

Tackling anxiety through innovation: Development and pilot study of an in-the- moment messaging intervention for young adults

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Abstract

Objective: Anxiety disorders are highly prevalent around the world and are associated with significant disability, comorbidity and costs to society. Digital tools have the potential to deliver equitable, convenient and sustainable interventions for anxiety. We aimed to co-design and pilot-test an in-the-moment intervention to help young people manage anxiety. Young people with lived experience of anxiety were recruited to participate in co-design workshops with the results informing the development of the Tackling Anxiety through Innovation (TAI) intervention. TAI delivers personally tailored messaging prompting engagement in self-care behaviours at times of high anxiety/stress.

Methods: Young people aged 16 to 24 years were recruited into a four-week pilot study. Participants completed the Depression Anxiety Stress Scale – 21 Items (DASS-21) at baseline and four-week follow up, as well as a survey to assess the acceptability of the intervention and its components.

Results: Participants ($n = 24$) reported the intervention to be highly acceptable and useful. Participants scheduled an average of eight events over the 4 weeks. DASS-21 scores improved significantly from baseline to follow up: anxiety (mean difference 2.42 (SD = 3.65), $p = 0.004$), depression (3.79 (SD = 3.65), $p < 0.001$) and stress (3.50 (SD = 3.30), $p < 0.001$). Participants particularly liked the ability to personalise the messages, the timing and format of the messages, and the reminders to engage in helpful behaviours.

Conclusions: This study adds to the evidence for the use of digital tools in delivering tailored anxiety self-management support to young people. Further refinement and expansion of the intervention are needed to determine its efficacy on a larger scale.

Keywords

Anxiety, mental health, digital mental health intervention, young adults, wearables, sensors, text message, self-management

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Introduction

Background

Anxiety disorders are the most common mental disorders globally, yet only one in four people with the condition receive treatment.¹ Anxiety disorders include generalised anxiety, panic, post-traumatic stress, specific phobias, social anxiety, agoraphobia and separation anxiety.¹ They

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are associated with significant disability, comorbidity and high economic costs due to their prevalence and chronic nature.² Half of all mental disorders start by age 14³ and 75% by age 25.⁴ Anxiety disorders with childhood onset have been associated with increased symptom severity, comorbidity and rates of suicide.⁵

Young adulthood is a critical period for early mental health intervention to prevent a trajectory towards severe mental illness.⁴ However, mental healthcare has traditionally been modelled on supporting adults at crisis point and does not consider the unique presentations and needs of young adults with emerging signs of mental distress.^{6,7} Community-based service availability varies greatly across the world, with significant gaps in access for young people.³ Moreover, help-seeking for mental health among young people is low, with common barriers including fear of stigma, concerns about confidentiality/privacy, and low levels of knowledge about accessing support.⁸

Where resources for in-person services are limited, digital interventions have potential to improve the delivery of sustainable and convenient health services, including brief interventions to support mental health.^{7,9–12} Mobile apps and short message service (SMS) in particular have been found to be effective and equitable methods of delivery for a number of psychological health interventions.¹³ Tailored, in-the-moment solutions focused on supporting individuals to self-manage their psychological symptoms have demonstrated potential to effectively reach young adults with mild to moderate anxiety.⁷ However, uptake and engagement of digital mental health services vary,⁹ with prior work citing technical issues⁷ as well as user concerns about privacy/anonymity, human connection, lack of personalisation, and intervention credibility.¹⁰

Wearable devices may facilitate pragmatic interventions for anxiety via digital biofeedback methods.¹⁴ Commercially available wearables such as wrist-worn sensors are becoming ubiquitous and can passively collect relevant data to inform wearers about physiological changes.^{15,16} Some of the metrics already being collected by many commercially available wearables, such as cardiac, respiratory, neurological electrical activity, body temperature and galvanic skin response, have been found to provide objective information about an individual's state of anxiety or stress response,^{17,18} and potentially inform intervention delivery.⁷ More research is needed about the acceptability, usability and engagement in interventions leveraging commercial wearables to support young people in self-managing anxiety.⁷

As part of a larger project that involved a field-testing study of commercially available wearables in the detection of anxiety and stress, we used co-design workshops with young people to develop TAI (Tackling Anxiety through Innovation), a tailored, in-the-moment SMS self-management support programme for young people with mild to moderate anxiety in Aotearoa New Zealand (NZ).

This paper presents the co-design of the intervention and feasibility pilot study.

