Suicide Development

Not everyone who possesses the risk factors for suicide described earlier in this chapter will then go on to attempt suicide. Risk factors for suicide are simply indicative of risk. The presence of these factors is neither sufficient nor necessary to result in suicide, and as such, knowledge of these factors does not automatically translate to an ability to accurately predict who will attempt suicide. Recently, particular risk factors such as hopelessness and mental health problems have been found to be associated with suicidal ideation but not attempts (Klonsky & May, 2014; Nock et al., 2013). Other factors, such as low social support, are associated more strongly with suicide attempts than ideation (Pompili et al., 2014). This further complicates our ability to accurately predict suicide. As the lifetime rates of suicidal ideation are much higher than the lifetime rates for suicide attempts (Klonsky & May, 2014), it is important to understand what factors may lead a person to progress from ideation to attempt, to increase our ability to accurately predict suicide.

Theories of suicide development which have existed for decades—e.g., Durkheim's (2006; first published in 1897) sociological theory of suicide, Baumeister's (1990) escape theory, and Shneidman's (1993) psychache theory—largely fail to account for which factors put an individual at acute risk of suicide attempt, following suicidal ideation. Instead, as Klonsky and May (2014) describe, such theories conflate the reasons for why people might feel suicidal with why they might act on these feelings, and they fail to specify whether the theorised factors explain ideation, attempts, or both. A lack of knowledge about this transition from ideation to action is perhaps partially to blame for the slow progress that has been made in suicide prevention to date (Klonsky & May, 2014). With the number of suicide deaths on the rise, developing effective suicide prevention methods is of utmost importance, and thus it is crucial that we gain a deeper understanding of who will attempt suicide. More recently, a second wave of theories of the development of suicidal behaviour has emerged, with a focus on the ideation to action transition and the risk factors which may be associated with it. These theories include the interpersonal psychological theory of suicide, the integrated motivational-volitional model, and the three step theory, each of which are discussed below.

Interpersonal Psychological Theory of Suicide. Joiner's (2005) interpersonal psychological theory of suicide treats the development of suicidal ideation and the transition from ideation to attempt as two separate processes, with different risk factors and explanations for each process. Joiner proposed that thwarted belongingness and perceived burdensomeness lead to suicidal ideation. What separates attempters from ideators at this point is that people who attempt suicide have acquired a high capability for suicide attempt. Self-injury is likely to be painful, and most people with suicidal ideation cannot tolerate the level of pain likely required to attempt suicide, fearing the potential pain, and thus even if they want to die, they are unable to attempt suicide. In comparison, individuals who have acquired tolerance to inflicting high levels of pain on themselves are less fearful of the potential pain, and thus are likely to attempt suicide according to this theory.

A systematic review conducted by Ma, Batterham, Calear, and Han (2016) examined research testing the interpersonal psychological theory of suicide to determine what evidence there was for the effect of thwarted belongingness, perceived burdensomeness, and acquired capability on suicidal ideation and attempt. The authors found the effect of perceived burdensomeness on suicidal ideation to have the strongest support across studies. Thwarted belongingness was tested much less frequently, contributed to less variance in suicidal ideation, and had a smaller effect size than perceived burdensomeness. Many studies in Ma et al.'s (2016) review found both perceived burdensomeness and thwarted belongingness to be predictive of suicide attempt too, rather than being specific to suicidal ideation like the interpersonal psychological theory of suicide proposes. Acquired capability had a moderate effect size on suicide attempt, but this relationship was only significant in around half of the studies that were examined, and again was not specific to suicide attempts, as acquired capability was significantly related to suicidal ideation as well (Ma et al., 2016). Overall these results suggest some support for the interpersonal psychological theory of suicide.

Integrated Motivational-Volitional Model. The integrated motivational-volitional model was developed by O'Connor (2011). This model incorporates a few more risk factors for suicide than the interpersonal theory does, namely stressful life events, access to means, and impulsivity. Following Joiner's footsteps, this model suggests that there are different processes driving ideation and attempt, with variables precipitating each phase. In the pre-motivational phase, background factors and life events result in an underlying vulnerability for suicide. The motivational phase follows, with signals of defeat or humiliation said to trigger a feeling of entrapment. The development of the motivational phase is precipitated by factors that pose a threat to the self, such as memory biases and rumination processes, which increase the likelihood of developing feelings of entrapment. Entrapment then drives the development of suicidal ideation, with suicide seen as the solution to current problems. The development of suicidal ideation is precipitated by thwarted belongingness and perceived burdensomeness. The final stage of the model is the volitional phase, where an individual transitions from suicidal ideation to attempt. This transition is precipitated by factors such as an acquired capability for suicide, access to means, a suicide plan, and impulsivity.

There is evidence to support the relationships specified in the integrated motivational-volitional model. For example, Wetherall et al. (2018) found that motivational and volitional phase factors were expressed at higher levels by participants who had a history of ideation or attempt compared to controls. This was the case specifically for the variables defeat, perceived burdensomeness, and acquired capability, among others. The authors also found that only volitional phase factors differentiated between those who had thoughts of suicide and those who had attempted suicide, with higher acquired capability and impulsivity reported by participants who had attempted suicide. Branley-Bell et al. (2019) report relationships that are consistent with those described by Wetherall et al. (2018), further supporting the claims of the integrated motivational-volitional model.

Three Step Theory. The three step theory was developed by Klonsky and May (2015). Like Joiner and O'Connor's theories of suicide, the three step theory explains the development of suicidal ideation and the progression to an attempt as separate processes. Klonsky and May (2015) propose that development of suicidal ideation begins with pain, whether it be emotional, mental, or physical. Pain decreases an individual's desire to live, as it punishes them for simply being alive. If this individual also feels hopeless (a risk factor unaccounted for by the interpersonal psychological theory of suicide and integrated motivational-volitional model) that their pain will go away, then suicidal ideation develops. Klonsky and May (2015) believe that one of these variables without the other is not sufficient to cause ideation; both pain and hopelessness must be felt.

The second step of the three step theory involves connectedness, which protects an individual against strong suicidal ideation. If an individual's connectedness is greater than their pain, their ideation will remain at a moderate level. In contrast, if an individual's level of pain is greater than their connectedness, or connectedness is absent entirely, the individual's suicidal ideation will be strong.

The third step occurs when an individual has strong suicidal ideation and the capacity to attempt suicide. Capacity for attempt is defined by three categories of variables: dispositional, acquired, and practical. Dispositional variables are those which are innate or genetic like sensitivity to pain. Someone with low pain sensitivity will likely be more capable of attempting suicide than someone who has high pain sensitivity. Acquired variables such as habituation to pain or the idea of death further lead to a higher capacity for suicide. Practical variables are factors which make an attempt easier to carry out, such as knowledge of, and access to, the means to attempt suicide. If an individual with strong suicidal ideation has the capacity to attempt suicide, based on the presence of these three types of variables, they are more likely to do so, according to the three step theory.

Klonsky and May (2015) examined each of the steps in this theory using a large sample of adults in the United States of America, and found support for all three steps of their theory. For the first step of the theory, they found pain and hopelessness to each be strongly correlated with suicidal ideation, and the interaction of pain and hopelessness statistically significantly predicted suicidal ideation. In support of the second step of the theory, they found a significant interaction between pain-hopelessness and connectedness, and a stronger correlation of connectedness with suicidal ideation in the high pain/high hopelessness subgroup compared to other subgroups. Supporting step three of the theory, Klonsky and May (2015) found all three types of capacity for suicide (dispositional, acquired, and practical) to distinguish between participants with a history of suicidal ideation and participants with a history of suicide attempts, with individuals who had attempted suicide expressing significantly higher levels of these variables.

Findings from the research of Dhingra, Klonsky, and Tapola (2019) further corroborate the conclusions of the three step theory, finding similar results for each of the three steps. However, contrary to Klonsky and May's (2015) research findings, Dhingra et al. (2019) found that connectedness was not lowest in individuals without both pain and hopelessness. Dhingra et al. (2019) postulate that this may be due to the way in which connectedness was measured in their study, as only interpersonal connectedness was measured. If connections to additional things such as jobs, roles, or a sense of purpose were measured, as Klonsky and May (2015) recommend, then a different result may have been seen.

Each of the three theories above describe only a few of the risk factors which are known to contribute to the occurrence of suicide and that were discussed earlier in Chapter One. It is important to note that people who experience suicidal ideation or behaviour often present with numerous risk factors for suicide, not just one or two. Therefore, theories that aim to predict or explain who is at risk of attempting suicide need to incorporate these various factors. Furthermore, they should aim to account for the complex interactions *between* these risk factors – which risk factors, when present together, will considerably increase a person's suicide risk, and which factors provide the strongest protective effect against these sorts of risk factors? These are questions which thus far have not been answered wholly by any of the modern theories described above. Comprehensive theories of suicide need to be developed to adequately address this gap.

Chapter Two: The Present Study: A Network Approach to Understanding Suicide

A network analytical approach may help us better understand who will attempt suicide depending on which risk and protective factors they experience. This approach will first be described in detail, followed by a discussion of relevant psychological literature which has adopted a network approach, and why it is appropriate to apply this technique to the risk and protective factors for suicide.

Network analysis is a statistical technique that enables researchers to explore complex associations between a group of variables, such as risk factors or symptoms. Emanating from this analysis is a visual network structure, which depicts the associations between variables (see Figure 1 for an example of a network structure), as well as the strength and direction of these relationships. Each node in the estimated network represents a variable, for example a symptom of a disorder. The connections between nodes are called edges, and these represent associations between nodes.

In network analysis, the centrality of each node can be measured. Centrality is a measure of how connected each node is to others in the network (Fonseca-Pedrero, 2018). Nodes with a higher number of connections to other nodes on the network are therefore more central. There are multiple measures of centrality, including strength, closeness, and betweenness. Strength sums the strength of all the edges connected to a node, while closeness is described as how strongly a node is *indirectly* associated with other nodes, being the inverse of the sum of the shortest paths between one node and all others (Epskamp, Maris, Waldorp, & Borsboom, 2016). Betweenness measures the number of shortest paths between two nodes that a node of interest is included in (Epskamp et al., 2016). If betweenness of a node is high, it suggests that the node is very important in connecting other nodes (Epskamp et al., 2016). Each of these measures of centrality were originally designed for social network analysis and so they may not be suitable in the context of interpreting psychological networks (see Bringmann et al., 2019 for a review of the suitability of centrality indices in psychological networks). With closeness and betweenness often subject to instability, strength is likely the most valuable measurement of centrality for psychological networks (Bringmann et al., 2019). Thus, for the remainder of this thesis, only strength centrality will be discussed.

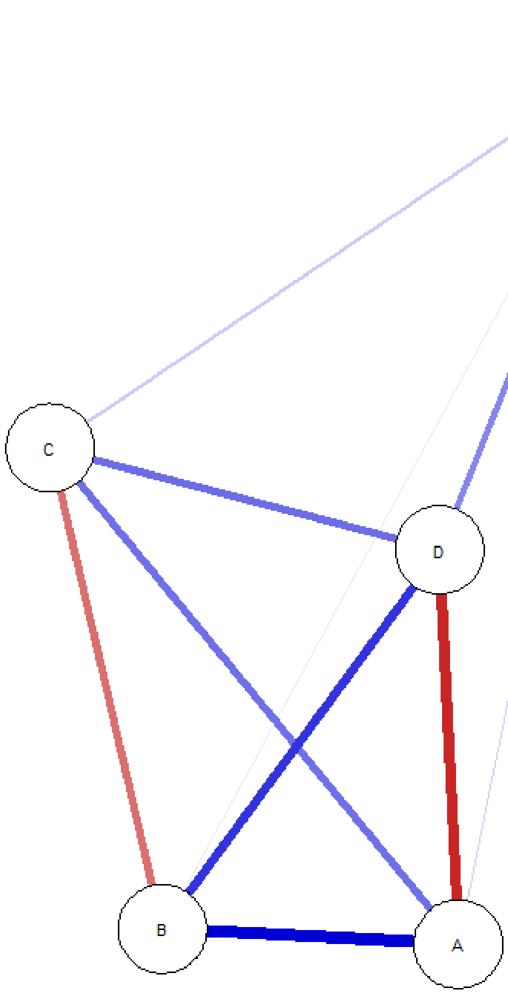


Figure 1. An example of a network structure. Each node (circles with the letters A, B, C, D, and E) represents a variable, and each edge (line joining two nodes together) represents the association of the variables it joins. Blue edges represent positive associations while red edges represent negative associations. The thicker the edge, the stronger the association.

Network Analysis and Psychopathology

The commonly held view towards psychopathology is that symptoms are caused by a latent mental disorder (Humphry & McGrane, 2010). From the latent variable viewpoint, if there exists a variable called ‘depression’, for example, which individuals have varying levels of, then individuals with high levels of this variable are very likely to develop symptoms such as low mood, amotivation, and fatigue. In other words, the presence of the disorder (in this example, depression) causes the symptoms associated with it. Network theory proposes a contrasting viewpoint. The use of network analysis in relation to psychopathology was conceptualised by Borsboom (2008), who suggested that psychopathology could be understood in terms of the complex, causal associations between symptoms. According to network theory, each symptom of psychopathology arises as a result of a previously experienced symptom, producing a causal network of symptoms, each of which influences the development of another. From a network theoretical perspective, the activation of multiple symptoms within a network results in the development of psychopathology. Thus, network analysis provides an alternative way of understanding how particular symptoms might be associated with one another, suggesting that they are not affected by a common cause (e.g., depression), but instead the symptoms causally affect one another.

Few researchers have attempted to explore suicide from a network approach thus far. Therefore, in order to understand how a network approach to understanding the risk and protective factors for suicide may be of use to researchers and mental health professionals alike, first it is cardinal to discuss how researchers have explored other psychological phenomena. Utilising a network perspective to explore psychopathology has increased our knowledge of the complexity of relationships between variables, which variables are most central to specific conditions, and how current treatment methods could be improved by utilising this information.

Complexity of relationships. Network analysis can be used to explore the complexity of relationships between a large number of variables. Such usage is exemplified by Boschloo et al. (2015) who estimated a network structure to explore 120 symptoms associated with twelve different DSM-5 diagnoses. The authors used data from over 34,000 participants in the United States of America, collected in the National Epidemiologic Survey on Alcohol and Related Conditions. The overall network structure supported the structure of the DSM-5, showing clustering of highly associated symptoms, relating to each of the different diagnoses. However, the network structure also showed associations between symptoms of one cluster with symptoms of another, with each diagnosis having an association with at least three others. Symptoms for both panic disorder and major depressive disorder were associated with symptoms of ten other diagnoses, for example. These overlapping symptoms may represent pathways to developing psychopathology comorbidities (Boschloo et al., 2015). Boschloo et al.'s (2015) research provides evidence of how network analysis can make clearer the complex associations of factors in a network. Given that suicide is also a complex phenomenon, it is plausible that a network analysis of risk and protective factors for suicide will result in increased clarity about how these factors relate to one another.

Centrality of variables. In recent years, network analysis has been used to examine associations between symptoms of psychopathology to determine which are most central to a disorder and how it develops. An example of research using network analysis to examine symptoms of mental disorders is a study by Fried, Epskamp, Nesse, Tuerlinckx, and Borsboom (2016). The authors estimated the network structure of 28 symptoms for depression in a sample of over 3000 people with depression. They examined the centrality of symptoms and how they were causally related, and also compared the centrality of symptoms which aligned with the DSM-5 to symptoms which did not.

Fried et al. (2016) found that symptoms which met DSM-5 criteria for depression did *not* have higher centrality than non-DSM-5 symptoms. DSM-5 symptoms such as loss of interest and low mood were highly central in the network of depression, but the non-DSM-5 symptoms of panic, anxiousness, and sympathetic arousal were too. Given that depression and anxiety are often comorbid, yet are seen as being two separate disorders (Fried et al., 2016), this was an interesting finding. It suggests that the symptoms of depression and anxiety may have a substantial overlap rather than being distinct networks, and thus when a few central symptoms are activated, the symptoms of both depression and anxiety can be further activated, resulting in the appearance of both disorders (Fried et al., 2016). Fried et al.'s (2016) research findings provide evidence for why it might be useful to explore associations within a network of suicide risk and protective factors, as the activation of a few highly central factors may be the crux of suicidal behaviour. Furthermore, knowledge of how risk factors for suicide interact with protective factors which are present at the same time may have important implications in our understanding of suicide risk.

Improvement of current treatment methods. Further to the increased understanding of complex associations and symptom activation that network analysis has provided researchers thus far, network analysis may also prove invaluable in improving methods of treatment or prevention. It is plausible that variables which are most central within a network of psychopathological symptoms could be powerful targets for treatment, because a central node causally influences many other nodes in a network. Therefore, by changing a central variable, the levels of other variables may be altered too. This could potentially reduce the likelihood of an individual developing psychopathology or reduce the severity of it if the symptom network has already been activated.

Borsboom (2017) proposes three ways in which a symptom network can be used to guide treatment. The first of these is a symptom intervention, where the state of only one symptom in the network is changed. An example of this is the provision of antidepressants to counteract low mood in a network of depression symptoms. The second way to use a network in psychological treatment is to intervene in the external field[1], eliminating one or more factors which are not included in the network, but which can trigger the activation of it. For example, alcohol use is not included in the symptom network for a DSM-5 diagnosis of depression, but it might trigger the activation of a symptom that is, such as low mood. In an external field intervention, alcohol use could be targeted, reducing the likelihood that the network for depression would be activated. The last way to use a network structure to guide treatment is to intervene across the whole network, altering the entire structure of the network by changing or interrupting connections between symptoms. An example of a network intervention is the provision of psychological therapy, which may decrease an individual's experience of numerous symptoms. This might result in less activation of these symptoms and therefore the associated symptoms in the network structure would not be activated either. Borsboom (2017) suggests that if the network of an individual's symptoms is known, then by using one or more of the three forms of intervention described above, a personalised treatment plan could be implemented. This targeted plan would be effective at transitioning the network structure back to a healthy state. If researchers can apply this way of thinking to a network structure of suicide risk and protective factors, effective methods of suicide intervention and prevention could be developed.

At present only a handful of studies have explored whether network analysis can be used to guide effective targeted interventions. One such study is that of Rodebaugh et al. (2018). The authors measured the symptoms of social anxiety disorder in a sample of 910

[1] In the present study, external field variables will not be distinguished from symptoms. External field variables are those which are not included as part of the symptom network but can trigger activation of symptoms in the network, thus potentially activating the whole network.

participants, using the Liebowitz Social Anxiety Scale. They then estimated a network of symptoms of social anxiety disorder to determine which symptoms were most central. Following this, they explored whether a change in these central variables was associated with symptom change in a second sample of 244 participants with social anxiety disorder who had received treatment such as cognitive behavioural therapy, mindfulness-based stress reduction, and aerobic exercise. Rodebaugh et al. found that the centrality of nodes was predictive of change during treatment, with high centrality being associated with more change during treatment. The authors conclude that using treatment to target highly central symptoms of social anxiety disorder may generalise across the symptom network, resulting in reduced social anxiety symptom severity overall, as measured by the Liebowitz Social Anxiety Scale. The results of this study should be interpreted cautiously due to poor stability of some centrality indices as noted by Rodebaugh et al. (see the Data Analysis subsection of Chapter Three in this thesis for more information about network stability). Rodebaugh et al.'s research exemplifies an important potential use of network analysis, in guiding effective targeted treatment.

Recent research by Papini, Rubin, Telch, Smits, and Hien (2019) also contributes to the current understanding of how node centrality is related to change during treatment. The authors first estimated a network of symptoms of post-traumatic stress disorder in 353 female participants prior to treatment with cognitive-behavioural therapy or health education group. Papini et al. hypothesised that the centrality of nodes would be predictive of the association between how much an individual node would change during treatment and how much the overall network would change. This was tested by calculating the association between node change and change in other nodes, such that a strong correlation would suggest that change in the overall network was dependent on change of specific symptoms. This association was then correlated with measures of centrality from the network of pre-treatment symptoms. The authors found that node strength centrality was strongly correlated with the strength of the correlation between individual node change and change across the overall network structure. These associations were statistically significant, supporting the hypotheses of Papini et al. that centrality of symptoms of post-traumatic stress disorder prior to treatment is predictive of symptom change during treatment.

Network Analysis and Suicide

Although suicide is not a mental disorder and it should not be conceptualised as one, it is plausible that a network analysis of the risk factors for suicide would prove valuable, much as it has in examining various forms of psychopathology. At present there are extremely few published studies that have used network analysis to examine suicide, with just four studies matching this description found in the process of writing this thesis. These were conducted by Shiratori et al. (2014), De Beurs, van Borkulo, and O'Connor (2017), Simons et al. (2019), and De Beurs et al. (2019). Each of these four studies will be briefly described below.

Shiratori et al. (2014) created a network structure of motives for 451 suicides that occurred in Japan between 2007 and 2009. Using police statistics, the precipitating events for each suicide were broadly categorised into eight groups, including family problems, economic and livelihood problems, and work-related problems, among others. The resulting network structure for this sample estimated physical illness, depression, and economic hardship to be the three most central motives for suicide. Each was highly connected to other nodes in the structure. As mentioned by Shiratori et al., there were limitations to this research, including the data itself. The data comprised of information collected by police officers, coming from suicide notes, for example, and this was then used to determine the motive for each suicide. For 861 cases (37.5% of the sample) the motives were categorised as unknown. As such, it is plausible the motives included in the analysis may not have been entirely representative of the true motives of the individuals who had died by suicide, and instead may have reflected the police officers' subjective interpretation of the circumstantial evidence that had been collected.

De Beurs et al. (2017) also conducted research utilising network analysis to examine an aspect of suicide. Using network analysis, they examined the association between suicidal thoughts, as measured by the Beck Scale for Suicidal Ideation (BSSI), and future suicidal behaviour. Participants were 366 individuals who were admitted to a hospital in Edinburgh, Scotland, following an attempted suicide, whose data were originally collected as part of a separate study about predictors of repeat suicidal behaviour. These participants were grouped by whether they had a repeat suicide attempt within 15 months or not. De Beurs et al. hypothesised that repeat attempters would have a more densely connected and therefore more easily activated suicidal thought network than non-repeaters, but this hypothesis was not supported. The overall network of BSSI-related variables showed that desire to attempt suicide had the highest centrality, followed by expectancy of attempt, and attitude towards attempt. Several variables were estimated to be directly related to repeat suicidal behaviour, some of which included arrangements after death, planning, and wish to die. De Beurs et al.'s research shows how visualising the complexity of associations between variables associated with suicide may help us to better understand this phenomenon.

Simons et al. (2019) conducted research published during 2019, in which a network approach was used to examine suicide. The authors aimed to estimate the network structure for suicidal ideation, comprising of risk and protective factors for suicide. The 276 participants were veterans recruited from Florida and South Dakota in the United States of America. Participants responded to a questionnaire which measured post-traumatic stress disorder symptoms, depression symptoms, suicidal ideation, traumatic stress, social support, alcohol dependence, effortful control, and distress tolerance. Simons et al. found that suicidal ideation was positively associated with depression, post-traumatic stress disorder, and alcohol use disorder. Protective factors such as effortful control and distress tolerance were negatively associated with suicidal ideation, as was social support. With a small sample size and many nodes included in the network (11 in one, 18 in another), the stability of the estimated network is questionable. Though participant numbers exceeded the minimum required for estimating a network with this number of nodes, as stability estimates are not reported the results of this study should be interpreted with caution.

The most recently published suicide network analysis was that of De Beurs et al. (2019). Network analysis was applied to cross-sectional data from 3508 participants in the Scottish Wellbeing Study to examine which factors in the interpersonal psychological theory of suicide and integrated motivational-volitional model were related to suicidal ideation. Factors which were measured included suicidal ideation and behaviour, depressive symptoms, social support, perceived burdensomeness, resilience, and impulsivity, among others. In a network of core constructs from both models, internal entrapment and perceived burdensomeness had the strongest relationship with suicidal ideation. In a separate network of psychological factors as well as core constructs from the models, twelve factors were directly related to current suicidal ideation, including perceived burdensomeness, depressive symptoms, and resilience. This research contributes to the current theoretical understanding of factors which directly or indirectly impact suicide risk.

The need for further suicide network research has been recognised by researchers in the field of psychology. In a review of recent developments and challenges for suicide research, O’Connor and Portzky (2018) urged researchers to utilise network analysis when studying suicide. Furthermore, De Beurs (2017) has argued that estimating a network of factors associated with suicidal behaviour may help researchers to validate theoretical models of suicide (like those described in Chapter One), understand differences between subgroups of people exhibiting suicidal behaviour, and help to create personalised interventions for suicidal behaviour.

To be able to create personalised interventions for suicidal behaviour in years to come, it is important to first gain an understanding of which risk factors are most central to a network of suicide risk, and how these can be implicated in altering suicide risk. As aforementioned, there are ways in which the network structure can be targeted in interventions, through reducing the activation of its variables (Borsboom, 2017) and thereby potentially reducing the likelihood of suicidal behaviour. By using network analysis to investigate the relationships of risk and protective factors for suicide, specific factors may be identified as being directly associated with suicidal ideation or central to heightened suicide risk, and these factors may then be targeted in individualised treatment. If the state of central risk or protective factors is changed in an individual's suicide risk network, other factors in the network will likely change too. This would reduce the individual's overall suicide risk in a much more drastic way than might otherwise be possible. Say access to means, depression, and substance abuse are all central to suicidal behaviour. In this scenario, these factors can each be targeted in an intervention, by reducing the individual's access to lethal means, and by providing psychological therapy or pharmacological support for the symptoms of depression and substance abuse. In turn this might change the state of other factors in the network that are associated with these. Providing that the interventions are successful, by targeting the highly central risk factors in the network, the overall risk that the individual will attempt suicide may decrease. It is important to mention that this has yet to be demonstrated (De Beurs, et al., 2017), with no published studies exploring the effectiveness of interventions targeting central risk factors for suicide as of yet. However, preliminary evidence from studies of psychopathology suggest that targeting central variables in an intervention may be an effective way to decrease symptoms network-wide (Papini et al., 2019; Rodebaugh et al., 2018).

Research Aims

Due to the dearth of network analysis applications to suicide thus far, the present study sought to conduct a network analysis exploring the associations of risk and protective factors for suicide in an international sample. The main aim of this research was to find out which factors were most central to suicide risk. Research to date has not yet determined how risk and protective factors for suicide relate in a network sense, and thus this was explored to provide further understanding of the complex reciprocal associations such factors have with one another.

It must also be noted that this research was a cross-sectional observational study, and therefore the results must be interpreted differently than if this was a longitudinal study. The use of cross-sectional data in a network analysis does not enable us to determine the direction of the relationships between nodes, and thus we cannot assume that the edges estimated in the network represent causal effects. However, the results of the analyses can be used to generate hypotheses about causal effects, which could be tested in future studies.

Table 3 lists the risk and protective factors which were included in the network analyses. Multiple risk and protective factors for suicide were described in Chapter One. Many of the factors described are dynamic in that they are amenable to change, making them feasible targets for suicide prevention and intervention. Only these factors which could broadly be described as dynamic were included in the network analyses. Knowledge of the network structure for suicide risk and protective factors could potentially give researchers and mental health professionals the ability to create targeted, effective treatment for individuals at risk of suicide. By using an intervention to target central suicide risk factors, other associated factors in the network may also change, further decreasing an individual's overall risk of suicide. Therefore, conducting a network analysis of the dynamic, changeable risk and protective factors for suicide could have ramifications for developing personalised suicide interventions. This could plausibly result in a decrease in the number of individuals attempting or dying by suicide in the future.

Table 3

Variables Included in the Network Analyses

Risk Factors	Protective Factors
Impulsivity	Employment stability
Substance abuse	Financial stability
Being bullied	Being in a committed relationship
Feeling anxious	Problem solving skills
Feeling depressed	Resilience
Feeling hopeless	Sense of belonging
Perceived burdensomeness	Self-esteem
Suicidal ideation	Access to mental health services
	Positive attitude towards mental health services
	Social support

Some of the factors listed in Table 3 have been broadly derived from the risk and protective factors described in Chapter One, rather than having identical terminology. These variables include feeling anxious, feeling depressed, financial stability, and being in a committed relationship. The variables feeling anxious and feeling depressed were created to measure two common mental health problems that were described in Chapter One as being associated with suicide risk, without specifically measuring whether participants met diagnostic criteria for an anxiety or mood disorder. Financial stability was measured rather than financial stress (a common stressful life event that is associated with suicide risk), hence instead reflecting a variable which may be protective of suicide. Being in a committed relationship was measured as an alternative to being married, which was listed as a protective factor for suicide. The remaining variables are exact duplicates of factors described in Chapter One.

