



Network Analysis Reveals Unique Associations of Mindfulness and Distress with Immunity in Māori and Non-Māori New Zealanders

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Abstract

Objectives A healthy immune system is required to protect against viral infection and ensure the efficacy of vaccines. Psychological distress can threaten immune resilience, while mindfulness practices can be protective. In New Zealand, Māori experience significantly higher levels of distress compared to non-Māori. The aim of this study was to explore the role of ethnicity in the relations among immunity, depression, anxiety, stress, and mindfulness relate to each other.

Method Network analysis was used to explore unique relations among distress (depression, anxiety, stress), mindfulness facets, and immune status in matched (age, ranging from 19 to 88 years, sex, and self-classified socio-economic status) samples of Māori ($n = 195$) and non-Māori ($n = 195$) participants from New Zealand.

Results The networks of distress, mindfulness, and immune status were significantly different between Māori and non-Māori participants. The mindfulness facets Describe and Act with Awareness were more strongly positively linked in Māori, and Non-judge and Depression more strongly negatively linked in Māori, while Describe and Non-judge were more strongly positively linked in non-Māori. For both Māori and non-Māori, similarities included a negative link between anxiety and immune status, strong positive links between the distress variables, and positive links between the mindfulness facets of Non-judge and Act with Awareness, Observe and Non-React, and Observe and Describe.

Conclusions These findings suggest that anxiety is strongly linked to poor immunity across both Māori and non-Māori in New Zealand while networks of mindfulness and distress also demonstrated differences unique for each of these groups. Both similarities and differences between Māori and non-Māori should be considered when developing targeted interventions to improve physical and mental health in New Zealand.

Preregistration This study is not preregistered.

Keywords Anxiety · Immune status · Mindfulness · Network analysis · Māori

The COVID-19 pandemic has exacerbated the need for interventions to address psychological distress due to worldwide lockdowns, loss of social connections, and workplace and financial pressures. Worldwide, the rates of depression and anxiety have been estimated to increase by 27.6% and 25.6% respectively following the COVID-19 pandemic in 2020

(Santomauro et al., 2021). Healthcare systems globally had been under immense pressure to respond to the pandemic, and the increase in mood disorders and distress required immediate action in order to reduce their impact on the health system and improve health and quality of life of affected individuals. Global mortality from viral infections such as influenza is between 290,000 and 650,000 per year, as estimated by the World Health Organization (WHO), and COVID-19 was increasing that toll by millions of deaths (Dong et al., 2021; WHO, 2023). Vaccination is a successful means of addressing these issues, but its effectiveness may be reduced when individuals' immune systems are less healthy (Sompayrac, 2019).

In New Zealand, nearly 10% of the general population suffered from distress symptoms in the 4 weeks prior to the 2020/2021 Annual New Zealand Health Survey, up from

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7.5% in the 2019/2020 survey (Ministry of Health, 2022). According to the Te Oranga Hinengaro – Māori Mental Wellbeing report: Māori, the indigenous people of Aotearoa, New Zealand, experience more distress symptoms compared to non-Māori in New Zealand, 34% compared to 24% for depression and 36% compared to 22% for anxiety (Russell, 2018). Māori face considerable inequities in most health indicators when compared to Pakeha (New Zealand European), as shown by not only higher psychological distress indicators but also higher rates of substance abuse, poverty, and incarceration for example (McDonald et al., 2021; Ministry of Health, 2022). In addition, colonization has had a direct negative impact on Māori health and how Māori have been historically treated by the health system.

As with other colonized indigenous populations, European settlers introduced pathogens to which Māori had no natural resistance; and therefore, survival became a critical issue in the nineteenth century (Pool, 2016). Traditional Māori healthcare relied on natural and spiritual remedies with specialist healers (Tohunga); however, the Tohunga Suppression Act 1907 made the practice of traditional healing illegal (Voyce, 1989). In New Zealand, the health system now is largely based on a biomedical, individually focused, deficit model, reflecting the dominant culture's beliefs and values and not in alliance with values and tikanga (practices/behaviours) of Māori culture (Zambas & Wright, 2016). This combined with barriers to access (such as location of hospitals and poverty) has led to inequalities in health outcomes for Māori (Zambas & Wright, 2016).

Distress is often used as an umbrella term to describe when an individual feels as if they are no longer in control of their emotions and includes anxiety, depression, and stress symptomatology (Petzold et al., 2020). While anxiety, depression, and stress fall under mood disorders, there are significant differences between their presentations (Cash & Whittingham, 2010). Anxiety is having negative, worrying feelings about the future or other non-present events; depression can be described as feeling very low and miserable, struggling to find pleasure in things that previously brought pleasure and losing hope for the future; and stress is where an individual feels emotionally or mentally strained from demanding circumstances (Medvedev et al., 2018). These descriptions identify that the distressed individual's attention is more focused on either past or potential future events rather than the present moment (Medvedev et al., 2018). Mindfulness practices could therefore potentially be used to alleviate distress through non-judgmental attention and awareness to present moment experiences (Krägeloh et al., 2019).

The human immune system appears to be negatively affected by psychological distress symptomatology (Sørensen & Benros, 2022). An association between depression and a dysregulated immune system has been evidenced by links between depression and chronic neuroinflammation,

infections such as COVID-19, and auto-immune disorders (Taquet et al., 2021). Anxiety has also been associated with the immune system, primarily through inflammation with a possible mechanism being the gut-brain axis (Peirce & Alviña, 2019). Short-term stress has been shown to be immune-protective, while chronic long-term stress has the opposite effect, dysregulating the immune system and leading to chronic inflammation (Dhabhar, 2014). However, the unique impact of depression, anxiety, and stress on immunity remains largely unknown.