Co-design and development of the TAI intervention

The co-design and development of the TAI intervention was guided by the mHealth Development and Evaluation framework,¹⁹ the participatory co-design cycle,²⁰ and two Aotearoa NZ specific Kaupapa Māori co-design approaches (summarised in Figure 1).^{21,22}

Opportunity identification. A governance group for the broader project, Te Rōpū Kaitiaki, provided guidance. The group comprised experts in adolescent mental health (clinicians and academics), individuals with mHealth and MedTech expertise, computer science expertise, youth workers, and Māori and Pacific researchers and clinicians. The group developed a research charter which outlined the ethical and professional values and principles to guide all project activities, including the co-design and development stages of the project (see Table 1).

Alongside guidance from Te Rōpū Kaitiaki we undertook end-user consultation with young people and with people working directly with young people with anxiety in the community. We completed a scoping literature review to examine the role of sensors in detecting the physiological signs of anxiety to initiate and direct interventions for its management,⁷ undertook work to explore available sensors, and met with sensor experts to discuss potential options for this project. The initial scoping work uncovered differing access to technology and mental health support services between urban and rural communities. Developing a solution specific to the needs and preferences of those living in urban areas may result in solutions inaccessible to those living in areas with greater digital divide and areas with more barriers to accessing mental health services – potentially exacerbating existing mental health inequities. This led to the decision to situate the co-design phase within communities with the greatest need for innovative mental health solutions.

Co-design workshops

Young adults aged 16 to 24 years who had a connection to anxiety (via lived experience or via supporting a loved one with anxiety) were invited to take part in co-design workshops held in a predominately rural region of Aotearoa NZ (Te Tai Tokerau Northland). All procedures were approved by the University of Auckland Human Participants Ethics Committee (UAHPEC24862). Co-design participants were required to provide written informed consent, communicate in English, and participate in at least one of the workshops. Friends and whānau (family) were welcome to join the participants for the focus group if they wished. Participants were given a