A small number of risk and protective factors that were discussed in Chapter One were not included in the network analyses. The focus of the present study was predominantly on individual differences in suicide risk, and factors which could likely be changed during treatment and intervention, thus increasing the likelihood of successful suicide prevention and decreasing suicide risk. Factors which were omitted from the network analysis which did not meet this objective (i.e., they likely could not be changed in psychological treatment) included sexual orientation, family history of suicide, personal history of self-harm or suicide attempt,[2] and physical health or disability.

Other factors were omitted as they were deemed too difficult to measure via a simple questionnaire. These variables included rural-urban status, socioeconomic deprivation, and exposure to suicide in the media. These variables are often measured in other research, particularly rural-urban status and socioeconomic deprivation, and so it may not be immediately apparent as to why these variables were deemed difficult to measure in the context of the present study. Rural-urban status was thought to potentially be difficult to determine in a New Zealand population due to the large number of towns which have small

[2] This specific risk factor is not descriptive of *current* self-harm or suicide attempts, but times in the past that this has occurred, thus it is considered a static risk factor.

populations, thus resulting in ambiguity about whether a particular location is rural or urban. Inclusion of this variable would have presented with further difficulties given some participants were from countries outside of New Zealand (see Chapter Three for more information), requiring additional knowledge of rural-urban distinctions outside of a New Zealand context. Like rural-urban status, socioeconomic deprivation may have presented with difficulties in the application across countries. Measurement of this variable would likely have required multiple items to be taken from standardised measures, potentially adding a further financial cost to this research, which, as will be discussed in Chapter Three, was not a feasible option. Furthermore, both rural-urban status and socioeconomic deprivation are quite stable dynamic factors, so although in theory these variables can be changed, it is likely difficult to do so, providing a secondary reason for the exclusion of these factors from the present study.

Additionally, from an ethical standpoint other factors were not appropriate to include in the questionnaire or resulting network structure due to the belief that the risks associated with including these items outweighed the potential benefits. For example, asking someone about whether they have access to means commonly used for suicide may pose a level of risk to someone who is in actuality experiencing suicidal ideation or planning a suicide attempt, such that they could be prompted to give thought to what methods are available to them. Asking about history of childhood abuse and neglect was also considered unethical in this study, as doing so could cause undue harm to participants with a history of this experience. In many cases abuse may not have been formally documented, with only a quarter of family violence incidents (which includes child abuse and neglect) being reported to the Police in New Zealand (It's Not OK, 2017). As such, asking participants whether they have a history of abuse could raise questions about the ethical responsibility to report this information, and the strict anonymity of the survey would make this extremely difficult to do.

The factors which were not included in the network analysis and the associated reasons for this are listed in Table 4. If other researchers replicate this study, they may wish to consider measuring these variables and including them in the network, if ethically possible, as they are important factors in determining suicide risk.

Table 4

Variables Excluded from the Network Analyses

Reason for Exclusion	Variable
Static variables, or variables that cannot plausibly be changed in psychological treatment	Sexual orientation Family history of suicide Personal history of self-harm or suicide attempt Physical health or disability
Difficult to measure via simple survey	Rural-urban status Socioeconomic deprivation Exposure to suicide in the media
High ethical risk	History of child abuse or neglect Access to means

This project has been preregistered as an Open Science Framework project which can be accessed online at https://osf.io/f395g/. The method and data analyses used in this study were decided upon prior to data collection, and these details are specified in the preregistration (see Appendix C: Open Science Framework Preregistration or https://osf.io/gdwnb). A data analysis script was also uploaded with the preregistration, to show the planned analyses and how they would likely be conducted. The final analysis script on the Open Science Framework includes some small modifications. Some researchers decide on data analysis methods *after* viewing the data, which has the potential to make their results appear more favourable than they are in reality (Wagenmakers, Wetzels, Borsboom, van der Maas, & Kievit, 2012). Preregistration is an Open Science practice which protects against this occurrence, with data analyses as well as other aspects of the research plan decided upon before data is collected (Nosek, Ebersole, DeHaven, & Mellor, 2018). This information is saved in an online repository such as the Open Science Framework, where it cannot be edited. As this research was preregistered, readers can be confident that the results of the analyses are not due to *p*-hacking (i.e., the results are not due to adapting the research hypotheses and analyses to find statistically significant results). Furthermore, storing the preregistration, questionnaire items, analysis script, and deidentified data for this research on the Open Science Framework ensures other researchers have access to all materials required to replicate this study, or to test the analyses of the present study, should they want to.

Chapter Three: Method

Participants and Procedure

The preregistration specified a target sample size of 500 participants. To conduct a stable network analysis, there needs to be at least as many observations as there are parameters (De Beurs, 2017). With eighteen risk and protective factors included in the analyses, this meant that there were 171 possible parameters (18 x 17/2 = 153 pairwise association parameters, plus 18 threshold parameters = 171), and therefore at least 171 participants were needed to ensure the network analyses were stable. As network analysis has better stability with larger samples, this study aimed to recruit a number of participants in excess of this minimum.

Participants were recruited via two methods which operated concurrently. One method involved posting an advertisement to social media, while the other involved advertising the study on Prolific Academic. Prolific Academic is a worldwide research participant recruitment website where participants are paid a small compensation for their time. The preregistration for this study stated that 300 participants would be recruited through Prolific Academic, and 200 through social media, with participants residing in New Zealand, Australia, the United States of America, and the United Kingdom. These four countries were recruited from as they are largely English speaking and have similar suicide rates. It was presumed that the majority of participants recruited through social media would live in New Zealand, as the Facebook groups which were advertised in were predominantly based in New Zealand, as were many of the people who would view and share the public advertisement on my personal Facebook page. In comparison, Prolific Academic includes sizeable numbers of individuals who live in the United States of America and the United Kingdom, and a fewer number who reside in Australia. By utilising two methods of recruitment, participants from each of these four countries were recruited.

The social media recruitment method involved posting an advertisement in Facebook groups about suicide prevention and mental health awareness in New Zealand. From these groups the advertisement was shared further by other people, to related Facebook groups and to personal profile pages. The advertisement comprised of a short description of the study along with a link to an information sheet specifically for social media participants (see Appendix A: Social Media Participants: Advertisement and Survey). The information sheet informed potential respondents about what their participation would involve. The information sheet for participants recruited via social media ended with a question asking for the participant's consent if they wished to continue to the survey. If the participant responded by answering "yes", the survey began. The second method of recruitment involved posting an information sheet to Prolific Academic (see Appendix B: Prolific Academic Participants: Information Sheet and Survey) which was created specifically for these participants, acting as both an advertisement and information sheet. As the information sheet for Prolific Academic participants was on the Prolific Academic website, people who wished to participate clicked the survey link on Prolific Academic, which took them directly to a question asking for their consent. Again, if the participant responded with a yes, they could begin the survey. As will be discussed in the Measures subsection, both groups of participants then completed the same survey items.

The preregistration stipulated that the survey was to remain online either until the survey reached the quota of 300 participants from Prolific Academic and 200 participants from social media, or for four weeks; whichever occurred first. Data collection began on the 25th of June 2019. It took two hours to recruit the quota of Prolific Academic participants, and three days to recruit the quota of social media participants. The quotas were used to measure the number of participants who met inclusion criteria for this research and reached the end of the survey. When the number of people meeting these conditions reached the preregistered target, the survey closed. The survey quota rules specified that to be included in the quotas participants must select yes to the consent question and provide answers to the demographic questions about their gender, age bracket, and the country they live in. Participants who did not consent to participate, did not provide answers to these demographic questions, or did not reach the end of the survey were excluded from the quotas. Survey branches were put in place to not allow people to participate in this study further if they failed to provide responses to these questions.

Sample size and participant demographics. There were 534 respondents to the surveys overall (301 from Prolific Academic and 233 from social media). The total number of participants is higher than the target sample due to a number of participants not reaching the end of the survey, and thus not being counted in the quotas. Of these 534 participants, 532 met the participant inclusion criteria stipulated in the preregistration. The inclusion criteria specified that participants must be aged 18 or older, and live in New Zealand, Australia, the United States of America, or the United Kingdom. Two participants recruited via social media signalled that they were from a country other than those listed above, so they were not able to participate further. One participant who was recruited via Prolific Academic did not specify which country they lived in, and for an unknown reason the survey branches did not work, failing to screen this person out and thus allowing them to complete all survey items. However, as the Prolific Academic website allowed the study advertisement to be viewed only by members living in one of the four specified countries, this participant can be presumed to reside in either New Zealand, Australia, the United States of America, or the United Kingdom, and so the participant was included in the data analyses. They do not appear in the country frequencies listed in Table 5 below but are included in all other counts and analyses.

Table 5

Participant Demographics

	Frequency	Percentage
Gender		
Male	171	33.20
Female	338	65.63
Gender diverse	5	0.97
Prefer not to answer	1	0.19
Age		
18 to 24	153	29.71
25 to 34	164	31.84
35 to 44	102	19.81
45 to 54	51	9.90
55 to 64	36	6.99
65 to 74	9	1.75
Country		
New Zealand	198	38.45
Australia	32	6.21
United States of America	146	28.35
United Kingdom	138	26.80

*Note***.** The frequencies for each country exclude one participant recruited from Prolific Academic who did not specify in the survey which country they lived in. Therefore, the total of the country frequencies do not add to 515, unlike the other demographic categories. The percentages associated with each country frequency have been calculated as a percentage of the total number of participants (515) rather than the number of participants who specified which country they live in (514).

Prior to analysing the data, the exclusion criterion was applied in line with the preregistration for this research. This stated that participants must respond to at least 75% of the Likert items to be included in the analyses. Of the 534 respondents, 19 participants were excluded from the data analyses for failing to respond to at least 25 of the 33 Likert items (75%) in this study. This left a total of 515 participants included in the data analyses. The number of participants recruited for this study was in excess of the minimum sample size required to achieve a stable network analysis (171), and so it was expected that the network analyses would be stable.

Participant demographic information is summarised in Table 5. The sample included participants from each country that the study aimed to recruit from, with 38.45% residing in New Zealand, 28.35% in the United States of America, 26.80% in the United Kingdom, and 6.21% in Australia.

Measures

Two surveys were created for the purpose of this study, containing items asking about demographic information and the variables of interest to this research (see Appendix A: Social Media Participants: Advertisement and Survey and Appendix B: Prolific Academic Participants: Information Sheet and Survey). One survey was given to all participants recruited through social media, while the other was given to all participants recruited through Prolific Academic. The two surveys had identical items measuring the variables of interest to this study. There were small differences in the demographic information collected and the way the survey ended. These will be described in more detail below.

The first section of both surveys collected demographic information about the participants. There were three items, and these asked participants to select their gender, age bracket, and the country they live in. The survey for Prolific Academic participants also collected Prolific Academic user IDs, as per the rules laid out by Prolific Academic.

The next section of the survey consisted of 33 Likert items relating to the eighteen variables of interest (see Table 6). The response scale for these items ranged from 1 *strongly disagree* to 5 *strongly agree*. Participants were instructed to choose a response that best described how much they agreed or disagreed with each statement.

Table 6

Variables and Corresponding Survey Items

Variable	Items
Stable employment	I work in a job which offers predictable income and consistent hours of work.
Financial stability	I earn enough money to meet my basic needs.
Committed relationship	I am in a committed relationship.
Impulsivity	I often do things without thinking. I often do not take my time when planning something. I often do not think things through.
Substance abuse	I think I have a drug or alcohol problem. In the past month, my drug or alcohol use has impacted my attendance at university or work. In the past month, I have failed to get important things done because of my drug or alcohol use.
Being bullied	In the past I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying. I am being bullied by another person, either physically, verbally, mentally, or by cyber-bullying.

Table 6 (continued).

Feeling anxious	I often feel anxious.
Feeling depressed	I often feel depressed.
Feeling hopeless	I often feel hopeless about my future.
Perceived burdensomeness	I often feel like a burden to the people who are close to me.
Suicidal ideation	I sometimes wish I was not alive. I sometimes think about wanting to die. I sometimes think about wanting to take my own life. I sometimes think about suicide.
Problem solving	I am good at solving problems in my daily life.
Resilience	I recover quickly after encountering difficulties. I easily adapt to change.
Sense of belonging	I feel accepted by other people. I feel connected to other people. I feel included by other people.
Self-esteem	I feel good about myself.
Access to mental health services	I am able to access mental health services if I need them. I would access mental health services if I required them.
Positive attitude towards mental health services	I believe mental health services are effective at reducing suicidal ideation and suicidal behaviour. I think mental health services are beneficial.
Social support	When I am in a crisis, I can count on someone to give me good advice. I have someone to talk to about myself or my problems. I have someone to talk to who understands my problems.

The Likert items were not taken from pre-existing instruments primarily due to the time and money constraints associated with completing a thesis for a Masters degree. Well-known instruments often come at a price, and this study already exceeded available financial resources, due to the planned cost of participant incentives. This left no room for other potential costs such as purchasing instruments. Furthermore, the majority of relevant instruments that were freely available for use in psychological research specified that distribution of the survey must be controlled, allowing only the people participating in this research to view the instrument unless written permission was obtained from the author of the instrument. This is similarly the case for many paid instruments. Because of the limited permissions, if these instrument items were used in the survey, they could not be included in a document put online such as on the Open Science Framework. As this research aimed to uphold Open Science practices, being able to put the survey items online following completion of the research was a high priority, enabling transparency and providing other researchers with all of the resources required to replicate this research. For these reasons, the Likert items used in the survey were created solely for the purpose of this research and were not taken from other sources. The validity and reliability of these items was not tested prior to data collection. Researchers wishing to replicate this study using the same items may wish to do these tests.

Network analysis research often uses a single item to measure a specific symptom or variable. However, this sometimes results in the measured item not completely representing the variable that is being targeted (McNally, 2016). To mitigate this McNally (2016) suggests network theorists use multiple items to measure a single variable. Consequently, nine of the eighteen variables being studied in this research were measured using multiple Likert items. The variables that were measured by multiple items in the survey were impulsivity, substance abuse, being bullied, suicidal ideation, resilience, sense of belonging, access to mental health services, positive attitude towards mental health services, and social support (see Table 6). The items for each variable were averaged to create a mean value for that variable for each participant. The mean values were included in the analyses, rather than the individual items measuring these nine variables. If participants failed to respond to one of the items that was used to create a mean value, the mean value for that variable for that participant was not calculated or included in the analyses (see Data Analysis subsection for more detail). For the remaining nine variables in this research, only one item was used to measure each variable. At face value, a single item appeared to be able to measure each of these variables, such that multiple items were not required to measure them. These individual items were included in the analyses. This meant the survey was reasonably concise, and not hugely time consuming to participants, thus increasing the likelihood of participation.

To incentivise participation, participants who were recruited via social media had the option to choose a charity which they wanted Massey University to donate NZD2 to on their behalf. The three options that participants could choose from were the Mental Health Foundation of New Zealand, Voices of Hope, and the Key to Life Charitable Trust. Each of these New Zealand-based charities aim for suicide prevention or are related to mental health. Prolific Academic participants were not shown this question, as they instead received £1 (approximately NZD2) via Prolific Academic on completion of this survey to compensate them for their time.

In the final section of the survey, all participants were asked if they would like to receive a summary of findings. If social media participants indicated that they wanted to receive the summary of findings, they were redirected to a separate survey and were asked to input their email address. Using a separate survey to collect this information kept their survey responses anonymous. Prolific Academic participants simply indicated whether they wanted to receive the summary of findings or not. They were not required to provide an email address. Instead, as aforementioned, all participants recruited via Prolific Academic had their Prolific Academic user IDs recorded, as the website does not permit researchers to collect email addresses from participants. The summaries will be sent via the website's messaging service to the participants who indicated that they wished to receive the summary. The summary of findings (see Appendix D: Summary of Findings for Participants) will be sent to participants upon completion and submission of this thesis.

Data Analysis

The data analyses for this research were conducted in R version 3.6.0 (R Core Team, 2019). The R packages that were used for network estimation, centrality analyses, and stability analyses were *qgraph* (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012) and *bootnet* (Epskamp et al., 2018). The full analysis script is available on the Open Science Framework, which can be accessed at https://osf.io/f395g/.

Missing values. There were missing values present in the data, with four participants missing between one and seven Likert items. If the missing value was going to be used to calculate a mean variable (e.g., impulsivity, where three Likert items were averaged to create the impulsivity node in the network), then the mean of that variable for that participant was not calculated. Consequently, participants' responses for that variable were not included in the network analysis, but their complete responses to other variables were. If the missing value was *not* going to be used to calculate a mean (e.g., feeling depressed, where only one Likert item was used to create the feeling depressed node in the network), then this value was not included in the network analysis. During network estimation, all missing values were managed through pairwise complete observations. This is where missing values are removed from pairwise correlations calculated in the network estimation process, such that only complete pairs of observations are included in the correlation matrix and subsequent network structure.

Network analysis. The primary aim of this study was to estimate the network of risk and protective factors for suicide using the survey responses of participants. In cross-sectional research such as this, directionalities of causal effects are difficult to definitively determine without making a number of assumptions (e.g., that no feedback loops are present), and as such an undirected network is estimated. One class of network estimation which is suitable for use with undirected, cross-sectional data is pairwise Markov random fields, which includes a type of network called a partial correlation network (Epskamp et al., 2016; Epskamp et al., 2018). In partial correlation network structures, an edge reflects the conditional dependence of two nodes, such that after controlling for all other nodes in the network, the relationship shown between two nodes is not due to the presence of another node (Epskamp et al., 2016). The presence of an edge can indicate a *potentially* causal relationship between two nodes (Epskamp et al., 2016). Where an edge is not present between two nodes, the variables are conditionally independent when controlling for the other nodes in the structure (Epskamp et al., 2016).

The *bootnet* package in R was used to estimate the network structure of associations between the eighteen risk and protective factors measured in this research. Partial correlation networks such as that estimated in the present study can be regularised using the least absolute shrinkage and selection operator (LASSO) method with Extended Bayesian Information Criterion (EBIC) model selection to select the best network. Regularisation limits the sum of absolute partial correlation coefficients and shrinks many edge estimates to zero, thus resulting in a sparse overall network structure (Epskamp et al., 2018). This acts to reduce the number of spurious associations which are present and make the network structure more easily interpretable (Epskamp & Fried, 2018). The LASSO tuning parameter λ controls how sparse the estimated network is. If it is set to a low value, not many edges get removed and thus a number of spurious associations remain, and if it is set to a high value, lots of edges are removed, including some associations which are potentially true (Epskamp & Fried, 2018). As per the preregistration, λ remained at the default value of 0.5 in this study.

In this research, the estimated network was weighted, showing not only the associations of nodes but the strength of these associations. In the *bootnet* package, the thickness of an edge between two nodes in the network represents the strength of the correlation between the nodes, with a thicker edge signifying a stronger correlation. Strongly correlated nodes are also placed in closer proximity to one another. The colour of an edge indicates the direction of the correlation between the nodes, with positive correlations shown by a blue edge, and negative correlations a red edge.

Centrality analyses. In a network, some nodes may be connected to large numbers of other nodes, making them important to the overall structure of the network. This can be measured by analysing the strength centrality of each node in the network. As mentioned in Chapter Two, strength centrality sums the strength of all edges connected to a node (Epskamp et al., 2016). Using R, the *qgraph* package was used to calculate the strength centrality for each node.

Stability analyses. Testing for network accuracy and stability is a crucial step in psychological network estimation. The interpretation of a network can be questionable due to the limited sample sizes that psychological research often uses (Epskamp et al., 2018). If the accuracy of the estimated edges or centrality of nodes is not known, false conclusions may be drawn from the network structure about the importance of some variables as well as their relationships.

To mitigate this problem, several analyses were conducted to check network stability, using the *bootnet* package in R as per the preregistration for this study. These analyses included testing for edge-weight accuracy, centrality stability, edge-weight difference, and centrality difference, as described in a tutorial paper by Epskamp et al. (2018). From the results of the stability tests that this research conducted, inferences can be made about the stability of the network and the accuracy of the estimated associations. As this is a relatively new area of research, each of the four stability tests are described below.

Edge-weight accuracy. A bootstrapped confidence interval is estimated to assess how variable the edge-weights are. The results of this stability test are used to show the accuracy of the edge-weight estimates, and to compare edges with one another. If the bootstrapped confidence intervals around edge-weights are large, it may indicate that the edge-weights are not significantly different to other edge-weights in the network, such that care should be taken when interpreting the order of edge-weights in the network (Epskamp et al., 2018). Epskamp et al. (2018) stress, however, that the results of this test cannot be used to determine the significance of an edge being different from zero. LASSO regularisation, like that used in this study, estimates spurious edges to be *exactly* zero, and then drops these from the network structure. Therefore, if an edge is observed in the network, its weight is not zero, because its inclusion indicates it is strong enough to remain after regularisation has taken place.

Centrality stability. This test bootstraps centrality indices to measure whether the order of node centrality is the same when a network is re-estimated for a subset of the data, with fewer cases included. A case represents one observation of all variables, for example a participant in this study. The test assesses the correlation of the original centrality indices and the centrality indices of the subset of data. The centrality indices are said to be prone to error if the correlation changes a lot after dropping case (Epskamp et al., 2018). In their tutorial paper on stability analyses, Epskamp et al. (2018) present a measure termed the correlation stability coefficient, or CS-coefficient. This is used to quantify centrality stability of subset bootstraps of centrality. The authors state that a CS (cor = 0.7) represents the maximum proportion of cases that can be dropped, such that there is a 95% probability that the original centrality indices and the network subset centrality indices will have a correlation of 0.7 or higher. Epskamp et al. (2018) recommend a CS-coefficient score to be higher than 0.5 to later interpret centrality differences, and ideally it should not be less than 0.25. However, they acknowledge this is an arbitrary cut-off, and it should be interpreted as such.

Edge-weight difference. This test is used to investigate whether two edges significantly differ from one another. It takes the difference between the two bootstrapped edge-weight values and constructs a bootstrapped confidence interval around these. This can be used for a null hypothesis test, by checking if zero is included in the bootstrapped confidence interval, and therefore whether the two edges likely differ from one another. Epskamp et al. (2018) caution that researchers should not assume that a nonsignificant edge-weight difference provides evidence that two edge-weights are equal. Although the test has a Type I error rate close to the significance level, it has a slightly lower level of power in rejecting null hypotheses when two edge weights are in reality different from one another. The implication of this is that the test will find fewer significant differences than in truth exist, and thus the results should be interpreted with some caution.

Centrality difference. The centrality difference test measures whether the centrality of two nodes significantly differs from one another. This test is similar to the edge-weight difference test, but instead of taking the difference between two bootstrapped edge-weights, it uses bootstrapped centrality indices, and creates a bootstrapped confidence interval around these difference scores. Much like the edge-weight difference test, the centrality difference test allows for null hypothesis testing, by checking whether zero is included in the bootstrapped confidence interval. The centrality difference test also requires caution in interpretation, due to low power in rejection of the null hypothesis when two centrality indices are in reality different, as is described for the edge-weight difference test above.

Gender analyses. A secondary aim of this research was to analyse the differences in the network structures of males and females. As with the primary network analysis in this research, the gender network analyses required a minimum number of 171 participants of each gender in order to conduct stable analyses. This minimum was met, with 171 males and 338 females participating in this research. The same process as was described in the Network analysis subsection of the Data Analysis section was repeated with male participant responses and female participant responses to estimate the network structures for each gender. The network estimations were followed by centrality and stability analyses for each network, following the same process as what was described in the Centrality analyses and Stability analyses subsections above.

Data Sharing Policy

An anonymised copy of the data used for this research has been made available on the Open Science Framework, along with the R script that was used to run the analyses. A copy of the survey items and data dictionary are also available. These documents can all be accessed at https://osf.io/f395g/. The data sharing policy of this research aligns with the open data guidelines stipulated in Massey University's revised Code of Ethical Conduct for Research, Teaching and Evaluation Involving Human Participants (2017).

Ethics

Approval for this study (Application NOR 19/19) was given by the Massey University Human Ethics Committee: Northern.

The primary ethical issue considered in this study was the risk of discomfort to participants. A very small number of questions in this study asked about suicidal ideation, which had the potential to cause discomfort or distress to participants. However, research suggests that asking about suicide does not increase a person's risk of suicide and doing so may even reduce suicidal ideation (Dazzi, Gribble, Wessely, & Fear, 2014). Thus, it was deemed highly unlikely that measuring suicidal ideation would result in an increase in suicide risk for participants. Potential discomfort was mitigated by suggesting in the information sheet prior to the survey that if participants felt distressed during participation, they should stop and call a mental health or suicide prevention helpline relevant to their country. Phone numbers for these services as well as emergency services were listed at this point and were listed again at the end of the survey.

The type of information being collected in the survey was another important ethical consideration for this research. In a very broad sense, the factors are statistically predictive of suicide, but the questions being asked were specifically about attributes known to bear some relation to suicide risk. A suicide risk assessment of the type used in clinical practice was not conducted. As such, none of the information collected indicated whether an individual was at any immediate risk of suicide. Furthermore, given participants may have been hesitant to share information even broadly related to the topic of suicide, the survey was deliberately constructed to be completely anonymous, such that participants could not be identified. Therefore, direct action in response to participant suicide risk would not have been able to be taken.

Chapter Four: Results

Descriptive Statistics

Presented below are two figures (Figure 2 and Figure 3) which show the 33 Likert items used in the survey, and what percentage of participants endorsed each response scale option. This information is spread across two figures simply because it was too large to fit on a single page. The response options for the Likert items ranged from 1 *strongly disagree* to 5 *strongly agree*. Descriptive statistics for the variables are reported in Table 7.

On average, participants in the sample neither agreed nor disagreed that they were impulsive (measured by three items, $M = 2.51$, $SD = 0.99$), and they tended to disagree with statements regarding personal substance abuse (measured by three items, $M = 1.49$, $SD = 0.91$). Many participants agreed that they felt anxious ($M = 3.74$, $SD = 1.25$, 69% agreed), depressed ($M = 3.32$, $SD = 1.34$, 53% agreed), and hopeless ($M = 3.18$, $SD = 1.46$, 50% agreed). Across the four items measuring suicidal ideation, participants neither agreed nor disagreed that they experienced this ($M = 2.54$, $SD = 1.42$). However, as shown in Figure 3, many participants agreed or strongly agreed with the statements measuring suicidal ideation, thus the sample did include a number of participants who experienced suicidal ideation.

Participants in this study on average agreed with statements regarding their ability to access to mental health services (measured by two items, $M = 3.69$, $SD = 1.01$) and having a positive attitude towards these services (measured by two items, $M = 3.91$, $SD = 0.98$). Additionally, participants on average agreed with statements about having a high level of social support and a sense of belonging (each measured by three items, $M = 3.72$, $SD = 1.12$ and $M = 3.10$, $SD = 1.09$ respectively). On average the sample expressed that they had good problem solving skills ($M = 3.60$, $SD = 1.00$) and were resilient (measured by two items, $M = 3.16$, $SD = 1.09$).