Over recent years, there has been an increase in the application of mindfulness-based interventions to support individuals to reduce psychological distress (Krägeloh et al., 2019), as well as an increase overall well-being in populations (Medvedev et al., 2018). Mindfulness practices originally stemmed from Buddhist teachings that transcend religion or philosophy as they are more concerned with exploring the nature of the human mind and our capacity for knowing (Kabat-Zinn, 2015). Mindfulness is a way of living and thinking that involves fostering and nurturing awareness that arises from purposefully and non-judgmentally paying attention, in the present moment (Kabat-Zinn, 1994). This definition implies mindfulness can be simply applied to any area of a person's life with mindful breathing being a common practice (Singh et al., 2020).

Mindfulness provides a framework for a meditative experience which emphasizes focused awareness of the present moment, usually beginning with breath awareness. Many well-being benefits have been shown to occur when mindfulness interventions have been introduced to different population groups (Krägeloh et al., 2019). In particular, mindfulness is associated with improved sleep and concentration, less mood disturbances and stress symptoms, and greater affect tolerance (Hartstone & Medvedev, 2021). Carlson et al. (2007) demonstrated that a Mindfulness-Based Stress Reduction (MBSR) intervention in breast and prostate cancer patients, produced pre- and post-intervention improvements in many health indices including salivary cortisol levels, immune cell counts, blood pressure, and heart rate. Changes in cortisol levels and immune patterns were consistent with less stress and mood disturbance and enhanced quality of life. Thus, the practice of mindful meditation has been associated with improved immune system function.

A review by Black and Slavich (2016) of 20 randomized controlled trials found that mindful meditation was associated with reduced circulation of pro-inflammatory proteins produced by immune cells such as C-reactive protein, and transcription factors that modulate the activity of immune cells such as nuclear factor κ B. Immune cells that decline in HIV-positive patients indicating disease onset (such as CD4⁺ T lymphocytes) were either increased or the rate of decline diminished with mindful meditation. They also found that mindful meditation stalled immune cell telomere length loss,

and increased telomerase activity—both indicating protection of the immune system (Black & Slavich, 2016). Chronic stress leads to persistently elevated cortisol levels that can dysregulate immune functioning (Morey et al., 2015). A review by Reive (2019) tentatively supported that MBSR interventions helped allostasis return by beneficially regulating metabolic, immune, cardiovascular, and neuro-endocrine biomarkers.

Mindfulness, along with many other words in English, has not been directly translated into Te Reo Māori (the Māori language) but rather defined as a concept, as within Māori culture mindfulness is seen to be naturally embedded within cultural practices rather than as a separate entity (McDonald et al., 2021). Mindfulness from a Māori perspective is a combination and connection between manaakitanga (respect, caring, generosity); aroha (love, compassion); kai-tiakitanga (look after, protect, care for); karakia (prayer, blessings, forgiveness, compassion); and wairua (spiritual; McDonald et al., 2021). Māori mindfulness practices for well-being enhance the connection between the spiritual world and the natural world; the central premise being the physical breath is seen as the gateway to connect one's body and mind to aspects of the environment and to one's ancestors (McDonald et al., 2021), thus reemphasizing a holistic way of life that the individual does not exist alone but as a product of a collective past, present, and future beings. A traditional greeting for Māori is the hongi, where two people press noses and exhale deeply (Karl et al., 2022). The sharing of breath in Te Ao Māori is viewed as a deep connection to each other, between families, and with their ancestors. The hongi demonstrates how existing mindfulness practices are utilised within Māori culture and signifies the importance of breath awareness.

The Māori language was traditionally an oral language where pūrākau (storytelling), karakia (prayer), waiata (song), tā moko (tattoo), whakairo (carvings), and raranga (weaving) were an integral part of the sustainability, expression, and presentation of Te Ao Māori (Māori worldview; Durie, 1998; McDonald et al., 2021). These traditional practices and life experiences evoke a state of mindfulness as they require full awareness and non-judgmental attention to one's thoughts and feelings, thus fully immersing in the present moment. An example is the haka or a Māori posture dance that uses chants to call on ancestors and spiritual guidance through this encounter in order to preserve or celebrate life. A haka enhances group cohesion as it is typically performed in a group before a challenge or to acknowledge a great event or occasion and requires each individual to be fully immersed in the present moment in order to create a workable space for action. While the Māori interpretation of mindfulness emphasizes the spiritual connection (differing from the more secular Western interpretation), the application of mindfulness in both Western and Māori societies

today requires the individual to be aware and present in the moment with a non-judgmental attitude (Kabat-Zinn, 1994; Karl et al., 2022). Both societies incorporate mindfulness into daily life; however, Western society focuses on breathing meditation and training in non-judgmental observing (noticing how the world is moving by), whereas Māori culture focuses on reconnecting with traditionally Māori practices enhancing the spiritual connection to Te Ao Māori.

Recent mindfulness practices such as MBSR (Kabat-Zinn, 1994) and Mindfulness-Based Cognitive Therapy (MBCT; Segal et al., 2002) have at times diverged from religious and spiritual foundations, which may be less effective for Māori and other indigenous cultures where spiritual well-being is a critical and integral core of health and well-being models (McDonald et al., 2021). These cultural differences may influence how the mechanism of mindfulness works for Māori and other New Zealanders and needs to be investigated using appropriate methodology to ensure mindfulness interventions are culturally acceptable and effective.