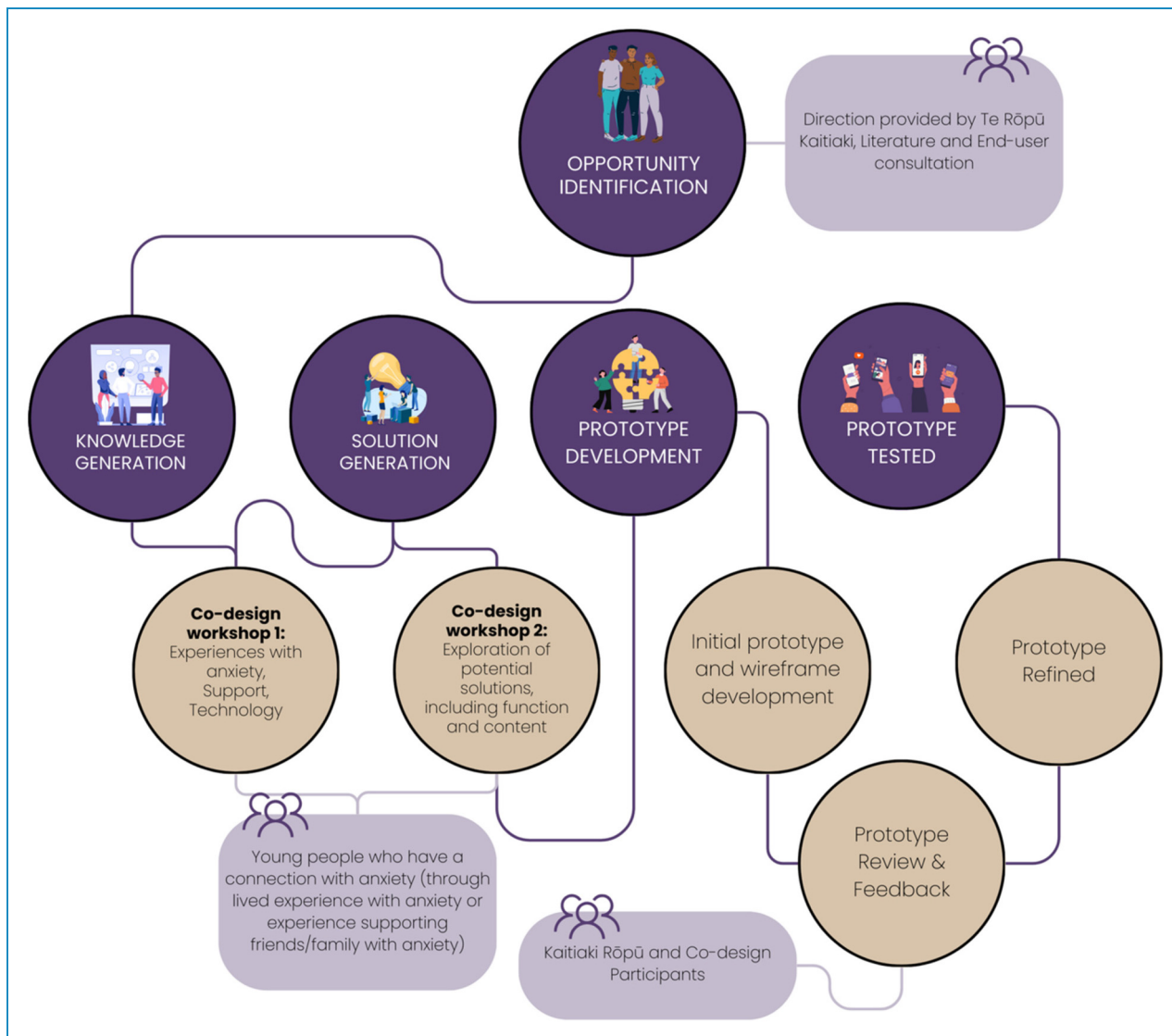


Figure 1. TAI co-design and development process. TAI: Tackling Anxiety through Innovation.

voucher (NZD \$100.00) following participation to reimburse them for their time and any costs associated with participating in the workshops. Workshops were facilitated by a local Māori researcher (TT) and supported by others on the research team. Notes and photos from the focus groups were collated and summarised (see Figure 2).

There were two stages of workshops (see Figure 1), first focussed on knowledge generation then solution generation.

1. Knowledge Generation: Exploration of personal experiences with anxiety, support, and technology.

Participants were first asked to briefly talk about their experiences with anxiety, or they could conceptualise and communicate their experience via drawing or writing. Participants shared both the physical and

mental impacts, the exacerbation of these impacts when anxiety is not mitigated, and judgement by peers.

Participants were asked to share any thoughts or ideas relating to support or coping methods when experiencing anxiety. Participants often utilised visual and/or audio stimuli (i.e. listening to music, looking at photos, TikTok and YouTube), or relied on their key support people (whānau, friends and therapists) and their spirituality. When asked about things that are unhelpful, participants cited people who have a lack of understanding about anxiety and those who pressure a person with anxiety into anxious situations.

Finally, participants were asked to share ideas regarding digital support to help young people experiencing anxiety. Participants stated that they knew when and where they would potentially experience anxiety

Table 1. Research charter principles as applied to project co-design and development.

Values/principles	Application to the co-design and development
Te Tiriti o Waitangi	We are committed to fulfilling our obligations to Te Tiriti o Waitangi. ²³ We will ensure targeted recruitment and representation of rangatahi Māori (Māori youth), we will value Mātauranga Māori (Māori knowledge systems), and co-design workshops will be Māori-led
Equity	We will prioritise underserved and underrepresented communities in our research to support fairness and equitable health outcomes, including representation from rainbow communities (LGBTQ+), those living with a disability, and rural communities
Research excellence	We strive for high quality, evidence-based research that positively contributes to science and knowledge for the collective benefit of society
Translation/transformation	Our research will be innovative to promote research translation and system transformation. We will centre the workshops within communities for which translation would occur
Equal partnership with our young people	We will establish and uphold partnerships with our young people that are built on equality, mutual respect, reciprocity and self-determination. The co-design workshops will privilege the voice, preferences and views of our young people in the development of the TAI intervention. The workshops will be held in a youth safe space
Collective benefit	We will ensure that our research conduct will be mutually beneficial for the communities that we collaborate with. The intervention designed should be such that if effective is accessible for the communities involved in designing

(continued)

Table 1. Continued.

Values/principles	Application to the co-design and development
	it. All participants will be offered a voucher for their contribution and kai (food), and will be invited to participate in pilot study
Manaakitanga (to care for others)	We will be kind, supportive, caring and respectful to our participants, partners, collaborators and stakeholders
Respect for data	We will collect, manage and store data safely and securely. We hold accountability to and respect for the individuals from whom the data is derived
Integrity	We will conduct our research in a manner that is ethical, honest and transparent

TAI: Tackling Anxiety through Innovation.

and that a digital solution that helped them to better prepare for anxiety-provoking events ahead of time would be beneficial as it would allow them to proactively engage in coping methods before anxiety starts. Participants suggested that supportive messages or prompts from their mobile phone may be an effective way to achieve this.

