Examining Skill Enactment and Knowledge Acquisition in Digital Cognitive Behavioural Therapy for Depression and Anxiety

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A thesis submitted for the degree of Doctor of Philosophy of
The Australian National University

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Hayley Jackson

10 September 2024

Paper 1

Jackson, H. M., Calear, A. L., Batterham, P. J., Ohan, J. L., Farmer, G., & Farrer, L. M. (2023). Skill enactment and knowledge acquisition in digital cognitive behavioral therapy for depression and anxiety: Systematic review of randomized controlled trials. *Journal of Medical Internet Research*, *25*, e44673. https://doi.org/10.2196/44673

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Paper 4

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Statement of Contribution

This thesis is submitted as a Thesis by Compilation in accordance with https://policies.anu.edu.au/ppl/document/ANUP_003405

I declare that the research presented in this Thesis represents original work that I carried out during my candidature at the Australian National University, except for contributions to multi-author papers incorporated in the Thesis where my contributions are specified in this Statement of Contribution.

Paper 1: Skill enactment and knowledge acquisition in digital cognitive behavioral therapy for depression and anxiety: Systematic review of randomized controlled trials

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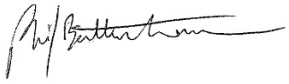
Philip Batterham 

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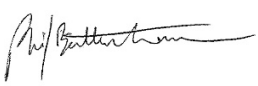

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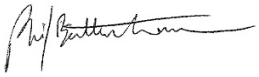

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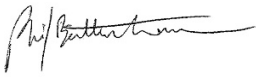

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Abstract

Substantial evidence supports the effectiveness of digital mental health interventions (DMHIs) in treating and preventing depression and anxiety disorders. Interventions based on cognitive behavioural therapy (CBT) show the most robust evidence. However, challenges remain in effectively engaging users with DMHIs. Most research has relied on usage metrics such as the number of logins or modules accessed to measure engagement. This approach may not fully capture other important processes, such as the application of intervention strategies in daily life (i.e., skill enactment) or the acquisition of knowledge about mental health and strategies to address symptoms (i.e., knowledge acquisition). Accordingly, this thesis aimed to investigate skill enactment (primary aim) and knowledge acquisition (secondary aim) in digital CBT interventions for depression and anxiety. Four studies were conducted that used narrative synthesis, quantitative, and/or qualitative approaches. Study 1 was a systematic review that synthesised the literature on skill enactment and knowledge acquisition in randomised controlled trials (RCTs) of digital CBT interventions for depression and anxiety. Study 2 examined predictors of engagement and explored the relationship between skill enactment and mental health outcomes among adolescents in a cluster-randomised controlled trial (cRCT) of a school-based online depression prevention program. Study 3 employed mixed methods to assess the effects of a video-based intervention on skill enactment, evaluate the impact of skill enactment on mental health outcomes, and explore experiences of skill enactment among university students with mild to moderate psychological distress. Study 4 qualitatively explored experiences of learning and enacting skills among adult users of publicly available digital CBT interventions. Results suggest that digital CBT interventions can enhance skill enactment and knowledge acquisition among adults with elevated symptoms or those who recognise a need for treatment (Studies 1 and 4). While both constructs are likely important for mental health outcomes in these contexts, their significance may vary depending on the specific type or aspect of skill enactment or knowledge, as well as factors such as perceived control, motivation to change, and active coping. In contrast, no significant changes in skill enactment were observed among young adult users of a digital CBT program (Study 3), nor was skill enactment found to influence mental health outcomes among adolescents or young adults (Studies 2 and 3). Key factors influencing skill enactment included perceived learning and knowledge reinforcement, the relevance and usefulness of intervention strategies to the individual user, and barriers such as time constraints and low motivation. The thesis advances understanding of engagement with digital CBT interventions by consolidating evidence on skill enactment and knowledge acquisition, while offering new insights into skill enactment among different groups of young people and user experiences of learning and implementing skills outside trial settings. The

thesis findings suggest that personalised content, learning support strategies, and ongoing resources beyond the intervention may help support the acquisition, retention, and use of knowledge and skills. Enhancing skill enactment and knowledge acquisition may be critical for optimising the impact of DMHIs, although further investigation into the mechanisms by which these constructs influence mental health outcomes is warranted.