There is growing evidence to suggest that psychological distress negatively impacts the immune system (Ray et al., 2017; Sørensen & Benros, 2022), while the practice of mindfulness may play a protective role in both physical and mental health (Enkema et al., 2020; Morey et al., 2015). However, the complex interactive links between immunity, distress symptoms such as anxiety, depression, and stress, and mindfulness facets are not well understood. This lack of research may be due to prior methodological limitations, which can be overcome by using novel network analysis (Chalmers et al., 2022).

Non-judge and Act with Awareness, Observe and Non-React, and Observe and Describe

In the realm of mindfulness research, the Five Facet Mindfulness Questionnaire (FFMQ) has become an instrumental tool. Developed by Baer et al. (2006), it is notable for its extensive use and validation (Bartos et al., 2023; Lecuona et al., 2022; Okafor et al., 2023). The FFMQ is characterized by five distinctive facets. The facet of Act with Awareness pertains to the practice of being fully attentive to activities in the present moment. Non-Judge involves the cultivation of an accepting and non-evaluative attitude towards thoughts and emotions. The Describe facet refers to the capacity to articulate one's experiences through language. Observe is a facet that relates to the conscious noticing and attention to both internal and external experiences. Finally, Non-React encapsulates the approach of acknowledging thoughts and emotions without becoming entangled in them (Baer et al., 2006). The FFMQ has been applied in over 100 studies published in the *Mindfulness* journal between 2022 and early 2023 to measure mindfulness (Gan et al., 2023; Ketay et al.,

2023; Kümmerle et al., 2023). This extensive usage attests to its validity and underscores its importance in mindfulness research.

Each facet provides a unique perspective on mindfulness and its relationship with various aspects of psychological well-being. For instance, the facet of Act with Awareness has been found to have a strong association with negative affect, while Non-judge and Describe also have significant relationships with psychological symptoms (Azizi et al., 2022). In the context of college students, all facets—except for Observe—have been linked to lower levels of physical symptoms of stress, with this relationship mediated by a decrease in perceived stress (McBride et al., 2022).

A network analysis by Medvedev et al. (2020) explored the direct associations between mindfulness facets, compassion, positive and negative affect, depression, anxiety, and stress. Results showed strong relations between all distress variables as well as a direct relation between compassion and positive affect. In addition, compassion showed a strong negative relation with depression (Medvedev et al., 2020). A strong negative correlation was found between the Non-judge facet of mindfulness and negative affect, anxiety, and depression (Medvedev et al., 2020). Results also showed that the Non-react facet of mindfulness had a strong negative association with stress, and that Act with Awareness facet had a strong negative association with anxiety (Medvedev et al., 2020). In sum, these findings show that mindfulness and distress symptoms are intimately related; however, some limitations reported were that the study did not address immunity and did not distinguish between Māori and general populations of New Zealand. This is an important limitation, as differences between Māori and non-Māori in how distress is experienced and mindfulness interpreted may affect how these factors relate to the immune system.

Network analysis is increasingly used in psychology to estimate relations between a number of variables at once, estimating and mapping out partial correlations, that is, determining unique relationships between two variables while accounting for the influence of all other variables in the network on that relationship (Borsboom et al., 2021). To illustrate resulting relations and the structure of the overall network, variables are represented by circles (“nodes”), while the strength and direction of the relationships are represented by coloured lines linking the nodes (“edges”; Borsboom et al., 2021). Thicker edges represent stronger relationships: with red representing negative relationships, and blue or green representing positive relationships (Borsboom et al., 2021). Nodes with the most and strongest edges to other nodes represent the most important variables in the network (Haslbeck & Waldorp, 2018). Advantages of network analysis include reducing the need for repeated testing of relationships and

therefore minimizing the risk of making type one errors; and relinquishing arbitrary assignment of independent and dependent variables as in mediation/moderation/regression analyses (Åkerblom et al., 2021). Increased insight into how distress variables and mindfulness facets are linked to the immune system as a function of ethnicity can lead to the development of more targeted interventions to foster improved immune status. Network analysis also estimates predictability of each variable in the network, which identifies variables that are the most influential and therefore should be considered when designing health-related interventions (Haslbeck & Waldorp, 2018).

Mindfulness has benefits for both Māori and general populations; thus, it is likely that interactive relations between mindfulness facets, distress, and immunity have both similarities and differences between these populations. Identifying the strongest relations could help shape ethnicity-sensitive treatment pathways. Currently, there is lack of research focused on investigating and comparing interactive networks of immunity, psychological distress, and mindfulness in non-indigenous and indigenous populations. The aim of this study is to apply network analysis to investigate and compare unique links between immunity, psychological distress, and mindfulness facets in the general New Zealand and Māori populations.

Method

Participants

The sample included Māori participants and “Other New Zealanders” (Others). The Others category consisted of non-Māori participants and comprised predominantly NZ European participants, then Pasifika, Asian, or other ethnicities. We matched our sample of 195 Māori participants to 195 participants from the Others group ($n=893$). The two groups were matched for age ($M=41$ years for both groups, $SD=15.30$, ages ranged from 19 to 88 years), sex (69 males 35% and 126 females 65% in each group), and subjective socio-economic status measured by the Scale of Subjective Social Status (Others mean = 5.60, Māori mean = 5.50).

Procedure

The survey was administered online by Qualtrics Survey Administration in New Zealand, and included potential incentive for participation (on average NZ\$5 per participant). Māori participants were further recruited via snowballing techniques.