2. Solution generation: Exploration of potential solutions, including function and content, and the insights discussed in workshop 1 were presented and participants discussed the ideas proposed. Overall, participants were highly supportive of a potential solution that provided personalised support messaging, or prompts delivered in critical moments. Participants also supported the ability to pre-plan support message delivery for situations or events where they might feel anxious. Although most participants were not current wearers of sensors, they responded positively to the inclusion of a wearable sensor in the intervention. Timing and frequency of messages were also key as participants cautioned against sending too many messages and potentially causing disruption or exacerbation of anxiety. Participants also highlighted the importance of personalisation, taking into account that anxiety-provoking situations will be different for everyone. Further considerations included being mobile-friendly and positive framing of intervention content.

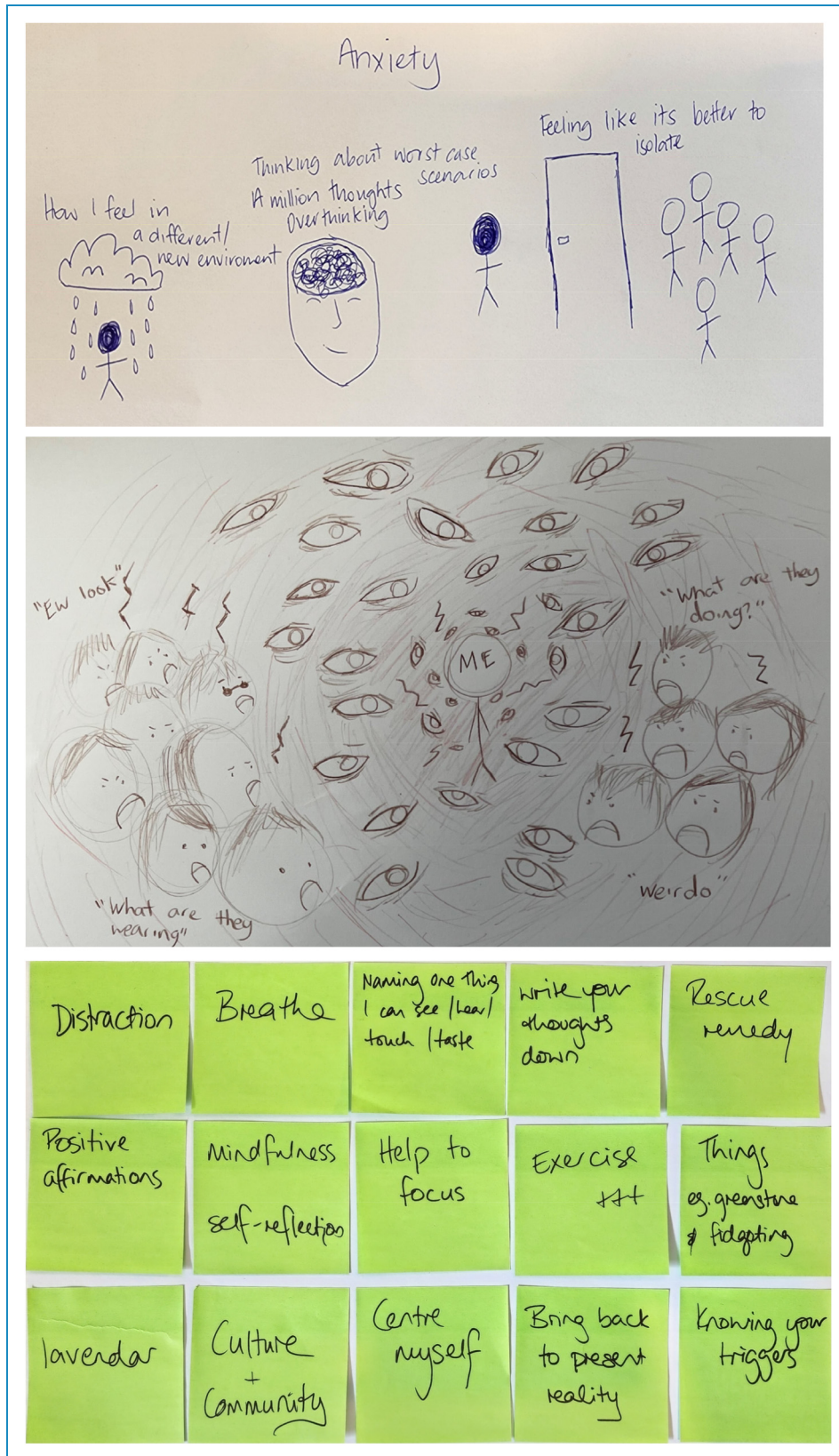


Figure 2. Images from co-design workshops.