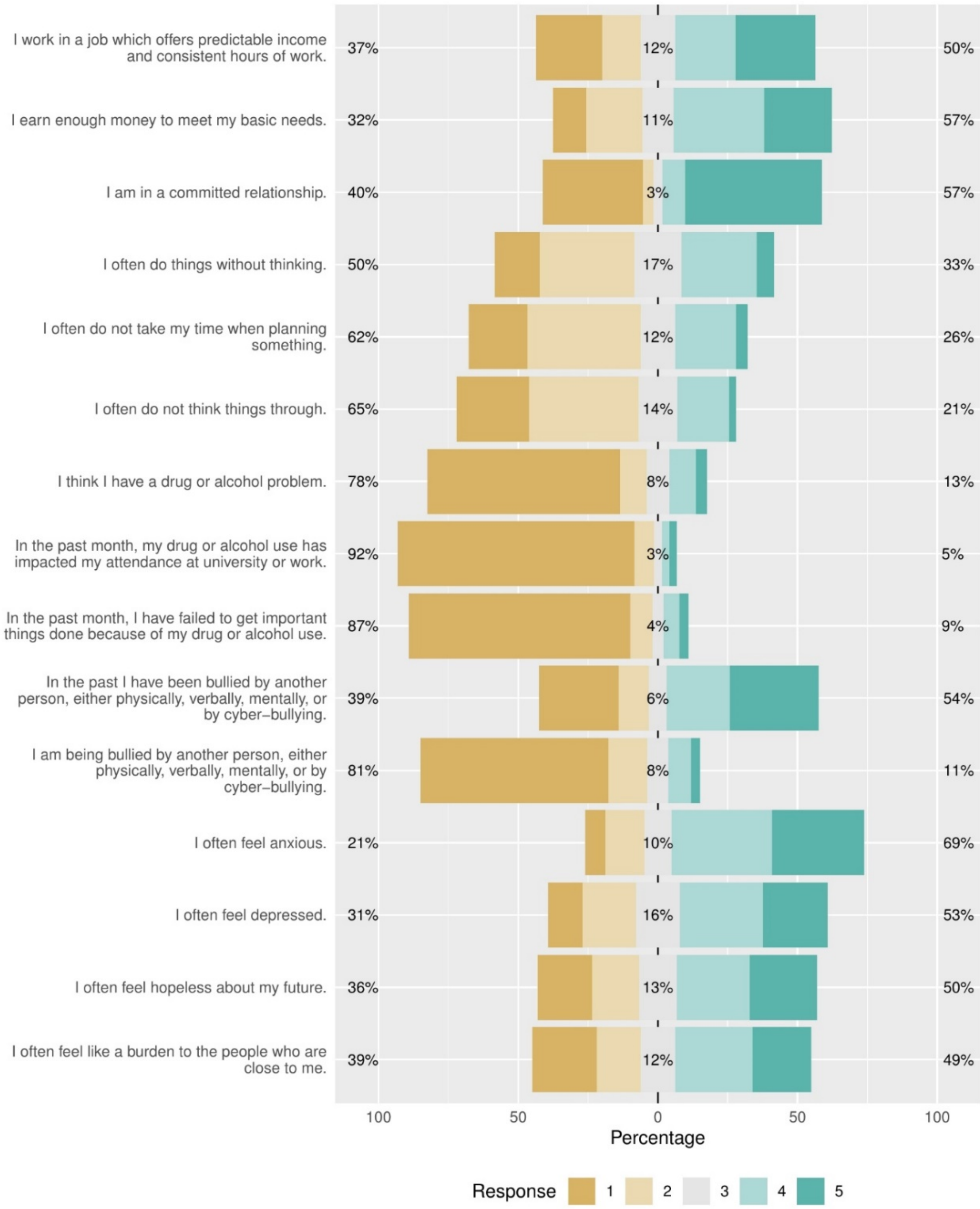


Figure 2. Likert graph showing the percentage of responses for each response option for Likert items 1 through 15. The response scale ranged from 1 *strongly disagree* to 5 *strongly agree.*

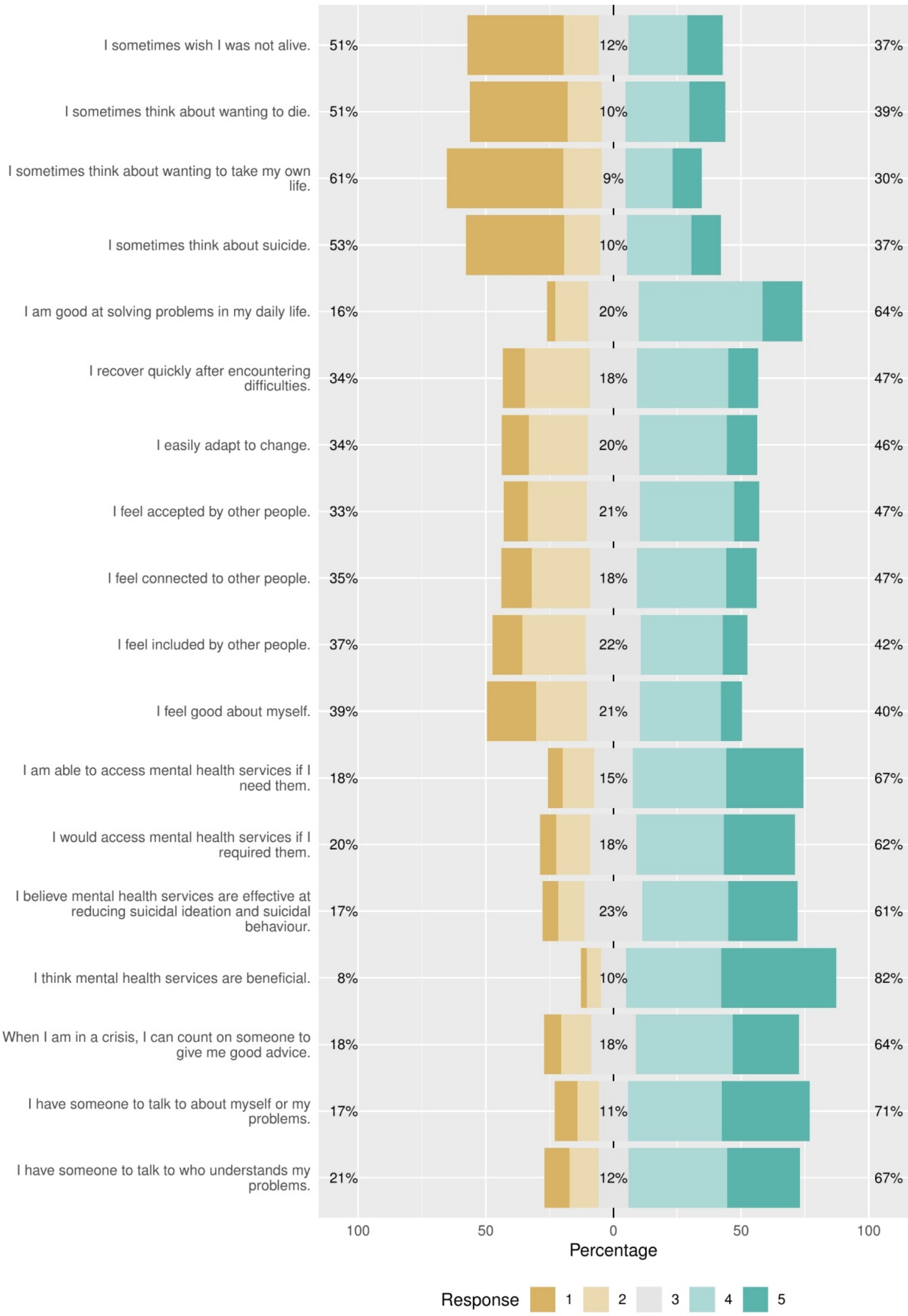


Figure 3. Likert graph showing the percentage of responses for each response option for Likert items 16 through 33. The response scale ranged from 1 *strongly disagree* to 5 *strongly agree.*

Table 7

Descriptive Statistics

Variable	*M*	*SD*	*α*
Impulsivity	2.51	0.99	0.81
Substance abuse	1.49	0.91	0.85
Being bullied	2.42	1.17	0.55
Suicidal ideation	2.54	1.42	0.96
Resilience	3.16	1.09	0.79
Sense of belonging	3.10	1.09	0.90
Access to mental health services	3.69	1.01	0.60
Positive attitude towards mental health services	3.91	0.98	0.79
Social support	3.72	1.12	0.91
Stable employment	3.18	1.56	
Financial stability	3.37	1.36	
Committed relationship	3.31	1.85	
Feeling anxious	3.74	1.25	
Feeling depressed	3.32	1.34	
Feeling hopeless	3.18	1.46	
Perceived burdensomeness	3.08	1.48	
Problem solving	3.60	1.00	
Self-esteem	2.90	1.27	

Note. Cronbach's alpha is shown only for variables that were measured by more than one item.

Table 8

Pearson's Correlations Between Suicide Risk and Protective Factors

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Stable employment																	
2 Financial stability	.51*																
3 Committed relationship	.20*	.22*															
4 Impulsivity	-.04	-.13	-.07														
5 Substance abuse	-.05	-.08	-.12	.37*													
6 Being bullied	-.09	-.24*	-.11	.13	.15*												
7 Feeling anxious	-.14*	-.22*	-.08	.25*	.18*	.31*											
8 Feeling depressed	-.20*	-.32*	-.22*	.30*	.29*	.35*	.68*										
9 Feeling hopeless	-.24*	-.37*	-.26*	.32*	.28*	.31*	.59*	.78*									
10 Perceived burdensomeness	-.22*	-.34*	-.21*	.32*	.27*	.34*	.57*	.69*	.75*								
11 Suicidal ideation	-.18*	-.28*	-.2*	.22*	.27*	.29*	.51*	.70*	.66*	.62*							
12 Problem solving skills	.23*	.33*	.22*	-.26*	-.14*	-.11	-.34*	-.43*	-.45*	-.42*	-.33*						
13 Resilience	.24*	.27*	.20*	-.10	-.12	-.20*	-.41*	-.49*	-.46*	-.41*	-.42*	.59*					
14 Sense of belonging	.23*	.36*	.27*	-.15*	-.15*	-.26*	-.43*	-.55*	-.54*	-.51*	-.46*	.44*	.51*				
15 Self-esteem	.25*	.37*	.27*	-.22*	-.22*	-.23*	-.53*	-.69*	-.65*	-.64*	-.60*	.51*	.52*	.62*			
16 Access to MHS	.17*	.22*	.14*	-.10	-.07	-.14*	-.22*	-.32*	-.30*	-.26*	-.33*	.24*	.22*	.36*	.31*		
17 Positive attitude towards MHS	.10	.18*	.10	-.04	-.11	-.15*	-.14*	-.21*	-.19*	-.12	-.27*	.14*	.21*	.24*	.22*	.45*	
18 Social support	.21*	.29*	.32*	-.14*	-.16*	-.13	-.20*	-.36*	-.40*	-.32*	-.36*	.33*	.31*	.56*	.44*	.51*	.38*

Note. MHS = mental health services. * $p < .05$

To measure internal consistency, Cronbach's alphas were calculated for variables measured by multiple items (see Table 7). Most of these variables showed acceptable internal consistency, with the variables impulsivity, substance abuse, suicidal ideation, resilience, sense of belonging, positive attitude towards mental health services, and social support having Cronbach's alphas ranging from 0.79 to 0.96. Smaller Cronbach's alphas were seen for the variables being bullied ($\alpha = 0.55$) and access to mental health services ($\alpha = 0.60$), suggesting these variables may have poor internal consistency. This may simply have been because each of these variables were only measured by two items.

Pearson's correlations were calculated between all variables (see Table 8). The strongest positive correlation was between feeling depressed and feeling hopeless ($r = .78$, $p < .001$), followed by feeling hopeless and perceived burdensomeness ($r = .75$, $p < .001$). Strong positive correlations were also seen between suicidal ideation and the variables feeling depressed ($r = .70$, $p < .001$), feeling hopeless ($r = .66$, $p < .001$), and perceived burdensomeness ($r = .62$, $p < .001$).

Network Estimation

The network structure of risk and protective factors for suicide is presented in Figure 4. It is important to bear in mind that this is a regularised partial correlation network, and thus the associations that are visible in Figure 4 are only those which remain after controlling for all of the other nodes in the network and removing statistically spurious associations. Consequently, even the very small associations shown in this network estimation may be meaningful, as they are not equivalent to a correlation of zero.

The nodes stable employment and financial stability (nodes 1 and 2 in Figure 4) showed the strongest positive association (partial correlation (hereafter r_p) = .48) in the network, followed by the nodes problem solving and resilience (nodes 12 and 13, $r_p = .40$).

Moderate positive associations were seen between the nodes feeling depressed and feeling hopeless (nodes 8 and 9, $r_p = .38$), feeling hopeless and perceived burdensomeness (nodes 9 and 10, $r_p = .38$), feeling depressed and suicidal ideation (nodes 8 and 11, $r_p = .33$), and feeling anxious and feeling depressed (nodes 7 and 8, $r_p = .33$). Slightly weaker positive associations were seen between access to mental health services (node 16) and the nodes social support (node 18, $r_p = .29$) and positive attitude towards mental health services (node 17, $r_p = .29$). The node sense of belonging (node 14) showed a weak positive association with the nodes social support (node 18, $r_p = .29$) and self-esteem (node 15, $r_p = .23$).

There were a large number of very weak positive associations between nodes in the estimated network. Such associations were seen between the node perceived burdensomeness (node 10) and the nodes feeling anxious (node 7, $r_p = .12$) and suicidal ideation (node 11, $r_p = .12$), Other nodes which showed weak positive associations were feeling hopeless and suicidal ideation (nodes 9 and 11, $r_p = .10$), positive attitude towards mental health services and social support (nodes 17 and 18, $r_p = .14$), resilience and sense of belonging (nodes 13 and 14, $r_p = .14$), and problem solving skills and self-esteem (nodes 12 and 15, $r_p = .15$). The network structure also showed that self-esteem (node 15) had weak *negative* associations with feeling depressed (node 8, $r_p = -.23$) and perceived burdensomeness (node 10, $r_p = -.19$).

The strength centrality of nodes in the estimated network of risk and protective factors for suicide is shown in Figure 5. As discussed elsewhere in this thesis, strength centrality is a measure of how strongly connected a node is to others in the network. The strength centrality of a node is measured by summing the strength of the edge-weights which are connected to it. The node with the highest strength centrality was feeling depressed, followed by feeling hopeless. The nodes self-esteem, perceived burdensomeness, and social support were also central to the estimated network, showing moderate strength centrality. The least central nodes in terms of strength were being bullied and substance abuse.

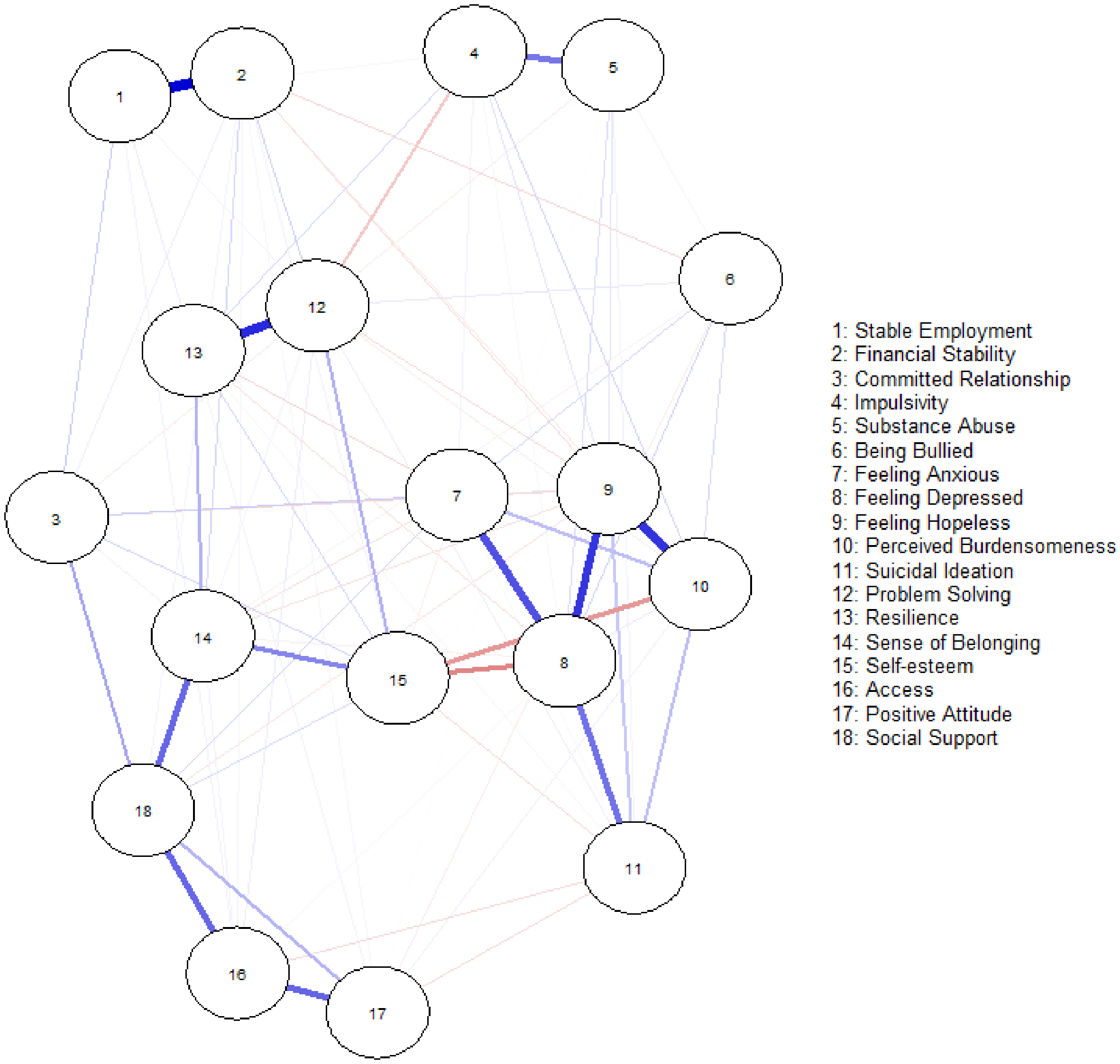


Figure 4. Network structure of risk and protective factors for suicide. Risk and protective factors are shown as nodes, and the relationships between them are shown as edges. Blue edges signify a positive association, whilst red edges signify a negative association. The strength of an association is shown by the thickness of the edge, with a thicker edge representing a stronger association between two nodes.

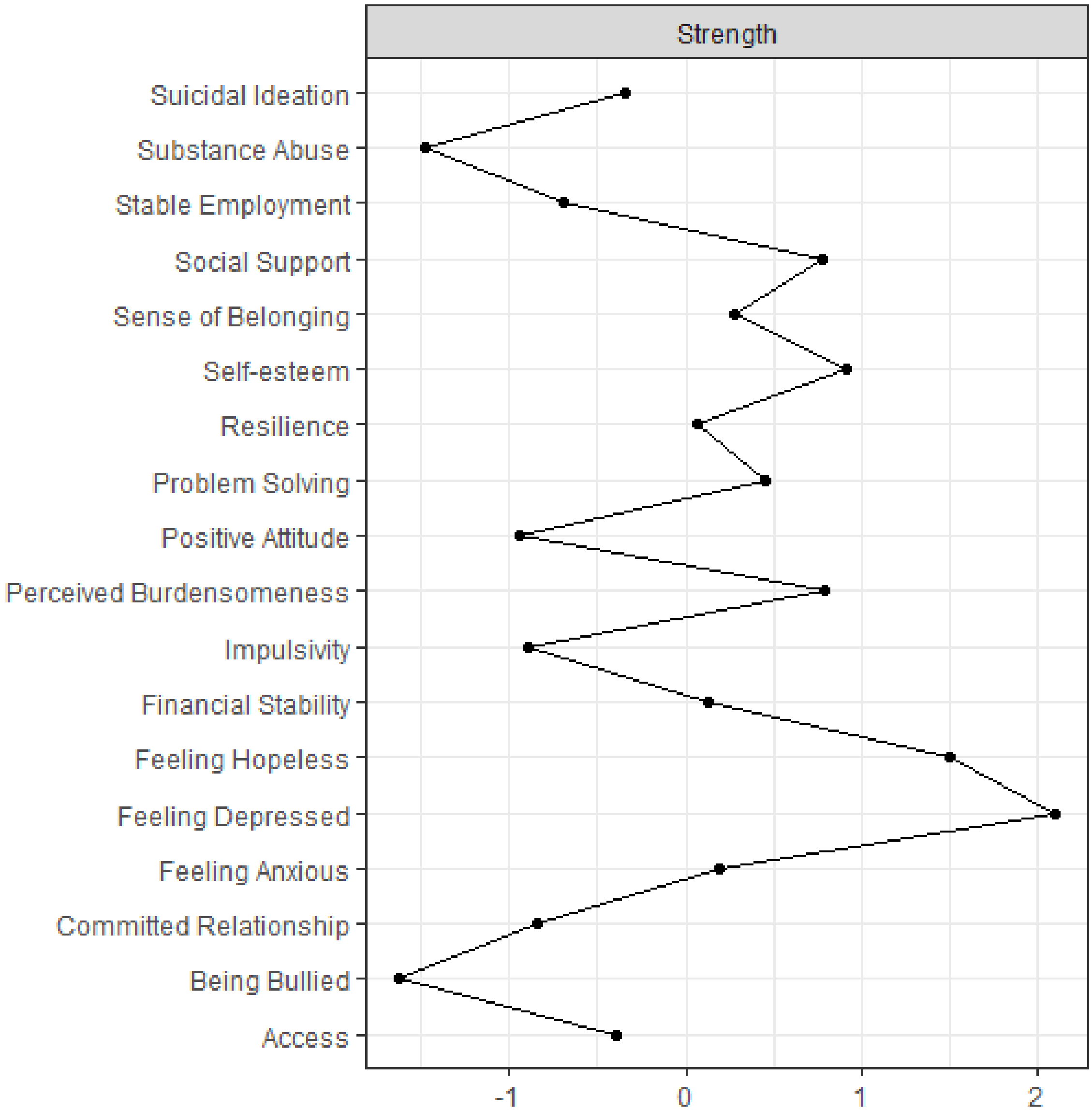


Figure 5. Strength centrality of risk and protective factors for suicide.

Gender Analyses

The estimated network structure of risk and protective factors for suicide for males is presented in Figure 6 and the estimated network of these factors for females is shown in Figure 7. To view the values of the estimated edge-weights in the male and female networks, see Appendix E: Supplementary Figures for heat maps depicting this information. There were many similarities across the two networks. For example, both networks showed moderate positive associations between feeling depressed (node 8) and the nodes feeling hopeless (node 9) and feeling anxious (node 7). Positive correlations were seen in both networks between the nodes feeling depressed and suicidal ideation (nodes 8 and 11), and impulsivity and substance abuse (nodes 4 and 5). Furthermore, weak negative associations were seen between self-esteem (node 15) and the nodes feeling depressed (node 8) and perceived burdensomeness (node 10) were seen in both networks.

There were also clear differences between the male and female estimated networks. In the male network, self-esteem (node 15) was weakly associated with suicidal ideation (node 11), while this association was not seen in the female network. The male network also showed positive associations between feeling depressed and perceived burdensomeness (nodes 8 and 10), and substance abuse and suicidal ideation (nodes 5 and 11), neither of which were present in the female network. Furthermore, a negative association between social support and suicidal ideation was seen only in the male network. The female network also included associations specific to females. For example, small positive associations between suicidal ideation (node 11) and the nodes feeling hopeless (node 9) and perceived burdensomeness (node 10) were seen only in the female network.

The strength centrality of nodes in the estimated networks for males and for females is shown in Figure 8. There are similarities in the strength centrality of some nodes in the male and female networks. For example, in both networks, feeling depressed has the highest strength centrality, and being bullied has the lowest. There are also differences between the two estimated networks, such as the node self-esteem having the second highest strength centrality in the male network but the fifth highest for females. For females the node with the second highest strength centrality was feeling hopeless, which was the third most central factor in the male network.

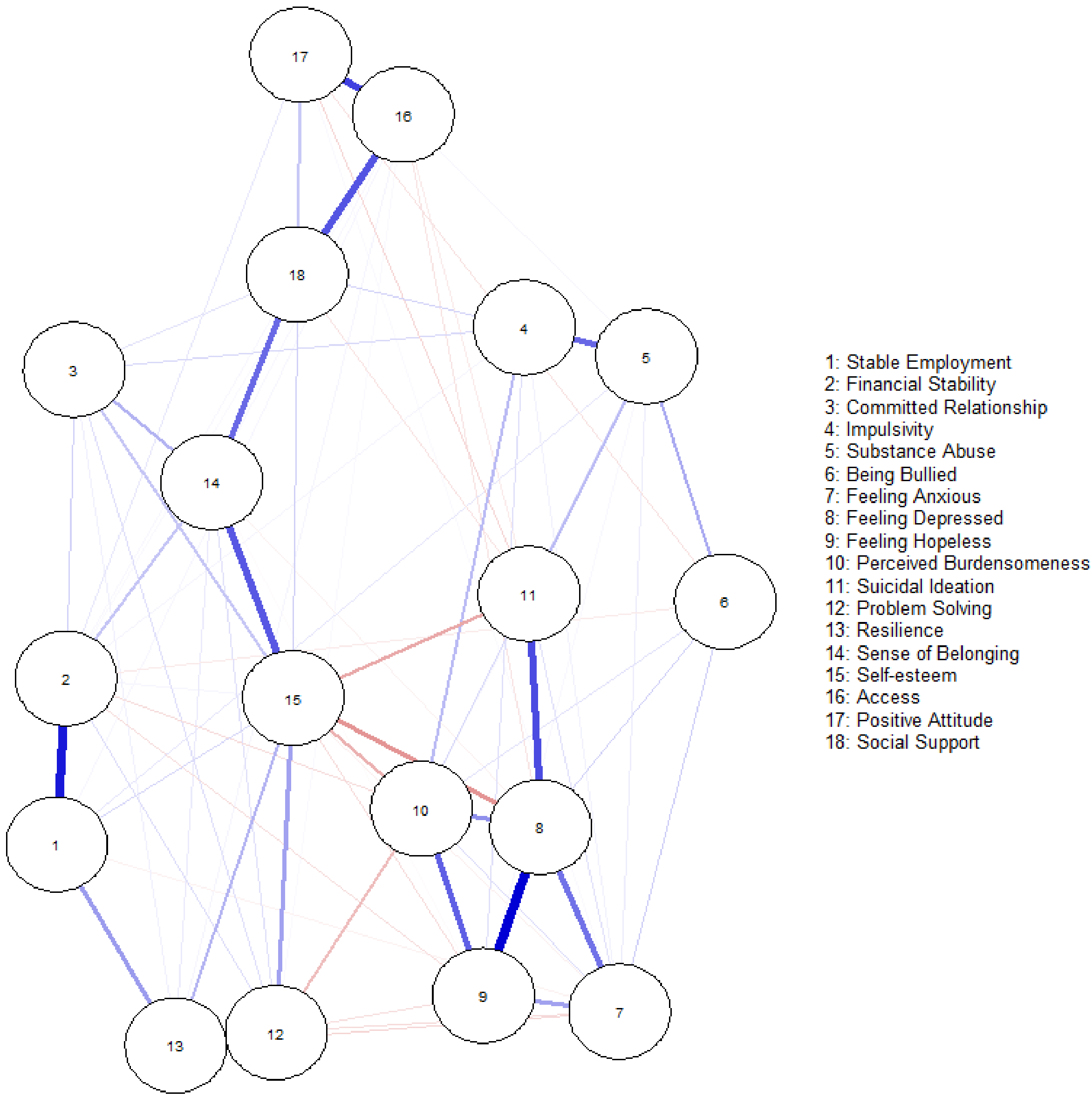


Figure 6. Network structure showing the relationship between risk and protective factors for suicide for male participants. Risk and protective factors are shown as nodes, and the relationships between them are shown as edges. Blue edges signify a positive association, whilst red edges signify a negative association. The strength of an association is shown by the thickness of the edge, with a thicker edge representing a stronger association between two nodes.