Measures

Socio-economic status was measured on the Scale of Subjective Social Status by indicating on a ladder from 1 “worst off” to 10 “best off” where participants believed they ranked compared to others in their community (Adler et al., 2000).

The Immune Status Questionnaire (ISQ) is a 7-item questionnaire measuring perceived immune status by asking how often in the last year participants have suffered various ailments including cough, fever, diarrhea, skin problems, headache, and common cold (Wilod Versprille et al., 2019). Responses are scored on a 5-point Likert scale ranging from 1 (*Never*) to 5 (*Almost always*). Responses are then summed and categorized into groups from 0 to 10, with 0 indicating the highest level of ailments and therefore more compromised immune status, and 10 indicating the least level of ailments and therefore the strongest immune status. Reliability of the ISQ was acceptable with Cronbach’s alpha (α) and McDonald’s Omega (ω) both 0.71 for the total dataset, with $\alpha=0.75$ and $\omega=0.74$ for Māori participants, and both α and ω of 0.69 for Others.

Psychological measures included a non-clinical measure of distress, the 21-item Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995), and a measure of mindfulness, the 39-item Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). The DASS-21 comprises questions asking how often certain experiences applied in the last week (e.g., “I found it hard to wind down”) and is answered on a 4-point Likert scale ranging from 0 (*Did not apply to me at all*) to 3 (*Applied to me very much, or most of the time*). Subscale scores are calculated for depression, anxiety, and stress. The full scale and subscales all indicated excellent reliability with α equal to ω for the full scale at 0.95, depression subscale 0.93, anxiety 0.86, and stress 0.88. The FFMQ comprises questions asking if certain experiences are generally true (e.g., “When I’m walking, I deliberately notice the sensations of my body moving”) and is answered on a 5-point Likert scale ranging from 1 (*Never or very rarely true*) to 5 (*Very often or always true*). Subscale scores are calculated for Observe, Describe, Act with Awareness, Non-judge, and Non-react. Reliability of the FFMQ has been well established with the full scale returning α of 0.90, and ω of 0.87 for the total dataset. Subscale α and ω ranged from 0.78 (Non-react) to 0.90 (Act and Non-judge) for the total dataset, with α and ω ranging from 0.77 to 0.91 for Māori participants, and α and ω ranging from 0.78 and 0.90 for Others. Therefore, all subscales demonstrated adequate reliability in both Māori and Others.

Data Analyses

Associations between immune status, the five facets of mindfulness, depression, anxiety, and stress were explored using partial correlation networks split by Māori and

Others in order to map out how the associations were related and to compare if or how associations differed. Partial correlations measure unique associations between two variables whilst accounting for all other variables in the network (Epskamp & Fried, 2018). Age, sex, and socio-economic status were removed from the networks as they had been matched before data analyses. Immune status, depression, anxiety, stress, and the five facets of mindfulness were included as nodes in the Gaussian Graphical Model (GGM). There were no missing values.

R software (version 4.04; R Core Team, 2021) was used to conduct the network analyses, specifically the Bayesian Gaussian Graphical Models (BGGM) package (Williams & Mulder, 2020). BGGM uses Bayesian rather than Frequentist techniques to eliminate the need for accurate long-run sampling distributions and can therefore be applied to non-parametric data (Williams, 2021). Measures of uncertainty under the Bayesian approach focus on posterior probabilities, and the examination of posterior distributions of each partial correlation (Williams, 2021). The “explore” function using “mixed” type enabled us to estimate partial correlations across all variables using a semi-parametric copula model based on ranked likelihood (Williams, 2021). Measures of uncertainty under the Bayesian approach focus on posterior probabilities, and the examination of posterior distributions of each partial correlation (Williams, 2021). The selected partial correlation matrix provided estimates of relationships whose 95% Highest Posterior Density Intervals (HPDI) did not include zero. In Bayesian statistics, a 95% HPDI is a range in which there is a 95% probability that the true value of the parameter of interest lies, given the data and the prior (Kruschke, 2014). We opted for a 95% HPDI instead of other intervals (e.g. the suggested 89% by Kruschke, 2014) for its conventional use in the field. Nonetheless, we recognize and fully acknowledge the flexibility in Bayesian analysis in setting these intervals. Future research in this area may provide more specific data to inform prior distributions in similar network analyses.

Individual GGMs were estimated and plotted for Māori and Others using the Fruchterman-Reingold algorithm from the “qgraph” function in the R library, and the layout was averaged across the two GGMs to facilitate comparisons (Fruchterman & Reingold, 1991). Nodes with the most and strongest edges were placed in the centre of the diagram, and dyads with strong edges close together (Epskamp et al., 2012). Further analyses were required to test differences in association after plotting the GGMs as the position of nodes can be unstable (Kappelmann et al., 2021). Mean differences for each node-to-node association in Māori and Others and their associated 95% CIs were estimated using 5000 posterior estimates.

In order to provide a more comprehensive interpretation of our results within a Bayesian framework, we have reframed our understanding of statistical significance. We have done so by defining a region of practical equivalence (ROPE) around the null hypothesis (Kruschke, 2018). This area is an interval around zero which represents a range of values that are practically equivalent to null effect. The size of the ROPE was set to $[-0.10, 0.10]$ based on the context of our data and what we deem a negligible effect in the correlation measures.

Instead of solely relying on whether the 95% CIs of the mean difference estimates contain zero, we now report the proportion of the posterior distribution of the mean differences that falls outside the ROPE. This provides us with a more nuanced understanding of the effect and takes into account the uncertainty in the estimation. As Gelman and Stern (2006) have pointed out, the difference between significant and non-significant is itself not significant. Hence, if a substantial proportion of the posterior distribution (e.g. > 95%) falls outside the ROPE, we consider the effect as plausible and sizeable. This reframing aligns better with the Bayesian philosophy, where uncertainty is inherent and dichotomous interpretations of significance are not ideal. It also better informs our understanding of the practical implications of our results.