Initial prototype development

Insights from the first two workshops elucidated a potential digital solution to support young people experiencing anxiety in real time: a digital platform that allowed users to schedule anxiety-provoking events into a calendar, then receive supportive personalised text messages prior to the event. Initial wireframes were developed using Figma, and a message library drafted.

Prototype review and refinement. The initial wireframes for the TAI platform and messages were reviewed by co-design participants via online meetings with the co-design facilitator. The co-design facilitator presented the wireframes and described the intention and function. Participants preferred a solution that emphasised positive/healthy actions they could take (rather than discourage coping strategies that might be unhealthy) and were personalised to an individual's preferred methods of coping. Participants also preferred strategies that were easy to act on (e.g. going for a walk or listening to music) and were culturally appropriate. This feedback was incorporated into the final TAI intervention.

TAI intervention

TAI was developed to provide in-the-moment self-management support for young adults with mild to moderate anxiety. The content was developed by a multidisciplinary team, led by a health psychologist (RD) and a Māori health researcher (TT). Content was informed by the co-design workshop findings alongside learnings from the previous messaging programmes.^{24,25} A library of simple, tailored text messages was developed to support in-the-moment anxiety management, providing general encouragement with helpful sayings, prompting outreach

to helpful individuals, and suggesting stress-relieving activities that were identified during the co-design process. Each participant would receive two text messages in the hour leading up to a potentially stressful event (45 minutes and 15 minutes prior) to allow enough time to read the messages and act on them without interfering with the event itself.

To accommodate personal preferences and cultural characteristics, a bespoke in-house online platform collected participants' preferred name, ethnic background, names of two supportive individuals, three helpful activities and four helpful sayings. In New Zealand, there are ethnic disparities in rates of mental health problems and in access to culturally aligned services.²⁶ To ensure relevance to these populations, messages included key greetings and words in Te Reo Māori (Māori language) and other common Pacific language greetings spoken in New Zealand, although messages remained predominantly in English. For helpful activities and sayings, participants could choose from a list of pre-populated options or create their own. Examples of TAI message components can be seen in Table 2. Customised responses were reviewed by a researcher for grammatical correctness and inappropriate language. All preferences were used to populate a schedule of tailored messages to be delivered by SMS in the hour before each stressful event.

The TAI platform also included a tool for participants to schedule the days and times of any upcoming events they thought could be stressful or anxiety-inducing. Participants could schedule as many events as they wished during the four-week study period. Messages for the first 12 events were unique in the combination of helpful sayings, activities and people they included, and then repeated for any subsequent events. The TAI platform was connected to an in-house system designed to send and receive messages through a message gateway company for delivery to any mobile phone registered with a New

Table 2. TAI text message examples.

Message timing	Personalisation components	Participant culture	Example text message
45 minutes prior to scheduled stressful event	Greeting, name, activity, support person	Māori	Kia ora Hemi. If you are feeling stressed and anxious, why not call or text James or take time to do some meditation or connect with your tūpuna
	Greeting, name, activity, support person	Other	Hi Lily. It might help to plan a workout or listen to some music. Remember [support name] is here for you
15 minutes prior to scheduled stressful event	Greeting, name, saying 1, saying 2	Samoa	Talofa Sam. Remember to try and focus your attention on the things you can control, and remember you are not alone!
		Māori	Kia ora Hemi. Remember your mana. You are strong and will get through this!

Zealand mobile network. Once a participant scheduled an event in the TAI platform message schedules were populated dictating the specific messages and their delivery time. The project team had the ability to review and edit scheduled messages if needed. A participant could stop their messages at any time by replying with the word 'STOP', which automatically cancelled all remaining messages on their schedule. The system was designed to maintain logs of all outgoing and incoming messages. There was no cost to participants to receive or reply to messages.

At the outset of the larger project, our aim was to identify a consumer wearable that could accurately detect heightened stress and anxiety as it occurs and develop an intervention that could be implemented simultaneously. In our field testing of existing consumer wearables, we identified a number of issues which have been published elsewhere²⁷ and full findings will be published separately. In the absence of a consumer-grade wearable that we could confidently use to meet this aim, we restricted to testing the feasibility and acceptability of young people wearing a commercially available sensor alongside our TAI programme. We chose to offer participants the opportunity to use a commonly available smartwatch (Fitbit Inspire series) or to continue wearing their own smartwatch. Participants were encouraged to wear their device as much as possible during the four-week study period, including overnight.

Feasibility, acceptability and perceived impacts of the TAI intervention

The feasibility, acceptability and perceived impacts of the TAI intervention were assessed in a pilot study.