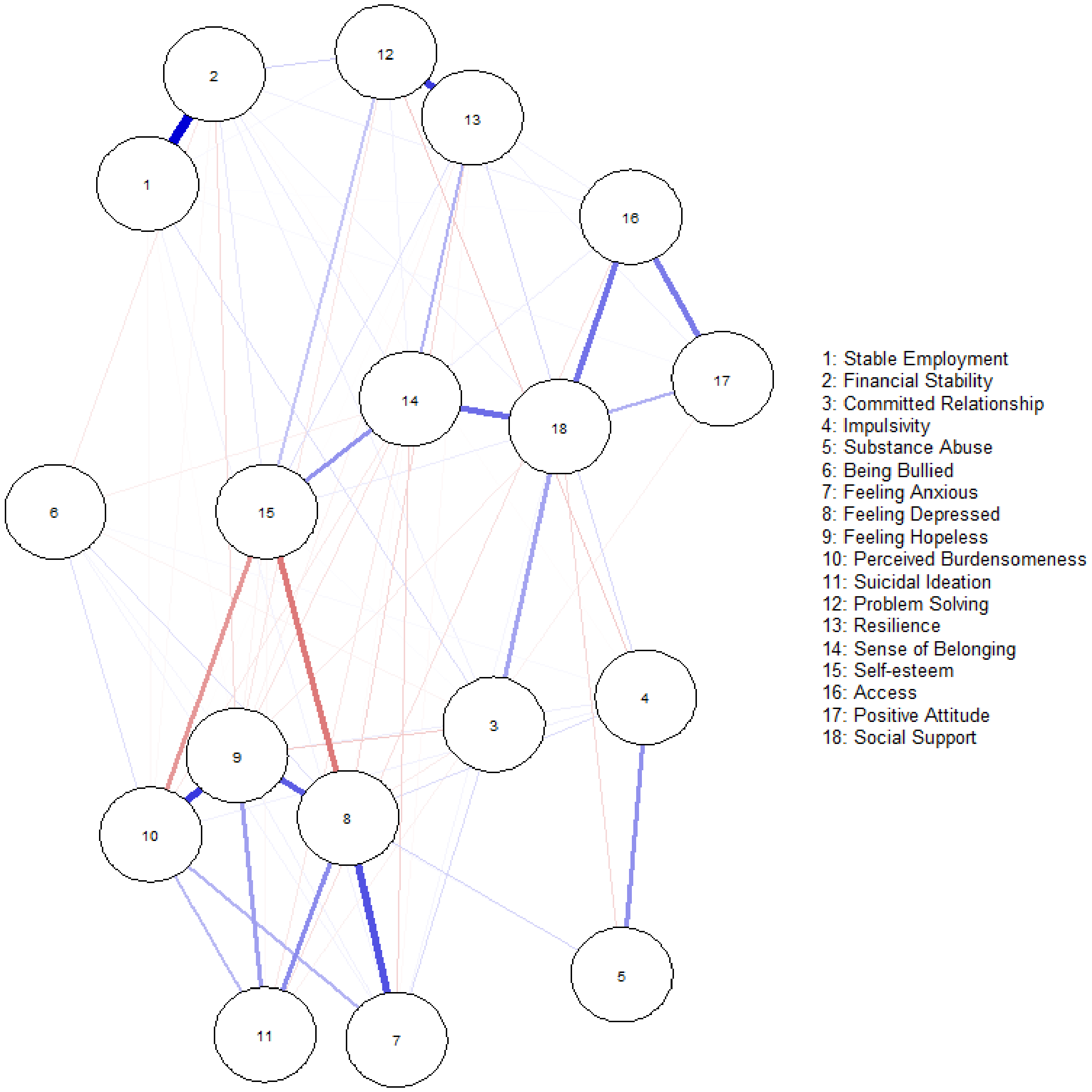


Figure 7. Network structure showing the relationship between risk and protective factors for suicide for female participants. Risk and protective factors are shown as nodes, and the relationships between them are shown as edges. Blue edges signify a positive association, whilst red edges signify a negative association. The strength of an association is shown by the thickness of the edge, with a thicker edge representing a stronger association between two nodes.

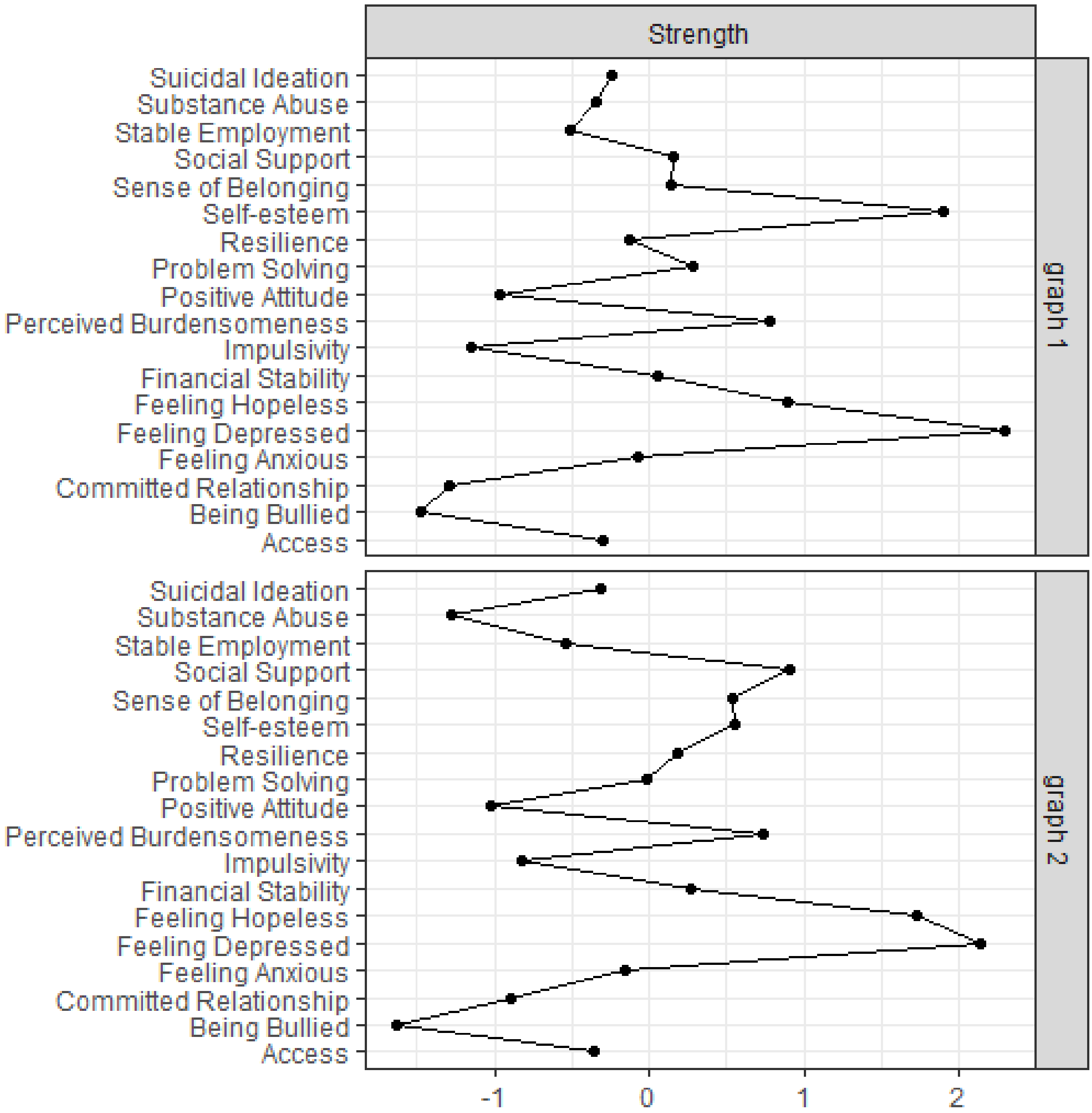


Figure 8. Strength centrality of risk and protective factors for suicide for males (top) and females (bottom).

Stability Analyses

Four stability analyses were conducted for each of the three estimated networks. As described in Chapter Three, the interpretation of a network can be questionable due to the limited sample sizes that psychological research often uses (Epskamp et al., 2018). Because of this, false conclusions may be drawn from the network structure regarding the importance of some variables and their relationships with others if the accuracy of the estimated edge-weights or node centralities is not known. The stability tests conducted in this study examined edge-weight accuracy, centrality stability, edge-weight difference, and centrality difference. The results of these tests are described below.

Edge-weight accuracy test. The edge-weight accuracy test examines how accurate the estimated edge-weights are. Estimated networks that have high power (i.e., few nodes or large numbers of participants) have more reliably estimated edges, and thus should show smaller confidence intervals around the edges in the edge-weight accuracy test (Fried, 2017). The edge-weight accuracy test for the estimated network for all participants showed that the confidence intervals of most edges were wide and overlapped with the confidence intervals of others (see Figure 9). When confidence intervals do *not* overlap, it indicates that the statistics are significantly different to one another. However, the opposite is not true – statistics which have overlapping confidence intervals may still significantly differ from one another (Epskamp et al., 2018). Therefore, although many of the confidence intervals around edge-weights overlap with the confidence intervals of others, these edges may still differ significantly from other edge-weights estimated in the network.

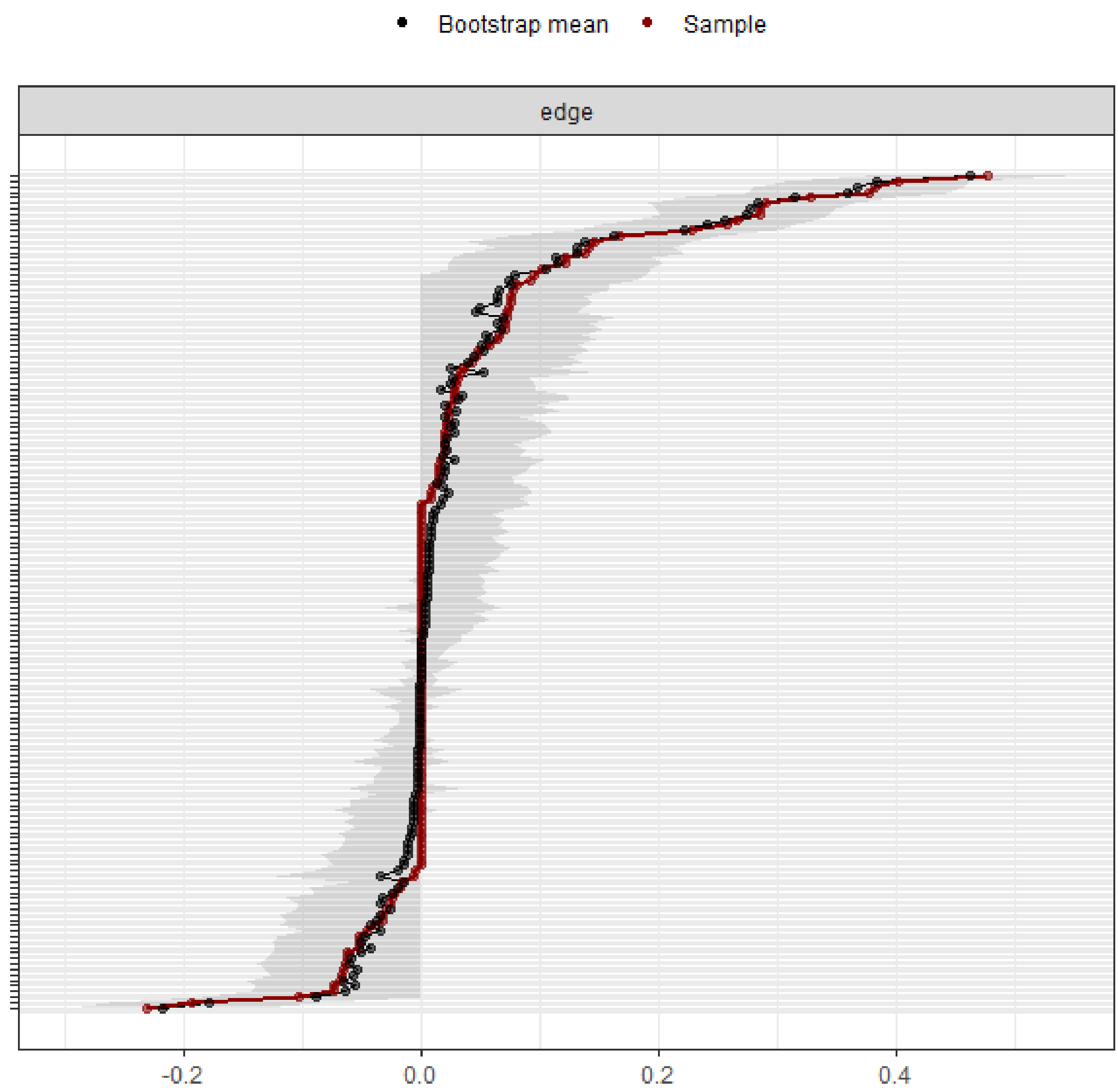
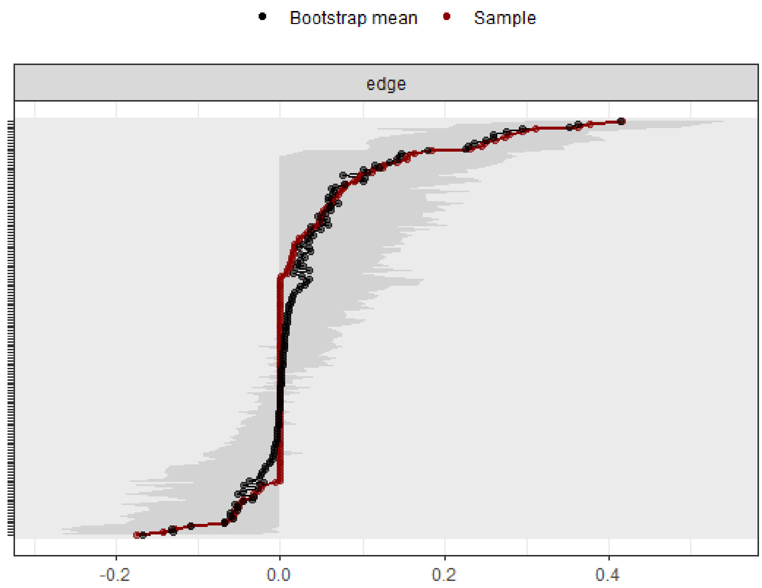


Figure 9. Edge-weight accuracy test showing the bootstrapped confidence intervals of the estimated edge-weights for the network of risk and protective factors for all participants. The red line indicates the sample values, the black line indicates the bootstrap mean, and the grey area represents the bootstrapped confidence intervals. The horizontal lines each represent one edge of the network, with the highest edge-weights at the top of the graph, and the lowest edge-weights at the bottom. The labels along the y axis have been removed to increase legibility, given the number of edges in the graph.



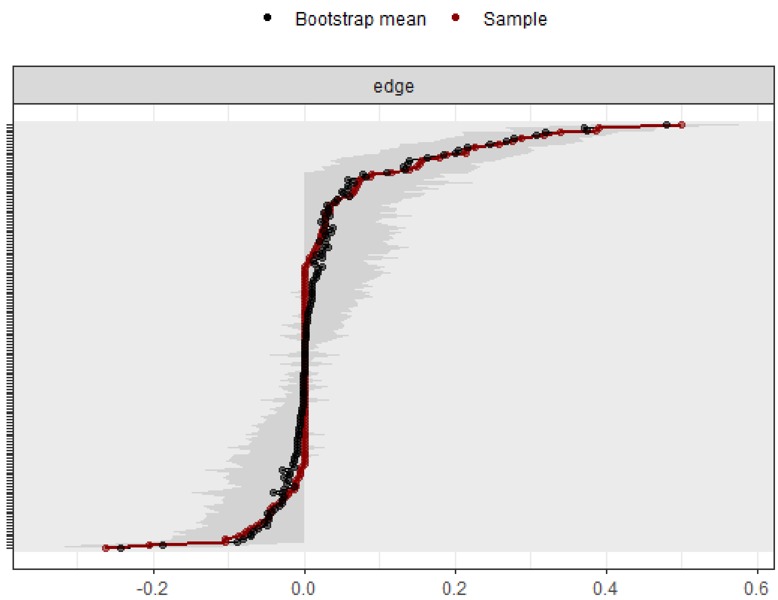


Figure 10. Edge-weight accuracy test showing bootstrapped confidence intervals of the estimated edge-weights for the network of risk and protective factors for males (top), and females (bottom). The red line indicates the sample values, the black line indicates the bootstrap mean, and the grey area represents the bootstrapped confidence intervals. The horizontal lines each represent one edge of the network, with the highest edge-weights at the top of the graph, and the lowest edge-weights at the bottom. The labels along the y axis have been removed to increase legibility, given the number of edges in the graph.

Similar results can be seen in the edge-weight accuracy tests for males, and for females (see Figure 10). For males, the confidence intervals around edges were large, and almost all of these confidence intervals overlapped with others. For females, the confidence intervals around edges were much smaller, but they still overlapped with other confidence intervals in many cases. However, as described above, the presence of overlapping confidence intervals does not mean that the edge-weights are not statistically significantly different from others.

Centrality stability test. The centrality stability test bootstraps centrality indices to measure whether the order of node centrality is the same when a network is re-estimated for a subset of the data, with fewer cases included. The centrality stability test showed that node strength centrality was quite stable, with only a small drop in strength (see Figure 11). This apparent stability was quantified using a CS-coefficient. As described in Chapter Three in the Stability analyses subsection, the CS-coefficient "quantifies the maximum proportion of cases that can be dropped to retain, with 95% certainty, a correlation with the original centrality of higher than (by default) 0.7" (Epskamp et al., 2018, p. 204). For the main estimated network, the CS-coefficient was 0.75. As this proportion is well above 0.25 (the minimum acceptable value), and also above 0.5 (the *preferred* minimum acceptable value, see Epskamp et al., 2018), the centrality stability test suggests that node strength centrality is very stable for this network. A CS-coefficient of 0.75 means that 75% of the cases (i.e., participants) in the network can be dropped while still retaining a correlation of at least 0.7 between the original strength centrality and the strength centrality of the subset.

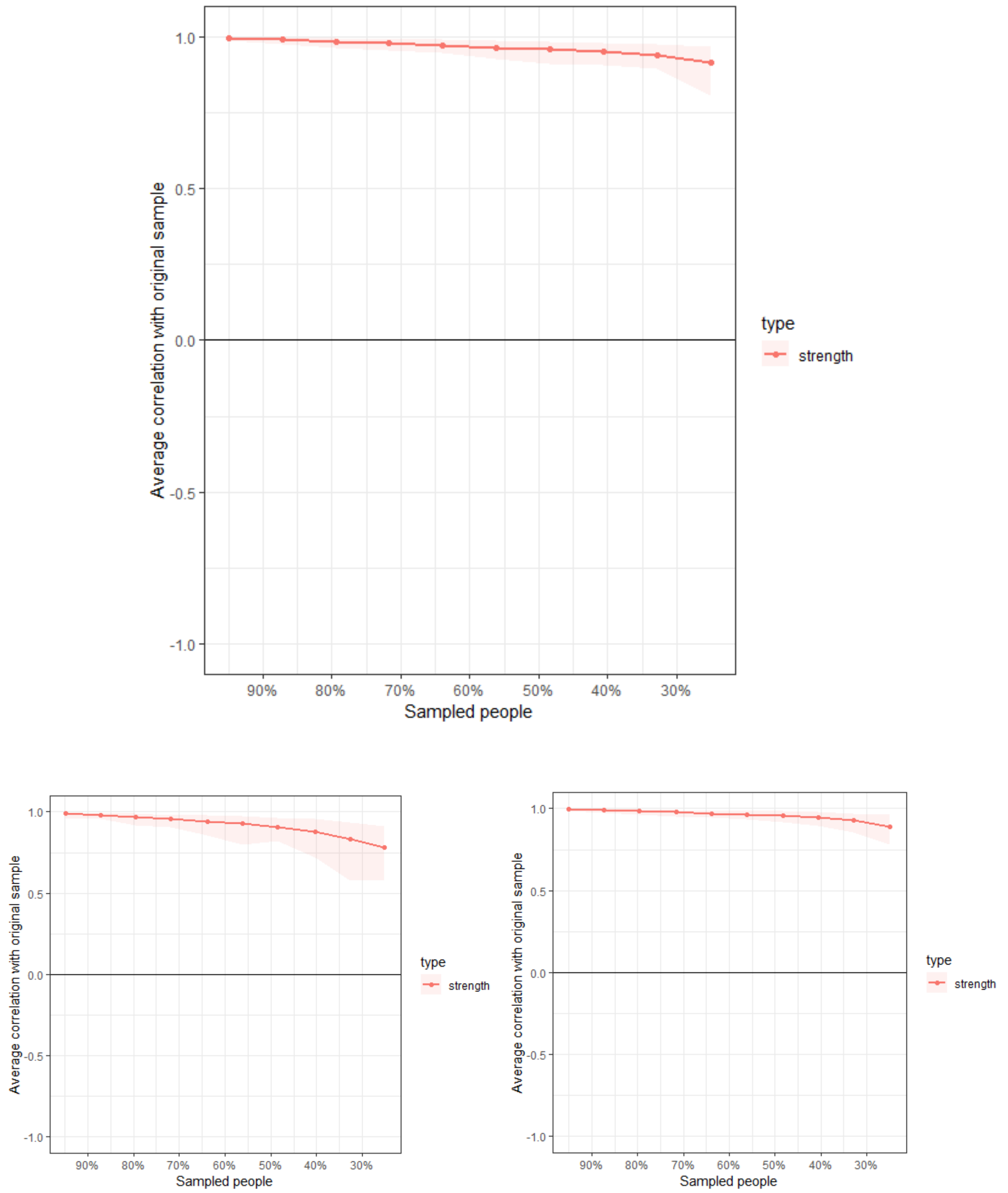


Figure 11. Centrality stability test, showing the average correlation between strength centrality of subsets of the sample with proportions of participants dropped and the original sample. The top graph shows the centrality stability of the estimated network for all participants, bottom left for male participants, and bottom right for female participants. The red line represents the mean and the area around it represents the range from the 2.5th quintile to the 97.5th quintile.

The results of the centrality stability test for the male network suggest that node strength centrality was stable, with a small drop in strength shown by the red line and area in Figure 11. For this network, the CS-coefficient was 0.515, meaning that 51.5% of the cases in the male network can be dropped while still retaining a correlation of at least 0.7 between the original strength centrality and the strength centrality of the subset. As this proportion is above 0.5, the centrality stability test suggests that node strength is stable for this network.

The centrality stability test for the female network showed that node strength centrality was very stable, with only a slight drop in strength. The CS-coefficient for this network was 0.751, such that 75.1% of the cases in the female network can be dropped while still retaining a correlation of at least 0.7 between the original strength centrality and the strength centrality of the subset. As the CS-coefficient is well above 0.5, the centrality stability test suggests that node strength centrality is very stable for the female network.

Edge-weight difference test. The edge-weight difference test investigates whether two edges significantly differ from one another, by taking the difference between two bootstrapped edge-weight values and constructing a bootstrapped confidence interval around these. The edge-weight difference test for the estimated network for all participants showed that there were a large number of edges that were significantly different from one another (see Figure 12). For both the male and female networks, the overall numbers of significantly different edges were similar to the number seen in the network for all participants. However, there were clear differences in *which* edges were significantly different in the male network compared to the female network.

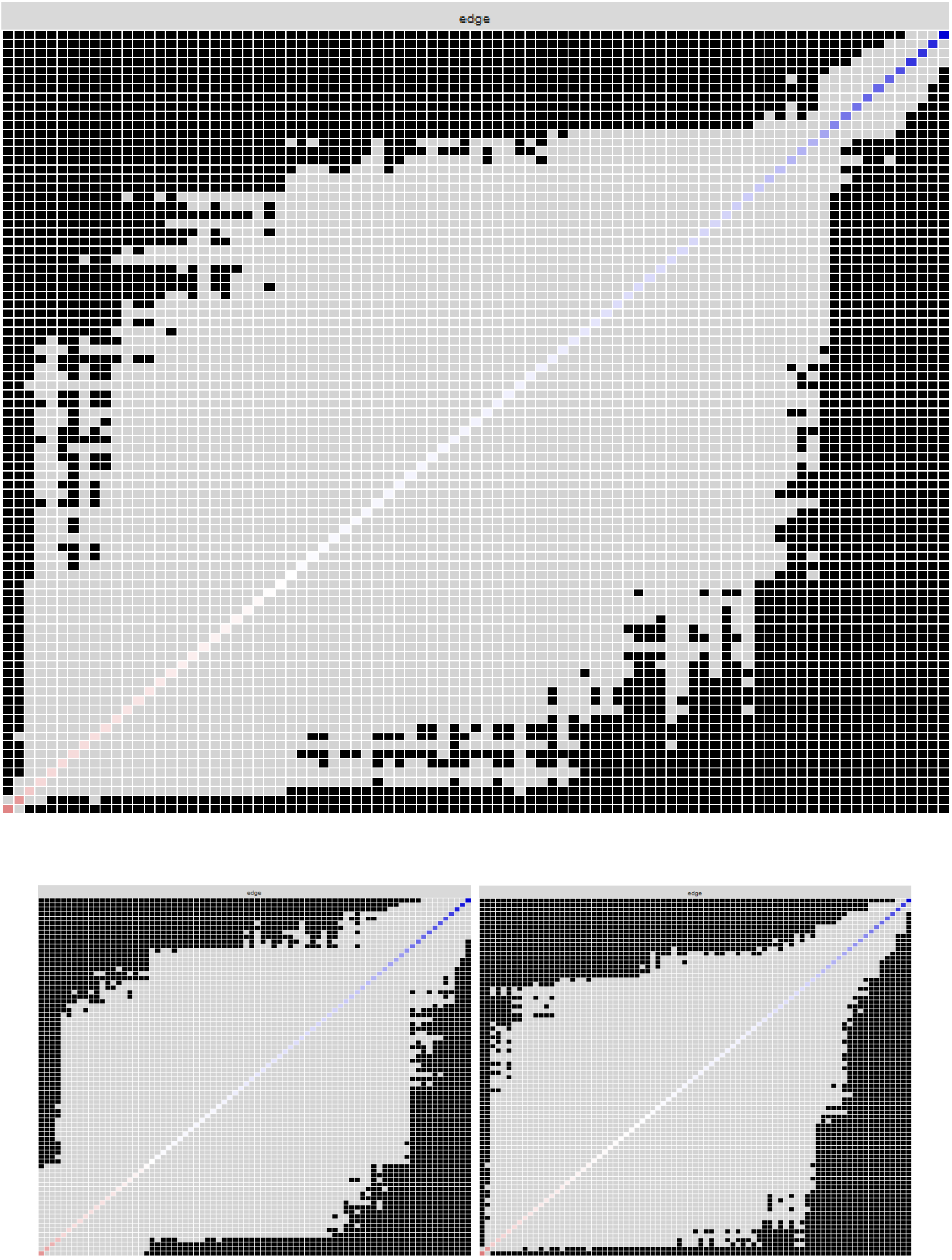


Figure 12. Edge-weight difference test, showing the bootstrapped difference between edge-weights in the estimated network for all participants (top), males (bottom left), and females (bottom right). Axis labels were removed due to illegibility. Black boxes indicate nodes that differ significantly from each other, and grey boxes indicate nodes that do not differ significantly from one another. Coloured boxes correspond to the colour of the edges in the estimated networks.

Centrality difference test. The last stability test that was run was a centrality difference test (see Figure 13). Like the edge-weight difference test, this test examines whether the centrality indices of two nodes significantly differ from one another. It takes the difference between two bootstrapped centrality indices and constructs a bootstrapped confidence interval around these. The results showed that the strength centrality of many nodes significantly differed from the strength centrality of other nodes in the network.

The centrality difference test for males showed that most node strength centralities did not significantly differ from the strength centrality of other nodes in the network. The two nodes which significantly differed from most other nodes in the network for male participants were self-esteem and feeling depressed, both of which had high strength centrality. The node with the highest strength centrality was feeling depressed, and the node with the lowest strength centrality was being bullied.

The centrality difference test for females also showed that many node strengths significantly differed from the strength of other nodes in the network. The nodes which significantly differed from most other nodes in the network for female participants were feeling hopeless and feeling depressed, while the nodes substance abuse, social support, sense of belonging, self-esteem, perceived burdensomeness, impulsivity, being bullied, and positive attitude towards mental health services also significantly differed from a large number of nodes. However, a number of these nodes had low centrality in the estimated network, including substance abuse, impulsivity, being bullied, and positive attitude towards mental health services, which may explain why these factors show significant differences with a number of other nodes. The nodes with the highest and lowest strength centrality in the network for females were the same as the ones in the network for males, with the node with the highest strength centrality being feeling depressed, while the node with the lowest strength centrality was being bullied.