In order to elucidate the relative importance of the nodes in the networks for the Māori and Others, we conducted a predictability analysis. This analysis was carried out using the “predictability” function in the R package BGGM (Williams, 2021). Predictability, within the context of a Gaussian Graphical Model (GGM), is a measure that represents the proportion of variance in a node that can be explained by its neighbouring nodes in the network (Haslbeck & Fried,

2017). Essentially, this analysis helped us to assess which variables (or nodes) could be targeted for change via interventions on the first place. It does so by indicating which nodes are most influenced by their connections within the network (Haslbeck & Waldorp, 2018).

Results

Zero-order correlations with mean scores and standard deviations are included in Supplementary Tables S1 and S2. Although, depression, anxiety, and stress are closely related, they correlate between 0.73 and 0.76 in the Others network, and between 0.79 and 0.81 in the Māori network, which is below the conservative cut-off point of 0.90 for multicollinearity. Figure 1 shows GGMs representing the networks of unique associations between immune status, depression, anxiety, stress, and the five mindfulness facets (Observe, Describe, Act with Awareness, Non-judge, Non-react) split by Māori and Other New Zealanders. Blue edges represent a positive relationship, and red edges represent a negative relationship, with the thickness and depth of colour in the edges representing the strength of association (thicker, darker edges represent stronger associations; Borsboom, 2017).

Visual inspection of the GGMs highlighted some similarities between the networks of Māori and Others, including (1) a negative relation between anxiety and immune status; (2) strong positive relations between the depression, anxiety, and stress variables; (3) positive relations between the mindfulness facets of Non-react and Observe, Observe and Describe, and Non-judge and Act with Awareness; and (4) a negative relation between Observe and Non-judge. However, differences between the two networks were also detected.

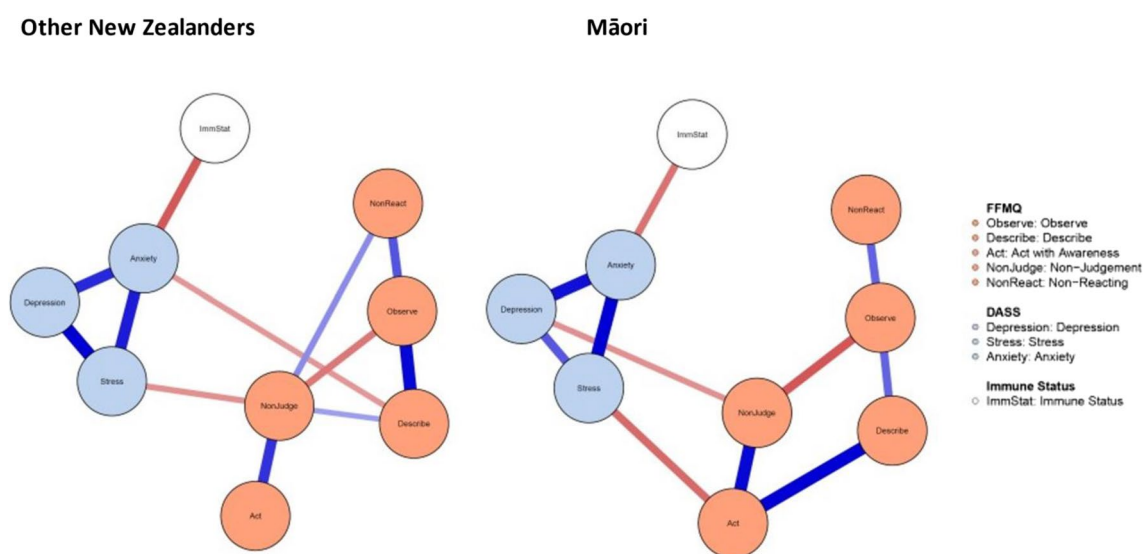


Fig. 1 Network analyses of immune status, mindfulness facets, depression, anxiety, and stress split by Māori and Other New Zealanders

In the Māori network, a negative relation between Act with Awareness and stress, a negative relation between Non-judge and depression, and a positive relation between Describe and Act with Awareness emerged which were not present in the Others network. In the Others network, negative relations between Non-judge and stress and Describe and anxiety, along with positive relations between Non-react and Non-judge and Describe and Non-judge, emerged which were not present in the Māori network.

Figure 2 shows the estimated mean differences for each node-to-node association for Māori and Others and the 95% CIs for these differences using 5000 posterior estimates. Three CIs did not include zero, indicating there was a statistically significant difference in the association between these nodes in Māori and Others. Specifically, Describe and Act with Awareness were more strongly positively associated in Māori, Act with Awareness and depression were more strongly negatively associated in Others (however this relationship did not reach significance in the GGM), and Describe and Non-judge were more strongly positively associated in Others. While the 95% CI for the difference between Māori and Others in the association between Non-judge and depression did contain zero, this negative relation