Methods

Study design

A four-week, non-randomised pilot study was conducted between August and November 2023. All study documents and procedures were approved by the University of Auckland Human Participants Ethics Committee (UAHPEC26054).

Participants and recruitment

Eligibility criteria for the pilot study included young adults aged 16 to 24 years, ability to communicate in English, daily access to a smartphone and the internet, ability to provide informed consent, mild to moderate anxiety based on responses to the Depression Anxiety Stress Scales – 21 Items (DASS-21).²⁸ The only reasons for exclusion aside from the above criteria were not being available for the duration of the four-week pilot study and not having an Aotearoa NZ mobile number. A list of local and national

mental health resources, crisis hotlines and service providers was provided to anyone who registered interest in the study.

Recruitment occurred via flyers distributed through universities and community organisations in Tāmaki Makaurau Auckland and Te Tai Tokerau Northland, Aotearoa NZ. Potential participants could access the online participant information and consent form directly (hosted in REDCap²⁹) or request that a research assistant contact them to provide assistance. All participants provided written informed consent electronically before participating. Participants who agreed to take part were contacted for their intervention preferences and to schedule a time for onboarding (TAI platform and Fitbit account setup). Participants were given two NZD \$50 vouchers (one at enrolment and one at follow-up completion).

Measures

Baseline measures included demographics and DASS-21 scores. The DASS-21 is a widely used and publicly available assessment instrument for depression, anxiety and stress.²⁸ At the end of the four-week intervention all participants were asked to complete a final web-based survey in REDCap which included the DASS-21 and questions about their satisfaction with the programme and Fitbit, their usefulness and usability, and perceived impacts. Intervention preferences were obtained through the system recorded data in the TAI platform.

Analysis

Descriptive statistics were calculated for baseline demographic and mental health characteristics, intervention preferences and measures of self-reported engagement with the programme. Counts and percentages were reported for categorical variables and means and standard deviations for continuous variables. Qualitative comments were analysed using a simple content analysis approach to identify common themes and insights from the data. Change in mean DASS-21 score from baseline to four-week follow up was calculated using a paired t-test.

Results

Seventy-two individuals clicked on the study link with 31 (43%) being eligible to participate. Of the 31, 26 completed consent and 25 went on to enrol in the study. Of the 25 enrolled, one withdrew before commencing participation, leaving a total of 24 participants. Table 3 presents the characteristics of the pilot study participants at baseline.

Engagement and usability

Participants scheduled an average of eight events over the four-week study (range = 2–26) with an average of 19

Table 3. Pilot sample characteristics.

	n (%)
Ethnicity ^a	
Māori	4 (17)
Asian	7 (29)
European	15 (63)
Age; years (mean, SD, range)	19.6, 2.55, 16–24
Gender (female)	18 (75)
Location	
Auckland/Tāmaki Makaurau	15 (63)
Northland/Te Tai Tokerau	7 (29)
Other	2 (8)
Employment status	
Employed	4 (17)
Student	20 (83)

^aMultiple output method.

messages sent per participant (range = 4–58). When asked how many messages they read, 22 (92%) reported reading most or all the messages (14 = all, 8 = most). For those that did not read all the messages (n = 10), the most common reason was that they were too busy (n = 6) or that they were unhelpful (n = 5).

Four participants reported issues including that the platform sometimes didn't load, wouldn't let them delete events, they did not have their phones accessible at the time of the messages, or they didn't always know the timing of events so couldn't schedule them. Three participants identified issues with the messages including that some messages didn't make sense or were not received.

All participants opted to wear a study Fitbit. During the daytime, two-thirds (n = 16; 67%) reported wearing their sensor all day, with the remaining wearing it most of the day (n = 5; 21%), or a few hours per day (n = 3, 13%). Similarly, over two-thirds (n = 17; 71%) reported wearing it at night. The most common reasons for not wearing it all the time were that they forgot (n = 6) or that they found it annoying or uncomfortable (n = 5). When asked how often they checked the information available on the sensor (e.g. step count, sleep and heart rate), 18 (75%) reported checking it multiple times a day, four (17%) once a day, and the remaining two (8%) participants reported not checking it at all.

When asked what they thought about the Fitbit overall, responses were largely positive, referring to the usefulness of the information being tracked, ease of use and convenience of being able to see messages without needing to take out a phone.

'It was definitely useful to be able to see the TAI texts without having to take out my phone, especially when I was in a setting where taking out my phone was inappropriate'. – Participant ID:13

When asked what they liked about wearing the sensor, participants mostly endorsed the ability to see how their heart rate changed during moments of stress/calm, track their steps and sleep, and see patterns over time. Participants also liked the watch's ease of use, light-weight/thin profile and long battery life.