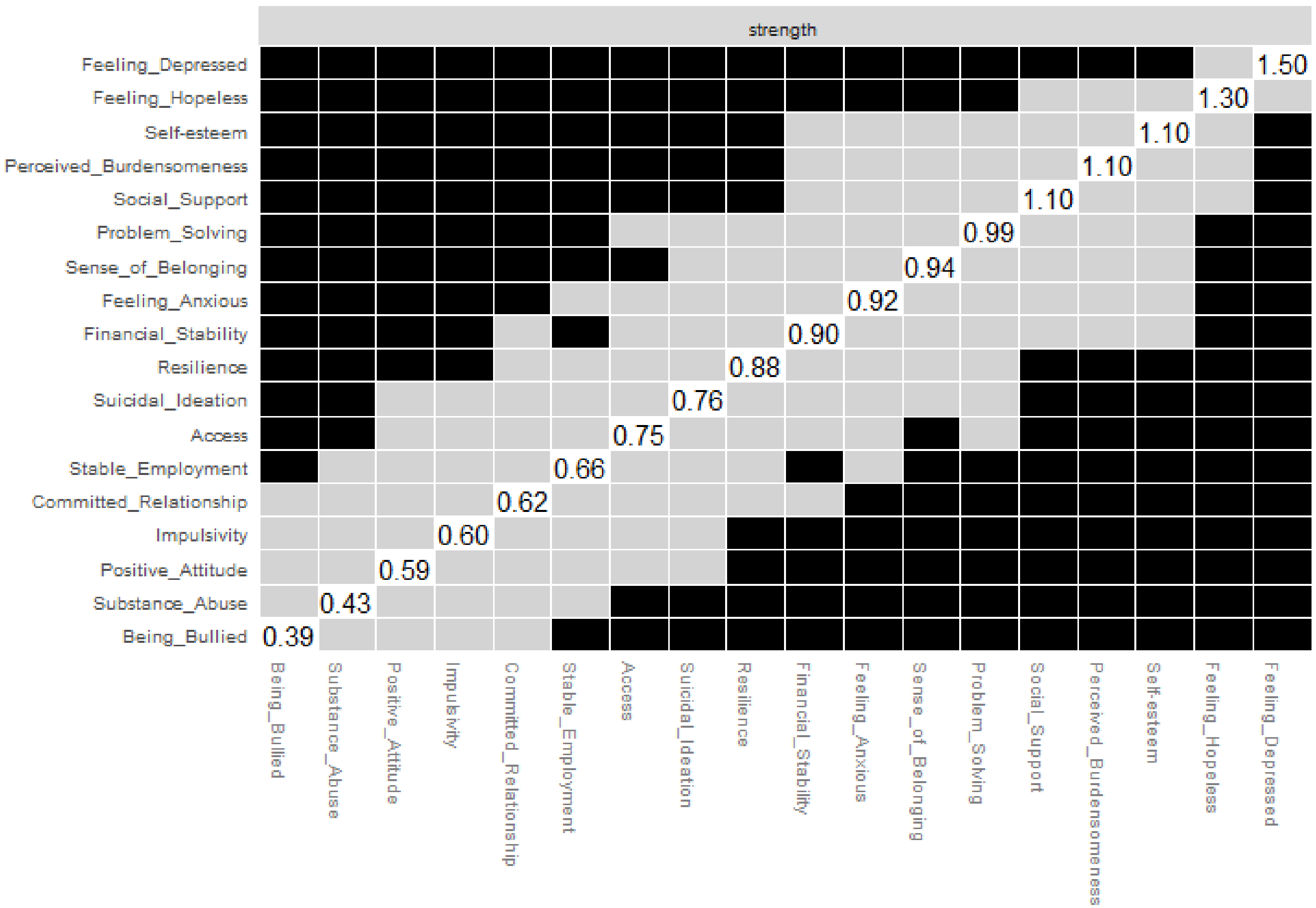


Figure 13. Centrality difference test, showing the bootstrapped difference between node strength centrality of the eighteen risk and protective factors for suicide for all participants. Black boxes indicate nodes that differ significantly from each other, and grey boxes indicate nodes that do not differ significantly from one another. White boxes show the node strength centrality.

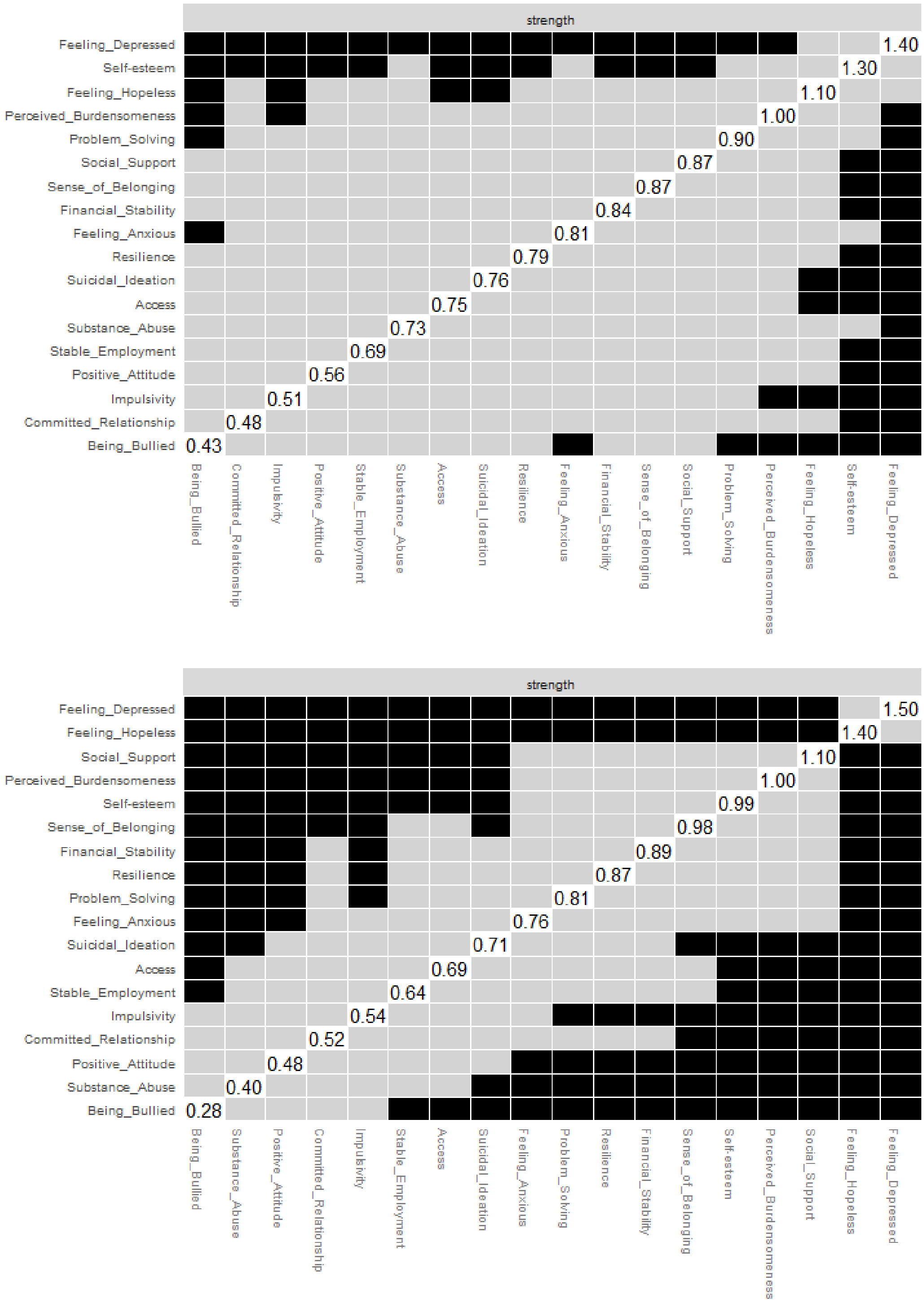


Figure 14. Centrality difference test, showing the bootstrapped difference between node strength centrality of the eighteen risk and protective factors for suicide for males (top), and females (bottom). Black boxes indicate nodes that differ significantly from each other, and grey boxes indicate nodes that do not differ significantly from one another. White boxes show the node strength centrality.

Exploratory Analyses

Following completion of the preregistered confirmatory analyses, exploratory analyses were conducted. This was deemed appropriate for two reasons. Firstly, the items that were used to measure some nodes in the network looked like they might be measuring the same constructs as others. This was noticed due to the presence of very strong associations between some related nodes in the estimated network. Strong associations in an estimated network are sometimes due to the nodes being measured by semantically similar items. Secondly, some variables had a low Cronbach's alpha, suggesting that the items may not have been a reliable measure of the constructs. The aim of the exploratory analyses was to see if the overall network structure and node centrality changed following altering some of the variables in the estimated network. These analyses were not preregistered.

To address the first reason for conducting these exploratory analyses, nodes which appeared to be measuring the same construct were identified. This was determined by examining the Likert items for their face validity, and the visible strong associations of nodes in the network estimation for all participants (refer back to Figure 4). Once identified, the Likert items were combined to create an average of the two nodes, and the new node was added to the network in place of the original nodes. This process occurred for the nodes stable employment and financial stability, and for problem solving and resilience.

Additionally, two variables in the network were identified as having a low Cronbach's alpha for the items they were measured by, suggesting they were not very reliable measures. These variables were being bullied ($\alpha = 0.55$) and access to mental health services ($\alpha = 0.60$). To test if the items used to create these variables were instead measuring different constructs, the individual Likert items for being bullied and for access to mental health services were included separately in the exploratory network in place of the original averaged nodes.

The exploratory network analyses included all four of the above changes in one network estimation. The resulting network is shown in Figure 15, and node strength centrality is shown in Figure 16.

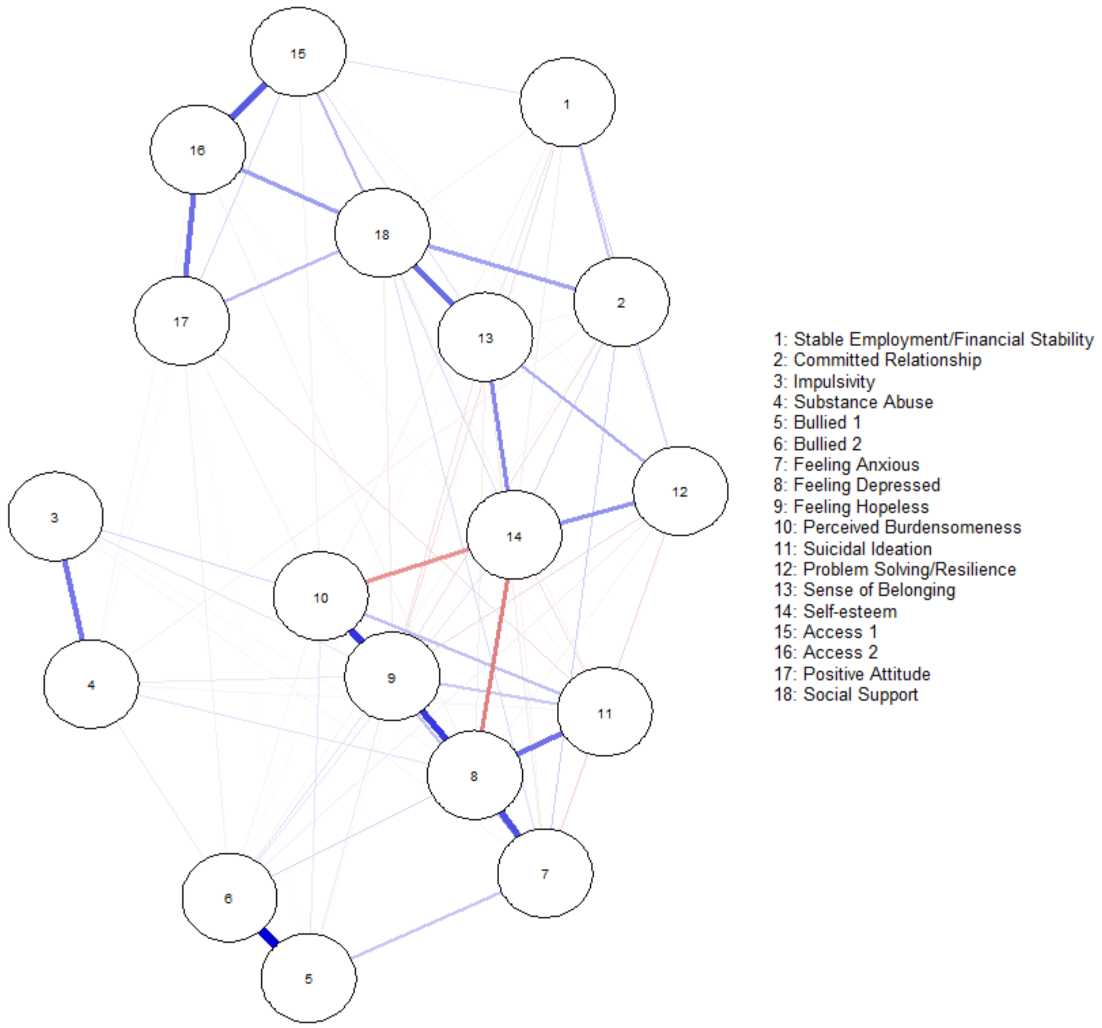


Figure 15. Exploratory network structure of risk and protective factors for suicide. Risk and protective factors are shown as nodes, and the relationships between them are shown as edges. Blue edges signify a positive association, whilst red edges signify a negative association. The strength of an association is shown by the thickness of the edge, with a thicker edge representing a stronger association between two nodes.

In the exploratory network (Figure 15), the combined resilience/problem solving skills node (node 12) had a very weak positive association with the combined stable employment/financial stability node (node 1, $r_p = .09$). The combined resilience/problem solving skills node was also weakly positively associated with the nodes sense of belonging (node 13, $r_p = .16$) and self-esteem (node 14, $r_p = .20$), similar to the associations seen in the original network between the individual nodes. The combined resilience/problem solving node also had a few very weak negative associations in the exploratory network. These associations were namely with feeling anxious (node 7, $r_p = -.08$) and feeling hopeless (node 9, $r_p = -.08$).

The combined stable employment/financial stability node (node 1) showed weak positive associations with many nodes in the exploratory network. The strongest of these very weak associations was with committed relationship (node 2, $r_p = .11$), and as aforementioned with the combined resilience/problem solving skills node (node 12). Similar associations were seen between the individual items in the original network estimation.

The exploratory network estimation showed that the two Likert items for being bullied (nodes 5 and 6) had a moderate positive association with one-another ($r_p = .47$). The exploratory analyses suggest these two items are measuring related constructs, based on the strong association seen between these items in the exploratory network.

The same can be said for the Likert items measuring access to mental health services (nodes 15 and 16), which also showed a moderate positive association in the exploratory analyses ($r_p = .31$). Overall the associations seen in the exploratory network between the two Likert items for access to mental health services with other nodes were similar to the associations with the averaged node in the original network. Both the original and exploratory networks showed associations of this node with the nodes positive attitude towards mental health services and social support. However, in the exploratory network, the second Likert item ("I would access mental health services if I required them" – node 16) had a stronger association with the node positive attitude towards mental health services (r_p = .27) than the first Likert item ("I am able to access mental health services if I need them" – node 15, r_p = .08) did. The same was seen with the associations of these items with social support (node 18), with node 16 showing a slightly stronger association with this node than node 15 showed (r_p = .18 and r_p = .14 respectively).

In the exploratory network estimation, the nodes feeling depressed and feeling hopeless were the most central nodes in the network (see Figure 16), similar to the original network. The nodes self-esteem, social support, and perceived burdensomeness were also central to the exploratory network, with a slight increase in strength centrality compared to the original network. The least central nodes were different in the exploratory network, with impulsivity now having the lowest strength centrality, rather than the node being bullied, which was the least central in the original network. Other low centrality nodes in the exploratory network were substance abuse and the newly-created node combining stable employment and financial stability. The centrality of the items for being bullied and access to mental health services was higher in the exploratory network than they were in the original network as averaged variables.

Overall, the results of the exploratory analysis suggest that the main findings of the original network estimation are robust, with the nodes with the highest centrality remaining largely unchanged between the two networks, despite the changes tested in the exploratory analysis. Many associations also remained consistent across the preregistered and exploratory analyses.

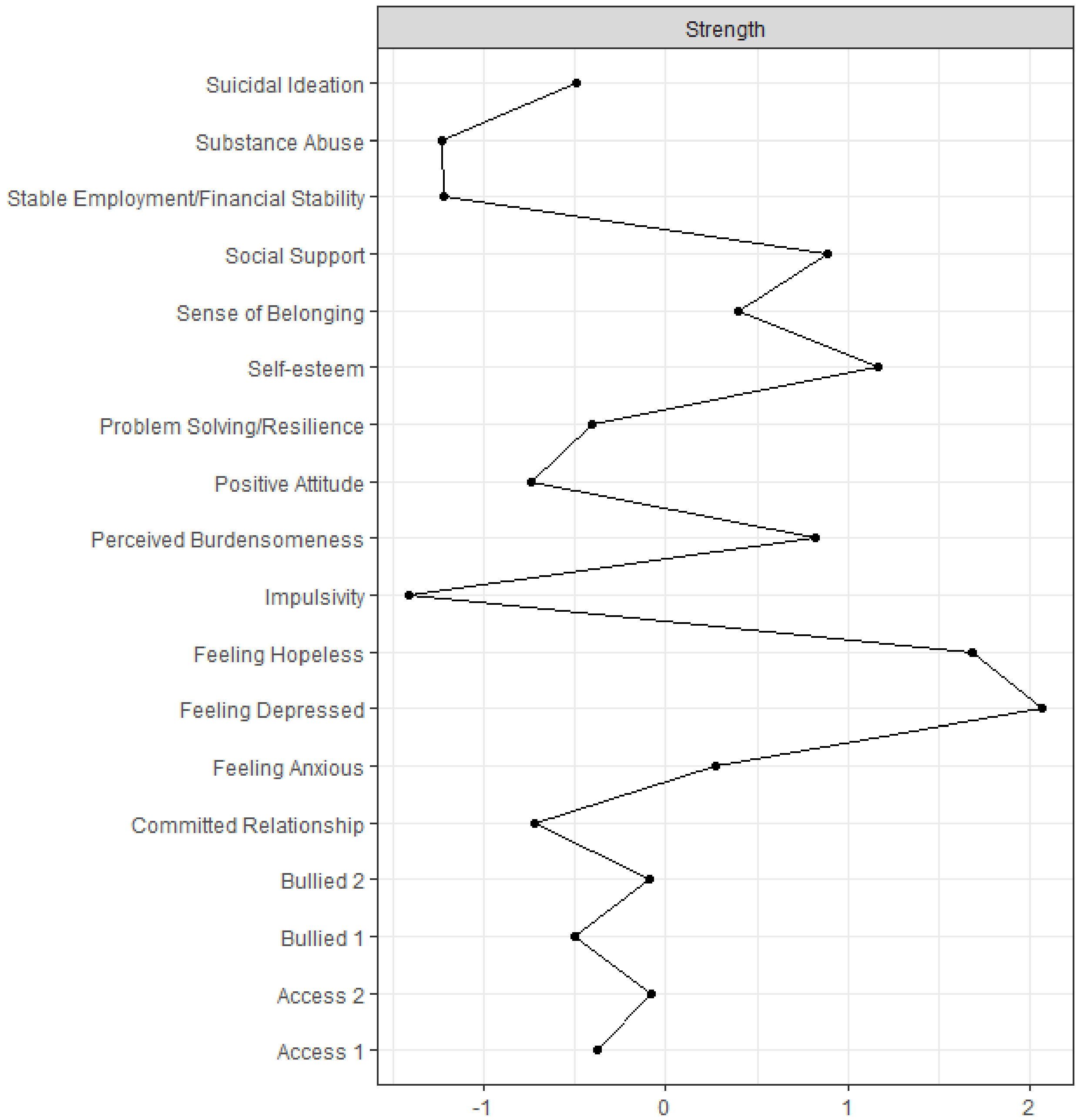


Figure 16. Strength centrality of nodes in the exploratory network of risk and protective factors for suicide.

Chapter Five: Discussion

The present study has detailed a novel approach to understanding the risk and protective factors for suicide, with the aim of understanding how these factors relate in a network sense and which factors are most central. A discussion of the present study's key findings and related literature begins below, followed by a comparison of the estimated networks for males and females. The chapter will conclude with an elucidation of the study's limitations, recommendations for future research, and practical and clinical implications.

Key Findings

There were two broad categories of key findings in the network analyses of the present study. These key findings pertain to the risk and protective factors which were estimated to be most central in the network, and the factors which were directly connected to suicidal ideation

The preregistered aim of the present study was to find out which factors were most central in the network of suicide risk and protective factors. The risk factors in the estimated network that had the highest strength centrality were feeling depressed, feeling hopeless, and perceived burdensomeness, which had the first, second, and fourth highest strength centrality respectively. Feeling depressed was the most central variable, which was similarly the case in Shiratori et al.'s (2014) estimated network of reasons why people suicided. The two other published suicide network studies that included some of these factors (see De Beurs et al., 2019; Simons et al., 2019) did not report their centrality, and thus this cannot be compared. Depression, hopelessness, and perceived burdensomeness are consistently associated with suicide in the empirical literature (for example Hallensleben et al., 2019), so it is unsurprising that these variables are three of the most central risk factors to suicide in the present study.

Feeling hopeless and perceived burdensomeness are each implicated in at least one of the three theories of suicide discussed in Chapter One. The theories discussed included the interpersonal psychological theory of suicide, integrated motivational-volitional model, and three step theory. Perceived burdensomeness is a key variable in both Joiner's (2005) interpersonal theory of suicide and O'Connor's (2011) integrated motivational-volitional model. Joiner proposed that this variable directly leads to suicidal ideation, at which time other variables impact the transition from ideating suicide to a suicide attempt. In O'Connor's model too, perceived burdensomeness motivates suicidal ideation. Feeling hopeless is implicated in the first step of Klonsky and May's (2015) three step theory of suicide. In this theory, when an individual feels hopeless about their situation and is also experiencing pain, then suicidal ideation develops. Not only were feeling hopeless and perceived burdensomeness central in the network of suicide risk factors in the present study, but they were also directly positively associated with suicidal ideation. These findings provide some support for these theories, in which hopelessness and burdensomeness are proposed to directly lead to suicidal ideation. The present study thereby contributes to furthering our understanding of these modern theories of suicide.

Although feeling depressed is not explicitly incorporated into any of the three theories of suicide described in Chapter One, it is clear from empirical research that depression is involved in many suicides (for example, see Chesney et al., 2014; Hallensleben et al., 2019). Furthermore, as aforementioned suicidal ideation is specified as a symptom of major depressive disorder in the DSM-5, and in general, demographic statistics suggest individuals with depression may experience suicidality. For example, in New Zealand approximately 21% of individuals with major depressive disorder report suicidal ideation, 8% report having a suicide plan, and 4% report having attempted suicide (Oakley-Browne, Wells, & Scott, 2006). A large number of people worldwide have depression, with the World Health Organisation (2018) estimating 300 million people are affected by this disorder.

The protective factors with the highest strength centrality in the estimated network were self-esteem and social support, which had the third and fifth highest strength centrality respectively. The four known suicide network analysis studies (see De Beurs et al., 2019; De Beurs, et al., 2017; Shiratori et al., 2014; and Simons et al., 2019) did not include these variables, and as such their place in the present network cannot be discussed in relation to other network research findings. Finding these two protective factors to have high strength centrality in the estimated network suggests that these may be important factors to consider when determining suicide risk. Instead of exclusively focusing on the reduction of risk, taking an approach to suicide prevention that is also strengths-based and focuses on developing protection against suicidal behaviour could potentially be an effective strategy to reduce risk. If we were able to better comprehend the relationships between protective factors and suicide risk, and act to change those that time and time again are highly central (in tandem with reducing those factors which put someone at increased suicide risk), then it may be possible to reduce suicide risk. At present, without much evidence of which protective factors are *most* effective at decreasing suicide, a strengths-based approach to decreasing suicide is not well-developed. Further research about protective factors and how they relate to suicide in a network sense would help to bridge this gap, increasing comprehension of the relationships between these variables as well as their relative ability to protect against suicide.

A small number of researchers have recently published studies which have focused on the utilisation of a strengths-based approach to suicide assessment or intervention. Such studies contribute to further understanding of protective factors for suicide, and how these can be implicated practicably in suicide prevention. Allen et al. (2017) tested how effective a strengths-based suicide prevention method, Qungasvik, was among Alaska Native Yup'ik people. This culture typically focuses on building strengths and promoting well-being within the community in order to protect against suicide, rather than trying to reduce suicide risk per se (Allen et al., 2019). The strengths-based intervention was effective at increasing levels of suicide protective factors specific to the Yup'ik culture, with more intensive Qungasvik intervention being associated with greater increases in suicide protection compared to the less intensive version of the intervention (Allen et al., 2017). These findings hint at strengths-based suicide prevention programmes being plausible methods for reducing suicidality through increasing protective factors. Further research in this area is needed.

As well as examining the centrality of nodes, the present study aimed to determine which nodes were directly associated with suicidal ideation. In the estimated network, the risk factors that were most strongly associated with suicidal ideation were feeling depressed, perceived burdensomeness, substance abuse, feeling hopeless, and feeling anxious. The association between suicidal ideation and depression was the strongest of these relationships, with a moderate positive correlation estimated between these variables. The associations of suicidal ideation with perceived burdensomeness and hopelessness were considered weak, and associations with substance abuse and anxiety were very weak.

A couple of similar associations were reported in earlier suicide-related network estimation research. Both Simons et al. (2019) and De Beurs et al. (2019) reported a positive association between suicidal ideation and depression or depressive symptoms. Additionally, De Beurs et al. (2019) reported an association between suicidal ideation and perceived burdensomeness. The variables included in Simons et al.'s (2019) and De Beurs et al.'s (2019) network structures were different to those in the present study, with theirs including mental disorders and suicide resilience factors, and factors associated with two models of suicide, respectively. However, the association of suicidal ideation with depression and perceived burdensomeness exists in each network after controlling for all other variables, such that its association in each of these network studies suggests conditional dependence between the variables, and a potentially causal relationship—though that may not necessarily be the case.

It is plausible that the relationship between depression and suicidal ideation is due to a variable that was not measured in the present study, such as genetics or experience of pain. Some research suggests that polymorphisms of particular genes may influence whether an individual with depression experiences suicidal thoughts and behaviour. For example, Antypa et al. (2016) found a significant association between specific genotypes of the MAPK1-rs13515 gene and attempted suicide among individuals with a mood disorder, with a high number of individuals who carried the TT genotype having attempted suicide, while very few individuals with the CC genotype had. Other research suggests that variables such as psychological and physical pain may play a role in the development of both depression and suicidal ideation. Individuals with depression tend to have an increased perception of both psychological and physical pain (Conejero, Olié, Calati, Ducasse, & Courtet, 2018). Individuals who are at risk of suicide also tend to have an increased perception of psychological pain but their perception of physical pain is *decreased* (Conejero et al., 2018). Decreased perception of physical pain may relate to an individual's acquired capability for suicide. This is a variable included in each of the three theories of suicide described in Chapter One (interpersonal psychological theory of suicide, integrated motivational-volitional model of suicide, and three step theory) but it was not included in the network structure in the present study. Inclusion of such variables in future network studies may prove valuable in determining factors central to increased risk of suicide, potentially helping to explain the relationship between depression and suicidal ideation, if it is not a directly causal relationship.

Not one of the four published suicide-related network analyses included the variables substance abuse, feeling hopeless, or feeling anxious, which the present study included and found an association of suicidal ideation with. However, non-network research largely supports the plausibility of these associations, as well as the relationship of suicidal ideation with feeling depressed and perceived burdensomeness. In an ecological momentary assessment study, Hallensleben et al. (2019) found significant positive associations between suicidal ideation and feeling depressed, perceived burdensomeness, and hopelessness. The authors reported that hopelessness and perceived burdensomeness also predicted future suicidal ideation in their multilevel analyses. The results of the present study support Hallensleben et al.'s (2019) findings, with suicidal ideation being positively correlated with feeling depressed, feeling hopeless, and perceived burdensomeness.

Associations between suicidal ideation with anxiety and substance abuse have also been reported in previous research, such as that of May and Klonsky (2016). Individuals in their meta-analysis who had experienced suicidal ideation were more likely to have an anxiety disorder or drug use disorder than individuals without suicidal ideation, with moderate effect sizes. The size of these relationships was slightly larger for individuals who had also attempted suicide compared to those with suicidal ideation only. The relationships estimated in the present study between suicidal ideation and the variables feeling anxious and substance abuse are consistent with May and Klonsky's (2016) findings.

A number of protective factors were directly negatively related to suicidal ideation, with higher levels of these variables being associated with less suicidal ideation. These protective factors were resilience, self-esteem, access to mental health services, and a positive attitude towards mental health services. Resilience was negatively associated with suicidal ideation in De Beurs et al.'s (2019) estimated network too. As expected, other literature supports the plausibility of a protective relationship between resilience and suicidal ideation.