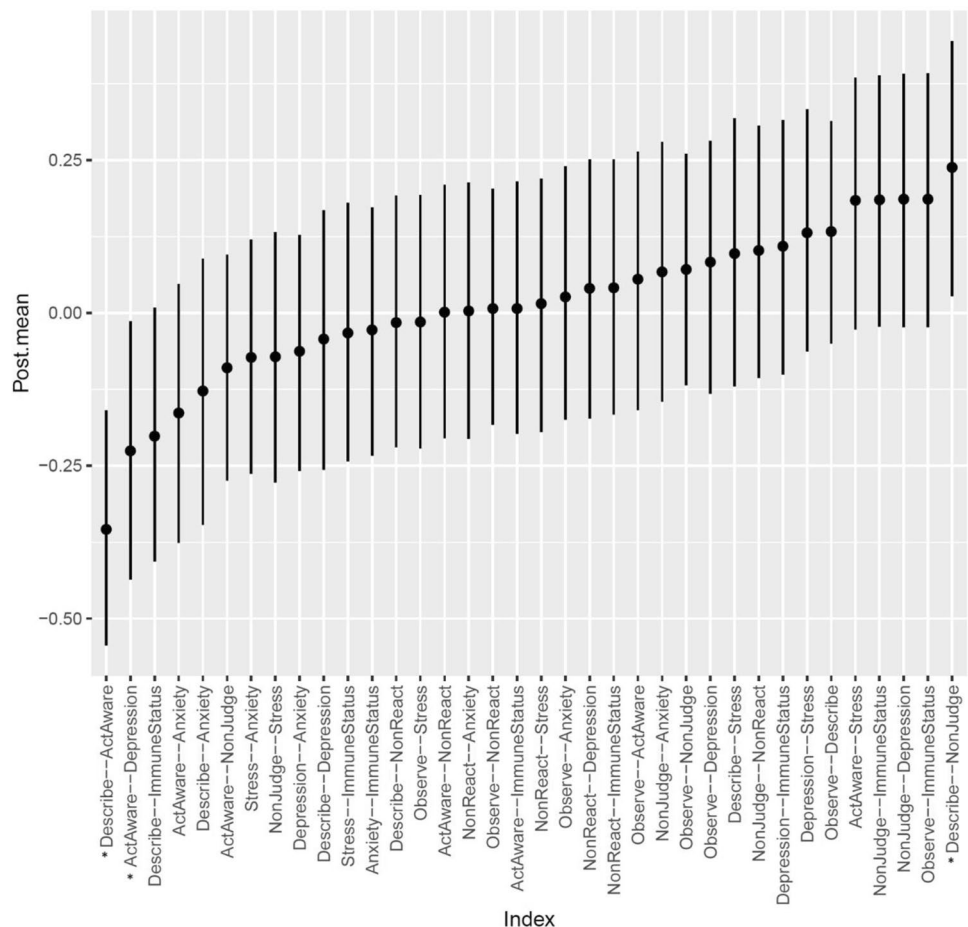
appears to be stronger in Māori than Others (as was highlighted in the GGM) and may reach significance in a larger sample.

We calculated predictability values for each node in both Māori and Others networks, thus providing an insight into how each facet of mindfulness, distress, and immunity, which may be influenced by the other variables in the network. Figure 3 shows that anxiety had the highest predictability followed by stress, depression, and Non-judge in both networks indicating that predictability estimates are very similar in both networks. A table showing the estimates and their associated 95% CIs for Māori and Others is available in Supplementary Table S3.

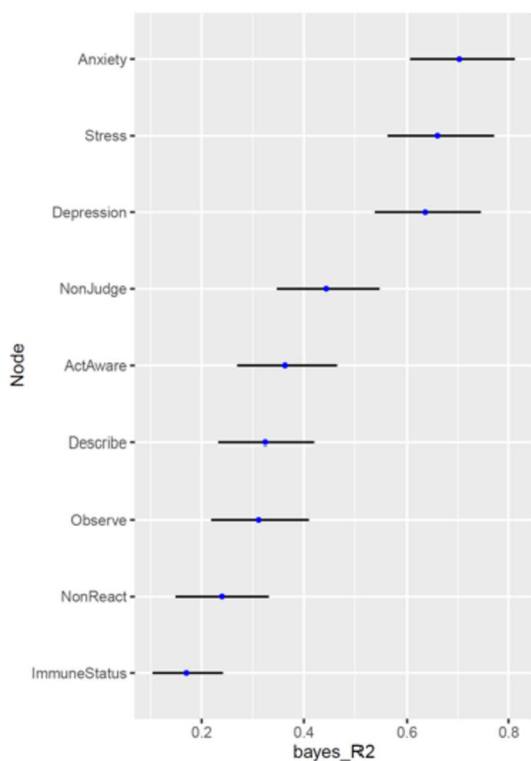
Discussion

This study investigated and compared interactive networks of immunity, anxiety, stress, depression, and mindfulness facets in the general New Zealand and Māori populations. The results demonstrated similarities between Māori and non-Māori, which included a negative relationship between anxiety and immune status, strong positive associations between the distress

Fig. 2 Differences for each node-to-node association between Māori and Other New Zealanders. Dots show mean difference between Māori (g2) and Other New Zealanders (g1) for each association; error bars show 95% credible intervals for this difference using 5000 posterior estimates. Associations with credible intervals that do not include zero are highlighted with an asterisk and are deemed to be statistically significantly different for Māori and Other New Zealanders