'I liked that it was quite small and I forget that it is on my wrist sometimes and has a really long battery life so I didn't have to charge it very often'. – Participant ID:37

'The sensor felt like a normal watch and didn't feel like I was "hooked up" to a scientific machine analysing my heartbeat like hospitals do. It was nice to access all the information on my wrist at any time'. – Participant ID:61

When asked what they disliked about wearing the sensor, participants mostly commented on discomfort, particularly when wearing all day or while sleeping. The watch's notifications (such as reminders to move) could also be unhelpful. Only four participants reported technical issues with the sensor including issues with charging, display glitches, data inaccuracies and issues with syncing.

Acceptability

All participants reported they would recommend TAI to others with anxiety (n = 24; 100%) and all but one participant (n = 23; 96%) reported that they would use a programme like TAI again in the future. Free text responses about thoughts on TAI were largely positive.

'I think the messages of encouragement/positive messages were real helpful to make you sit back and take a breather. that we're just human at the end of the day. I really appreciated them'. – Participant ID:1

'The TAI programme reminded me that I had people I could talk to in order to help manage my anxiety and this really helped me when I was feeling overwhelmed and worried'. – Participant ID:36

Regarding the TAI messages, participants reported that they liked their timing leading up to an event, the reassurance that everything would be okay, and the ability to receive this support remotely and anonymously.

'...it was like getting a message from a friend and I found that quite comforting because sometimes all I wanted was a little help without having to talk to someone'. – Participant ID:19

When asked what they disliked about the messages, participants described a lack of variety in the messages/content and advice that was too generic or impractical. When asked what messages they found particularly helpful participants noted the positive framing and the tailored elements such as their chosen activities or people.

'The personalisation process made all the messages valuable and more impactful when I got them'. – Participant ID:61

'The beneficial messages were the ones that gave me tips, such as listening to music or going for a short walk'. – Participant ID:61

Three-quarters (n = 18) of participants reported that the timing of the message delivery was helpful and appreciated. For some it appeared that the messages closest to the event were most useful whereas others liked receiving them earlier.

'It was good to have them multiple times, not too close to the event'. – Participant ID:48

'The timing of the messages was helpful as 15 minutes beforehand was generally enough time to calm myself down without elapsing enough time to become stressed yet again. However, I sometimes did not find the 45-minute beforehand message as helpful as my mind was oftentimes focused on another task'. – Participant ID:13

For the one-quarter who reported the timing was not always helpful, reasons included that they sometimes reminded them of their stress or increased their stress/anxiety when they were not thinking about it. When asked if there was a better time to receive the messages, suggestions were to send them at unplanned/unscheduled stressful times, or after stressful events to offer praise, encourage reflection, or be a pick-me-up if they hadn't gone well.

Perceived impacts

Participants were asked whether they felt the TAI messages had impacted them. Most provided positive responses, commonly reporting that it had increased their awareness of their mental state and what they can do to support their mental health.

'I think it had a bit of an impact on my thinking in anxious situations. It made me stop and think and I feel like I can carry on that skill'. – Participant ID:4

'It has reminded me to take time for myself in stressful situations'. – Participant ID:49

Only a few participants reported that TAI hadn't impacted them, but commented that they had still enjoyed participating or could see it helping others.

Over half of participants (n = 14; 58%) reported the intervention prompted behaviour change. Most reported the messages made them pause and remember to breathe or engage in helpful behaviours. Some participants gave specific details of how TAI had positively impacted them.

'Since starting this study I've gotten my first job and that was something that I was very excited to start but as someone with anxiety it can be hard to be around people and receiving the messages made me push myself and open up more'. – Participant ID:19

Some participants described noticing the changes in their heart rate on their Fitbit when they were stressed or anxious and used this information to try and alleviate the stress.

'It helped me see what situations raised my heart rate, linking these events to my stress and anxiety. Plus it helped me monitor my exercise and allowed me to link this as a beneficial tool to aid and target my anxiety and stress'. – Participant ID:61

DASS-21

There was a significant decrease on all three subscales of the DASS-21 between baseline and 4-week follow up (Table 4): anxiety (mean difference 2.42 (SD = 3.65), $p = 0.004$), depression (mean difference = 3.79 (SD = 3.65), $p < 0.001$) and stress (mean difference = 3.50 (SD = 3.30), $p < 0.001$).

Suggestions for improvement

When asked about how else to support young adults with managing stress/anxiety, participants suggested offering linkage to more support, such as alerting a family member, an interactive app with guided breathing activities

or counselling services. They suggested providing options to receive support at times of unexpected spikes in anxiety and reiterated the need for more variety and personalisation.