For example, Roy et al. (2007) measured resilience in suicide attempters and non-attempters using the Connor-Davidson Resilience Scale, and found that suicide attempters had significantly lower resilience. The results of another study reported a negative association between resilience and suicidal ideation, such that lower resilience was correlated with more suicidal ideation (Liu, Fairweather-Schmidt, Roberts, Burns, & Anstey, 2014). Furthermore, researchers such as Sher (2019) suggest trying to improve the resilience of people who are at high risk of suicide as a way to potentially reduce the probability of suicide. Having more resilience may protect against suicide during times of increased risk, such as following a stressful life event. Being flexible and adapting to the situation would possibly decrease the stress associated with the event, and in turn decrease the probability of suicidal ideation. Other researchers may wish to explore these hypotheses further.

No suicide network research has yet included associations between suicidal ideation and the protective factors of self-esteem, access to mental health services, and a positive attitude towards mental health services. However, a number of non-network studies have similar findings, such as those that have focused on the relationship between self-esteem and suicide. Such studies report that individuals with low self-esteem tend to have elevated levels of suicidal ideation (Fergusson et al., 2003), and are more likely to attempt suicide (Thompson & Light, 2011). This supports the finding in the present study that individuals with high self-esteem tended to have lower suicidal ideation.

The present study found an association between suicidal ideation and having access to mental health services, such that suicidal ideation was low when individuals perceived that they could access these services if they needed to. Research on this association thus far has been slim, and as such, further research is needed in order to better comprehend the implications that this protective factor could have on suicidal ideation and risk, both in a network sense and in general. It is plausible that when individuals are connected to mental health services during times of high suicide risk, preventable suicides may be thwarted (Stanley, Hom, & Joiner, 2016). Thus, mental health service use could protect against the occurrence of suicide death. However, individuals who are at the greatest risk of suicide tend to seek help from services at a lower rate, with individuals who have previously experienced suicidal ideation or suicide attempts seeking help less than individuals who have not experienced suicidality (Reynders, Kerkhof, Molenberghs, & Van Audenhove, 2015; Stanley et al., 2016). Individuals with suicidal ideation commonly cite structural barriers to seeking help from mental health services, namely including financial difficulty, availability of service, and transportation to service (Bruffaerts et al., 2011). Attitudinal barriers such as perceived ineffectiveness of treatment or problem insignificance are also cited by suicidal individuals as reasons for not seeking help (Bruffaerts et al., 2011).

The finding in the present study that suicidal ideation was negatively associated with having a positive attitude towards mental health services is not a relationship that has been explored much among published literature. Thus far there is very little research directly on the impact of a positive attitude towards mental health services on suicidal ideation and risk, with there being a slightly larger focus on the implications of the reverse relationship—negative attitudes towards treatment. Treatment in such research has included pharmacological interventions as well as psychological ones. Among the few studies specifically about positive treatment attitudes that are available, there is largely consensus that, for those at high risk of suicide, having a positive view about seeking help and the effectiveness of treatment results in higher service use (Stanley et al., 2016). This highlights the role that mental health literacy could play in suicide prevention. Increasing people's understanding of treatment and its effectiveness may result in increased service use, due to the perception of fewer barriers, particularly among vulnerable groups such as those at high risk of suicide.

Differences Between Male and Female Networks

There were a couple of key differences between the estimated networks for males and females. A difference that was surprising was the role self-esteem played in each network. In the male network, self-esteem had the second highest strength centrality, due to its connections with many other variables in the network. Additionally, self-esteem was directly associated with suicidal ideation in this network, such that males with a high level of self-esteem experienced less suicidal ideation. These observations were not present in the female network, suggesting that self-esteem may play a more important role in protecting against suicidal ideation for males than it does for females. In the general population, males tend to report higher levels of self-esteem than females do. Bleidorn et al. (2016) analysed the self-esteem of 985,937 participants from 48 countries to test whether there was a gender difference. The authors found a small effect of gender on self-esteem with males scoring higher in self-esteem than females. To check if this difference was apparent for the sample in the present study, the mean self-esteem for each gender was calculated. Males in the present study had slightly *lower* self-esteem on average than females did ($M = 2.88$, $SD = 1.23$, and $M = 2.91$, $SD = 1.29$ respectively)—the reverse finding to what Bleidorn et al. (2016) reported, albeit the difference between the genders in the present study was tiny, and not statistically significant.

It is important to point out that in both the male and female networks, self-esteem had a protective role against the variables feeling depressed and perceived burdensomeness. As feeling depressed and perceived burdensomeness were highly central to all of the present study's estimated networks, the potential role of self-esteem in altering these variables requires further attention. As discussed in Chapter Two, variables which are central to a network may be powerful targets for treatment, with the potential to reduce the likelihood or severity of suicide risk. Given that self-esteem was highly central in the male network and was associated with other highly central variables in both the male and female networks, self-esteem may be a viable target for suicide intervention. As suicide risk tends to be higher among males, and self-esteem had much higher strength centrality in the male network, this might be a more useful intervention for males than for females. By targeting this variable in an intervention, attempting to increase the level of self-esteem that an individual has, there may be further activation of variables in the network—such that feeling depressed and perceived burdensomeness are not experienced at such a high level, and nor is suicidal ideation. It is possible that intervening on central protective factors such as self-esteem may have important implications for preventing suicide or decreasing suicide risk, in addition to intervening on risk factors with high centrality such as depression.

The network analyses revealed a further difference between genders. A positive association was estimated between suicidal ideation and substance abuse for males, which was not present in the female network. This finding is somewhat unsurprising, as according to psychological autopsy data, approximately one third of males who have died by suicide had a substance use disorder, compared to only 15% of female suicides (Schneider, 2009). For individuals with alcohol use disorder in particular the suicide rates for males are on average five times that of females (Murphy, 2008). In general, males typically have a higher prevalence of substance use disorders worldwide (Murphy, 2008), with some research reporting males to be twice as likely to have a substance use disorder (Hall, Teesson, Lynskey, & Degenhardt, 1999) or to be currently abusing illegal substances (Tuchman, 2010).

Although the association between substance abuse and suicidal ideation for males is an unsurprising finding, it is an important one. Substance abuse had the second lowest strength centrality in the female participant network out of all 18 variables, but was slightly more central for males, being the sixth lowest. This suggests that substance abuse may play a larger role in suicide risk for males than it does for females, although this finding should be regarded as tentative until it is replicated in other studies. As with self-esteem, the biggest implication of this finding pertains to the prevention of suicide. If an individual is known to be abusing substances, a therapeutic intervention specifically targeting this factor may be effective at decreasing suicide risk. In the male network, substance abuse was also connected to variables that were more highly central to the network, such as perceived burdensomeness. Thus, acting to reduce substance abuse may impact central variables too, with lower substance abuse having the potential to reduce perceived burdensomeness (and vice versa) through further activation of the network.

Limitations and Future Research Recommendations

Sample. The sample of participants is an obvious limitation of this research. Firstly, it is not known whether the sample is representative of the populations sampled from, especially in regard to characteristics like ethnicity. The ethnicity of participants was not measured because there is such a diverse range of ethnic groups across New Zealand, Australia, the United States of America, and the United Kingdom, such that offering a dropdown list to choose from in a survey would likely not encapsulate all ethnic identities. The alternative option would have been for participants to type in the ethnicity they identify with most. However, it would have required substantial amounts of time to code this text which would then only be used in tables describing demographic information. Including such information would not have had a considerable impact on the dissemination of the findings in this thesis, as they would not have been included in the analyses in any way. Thus, after cultural consultation, it was decided to not measure the ethnicity of participants in this study. Because of this, it is unknown whether ethnic groups that are at disproportionately high risk for suicide (for example Māori people in New Zealand. See Chapter One) have been represented in this study, and therefore the results should not be assumed to generalise to such populations.

Other demographic characteristics that were not representative of the populations sampled from include gender and country. The sample included twice as many females as males, and very few gender diverse participants. There were also comparatively fewer participants from Australia than there were from New Zealand, the United States of America, and the United Kingdom. Furthermore, only these four countries were sampled from, and thus the results of this study cannot generalise beyond these countries.

An additional aspect of the sample which may bias the results is that participation in this study was incentivised, thus potentially garnering the participation of people who simply wished to receive the incentive. Participants recruited via Prolific Academic received NZD2 for their participation in this research, while participants recruited via social media chose one of three charities (Mental Health Foundation of New Zealand, Key to Life Charitable Trust, or Voices of Hope) for Massey University to donate NZD2 to on their behalf. These incentives were not deemed large enough to coerce participation. The monetary incentive offered to Prolific Academic participants was not large in comparison to incentives offered in psychological research. For example, in a multiple regression analysis, Latterman and Merz (2001) found that participants in psychological and biomedical research were paid an average of USD9.50 (equivalent to NZD14.83 at present) for an hour of research participation. The survey in the present study was estimated to take 5 to 10 minutes to complete, and as such, an incentive of NZD2 was fairly close to the average payment for this period of time.

Sample size. This study had a small sample size for a network analysis of 18 nodes, with just 515 participants included in the analyses. Other suicide network studies with large numbers of nodes have analysed data from thousands of participants. For example, De Beurs et al. (2019) had 3508 participants, and Shiratori et al. (2014) had 2293. With a relatively small sample size and a large number of nodes, there was initially concern that the analyses would have low power. At a minimum, it was estimated that 171 participants were required to achieve enough power for the analyses, with network stability being somewhat dependent on having at least as many observations as there are parameters (De Beurs, 2017). This minimum amount was surpassed. It was still a little surprising that the estimated network for all participants was as highly stable as it was (see Figure 11 in Chapter Four). The impact of small sample size was shown in the stability of the estimated network for male participants, which, although still showed good stability, showed a slightly steeper drop-off in strength centrality stability than the estimated network for female participants did (see Figure 11 in Chapter Four). This may be because the number of male participants only just met the minimum suggested sample size of 171 participants while the female sample size was nearly twice this number at 338 participants. Future suicide network research should aim to recruit a sample that is very much in excess of the minimum number required. This may increase the power of the analyses, potentially increasing the stability of the network estimation, and reliability of edge-weight estimations.

Use of unvalidated measures. As was mentioned in the Measures subsection of Chapter Three, the items used to measure the variables of interest in this study were not taken from pre-existing, validated measures. Many pre-existing scales that were considered during the development of the survey had restricted permissions, such that the survey would not have been allowed to be published online. Because this research is aiming to uphold Open Science practices such as transparency and reproducibility, being able to publish the survey items was considered important for the study. Furthermore, some of the other pre-existing measures which were considered during the development of the survey items either consisted of many items or were costly. It was important that the survey remained short as a whole to ensure participation did not take an exorbitant amount of time, which could dissuade individuals from participating, and thus the lengthier measures were ruled out for use in this research. Moreover, as the planned costs for this research already exceeded available financial resources, measures which came at a cost were not financially able to be used. Thus, instead the items were constructed for the purpose of this study. This meant that the survey could be published online on the Open Science Framework following completion of the research, the cost of conducting this study did not drastically exceed the budget, and the survey remained brief as a whole.

A limitation of not using pre-existing scales is nevertheless that the items used in the survey may not be valid or reliable measures of the constructs being surveyed. For example, minor oversights occurred in the development of the items for being bullied. Although both items clearly measured whether a participant had experience of being bullied, one was a past measurement ("In the *past* I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying" [emphasis added]), and the other was a current measurement ("I am *being* bullied by another person, either physically, verbally, mentally, or by cyber-bullying" [emphasis added]). The results of the survey showed that many participants reported that they had been bullied in the past, while comparatively few were currently being bullied, shown by the mean value for the current bullying item being near the minimum possible value. As the two items were averaged to create one node, the floor effect of the item measuring current bullying experience was not apparent in the figure used to estimate the network.

After calculating the Cronbach's alpha for the being bullied variable during the data analyses, it became apparent that the measure was not very reliable. This prompted the inclusion of the individual items in an exploratory analysis (see Exploratory Analyses to view the result). In this exploratory analysis, the individual items measuring being bullied showed higher strength centrality than their combined measure did in the original analysis. In hindsight, including these individual items (rather than the combined measure) in the main network may have been more appropriate.

A further limitation of constructing new items to measure the variables in the network was that nine variables were each measured by a single item. An example of this was the variable feeling depressed, which was measured by the item "I often feel depressed". The use of a single item to measure a node could be problematic, as it may not completely represent or capture the variable of interest (McNally, 2016). Further to this, Forbes et al. (2019) suggest that edge-weight estimations in partial correlation networks may be particularly vulnerable to measurement error when nodes are measured by a single item. Researchers who conduct network analyses in the future should ideally aim to measure each variable with multiple items in order to reduce the quantity of measurement errors.

Such limitations, although some of which are relatively minor, may have been reduced if pre-existing valid and reliable scales been used, rather than creating and using untested items as was done in the present study. Because of this, future research examining the risk and protective factors for suicide in a network sense should ideally utilise pre-existing scales where possible. This could result in higher validity and reliability of the survey items and would likely reduce the quantity of measurement errors. Alternatively, if researchers encounter similar time constraints to those predetermined by Masters thesis research, such as in the present study, survey items created by the researcher could be briefly tested in a pilot study prior to being used to survey participants for the network analysis. Convenience samples such as participants on Prolific Academic could be utilised to ensure fast data collection for research with a short time limit.

Use of cross-sectional data. Cross-sectional data were analysed in the present study, rather than time series data. The use of cross-sectional data in network analyses results in the direction of any relationships between nodes being undeterminable. Thus, in the present study, the direction of each relationship between pairs of nodes in the estimated network is unknown.

Directed networks (i.e., networks where the direction of relationships is estimated) rely on the assumption that the causal structure of the network is acyclic, in that it does not contain feedback loops (Epskamp et al., 2018). Feedback loops occur when a variable is able to cause itself through a chain of associations with other variables (Epskamp et al., 2018). In psychological research, acyclicity can be a difficult assumption to make. In the network of risk factors for suicide, for example, feeling hopeless might lead to feeling depressed, which might lead to perceived burdensomeness, which in turn leads to further feelings of hopelessness, such that feeling hopeless essentially results in greater feelings of hopelessness. Thus, estimating a directed network from data about suicide risk would potentially violate this assumption.

Another assumption relevant to determining the causality of relationships is that the structure of the true network is assumed to be sparse. The LASSO applied during network estimation (refer back to the Data Analysis subsection of Chapter Three for more information) relies on this assumption, estimating a network with few edges (Epskamp, Kruis, & Marsman, 2017). This process has low sensitivity, failing to detect all true edges, but has high specificity, estimating very few false positives (Epskamp et al., 2017), such that the edges in the estimated network likely reflect edges which are true. However, it may not be the case that the true network of suicide risk and protective factors is actually sparse, and therefore the estimated network structure cannot be assumed to be the only explanation of relationships between variables, nor can it be assumed that other explanations of these relationships are false (Epskamp et al., 2017).

Lastly, it is assumed that variables have high strength centrality due to having causal effects on other nodes. For example, the node feeling depressed may have had high strength centrality in the present study due to having causal effects on many nodes in the estimated network, as is suggested elsewhere in this thesis. However, there are other hypotheses which may explain the presence of edges in the estimated network. For example, these relationships may be present due to depression being affected *by* many other nodes in the network, which may be the case if depression is considered to be a relatively state-like emotional attribute. As the estimated network in the present study is undirected, alternative hypotheses cannot be ruled out.

In order to begin to describe the directionality of the relationships, as well as emphasise the likelihood of causality, time series data should be collected, with participants filling in measurements at multiple instances across a period of time (Borsboom & Cramer, 2013). If, for example, at time point 1 a person expressed they felt extremely depressed and burdensome, and at time point 2 they had strong suicidal ideation, this would enable us to more definitively infer temporal causality between the variables. As temporal data was not used in this study, we cannot rule out that suicidal ideation causes feelings of depression and burdensomeness, rather than the other way around. Epskamp et al. (2018) describe this temporal prediction as possibly being indicative of causality, in that the cause is an antecedent to the effect. Estimating temporal networks of suicide risk and protective factors would therefore enable researchers to more strongly imply causality in relationships between these factors.

To further test hypotheses about causal relationships, in addition to temporal network studies, experimental research that manipulates nodes should be conducted. Testing whether specific nodes are able to causally effect other nodes is pertinent to the argument of causality in network analysis. Knowledge gleaned from experiments testing the relationship between two nodes when one is experimentally manipulated would provide evidence for or against the causality of associations present in network analyses, which at this stage are only *presumed* to be causal based on the aforementioned assumptions. Therefore, researchers should consider conducting experimental studies, as well as time series ones.

Despite the inability to confidently conclude the direction of the estimated relationships in the present study, this research reflects an important step towards the ultimate goal of being able to use network analysis to guide methods aimed at reducing suicide risk. Using cross-sectional data to estimate a network of the risk and protective factors for suicide has stimulated the generation of hypotheses about the causality of relationships between risk and protective factors for suicide, which other researchers may wish to test. If time series and experimental research is conducted to test these hypotheses, evidence for or against the assumption that particular relationships represent causal effects will grow, such that the relationships estimated in the networks in this study may be supported or they may not. Hopefully other researchers will build upon the present study to determine the plausibility of causal effects and the feasibility of utilising network analysis to guide suicide prevention methods.

Practical and Clinical Implications

Network researchers argue that targeting interventions towards variables which are central to a network may be an effective method of intervention (McNally et al., 2015). Altering a central variable may result in changes in the many other variables that the central variable is connected to (Epskamp et al., 2018). In the scope of suicide prevention, this might involve intervening predominantly on factors such as feeling depressed, feeling hopeless, perceived burdensomeness, self-esteem, and social support, which the present study found to be central. Changing the state of these risk and protective factors could plausibly change the state of other variables in the network which were connected to these central factors, activating the network further to reduce suicide risk in a more effective, far reaching way than might otherwise be possible. The likelihood of this situation occurring in reality largely depends on the truth of assumptions about the causality of relationships in network estimations. If variables are central simply because they are affected *by* many other variables, rather than being a cause of other variables, then changing the state of central variables may not result in wider change across the estimated network.

As aforementioned, it is crucial to point out that these suggestions are largely untested, given there has been very little research to date about how effective it is to intervene on variables identified as central in the network analyses. However, network studies of this nature are beginning to be published and the preliminary evidence from psychopathology networks suggests that intervening on central variables may be an effective method of treatment (for example, see Papini et al., 2019; Rodebaugh et al., 2018). It may be the case that intervening on central variables is also an effective suicide prevention tactic. To test whether this may be the case, experimental network analyses need to be conducted to explore the relationship between node centrality and node change during treatment or intervention for suicide. Research of this nature would allow us to test whether targeting specific suicide risk and protective factors using various suicide prevention methods could effectuate change in these factors over time and how this change relates to the centrality of these variables. Such research would likely have high stakes due to the inclusion of participants at risk of suicide, and thus researchers wishing to investigate suicide prevention methods using network analysis will have to thoroughly consider the ethical implications of such research.

A second implication of suicide network research is that attending to associations of variables in the development of interventions may help to elicit more effective prevention methods. In the present study there were a large number of variables with significant connections to suicidal ideation. Variables with positive associations with suicidal ideation included feeling depressed, perceived burdensomeness, substance abuse, feeling hopeless, and feeling anxious, and those with negative associations included resilience, self-esteem, access to mental health services, and a positive attitude towards mental health services. As is suggested by definition of suicide risk, evidence from previous studies suggests that suicide risk factors have a cumulative impact (Perkins & Hartless, 2002; Roberts, Roberts, & Xing, 2010), such that possessing more risk factors for suicide confers a higher likelihood of attempting suicide. Finding such a variety of variables to be associated with suicidal ideation in the present study aligns with this. This finding could be indicative that methods of suicide prevention may be more effective if they aim to address *multiple* risk or protective factors. This suggestion is conjectural because the associations in the present study are undirected, and thus it is unknown whether the associations are causal. However, it is plausible that this may be the case, and therefore such hypotheses should be considered further.

Another important clinical implication of the present study arises out of the finding that protective factors are highly central in the network of suicide risk and protection. To date there has not been a great deal of research about protective factors for suicide, thus our understanding of how these relate to one another, as well as to suicide, is limited at best. However, as the protective factors of self-esteem and social support were found to be highly central in the present study, it may be the case that attempting to enhance protective factors, rather than aiming purely to remove risk factors, may be an especially effective method of preventing suicide. Thus, adopting a strengths-based approach in therapeutic interventions, in tandem with reducing the presence of risk factors, may help to reduce the likelihood of suicide.

Additionally, the results of the present study suggest that internal, individual factors may be of more relevance to suicide risk than societal factors. The implication of this is that the focus of preventative efforts may need to adjust to suit this. Of the risk and protective factors for suicide that were included in the network, variables which described individual characteristics and psychopathology, such as self-esteem and feeling depressed, were estimated to be most central. Variables of this nature were also most strongly related to suicidal ideation. The variables which were indicative of wider societal disparities, such as unemployment or financial difficulty, were not central to the network, nor were they directly associated with suicidal ideation. It is pertinent to mention that other societal factors, such as stigma, were not measured in this study but may prove to be strongly implicated in suicide risk, and thus such factors deserve attention in future research efforts. Societal factors might be important to address to reduce suicide rates at a population level. However, the results of the present study suggest that addressing individual factors may be particularly beneficial.

With the present study finding individual-level dynamic characteristics and psychopathology such as depression and perceived burdensomeness to be most central to suicide risk, providing treatment which targets these factors may be a more useful way to reduce suicide risk than addressing well-being at a population level. Though addressing well-being at a population level has intrinsic value, reducing suicide rates is still likely to require interventions that are specifically focused on enhancing the psychological functioning of individuals, particularly for individuals who are at high risk of suicide. If an individual’s own dynamic characteristics put them at high risk for suicide, then such variables may require more attention in suicide prevention methods. This could occur in psychological treatment, for example.

Overall, the results of the estimated network suggest that addressing depression may be a particularly effective method of suicide prevention. This variable had the highest strength centrality in each of the estimated networks and also had a direct positive association with suicidal ideation. As mentioned earlier, depression is an extremely common disorder (World Health Organisation, 2018). Importantly, disorders such as depression are dynamic, changing over time for any given individual (Nelson, McGorry, Wichers, Wigman, & Hartmann, 2017). Such fluctuations occur on a micro-level, from moment to moment, as well as a macro-level, from year to year (Nelson et al., 2017). This suggests that a person's level of depression is changeable, such that it could be altered through psychological treatment.

At present, there are a number of well-established psychological (Linde et al., 2015) and pharmaceutical (Cipriani et al., 2018) treatments for depression. Despite individuals preferring psychological treatment for depression significantly more than pharmacological treatment (McHugh, Whitton, Peckham, Welge, & Otto, 2013), many people with depression do not receive psychological treatment. A study examining the temporal trends of adolescent depression and treatment in the United States of America reported a rise in the number of adolescents diagnosed with depression, in tandem with increased rates of pharmacological treatment for depression (Mojtabai, Olfson, & Han, 2016). In comparison, rates of psychological therapy remained static for this population between 2005 and 2014 (Mojtabai et al., 2016), suggesting that the ratio of adolescents receiving pharmacological care for depression to adolescents receiving psychological therapy for depression has gone up, such that there is a disparity in the types of treatment provided for depression. Olfson, Blanco, and Marcus (2016) also report differences in the type of care provided to people with depression of various severity. Of individuals with serious distress and depression who had received treatment, 81.1% were treated with antidepressants while 32.5% participated in psychotherapy (Olfson et al., 2016). Among those with less serious distress and depression, 88.6% received antidepressants while just 20.6% received psychotherapy (Olfson et al., 2016).

Treatment provided to people with depression also tends to be less than adequate. Across 21 countries, only 16.5% of people who had received pharmacological or psychological treatment for depression received the minimally adequate standard of care (Thornicroft et al., 2017). The minimal standard of care for each treatment was defined using evidence-based guidelines around the amount of time that should be spent receiving pharmacological treatment and the number of visits to psychological treatment that an individual should have access to (Thornicroft et al., 2017). The results of Thornicroft et al.'s (2017) research suggest there is a need for increased access to adequate care, including psychological treatments.

Easy and adequate access to psychological treatment for depression may be pertinent to suicide prevention and intervention. By increasing access to adequate treatment, such as psychological intervention, individuals with depression will likely experience a decrease in symptoms of depression. Studies exploring treatment for depression as a method of reducing suicidal ideation have thus far shown promising results. In a study by Mewton and Andrews (2015), internet-delivered cognitive-behavioural therapy for depression significantly decreased the level of both depression and suicidal ideation, with moderate to large effect sizes. As depression is highly central to suicide risk, if symptoms of depression decrease, the likelihood of these individuals experiencing suicidal ideation or having elevated suicide risk will be reduced too. Therefore, ensuring individuals have access to psychological treatment for depression may be an effective method of reducing suicide. Future researchers may wish to explore the feasibility of this as a way of reducing suicide risk.

The ability to prevent suicide through psychological treatment hinges on an individual being in a position to receive help from a mental health service, and research suggests this does not happen at a high rate among people experiencing suicidal ideation (Reynders et al., 2015; Stanley et al., 2016). Individuals who are having suicidal thoughts may choose not to seek help from mental health services in part due to perceiving a variety of structural and attitudinal barriers to treatment. As mentioned earlier, these include financial difficulty, availability of service, perceived ineffectiveness of treatment, and believing their problem to be insignificant (Bruffaerts et al., 2011). Therefore, in order to increase help-seeking behaviour, and in turn be able to address an individual's internal suicide risk factors in psychological treatment, it may help to alter people's perception of barriers to mental health services (Holman & Williams, 2019).

Even if barriers to help-seeking are reduced, providing an increased number of psychotherapeutic interventions may be difficult due to issues in supply and demand. Currently in New Zealand there are not enough psychologists in the workforce to meet the mental health service demands of the population, with estimates suggesting a shortage of nearly 1000 psychologists (Health Central, 2018). The disparity between supply and demand has been ongoing for some time, with the New Zealand Psychological Society (2010) calling for an urgent workforce development strategy nearly a decade ago. If there is not a large enough workforce to meet demand, decreasing barriers to help-seeking such as perceived lack of availability of services may be difficult to effectuate. It must be noted that increasing the psychological workforce is suggested as an *indirect* implication of the results of the present study. This is very broadly inferred due to the high centrality of individual characteristics for suicide risk, such as depression, which would likely be reduced through psychological treatment. As such treatment lacks availability due to issues of supply and demand, it is posited that increasing the psychological workforce would have beneficial impacts for individuals requiring immediate assistance for high suicide risk or depression, enabling them faster access to adequate services.

Conclusion

Suicide causes hundreds of thousands of deaths worldwide each year, and this number will continue to steadily increase unless more efforts are applied to improving suicide prevention tactics. To be able to do this effectively, we need to increase our understanding of how risk and protective factors interact with one another, and how these factors relate to suicidal ideation and behaviour. In an attempt to fill this knowledge gap, the present study applied network analysis to common risk and protective factors for suicide, aiming to examine which factors were most central to the network structure, and which factors were directly associated with suicidal ideation.

Feeling depressed, feeling hopeless, and perceived burdensomeness were central risk factors for suicide, while self-esteem and social support were central protective factors. Many risk factors were directly associated with suicidal ideation, including feeling depressed, perceived burdensomeness, substance abuse, feeling hopeless, and feeling anxious. Additionally, four protective factors had direct negative connections to suicidal ideation: resilience, self-esteem, access to mental health services, and positive attitude towards these services. With the results of the present study in mind, practitioners should consider including a discussion about protective factors *as well as* risk factors when an individual is identified as being at risk of suicide, because a strengths-based approach to suicide prevention may be a viable addition to existing risk reduction tactics. Researchers should pursue time series and experimental network analyses of risk and protective factors for suicide and work together to develop ethically sound network intervention analyses examining suicide prevention methods.

The network approach to examining suicide risk and protective factors has thus far shown itself to be enlightening. With further research and the eventual development of targeted interventions for suicide, there is reason to hope that a reduction in suicide rates may occur in the future.

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Appendices

The appendices provided in the following pages include the advertisement, information sheet, and surveys for participants recruited through social media (Appendix A: Social Media Participants: Advertisement and Survey) and Prolific Academic (Appendix B: Prolific Academic Participants: Information Sheet and Survey), the preregistration for this research (Appendix C: Open Science Framework Preregistration), the summary of findings for participants (Appendix D: Summary of Findings for Participants), and supplementary figures (Appendix E: Supplementary Figures).