Other New Zealanders



Māori

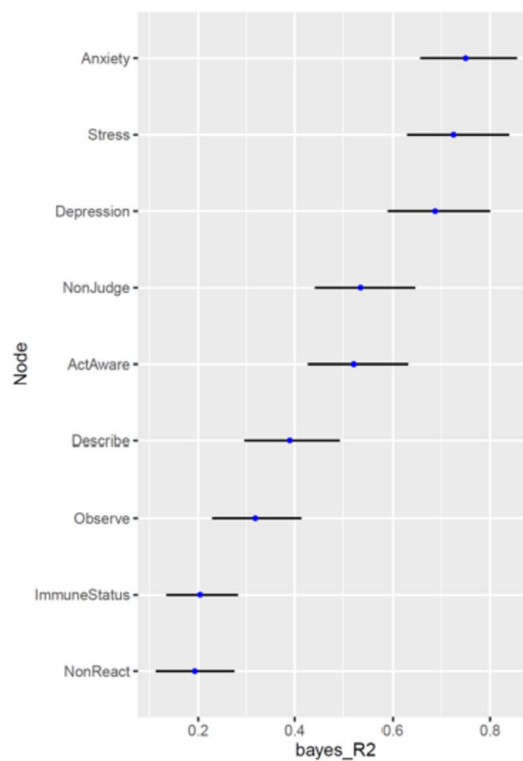


Fig. 3 Predictability of Other New Zealanders and Māori as measured by Bayes R^2

variables, and positive relations between the mindfulness facets of Non-judge and Act with Awareness, Observe and Non-react, and Observe and Describe. The predictability results indicated that anxiety explained the largest amount of change (variance) in other variables followed by stress, depression, and Non-judge facet of mindfulness, and these results were similar for Māori and non-Māori. These findings suggest that influencing these variables on the first place by means of an intervention may have the strongest impact on all other variables in the network, including immunity in both Māori and non-Māori.

However, there were also significant differences between Māori and Others networks. The mindfulness facets Describe and Act with Awareness were more strongly positively associated in Māori, Describe and Non-judge were more strongly positively associated in Others, and Non-judge and depression were potentially more strongly negatively associated in Māori. Although preliminary and based on modest samples, these results indicate that different ethnicities may respond better to tailored mindfulness interventions rather than standard mindfulness interventions. These tailored interventions would need to be designed with the input of a Māori cultural advisor to ensure that tikanga and Te Ao are fully considered.

There was a strong negative association between anxiety and immunity across both groups after accounting for depression, stress, and mindfulness facets, suggesting that higher levels of anxiety are associated with poorer immune function and vice versa. However, as a cross-sectional study using correlational methods, directionality of this relationship cannot be established in this study. Anxiety may have a negative impact on immune function; a weak immune system may make an individual more vulnerable to anxiety; or there may be a reciprocal link. The relationship between stress and immunity has been extensively studied, whereby stress is known to trigger an immune response (Marsland et al., 2017). Short-term stress itself can be adaptive, with the associated immune response necessary to maintain survival; however, long-term or chronic stress provoked immune response has been associated with the development of disease (Dhabhar, 2014; Marsland et al., 2017). While stress was strongly related to both anxiety and depression, we did not find a unique link to immune function, which was expected based on previous research (Lovibond & Lovibond, 1995). Anxiety is a psychophysiological response to a real or perceived threat that also involves stress (Daviu et al., 2019). Our results indicate that anxiety rather than stress may impact

the immune system on the first place, but this would need to be further studied in experimental research.

Anxiety has been estimated to affect around 36% of the Māori population and 22% of non-Māori in New Zealand, with the implication that their immunity may be also impacted (Russell, 2018). As Māori were shown to have poorer health outcomes in New Zealand when compared to non-Māori, higher anxiety levels could be a possible contributing factor (Russell, 2018). Depression and stress were not significantly associated with immune status in neither Māori nor Other participants but might link to the immunity indirectly through anxiety. This finding needs to be examined using interventions specifically targeting anxiety as they may be more effective in strengthening immunity in these populations.

Describe and Act with Awareness facets of mindfulness were more strongly linked in Māori participants compared to other New Zealanders, suggesting that higher levels of Describe ability were associated with higher levels of Act with Awareness and vice versa in the Māori population, whilst Describe and Non-judge facets were more strongly linked in Others. Describe refers to the ability to identify and label internal feelings and perceptions; Act with Awareness refers to the ability to maintain attention to present moment experiences; and Non-judge of inner experience refers to the ability to accept thoughts and feelings without assigning “bad” or “good” characteristics to them (Baer et al., 2008). In the Māori context, Describe is demonstrated in cultural practices such as *whaikōrero* (orator), *pūrākau* (storytelling), and *waiata* (song). Act with Awareness is manifested in many different cultural practices where each movement has a purpose and leads onto the next movement such as *raranga* (weaving), *haka* (posture dance), and *karakia* (prayer). If a person is not fully immersed in the activity, the spiritual connection is severed as the thoughts are elsewhere rather than focusing on connecting with ancestors and the environment, which require mindfulness. The stronger link between Describe and Act with Awareness in Māori participants supports the notion that mindful practice is embedded in the expression and presentation of *Te Ao Māori*. When one is not fully immersed in the task or activity at hand, there is a higher chance of making a mistake or not completing the task to the best of one’s abilities. On the other hand, in Western practices (such as Catholic prayer), there is a possibility of mind wandering that will not directly impact on the overall group performance and permits a larger extent of deviation from attention to the present moment.