'Maybe have an option if your heart rate is increased to notify a family member that there is a stressful event taking place so that they can reassure you in a more personal way'. – Participant ID:67

Discussion

This study sought to co-design and pilot test an in-the-moment intervention to support young people with anxiety. Our results showed that participants largely found that TAI, with simultaneous use of a commercially available sensor, was an acceptable and potentially useful tool in the self-management of mild to moderate anxiety. Perceived positive impacts of TAI were supported by a significant improvement in DASS-21 scores at follow up. These findings align with previous mHealth-based mental health interventions¹³ and interventions using sensors in the management of anxiety.⁷

Further evidence of the acceptability of TAI was found in the follow-up surveys, with all participants saying they would recommend the intervention to other people with anxiety and 92% stating they had read all or most of the intervention messages. Participants ranged in age from 16 to 24 years and nearly half (46%) identified as being of Māori or Asian descent. Nearly one-third were from Northland, New Zealand's most rural region. These participant characteristics indicate that this type of intervention has the potential to reach people of diverse backgrounds living with anxiety.

Most participants endorsed the content of the messages and reported behaviour changes in the moments before a stressful event, suggesting the ability to tailor content to meet their coping preferences was useful. The ability to personalise content has been highlighted as an important element in digital mental health interventions for young people.¹⁰

Table 4. DASS-21 scores from baseline to follow up.

DASS-21	Baseline		Follow up		t	p
	Mean	SD	Mean	SD		
Anxiety	10.21	2.021	7.79	4.180	3.247	0.004
Stress	12.04	2.629	8.54	3.501	5.201	<0.001
Depression	9.38	3.987	5.58	2.873	5.093	<0.001

DASS-21: Depression, Anxiety Stress Scales – 21 Items.

Although the use of the sensor did not play a direct role in the TAI intervention, participants largely endorsed wearing a sensor throughout the four-week study, with two-thirds stating they wore their Fitbit all day and nearly three-quarters (71%) wearing it all night. Most said they checked the sensor information at least a few times a day and found it useful. While the use of sensors was acceptable to participants in this study, given the challenges we experienced in using commercially available sensors to detect anxiety in the moment,²⁷ more research is needed to understand the viability of using them as part of an intervention. Moreover, while participants in our study could use a Fitbit at no cost, the price of these devices may be a barrier to widespread adoption in real-world settings.³⁰

Strengths of the TAI programme included that it was co-designed with members of the target population; that it was personally and culturally tailored; and that it used simple, remotely accessible technology which extended its reach outside the urban environment. TAI was designed for individuals with mild to moderate anxiety, addressing a gap in current mental health services. While the study was conducted in Aotearoa NZ, our findings may be useful to inform research in other contexts, as young people's acceptance of these types of interventions is not widely reported in the current literature.

Limitations of this study included the absence of a control group, small sample size and short study and follow-up timeframe, meaning the significant improvements we saw in participants' DASS-21 scores must be interpreted with caution. Only one-quarter of participants identified as male and none identified as gender non-binary. Participants also varied in the number of stressful events they scheduled (ranging from two to 26), meaning a potentially high degree of variability in participants' experience of TAI. While only one participant reported that the TAI programme increased their anxiety, more work is needed to understand the characteristics that make young people more or less likely to benefit from this type of intervention. A larger sample size and longer-term randomised controlled trial will be needed to understand the efficacy of TAI on self-management behaviours, clinical outcomes, sustainability and cost-effectiveness. Moreover, safely extending the intervention to young people with severe anxiety should be explored to ensure all service gaps are being addressed.

Conclusions

It is important that researchers ensure that mental health tools are developed to specifically address inequities in access to mental health support and in mental health outcomes. Further, they should be developed with implementation in mind ensuring that findings can be translated into practice. This project had a focus on equity from the start, leading to utilisation of simple and accessible

technology (e.g. text messaging), and our findings support continued use of text messaging in mHealth research. This study adds to the evidence for the use of digital tools in delivering tailored anxiety self-management support to young people. In particular, the use of SMS in intervention delivery and wearing a wrist-worn sensor were found to be acceptable by young people experiencing mild to moderate anxiety. Further refinement and expansion of the intervention is needed to determine its efficacy on a larger scale.

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Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: All study documents and procedures were approved by the University of Auckland Human Participants Ethics Committee (Pilot study UAHPEC26054; Co-design UAHPEC24862) and adhered to the National Ethical Standards for Health and Disability Research and Quality Improvement.

Guarantor: RD

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