Appendix A: Social Media Participants: Advertisement and Survey

Social Media Advertisement

For my Master of Science thesis, I am researching relationships between factors which are known to have some correlation with suicide risk. If you are aged 18 or over and live in New Zealand, Australia, USA, or UK, I would really appreciate it if you could fill out a quick survey. We are interested in hearing from anyone – you do not need to have had thoughts of suicide to participate. If you are interested in participating, click the link below for more information. Feel free to share this around, and please don't hesitate to get in touch (12131151@uni.massey.ac.nz) if you have any questions! 😉

-Mikayla

https://massey.au1.qualtrics.com/jfe/form/SV_cCn4gUopESS4NoN

Social Media Survey

Kia ora, bula vinaka, talofa, nǐ hǎo, and hello.

My name is Mikayla Holman, and as part of my Master of Science degree in Psychology I am researching relationships between attributes that are known to have some correlation with suicide risk. An online survey with quantitative questions will be used to measure these risk and protective factors.

You are invited to take part in this study. Whether or not you take part is your choice.

This information sheet will help you decide if you want to take part in the study. Please make sure you have read it all. It explains why I am doing this study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. Before you decide, you may want to talk about the study with supportive people, such as family, whānau, friends, or health providers.

Who can participate?

If you are aged 18 or over and can complete a survey written in English, you may participate in this study. You must currently be living in New Zealand, Australia, USA, or the UK to be eligible to participate.

I need approximately 500 people to complete the survey for this study.

What will participation involve?

If you choose to participate in this study, you will complete a survey online. It will take approximately 10 minutes to complete.

At the end of the online survey there will be an opportunity for you to choose one of three New Zealand charities for me to donate to at the completion of the research project. For every completed survey, I will donate NZ$2 to either the Mental Health Foundation of New Zealand, Voices of Hope, or Key to Life Charitable Trust, up to a total of $400.

Survey responses are also being collected from participants on Prolific Academic. These participants get paid approximately NZ$2 for their time. If you would prefer this option to the charity donation, you are welcome to sign up to Prolific Academic to participate in this research in that way instead.

The survey includes some questions which may cause discomfort. If you choose to participate, you will be asked questions about your own experience of suicidal thoughts. You may choose to not answer these questions, or any other survey questions which you do not want to answer.

If you feel distress or discomfort during the survey, it is recommended that you stop, and call someone you trust, or one of the below services.

If you live in **New Zealand**, the following free support services are available 24/7:

- Lifeline – call 0800 LIFELINE (0800 543 354) or text 4357
- Suicide Crisis Helpline – call 0508 TAUTOKO (0508 828 865)
- Need To Talk – call or text 1737
- <u>If you are in immediate danger, please call 111 or your local DHB mental health crisis team.</u>

If you live in **Australia**, the following free support services are available 24/7:

- Lifeline – call 13 11 14. Alternatively you can text 0477 13 11 14 between 6pm to 10pm AEDT, 7 days a week.
- <u>If you are in immediate danger, please call 000.</u>

If you live in the **United States of America**, the following free support services are available 24/7:

- Suicide Prevention Lifeline – call 1800 273 8255
- <u>If you are in immediate danger, please call 911.</u>

If you live in the **United Kingdom**, the following free support services are available 24/7:

- Samaritans – call 116 123
- <u>If you are in immediate danger, please call 999.</u>

How will data be managed?

The survey responses will be anonymous, so you will not be asked to provide your name or contact details. You will be asked to provide your email address only if you wish to receive a summary of findings. This information will be collected and stored separately to your survey responses to ensure your survey responses remain anonymous.

For the duration of this research project, the data that you provide will be accessed only by myself and the supervisor directly involved in this study. Once the data has been analysed and my thesis has been completed, a de-identified copy of the data will be made publicly available in an online repository for verification by other researchers. Any personally identifying information (e.g., your email address, if you provide it for research summary purposes) will not be included in the public dataset to ensure that it is not possible to identify who you are. Any identifying information that you provide will be stored on a password-protected computer until the research is complete (estimated date: December 2019), and then it will be deleted. The de-identified public dataset will be stored indefinitely.

Your rights

You are under no obligation to accept this invitation to participate. If you decide to participate, you have the right to: decline to answer any question and be given access to a summary of the project findings when they are available.

Questions?

If you have any questions about this research, please feel free to contact me or my supervisor.

Mikayla Holman

12131151@uni.massey.ac.nz

Supervisor: Dr. Matt Williams

M.N.Williams@massey.ac.nz

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 19/19. If you have any concerns about the conduct of this research, please contact Associate Professor David Tappin (Committee Chair), Massey University Human Ethics Committee: Northern, email humanethicsnorth@massey.ac.nz.

I have read and understood the above information and I want to participate in this study.

- ◯ Yes (1)
- ◯ No (2)

Gender:

- ◯ Male (0)
- ◯ Female (1)
- ◯ Gender diverse (2)
- ◯ Prefer not to answer (3)

Age:
Note - you must be at least 18 years old to participate in this survey.

- ◯ Please select below... (0)
- ◯ Under 18 (1)
- ◯ 18 - 24 (2)
- ◯ 25 - 34 (3)
- ◯ 35 - 44 (4)
- ◯ 45 - 54 (5)
- ◯ 55 - 64 (6)
- ◯ 65 - 74 (7)
- ◯ 75 - 84 (8)
- ◯ 85 or older (9)

Which country do you live in?

- ◯ Please select below... (0)

- New Zealand (1)
- Australia (2)
- United States of America (3)
- United Kingdom (4)
- Other (5)

Please select the response which best describes how much you agree or disagree with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I work in a job which offers predictable income and consistent hours of work. (Stable_Employment)					
I earn enough money to meet my basic needs. (Financial_Stress)					
I am in a committed relationship. (Committed_Relationship)					
I often do things without thinking. (Impulsivity_1)					
I often do not take my time when planning something. (Impulsivity_2)					
I often do not think things through. (Impulsivity_3)					

I think I have a drug or alcohol problem. (Substance_Abuse_1)	○	○	○	○	○
In the past month, my drug or alcohol use has impacted my attendance at university or work. (Substance_Abuse_2)	○	○	○	○	○
In the past month, I have failed to get important things done because of my drug or alcohol use. (Substance_Abuse_3)	○	○	○	○	○
In the past I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying. (Bullied_1)	○	○	○	○	○
I am being bullied by another person, either physically, verbally, mentally, or by cyber-bullying. (Bullied_2)	○	○	○	○	○
I often feel anxious. (Feeling_Anxious)	○	○	○	○	○
I often feel depressed. (Feeling_Depressed)	○	○	○	○	○
I often feel hopeless about my future. (Feeling_Hopeless)	○	○	○	○	○
I often feel like a burden to the people who are close to me. (Perceived_Burdensomeness)	○	○	○	○	○

Please select the response which best describes how much you agree or disagree with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I sometimes wish I was not alive. (Suicidal_Ideation_1)	○	○	○	○	○
I sometimes think about wanting to die. (Suicidal_Ideation_2)	○	○	○	○	○
I sometimes think about wanting to take my own life. (Suicidal_Ideation_3)	○	○	○	○	○
I sometimes think about suicide. (Suicidal_Ideation_4)	○	○	○	○	○
I am good at solving problems in my daily life. (Problem_Solving)	○	○	○	○	○
I recover quickly after encountering difficulties. (Resilience_1)	○	○	○	○	○
I easily adapt to change. (Resilience_2)	○	○	○	○	○
I feel accepted by other people. (Sense_of_Belonging_1)	○	○	○	○	○
I feel connected to other people. (Sense_of_Belonging_2)	○	○	○	○	○

I feel included by other people. (Sense_of_Belonging_3)

I feel good about myself. (Self-esteem)

I am able to access mental health services if I need them. (Access_to_MHS_1)

I would access mental health services if I required them. (Access_to_MHS_2)

I believe mental health services are effective at reducing suicidal ideation and suicidal behaviour. (Attitude_Towards_MHS_1)

I think mental health services are beneficial. (Attitude_Towards_MHS_2)

When I am in a crisis, I can count on someone to give me good advice. (Social_Support_1)

I have someone to talk to about myself or my problems. (Social_Support_2)

I have someone to talk to who understands my problems. (Social_Support_3)

Which of the below charities would you like me donate to on your behalf?

Note: Feel free to visit the below websites for more information about each charity.

Mental Health Foundation of New Zealand

Voices of Hope

I Am Hope Charitable Trust

○ Mental Health Foundation of New Zealand (1)

○ Voices of Hope (2)

○ I Am Hope Charitable Trust (3)

The summary of findings for the project will be available in December 2019. At this time it will be uploaded to the project page on Open Science Framework. You may wish to bookmark this link to access the summary in December. Alternatively, you may opt to receive an email with the summary of findings.

Would you like to receive a summary of the project findings by **email** when they are available?

If you choose 'Yes' you will be redirected to a page where you will need to enter your email address. Your email address will be collected separately to your survey responses. Your survey responses remain completely anonymous.

○ Yes (1)

○ No (2)

If yes was selected, the participant was redirected to a new survey with the below question.

To receive a summary of the project findings when they are available, please enter your email below:

____

End of survey message for all participants who complete the survey:

Thank you for participating!

If you have opted to receive a summary of the research findings, you will receive these in December 2019.

If you feel distress or discomfort due to this survey, it is recommended that you call someone you trust, or one of the below services.

If you live in **New Zealand**, the following free support services are available 24/7:

- Lifeline – call 0800 LIFELINE (0800 543 354) or text 4357
- Suicide Crisis Helpline – call 0508 TAUTOKO (0508 828 865)
- Need To Talk – call or text 1737
- If you are in immediate danger, please call 111 or your local DHB mental health crisis team.

If you live in **Australia**, the following free support services are available 24/7:

- Lifeline – call 13 11 14. Alternatively you can text 0477 13 11 14 between 6pm to 10pm AEDT, 7 days a week.
- <u>If you are in immediate danger, please call 000.</u>

If you live in the **United States of America**, the following free support services are available 24/7:

- Suicide Prevention Lifeline – call 1800 273 8255
- <u>If you are in immediate danger, please call 911.</u>

If you live in the **United Kingdom**, the following free support services are available 24/7:

- Samaritans – call 116 123
- <u>If you are in immediate danger, please call 999.</u>

If you have any further questions regarding this survey, feel free to contact Mikayla via email: 12131151@uni.massey.ac.nz

Appendix B: Prolific Academic Participants: Information Sheet and Survey

Prolific Academic Study Information Sheet/Advertisement

My name is Mikayla Holman, and as part of my Master of Science degree in Psychology I am researching relationships between attributes that are known to have some correlation with suicide risk. An online survey with quantitative questions will be used to measure these risk and protective factors.

You are invited to take part in this study. Whether or not you take part is your choice.

This information sheet will help you decide if you want to take part in the study. Please make sure you have read it all. It explains why I am doing this study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. Before you decide, you may want to talk about the study with supportive people, such as family, whānau, friends, or health providers.

Who can participate?

If you are aged 18 or over and can complete a survey written in English, you may participate in this study. You must currently be living in New Zealand, Australia, USA, or the UK to be eligible to participate.

I need approximately 500 people to complete the survey for this study.

What will participation involve?

If you choose to participate in this study, you will complete a survey online. It will take approximately 10 minutes to complete.

When you have completed the online survey, you will receive the link to Prolific Academic to get compensation for your time.

The study includes some questions which may cause discomfort. If you choose to participate, you will be asked questions about your own experience of suicidal thoughts. You may choose to not answer these questions, or any other survey questions which you do not want to answer.

If you feel distress or discomfort during the survey, it is recommended that you stop, and call someone you trust, or one of the below services.

If you live in **New Zealand**, the following free support services are available 24/7:

- Lifeline – call 0800 LIFELINE (0800 543 354) or text 4357
- Suicide Crisis Helpline – call 0508 TAUTOKO (0508 828 865)
- Need To Talk – call or text 1737
- If you are in immediate danger, please call 111 or your local DHB mental health crisis team.

If you live in **Australia**, the following free support services are available 24/7:

- Lifeline – call 13 11 14. Alternatively you can text 0477 13 11 14 between 6pm to 10pm AEDT, 7 days a week.
- If you are in immediate danger, please call 000.

If you live in the **United States of America**, the following free support services are available 24/7:

- Suicide Prevention Lifeline – call 1800 273 8255
- If you are in immediate danger, please call 911.

If you live in the **United Kingdom**, the following free support services are available 24/7:

- Samaritans – call 116 123
- If you are in immediate danger, please call 999.

How will data be managed?

The survey responses will be anonymous, so you will not be asked to provide your name or contact details.

For the duration of this research project, the data that you provide will be accessed only by myself and the supervisor directly involved in this study. Once the data has been analysed and my thesis has been completed, a de-identified copy of the data will be made publicly available in an online repository for verification by other researchers. Any personally identifying information will not be included in the public dataset to ensure that it is not possible to identify who you are. Any identifying information that you provide will be stored on a password-protected computer until the research is complete (estimated date: December 2019), and then it will be deleted. The de-identified public dataset will be stored indefinitely.

Your rights

You are under no obligation to accept this invitation to participate. If you decide to participate, you have the right to: decline to answer any question and be given access to a summary of the project findings when they are available.

Questions?

If you have any questions about this research, please feel free to contact me via the Prolific Academic messaging service. Alternatively, you may contact me or my supervisor via email.

Mikayla Holman - 12131151@uni.massey.ac.nz

Supervisor: Dr. Matt Williams - M.N.Williams@massey.ac.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 19/19. If you have any concerns about the conduct of this research, please contact Associate Professor David Tappin (Committee Chair), Massey University Human Ethics Committee: Northern, email humanethicsnorth@massey.ac.nz.

Prolific Academic Survey

I have read and understood the information about this study and I want to participate in this study.

○ Yes (1)

○ No (2)

Please enter your Prolific Academic user ID. ____________________

Gender:

- ◯ Male (0)
- ◯ Female (1)
- ◯ Gender diverse (2)
- ◯ Prefer not to answer (3)

Age:
Note - you must be at least 18 years old to participate in this survey.

- ◯ Please select below... (0)
- ◯ Under 18 (1)
- ◯ 18 - 24 (2)
- ◯ 25 - 34 (3)
- ◯ 35 - 44 (4)
- ◯ 45 - 54 (5)
- ◯ 55 - 64 (6)
- ◯ 65 - 74 (7)
- ◯ 75 - 84 (8)
- ◯ 85 or older (9)

Which country do you live in?

- ○ Please select below... (0)
- ○ New Zealand (1)
- ○ Australia (2)
- ○ United States of America (3)
- ○ United Kingdom (4)
- ○ Other (5)

Please select the response which best describes how much you agree or disagree with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I work in a job which offers predictable income and consistent hours of work. (Stable_Employment)	○	○	○	○	○
I earn enough money to meet my basic needs. (Financial_Stress)	○	○	○	○	○
I am in a committed relationship. (Committed_Relationship)	○	○	○	○	○
I often do things without thinking. (Impulsivity_1)	○	○	○	○	○
I often do not take my time when planning something.	○	○	○	○	○

(Impulsivity_2)					
I often do not think things through. (Impulsivity_3)	○	○	○	○	○
I think I have a drug or alcohol problem. (Substance_Abuse_1)	○	○	○	○	○
In the past month, my drug or alcohol use has impacted my attendance at university or work. (Substance_Abuse_2)	○	○	○	○	○
In the past month, I have failed to get important things done because of my drug or alcohol use. (Substance_Abuse_3)	○	○	○	○	○
In the past I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying. (Bullied_1)	○	○	○	○	○
I am being bullied by another person, either physically, verbally, mentally, or by cyber-bullying. (Bullied_2)	○	○	○	○	○
I often feel anxious. (Feeling_Anxious)	○	○	○	○	○
I often feel depressed. (Feeling_Depressed)	○	○	○	○	○
I often feel hopeless about my future. (Feeling_Hopeless)	○	○	○	○	○

I often feel like a burden to the people who are close to me. (Perceived_Burdensomeness)					

Please select the response which best describes how much you agree or disagree with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I sometimes wish I was not alive. (Suicidal_Ideation_1)					
I sometimes think about wanting to die. (Suicidal_Ideation_2)					
I sometimes think about wanting to take my own life. (Suicidal_Ideation_3)					
I sometimes think about suicide. (Suicidal_Ideation_4)					
I am good at solving problems in my daily life. (Problem_Solving)					
I recover quickly after encountering difficulties. (Resilience_1)					
I easily adapt to change. (Resilience_2)					
I feel accepted by other people.					

(Sense_of_Belonging_1)					
I feel connected to other people. (Sense_of_Belonging_2)	○	○	○	○	○
I feel included by other people. (Sense_of_Belonging_3)	○	○	○	○	○
I feel good about myself. (Self-esteem)	○	○	○	○	○
I am able to access mental health services if I need them. (Access_to_MHS_1)	○	○	○	○	○
I would access mental health services if I required them. (Access_to_MHS_2)	○	○	○	○	○
I believe mental health services are effective at reducing suicidal ideation and suicidal behaviour. (Attitude_Towards_MHS_1)	○	○	○	○	○
I think mental health services are beneficial. (Attitude_Towards_MHS_2)	○	○	○	○	○
When I am in a crisis, I can count on someone to give me good advice. (Social_Support_1)	○	○	○	○	○
I have someone to talk to about myself or my problems. (Social_Support_2)	○	○	○	○	○

I have someone to talk to who understands my problems. (Social_Support_3)	○	○	○	○	○

The summary of findings for the project will be available in December 2019. At this time it will be uploaded to the project page on Open Science Framework. You may wish to bookmark this link to access the summary in December. Alternatively, you may opt to receive a message through Prolific Academic with the summary of findings.

Would you like to receive a summary of the project findings when they are available?

○ Yes (1)

○ No (2)

End of survey message for all participants who complete the survey:

Thank you for participating!

If you have opted to receive a summary of the research findings, you will receive these via Prolific in December 2019.

To receive your compensation for participating, click here to be redirected to Prolific Academic.

If you feel distress or discomfort due to this survey, it is recommended that you call someone you trust, or one of the below services.

If you live in **New Zealand**, the following free support services are available 24/7:

- Lifeline – call 0800 LIFELINE (0800 543 354) or text 4357

- Suicide Crisis Helpline – call 0508 TAUTOKO (0508 828 865)
- Need To Talk – call or text 1737
- <u>If you are in immediate danger, please call 111 or your local DHB mental health crisis team.</u>

If you live in **Australia**, the following free support services are available 24/7:

- Lifeline – call 13 11 14. Alternatively you can text 0477 13 11 14 between 6pm to 10pm AEDT, 7 days a week.
- <u>If you are in immediate danger, please call 000.</u>

If you live in the **United States of America**, the following free support services are available 24/7:

- Suicide Prevention Lifeline – call 1800 273 8255
- <u>If you are in immediate danger, please call 911.</u>

If you live in the **United Kingdom**, the following free support services are available 24/7:

- Samaritans – call 116 123
- <u>If you are in immediate danger, please call 999.</u>

If you have any further questions regarding this survey, feel free to contact Mikayla via email: 12131151@uni.massey.ac.nz

Appendix C: Open Science Framework Preregistration

The Open Science Framework project page can be accessed at https://osf.io/f395g/

This project was preregistered on the 24th of June 2019. The preregistration was initially embargoed, because a link to the Open Science Framework project page was provided to participants so that they could bookmark the link to view the summary of findings at a later date, rather than providing their email address. Embargoing the preregistration stopped participants from viewing it during participation in the study. The embargo was lifted on the 20th of November 2019, at which time data collection and analyses were complete, and this thesis was nearing completion.

The preregistration begins below.

Study Information

1. Title (required)
    - 1.1. Network analysis of risk and protective factors for suicide
2. Authors (required)
    - 2.1. Mikayla S. Holman
    - 2.2. Matt N. Williams
3. Description (optional)
    - 3.1. Please give a brief description of your study, including some background, the purpose of the of the study, or broad research questions.
        - 3.1.1. This research will explore the associations between risk and protective factors for suicide by conducting a network analysis of these factors.
        - 3.1.2. A few researchers have conducted similar research, examining suicide through network analysis (see Shiratori et al., 2014; De Beurs, van Borkolo, & O'Connor, 2017; and Simons et al., 2019). However, this

research will analyse different variables compared to these studies. As such this research will be exploratory in nature in that it does not involve hypothesis-testing (so it is not confirmatory in a strict sense), but we are preregistering specific plans for data collection and analysis so that future readers of this research are able to distinguish which analyses were and were not planned in advance.

3.1.3. We aim to explore which risk and protective factors are highly central in a network analysis of these factors. Factors which are highly central in the network could be predictive of suicide in that they affect many other risk factors for suicide. This preregistered study will not be able to definitively determine the risk factors which causally lead to the highest risk of suicide. Instead it may help us to generate hypotheses about plausible causal connections, which other researchers may wish to test.

4. Hypotheses (required)

4.1. List specific, concise, and testable hypotheses. Please state if the hypotheses are directional or non-directional. If directional, state the direction. A predicted effect is also appropriate here. If a specific interaction or moderation is important to your research, you can list that as a separate hypothesis.

4.1.1. There are no hypotheses for this study. However, we do have research questions which we are aiming to answer with this study. Firstly, this study aims to explore which risk or protective factors are most central to suicide in a network analysis of these factors. Secondly, this study aims to conduct a separate network analysis of these variables for males and for females, to determine if the network structures for each gender are different.

Design Plan

In this section, you will be asked to describe the overall design of your study. Remember that this research plan is designed to register a single study, so if you have multiple experimental designs, please complete a separate preregistration.

5. Study type (required)
    - 5.1. Observational Study - Data is collected from study subjects that are not randomly assigned to a treatment. This includes surveys, natural experiments, and regression discontinuity designs.
6. Blinding (required)
    - 6.1. Blinding describes who is aware of the experimental manipulations within a study. Mark all that apply.
        - 6.1.1. No blinding is involved in this study.
7. Is there any additional blinding in this study?
    - 7.1. No
8. Study design (required)
    - 8.1. Describe your study design. Examples include two-group, factorial, randomized block, and repeated measures. Is it a between (unpaired), within-subject (paired), or mixed design? Describe any counterbalancing required. Typical study designs for observation studies include cohort, cross sectional, and case-control studies.

8.1.1. This is a cross-sectional study. There are no two-group, factorial, randomised block, or repeated measures. It does not involve counter-balancing.

9. Randomization (optional)

9.1. If you are doing a randomized study, how will you randomize, and at what level?

9.1.1. Not applicable.

Sampling Plan

In this section we'll ask you to describe how you plan to collect samples, as well as the number of samples you plan to collect and your rationale for this decision. Please keep in mind that the data described in this section should be the actual data used for analysis, so if you are using a subset of a larger dataset, please describe the subset that will actually be used in your study.

10. Existing data (required – pick one)

10.1. Preregistration is designed to make clear the distinction between confirmatory tests, specified prior to seeing the data, and exploratory analyses conducted after observing the data. Therefore, creating a research plan in which existing data will be used presents unique challenges. Please select the description that best describes your situation. Please do not hesitate to contact us if you have questions about how to answer this question (prereg@cos.io).

10.1.1. Registration prior to creation of data: As of the date of submission of this research plan for preregistration, the data have not yet been collected, created, or realized.

11. Explanation of existing data (optional)

11.1. If you indicate that you will be using some data that already exist in this study, please describe the steps you have taken to assure that you are unaware of any patterns or summary statistics in the data. This may include an explanation of how access to the data has been limited, who has observed the data, or how you have avoided observing any analysis of the specific data you will use in your study.

11.1.1. Not applicable

12. Data collection procedures (required)

12.1. Please describe the process by which you will collect your data. If you are using human subjects, this should include the population from which you obtain subjects, recruitment efforts, payment for participation, how subjects will be selected for eligibility from the initial pool (e.g. inclusion and exclusion rules), and your study timeline. For studies that don't include human subjects, include information about how you will collect samples, duration of data gathering efforts, source or location of samples, or batch numbers you will use.

12.1.1. Participants will be people aged 18 or older who live in New Zealand, Australia, United Kingdom, or the United States of America. People who are under 18 years old or who do not live in the four countries listed above will not be able to participate.

12.1.2. 300 participants will be recruited through Prolific Academic, with each of these participants being paid £1 (approximately NZ$2) through Prolific Academic to compensate for their time. The survey will be available to Prolific Academic users who live in New Zealand, Australia, United Kingdom, or the United States of America.

12.1.3. We are also going to advertise on social media to recruit a further 200 participants. These participants will primarily be from New Zealand, as we are unlikely to obtain many New Zealand-based participants from Prolific Academic. This recruitment via social media will include advertising in groups related to mental health, to try to obtain a reasonable representation of participants with higher levels of suicide risk. The compensation for participants recruited via social media is a charitable donation, where the participant chooses one of three charities which we will donate NZ$2 to on their behalf, up to a total of NZ$400 (= 200 participants).

12.1.4. Data collection will begin on the 25th of June, 2019.

13. Sample size (required)

13.1. Describe the sample size of your study. How many units will be analyzed in the study? This could be the number of people, birds, classrooms, plots, interactions, or countries included. If the units are not individuals, then describe the size requirements for each unit. If you are using a clustered or multilevel design, how many units are you collecting at each level of the analysis?

13.1.1. The sample size will be approximately 500 participants, 300 of which will be recruited from Prolific Academic, and 200 from social media. The minimum sample size needed to conduct the network analysis is 171.

14. Sample size rationale (optional)

14.1. This could include a power analysis or an arbitrary constraint such as time, money, or personnel.

14.1.1. To conduct a stable network analysis there needs to be at least as many observations as there are parameters. Eighteen risk or protective factors will be included in the analysis, equating to 171 interactions (18 + 18 x 17/2 = 171). Therefore, at least 171 people need to participate in the survey. Network analysis works best with a large sample size, and so we are aiming for a sample size substantially in excess of this minimum.

15. Stopping rule (optional)

15.1. If your data collection procedures do not give you full control over your exact sample size, specify how you will decide when to terminate your data collection.

15.1.1. Data collection will cease when one of the conditions below occur:

15.1.1.1. A) When 200 respondents are recruited via social media who consent to participate, meet demographic eligibility criteria, and reach the end of the survey, AND when 300 respondents are recruited via Prolific Academic who consent to participate, meet demographic eligibility criteria, and mark their response as complete.

OR

15.1.1.2. B) on the 23rd of July, 2019.

Variables

In this section you can describe all variables (both manipulated and measured variables) that will later be used in your confirmatory analysis plan. In your analysis plan, you will have the opportunity to describe how each variable will be used. If you have variables which you are measuring for exploratory analyses, you are not required to list them, though you are permitted to do so.

16. Manipulated variables (optional)

16.1. Describe all variables you plan to manipulate and the levels or treatment arms of each variable. This is not applicable to any observational study.

16.1.1. Not applicable

17. Measured variables (required)

17.1. Describe each variable that you will measure. This will include outcome measures, as well as any predictors or covariates that you will measure. You do not need to include any variables that you plan on collecting if they are not going to be included in the confirmatory analyses of this study.

17.1.1. Eighteen variables will be measured and used in the network analysis. A total of 33 Likert items will be used to measure these variables, with some variables being measured by one Likert item while others are measured by multiple Likert items. Each item will be measured on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The variables and their corresponding items are listed below.

17.1.1.1. Stable employment – “I work in a job which offers predictable income and consistent hours of work.”

17.1.1.2. Financial stability – “I earn enough money to meet my basic needs.”

17.1.1.3. Committed relationship – “I am in a committed relationship.”

17.1.1.4. Impulsivity – “I often do things without thinking.” “I often do not take my time when planning something.” “I often do not think things through.”

17.1.1.5. Substance abuse – “I think I have a drug or alcohol problem.” “In the past month, my drug or alcohol use has impacted my attendance at university or work.” “In the past month, I have failed to get important things done because of my drug or alcohol us.”

17.1.1.6. Bullied – “In the past I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying.” “I am being bullied by another person, either physically, verbally, mentally, or by cyber-bullying.”