Non-judge and Depression were potentially more strongly negatively associated in Māori when compared to Others. The skill of not judging thoughts as good or bad and accepting thoughts as they are cultivates a peaceful mind and can reduce depressive symptoms by letting judgements pass without focusing on them. Non-judge attitude increases

clarity and allows a person to focus on the present moment, rather than be pulled into depressive thoughts that overly focus on negative experiences in the past that form helpless thoughts for the future. Negative self-judgement is widely thought to contribute to depression (Ehret et al., 2015) and has been found to be a strong predictor of depression (Barcaccia et al., 2019). The impact of intergenerational trauma from colonization and systemic racism may be explanations for possible differences between Māori and Others in this relation. Intergenerational trauma refers to the ongoing struggles faced by indigenous populations who have been colonized, especially reflected by intergenerational poverty as a consequence of land seized, and loss of cultural understanding and knowledge (Pihama et al., 2014; Waretini-Karena, 2017). Systemic racism refers to the racism embedded in political, legal, economic, health, education, and justice systems (Braveman et al., 2022). These may combine to make self-judgement more impactful in Māori. This is a significant finding as it suggests that depression interventions for Māori could be more effective if emphasis was placed on the teaching of non-judgement mindfulness techniques. Overall, these findings suggest that traditional mindfulness interventions that are broadened and contextualised to cultivate a spiritual connection to *Te Ao Māori* may be more useful for Māori populations.

Limitations and Directions of Future Research

The generalizability of the results may be limited due to modest sample size and a single cross-sectional snapshot; and therefore, replication with different larger samples would be required to establish robustness of these findings. The observed differences may be statistical artefacts due to multicollinearity; however, the zero-order correlation matrix (see Supplementary Tables S1 and S2) indicates that the correlations are clearly different, which strengthens the evidence that the network differences are “true”. Future research could concentrate on replicating these results using longitudinal data, which will help to establish to what extent anxiety and other distress variables affect immunity over time and estimate potential protective role of mindfulness facets. Future research could also involve regular meditators as this can elucidate a potential effect of meditation practice on immunity in both Māori and non-Māori. Given our finding of a strong relationship between anxiety and immune status, further research could also replicate our analysis using clinical samples with generalised anxiety disorder or other anxiety disorders and compare them to healthy controls on immune status. In addition, directionality of the found relations cannot be assumed by our analyses due to the correlational nature of the method; and therefore, further experimental research needs to identify and confirm the direction of these relations. Construct validity of the FFMQ in a larger

Māori sample could also be examined in future as our sample may not be sufficient to establish robustness of the measurement. Finally, the fact that many variables were measured using common methods (e.g. self-report scales) might lead to spurious method effects associated with measurement rather than to the constructs being measured (Podsakoff et al., 2012). Future studies can address these limitations by examining our findings using more rigorous research designs such as longitudinal and experimental methods.

While our approach using the Fruchterman-Reingold algorithm allows for a visually clear and informative exploration of the individual relationships among our variables, we acknowledge that it might limit the specificity in comparing the network structures between the two groups (Māori and Others). Additionally, the positioning of nodes in the Fruchterman-Reingold algorithm might be interpreted by some readers as implying a hierarchy or order of importance that is not intended, given that the positioning of nodes can be influenced by various factors and not solely the strength of associations. Furthermore, we acknowledge that while our method does allow for a comparison of how associations differ between Māori and Others, the representation may lack the one-to-one correspondence that an MDS-scaled network with a rotated network for maximal closeness would provide. We are aware that these limitations could affect the interpretation and implications of our findings. Therefore, we have used matched sample to minimize a potential impact of this limitation that increases the validity of our approach. As we continue this line of research, we are certainly open to exploring other visualization techniques, such as MDS-scaled network and rotation method with larger samples, that could provide additional insights or clarity.

In conclusion, the present study sheds light on the distinctive networks of distress, mindfulness, and immune status between Māori and non-Māori participants in New Zealand. The facets of mindfulness, specifically Describe and Act with Awareness, were more positively associated in the Māori group, while Non-judge and Depression exhibited a stronger negative link. For non-Māori participants, the facets Describe and Non-judge demonstrated a stronger positive association. Both groups shared certain patterns, most notably the negative link between anxiety and immune status, suggesting that higher anxiety levels are associated with poorer immune health. Other shared patterns include strong positive links among distress variables and several interconnected mindfulness facets such as Non-judge and Act with Awareness, Observe and Non-React, and Observe and Describe. Our findings suggest that the networks of mindfulness and distress may involve psychological mechanisms unique to each group. These differences and similarities between the two groups have implications for designing targeted interventions. Anxiety, in particular, appears to be a

critical target given its strong link to immune health across both groups. The unique ways in which mindfulness facets are interconnected within each group also provide valuable insights for potential interventions. This study underscores the importance of considering cultural context in the study of mindfulness, distress, and immunity. Future research should further investigate the unique psychological mechanisms at play within each cultural group and how these can be leveraged to improve health outcomes.

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Author Contribution Moana Billot: conceptualization, data curation, writing—original draft preparation. Rebecca A. Chalmers: methodology, data curation, software, data analyses, writing—reviewing and editing. Matti Cervin: methodology, validation, writing—reviewing and editing. Anna Sutton: conceptualization, writing—reviewing and editing. Vincent M. Reid: conceptualization, writing—reviewing and editing. Nirbhay N. Singh: conceptualization, writing—reviewing and editing. Oleg N. Medvedev: supervision, conceptualization, data curation, methodology, software, data analyses, writing—reviewing and editing.

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Data Availability The data is included in the Supplementary File.

Declarations

Ethics Approval This study was approved by the University of Waikato Ethics Committee (FS2021-58), which follows ethical principles consistent with APA 7 edition guidelines.

Informed Consent All participants provide informed consent prior to participating in the study.

Conflict of Interest The authors declare no competing interests.

Use of AI AI was not used for writing and editing the manuscript.

Use of Māori Words We have used the conventions of New Zealand English according to which Māori words are considered part of the vocabulary and are thus not italicized.

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