17.1.1.7. Feeling anxious – “I often feel anxious.”

17.1.1.8. Feeling depressed – “I often feel depressed.”

17.1.1.9. Feeling hopeless – “I often feel hopeless about my future.”

17.1.1.10. Perceived burdensomeness – “I often feel like a burden to the people who are close to me.”

17.1.1.11. Suicidal ideation – “I sometimes wish I was not alive.” “I sometimes think about wanting to die.” “I sometimes think about wanting to take my own life.” “I sometimes think about suicide.”

17.1.1.12. Problem solving – “I am good at solving problems in my daily life.”

17.1.1.13. Resilience – “I recover quickly after encountering difficulties.” “I easily adapt to change.”

17.1.1.14. Sense of belonging – “I feel accepted by other people.” “I feel connected to other people.” “I feel included by other people.”

17.1.1.15. Self-esteem – “I feel good about myself.”

17.1.1.16. Access to mental health services – “I am able to access mental health services if I need them.” “I would access mental health services if I required them.”

17.1.1.17. Positive attitude towards mental health services – “I believe mental health services are effective at reducing suicidal ideation and suicidal behaviour.” “I think mental health services are beneficial.”

17.1.1.18. Social support – “When I am in a crisis, I can count of someone to give me good advice.” “I have someone to talk to about myself or my problems.” “I have someone to talk to who understands my problems.”

17.1.2. Gender will also be used in the analyses to compare the networks of males and females. The survey item measuring this is “Gender:” with the response options of male, female, gender diverse, or prefer not to answer. Only the responses of “male” and “female” will be included in the gender network analyses. We estimate that 171 participants of each gender are required to achieve stable network estimations, but we will report the analyses (along with stability analyses) regardless of whether we meet this number.

18. Indices (optional)

18.1. If any measurements are going to be combined into an index (or even a mean), what measures will you use and how will they be combined? Include either a formula or a precise description of your method. If you are using a more complicated statistical method to combine measures (e.g. a factor analysis), you can note that here but describe the exact method in the analysis plan section.

18.1.1. For nine of the variables in the network analysis we will be using the mean of two or more items from the survey. These variables and the corresponding items which will be averaged are listed below.

18.1.1.1. Impulsivity – “I often do things without thinking.” “I often do not take my time when planning something.” “I often do not think things through.”

18.1.1.2. Substance abuse – “I think I have a drug or alcohol problem.” “In the past month, my drug or alcohol use has impacted my attendance at university or work.” “In the past month, I have failed to get important things done because of my drug or alcohol us.”

18.1.1.3. Bullied – “In the past I have been bullied by another person, either physically, verbally, mentally, or by cyber-bullying.” “I am being bullied by another person, either physically, verbally, mentally, or by cyber-bullying.”

18.1.1.4. Suicidal ideation – “I sometimes wish I was not alive.” “I sometimes think about wanting to die.” “I sometimes think about wanting to take my own life.” “I sometimes think about suicide.”

18.1.1.5. Resilience – “I recover quickly after encountering difficulties.” “I easily adapt to change.”

18.1.1.6. Sense of belonging – “I feel accepted by other people.” “I feel connected to other people.” “I feel included by other people.”

18.1.1.7. Access to mental health services – “I am able to access mental health services if I need them.” “I would access mental health services if I required them.”

18.1.1.8. Positive attitude towards mental health services – “I believe mental health services are effective at reducing suicidal ideation and suicidal behaviour.” “I think mental health services are beneficial.”

18.1.1.9. Social support – “When I am in a crisis, I can count of someone to give me good advice.” “I have someone to talk to about myself or my problems.” “I have someone to talk to who understands my problems.”

Analysis Plan

You may describe one or more confirmatory analysis in this preregistration. Please remember that all analyses specified below must be reported in the final article, and any additional analyses must be noted as exploratory or hypothesis generating.

A confirmatory analysis plan must state up front which variables are predictors (independent) and which are the outcomes (dependent), otherwise it is an exploratory analysis. You are allowed to describe any exploratory work here, but a clear confirmatory analysis is required.

19. Statistical models (required)

19.1. What statistical model will you use to test each hypothesis? Please include the type of model (e.g. ANOVA, multiple regression, SEM, etc) and the specification of the model (this includes each variable that will be included as predictors, outcomes, or covariates). Please specify any interactions, subgroup analyses, pairwise or complex contrasts, or follow-up tests from omnibus tests. If you plan on using any positive controls, negative controls, or manipulation checks you may mention that here. Remember that any test not included here must be noted as an exploratory test in your final article.

19.1.1. Note: For the purpose of this preregistration, we are interpreting 'confirmatory analyses' to be the analyses that we are prespecifying in detail here.

19.1.2. The main aim of this research is to find out which risk or protective factors are most central in a network analysis of the 18 variables specified in this preregistration under Variables: Measured variables

19.1.3. The type of network that will be estimated in R is a regularised partial correlation network, with pairwise complete observations. We will use graphical LASSO estimation with EBIC model selection to regularise the network, using the *bootnet* package in R.

19.1.4. Centrality indices will be calculated in R using the *qgraph* package (see Analysis Plan: Inference Criteria).

19.1.5. Stability analyses will be conducted in R using the *bootnet* package (see Analysis Plan: Inference Criteria).

19.1.6. A secondary aim of this research is to analyse the differences between the network structure of the risk and protective factors for males and females. As the minimum sample size required for a stable network analysis of 18 nodes is 171, ideally we need to reach this minimum sample size for males and for females. The same process as above will be used to estimate these network structures, and stability analyses will be conducted for these network structures as well.

19.1.7. See the attached R script to see the planned analyses. Please note that the exact R script we use to analyses our data may end up slightly different to the one uploaded here. However, the analyses we run will still be the ones we have specified in this preregistration.

20. Transformations (optional)

20.1. If you plan on transforming, centering, recoding the data, or will require a coding scheme for categorical variables, please describe that process.

20.1.1. Not applicable

21. Inference criteria (optional)

21.1. What criteria will you use to make inferences? Please describe the information you'll use (e.g. p-values, bayes factors, specific model fit indices), as well as cut-off criterion, where appropriate. Will you be using one or two tailed tests for each of your analyses? If you are comparing multiple conditions or testing multiple hypotheses, will you account for this?

21.1.1. To determine which nodes in the network analyses are the most central, we will compute and plot centrality indices. These include strength, betweenness and closeness. This will be done using the *centralityPlot* function in the *qgraph* package in R.

21.1.2. In the *bootnet* package, the position of the nodes (variables) in the network reflect the strength of the edges (connections between nodes), such that closer nodes represent stronger associations. The thickness of an edge also reflects how strongly correlated the nodes are, with thicker edges representing stronger associations. The colour of the edges reflect the direction of the association between two nodes. Blue edges show a positive association, while red edges show a negative association. The reported network will include all edges that remain after the regularisation process (which will be done via Gaussian Markov random field estimation using graphical LASSO and extended Bayesian information criterion to select optimal regularisation parameter, and the default tuning parameter of 0.5).

21.1.3. Stability of the network analysis will be calculated using the *bootnet* package, which tests for edge-weight accuracy, edge-weights difference, centrality stability, and centrality difference. This information will help us to make inferences about the stability of the networks and the accuracy of the relationships they estimate.

22. Data exclusion (optional)

22.1. How will you determine what data or samples, if any, to exclude from your analyses? How will outliers be handled? Will you use any awareness check?

22.1.1. Participants must be 18 years old or over, and live in New Zealand, Australia, United Kingdom, or United States of America. If participants do not meet these criteria, they are unable to participate in the study, and the survey will end at this point. These participant's responses will not be included in any analyses.

22.1.2. We will also exclude any participant that fails to answer at least 75% of the Likert items. Participants must thus provide a response to at least 25 of the 33 Likert items to be included in the analyses.

22.1.3. We will include all cases, regardless of any outlying values, given that the response scale we will be using will limit the possibility of very substantially outlying responses. Exploratory analyses may be conducted to check for the presence of outliers.

22.1.4. No awareness checks are included.

23. Missing data (optional)

23.1. How will you deal with incomplete or missing data?

23.1.1. If a participant is missing a response to a Likert item which will be used to create a mean variable (e.g., impulsivity, for which 3 Likert items are averaged), the mean will not be calculated for that variable for that participant, and subsequently their response to that variable will not be included in the network analyses. However, the participant's other complete responses will still be included in the analyses. Pairwise complete observations will be used when correlating the nodes for use in the network (see preregistered R script). This may result in different sample sizes being included for each node in the analyses.

24. Exploratory analysis (optional)

24.1. If you plan to explore your data set to look for unexpected differences or relationships, you may describe those tests here. An exploratory test is any test where a prediction is not made up front, or there are multiple possible tests that you are going to use. A statistically significant finding in an exploratory test is a great way to form a new confirmatory hypothesis, which could be registered at a later time.

Other

25. Other (Optional)

25.1. If there is any additional information that you feel needs to be included in your preregistration, please enter it here. Literature cited, disclosures of any related work such as replications or work that uses the same data, or other context that will be helpful for future readers would be appropriate here.

25.1.1. Planned R analysis script and practice data

Appendix D: Summary of Findings for Participants

The below summary of findings will be sent to participants when this thesis is submitted. Participants recruited through social media who signalled they wished to receive this summary will receive it via email. Participants recruited through Prolific Academic who signalled they wished to receive this summary will receive it via Prolific Academic's messaging service. The charitable donations section of the summary will only be sent to participants recruited through social media, as only these participants were incentivised by a charitable donation to one of three charity options. The summary of findings for participants begins below.

Suicide Risk and Protective Factors: A Network Approach

Summary of Findings for Participants

Earlier this year you participated in my research about the risk and protective factors for suicide. I greatly appreciate your participation, and I am pleased to let you know that a summary of the findings is now available.

If you feel distressed when reading the summary below, a list of Support Services is provided at the end.

Research Aim

The aim of this research was to explore the relationships between factors which are known to put someone at risk of suicide (risk factors) and factors which protect against suicide (protective factors).

Procedure

As a participant, you completed a survey online. This began with a few questions relating to demographic information, which asked about your gender, age bracket, and which country you live in. Following this, you were asked how much you agreed with 33 statements such as “I often feel depressed” and “I sometimes wish I was not alive”. These items corresponded to 18 different variables, such as feeling depressed and suicidal ideation.

The data collected in the survey were analysed using network analysis. This is a relatively new statistical technique for studies examining suicide, but it has been used in the field of psychology for some time. In simple terms, network analysis can be used to explore how variables relate to one another. Many of the results of the network analysis are too complex to discuss in this summary. However, my supervisor (Dr Matt Williams) and I are writing a full scientific report of this research for publication, and you are welcome to contact me if you’d like to read it when it is published.

Participant Demographics

In total, 515 participants were recruited for this study, with 301 recruited through Prolific Academic and 214 recruited through social media. Of the participants, 171 were male, 338 were female, 5 were gender diverse, and 1 preferred not to answer. The sample included 198 participants from New Zealand, 32 from Australia, 146 from the United States of America, 138 from the United Kingdom, and 1 who did not respond to this item.

Results

Suicidal ideation was measured by 4 statements, and 30-39% of participants agreed with these statements, indicating about a third of the sample were having suicidal thoughts. Of the 515 participants, 69% agreed or strongly agreed that they felt anxious, 51% felt depressed, 50% felt hopeless, and 49% felt like a burden. Over half of the sample had been bullied in the past (54%), while 11% were currently being bullied. Very few participants perceived that they had a drug or alcohol problem (13%). Overall, participants felt they had good problem solving skills (64%), had social support (64-71%), were resilient (46%), and had a sense that they belonged (42-47%). More than half of the participants would access mental health services if they needed to (62%) and a similar percentage felt they were able to access these (67%) when required. Most participants thought mental health services were beneficial (82%), but fewer thought they were effective at reducing suicidal thoughts and behaviour (61%).

In the network, there were five variables which were positively related to suicidal ideation, such that high levels of these variables indicated having lots of suicidal thoughts. These variables were feeling depressed, perceived burdensomeness, substance abuse, feeling hopeless, and feeling anxious. There were also four variables which were negatively related to suicidal ideation, with high levels of these variables indicating fewer suicidal thoughts. These variables were resilience, self-esteem, access to mental health services, and a positive attitude towards mental health services.

Conclusion

Understanding how risk and protective factors for suicide relate to one another is a key step to improving our suicide prevention methods in the future. This study showed suicidal thoughts to be associated with a variety of risk and protective factors for suicide.

Charitable Donations – *this information will only be included in the Summary of Findings for participants who were recruited via social media.*

At the end of the survey, you chose one of three charities for Massey University to donate NZD2 to on your behalf. The total donations are as follows:

1. $220 to Mental Health Foundation of New Zealand
2. $82 to Voices of Hope
3. $49 to Key to Life Charitable Trust

I have now submitted my Master of Science thesis to Massey University for marking. In the coming months my supervisor and I will be writing this research up as a journal article in the hopes of getting it published.

Thank you again for your interest and participation in this study. If you have any questions, please feel free to contact me via email - mikaylaholman@hotmail.com.

Support Services

If you live in **New Zealand**, the following free support services are available 24/7:

- Lifeline – call 0800 LIFELINE (0800 543 354) or text 4357
- Suicide Crisis Helpline – call 0508 TAUTOKO (0508 828 865)
- Need to Talk – call or text 1737
- If you are in immediate danger, please call 111 or your local DHB mental health crisis team.

If you live in **Australia**, the following free support services are available 24/7:

- Lifeline – call 13 11 14. Alternatively, you can text 0477 13 11 14 between 6pm to 10pm AEDT, 7 days a week.
- If you are in immediate danger, please call 000.

If you live in the **United States of America**, the following free support services are available 24/7:

- Suicide Prevention Lifeline – call 1800 273 8255
- If you are in immediate danger, please call 911.

If you live in the **United Kingdom**, the following free support services are available 24/7:

- Samaritans – call 116 123
- If you are in immediate danger, please call 999.

Appendix E: Supplementary Figures

Each of the below figures contains a heat map showing the edge-weights for an estimated networks. The first is for the estimated network for all participants, second for male participants, third for female participants, and last for the exploratory network.

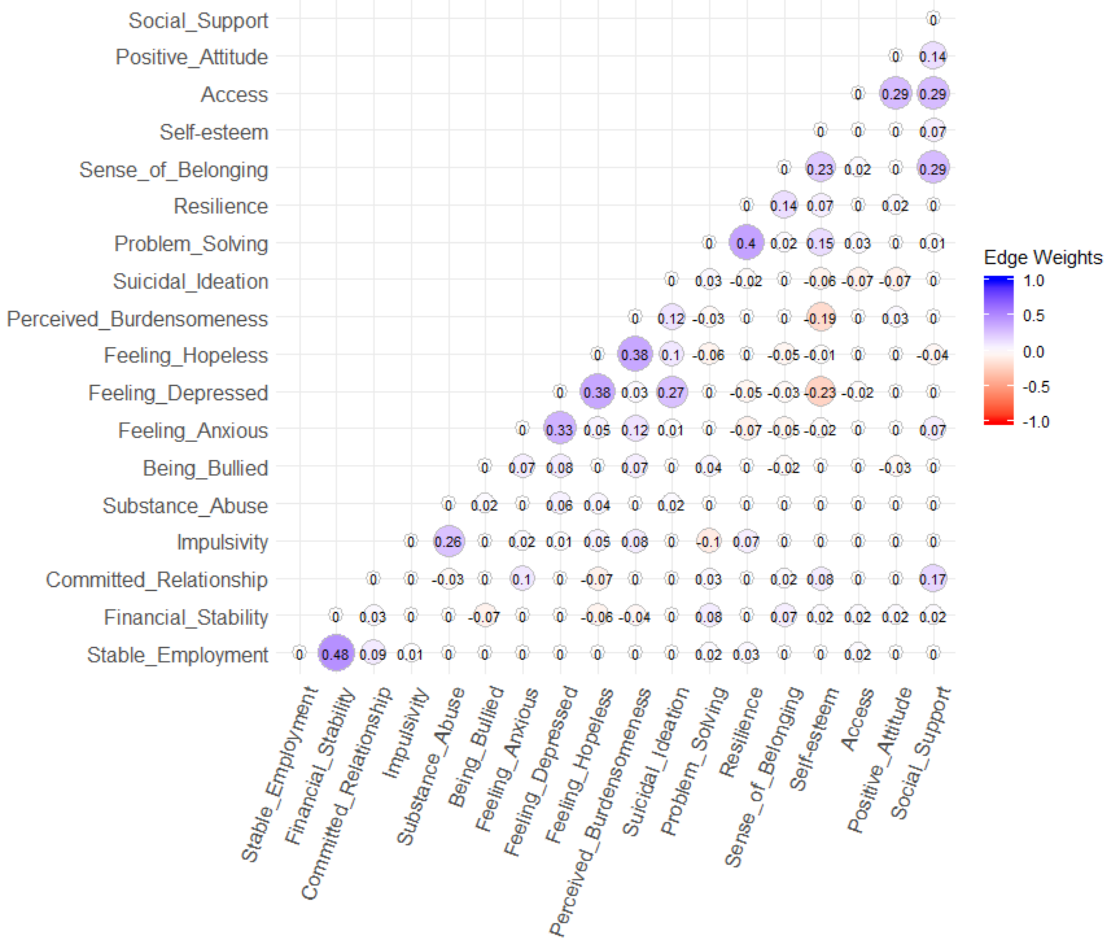

Figure E1. Heat map of edge-weights for the network of suicide risk and protective factors for all participants. Blue circles represent a positive association, while red circles represent a negative association. Opaque colour represents a stronger association, while pale or transparent colours represent weak associations.

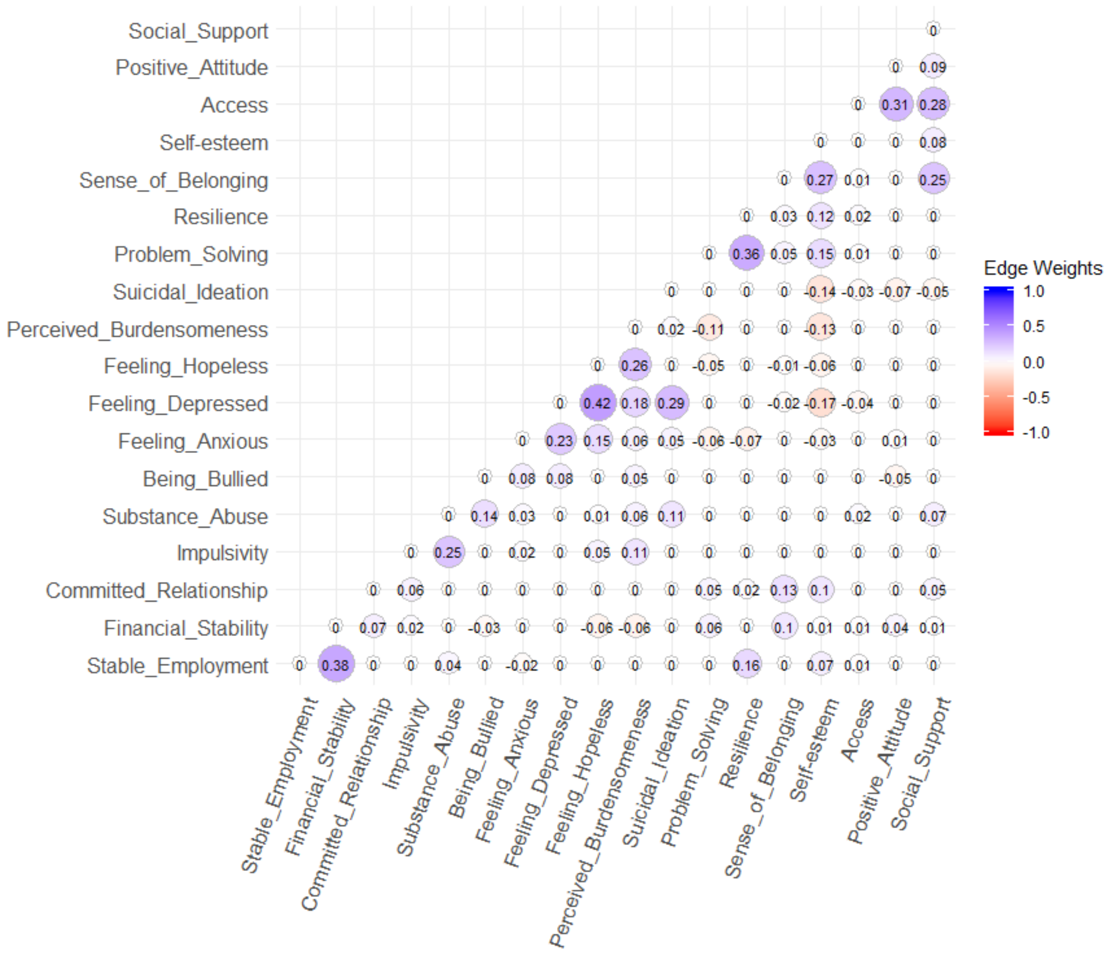

Figure E2. Heat map of edge-weights for the network of suicide risk and protective factors for male participants. Blue circles represent a positive association, while red circles represent a negative association. Opaque colour represents a stronger association, while pale or transparent colours represent weak associations.

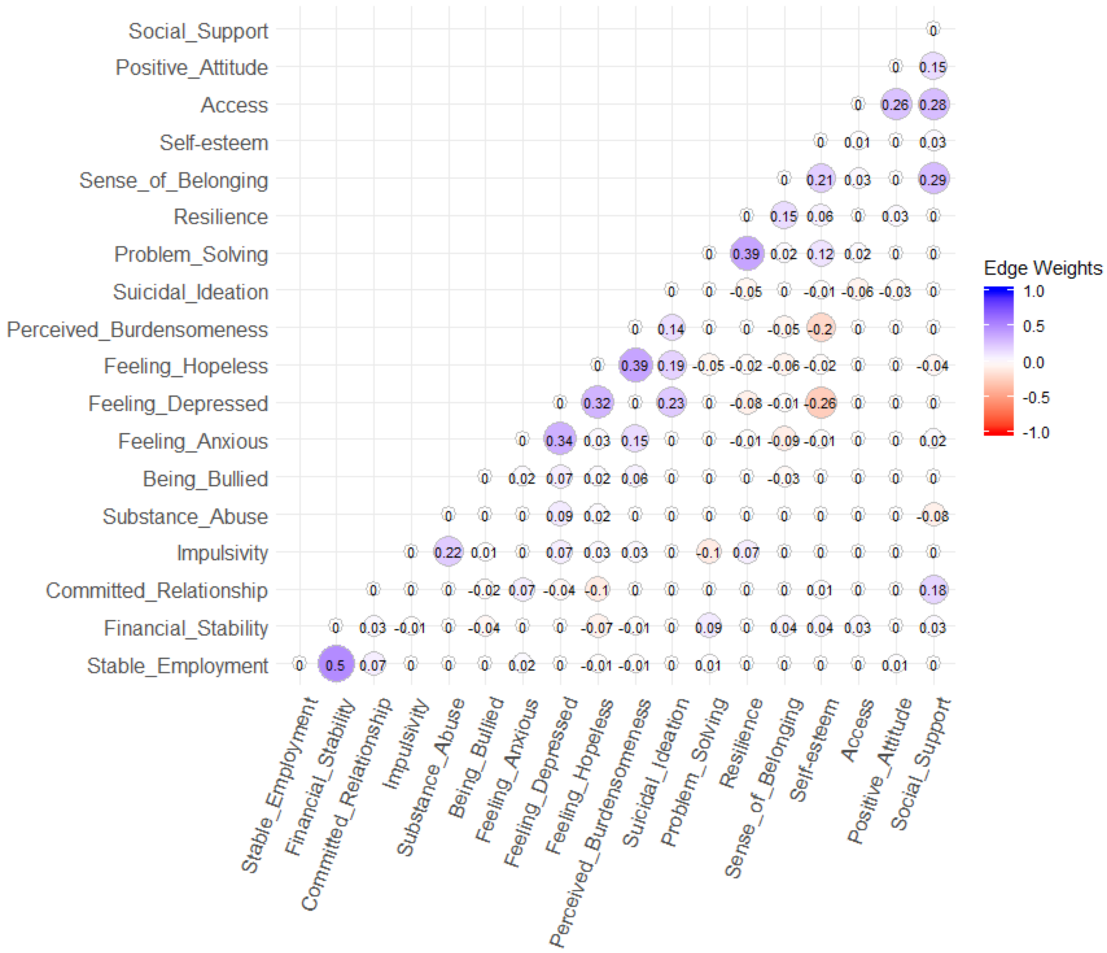

Figure E3. Heat map of edge-weights for the network of suicide risk and protective factors for female participants. Blue circles represent a positive association, while red circles represent a negative association. Opaque colour represents a stronger association, while pale or transparent colours represent weak associations.

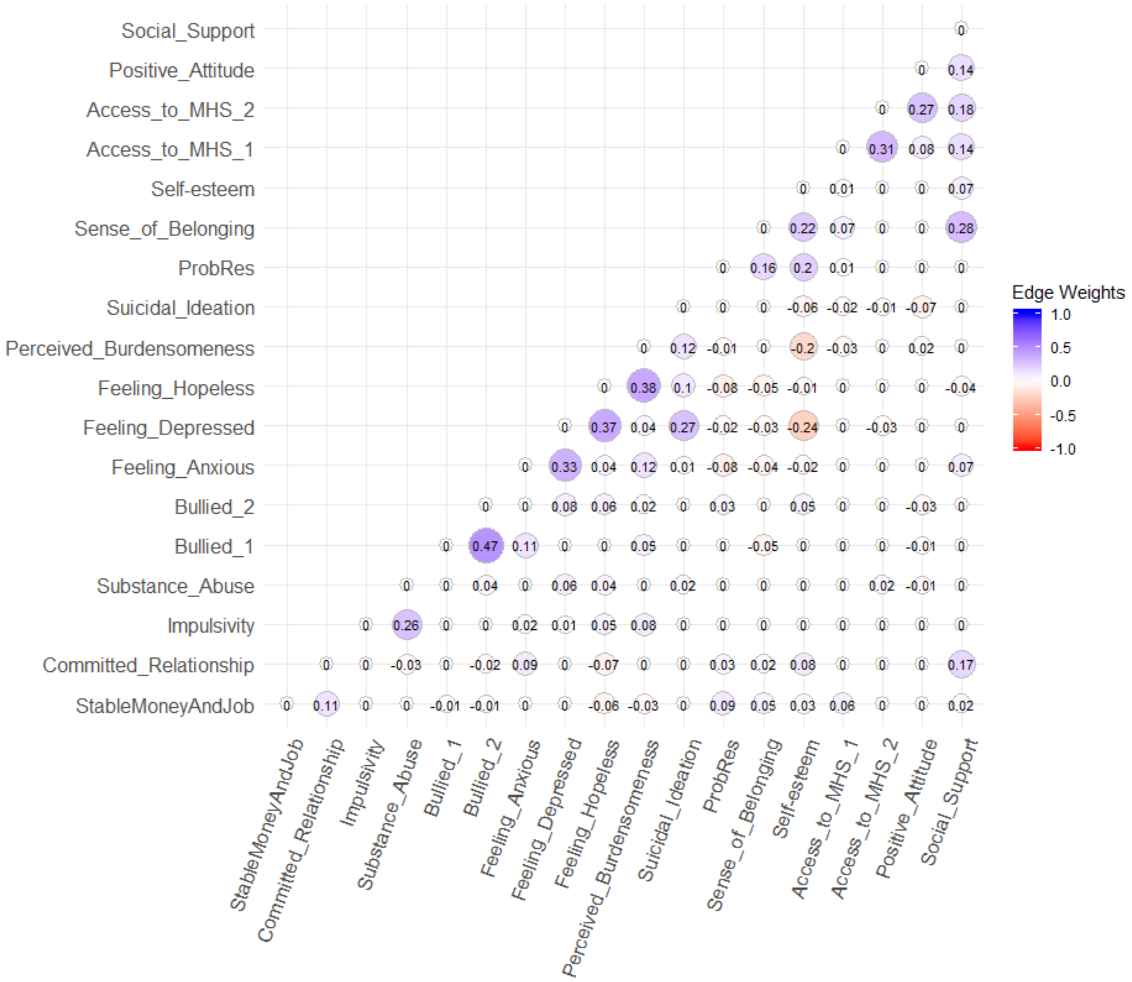

Figure E4. Heat map of edge-weights for the exploratory network of suicide risk and protective factors. Blue circles represent a positive association, while red circles represent a negative association. Opaque colour represents a stronger association, while pale or transparent colours represent weak associations.