List of Abbreviations

ANOVA: analysis of variance

CBT: cognitive behavioural therapy

COREQ: COnsolidated criteria for REporting Qualitative Research

CONSORT-eHEALTH: Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth

cRCT: cluster randomised controlled trial

DALY: disability-adjusted life year

DMHI: digital mental health intervention

DSS: Depression Stigma Scale

EFA: exploratory factor analysis

GAD-7: Generalized Anxiety Disorder Scale-7

GNATS: gloomy, negative automatic thoughts

ICC: intraclass correlation coefficient

ITT: intention-to-treat

JBI: Joanna Briggs Institute

JITAI: just-in-time adaptive intervention

MDI: Major Depression Inventory

MMRM: mixed model repeated measures

PHQ-9: Patient Health Questionnaire-9

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT: randomised controlled trial

SCAS: Spence Children's Anxiety Scale

TriPoD: Trial for the Prevention of Depression

UVC: Uni Virtual Clinic

UVC-Lite: Uni Virtual Clinic-Lite

YLD: years of life lived with disability

YLL: years of life lost due to premature mortality

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Chapter 1. General Introduction

1.1 Overview of Thesis Structure

This thesis describes a body of work investigating skill enactment and knowledge acquisition among users of digital interventions based on cognitive behavioural therapy (CBT) for depression and anxiety disorders. The thesis is structured into 6 chapters and adheres to the format of a thesis by compilation. The present chapter (Chapter 1) provides a general introduction, including an overview of the research context, a summary of relevant theory and research, a description of the research problem, and an outline of the specific thesis objectives and aims. Chapters 2 through 5 present the findings of four independent studies. Chapter 2 (Study 1) presents outcomes from a systematic review of the literature on skill enactment and knowledge acquisition in digital CBT interventions for depression and anxiety among adolescents and adults. Chapter 3 (Study 2) analyses data from a cluster randomised controlled trial (cRCT) to investigate predictors and outcomes of engagement (indexed as module completion and skill enactment) in a school-based online depression prevention program for adolescents. Chapter 4 (Study 3) reports findings from a mixed-methods study embedded within a randomised controlled trial (RCT) to evaluate the impact of a novel video-based intervention on skill enactment, investigate the association between skill enactment and mental health outcomes, and explore experiences and perspectives of skill enactment among university students. Chapter 5 (Study 4) reports results from a qualitative interview study of community users' experiences of learning and enacting skills from digital mental health interventions (DMHIs). The General Discussion (Chapter 6) synthesises findings across the individual studies, discusses their collective implications and limitations, and proposes directions for future research.

1.2 Background

1.2.1 Depression and Anxiety Disorders

Common mental disorders, such as depression and anxiety, represent a significant public health issue. Globally, approximately one in five adults (17.6%) meet diagnostic criteria for a common mental disorder each year, and nearly one-third (29.2%) experience a mental disorder during their lifetime (Steel et al., 2014). Depression and anxiety disorders are the most prevalent conditions (Australian Bureau of Statistics, 2020-2022; Ferrari et al., 2022). These disorders are ranked among the leading contributors to the global burden of disease (Ferrari et al., 2022), and are associated with substantial suffering for the individual as well

as high societal and economic costs (Chisholm et al., 2016; Lee et al., 2017). Furthermore, they account for a large and growing health burden among young people (Piao et al., 2022).

1.2.1.1 Prevalence of Depression and Anxiety Disorders

Depression describes a spectrum of mood-related symptoms and difficulties, ranging from sub-threshold depression (i.e., clinically relevant symptoms that do not fully meet the diagnostic criteria for a major depressive disorder) to diagnosable depressive or mood disorders (Thapar et al., 2022). Major depressive disorder is marked by persistent feelings of sadness or loss of interest or pleasure, accompanied by other symptoms such as changes in appetite or sleep and reduced energy or fatigue (American Psychiatric Association, 2013; World Health Organization, 2018). These symptoms interfere with daily life functioning and are present on most days, nearly every day for at least two weeks (American Psychiatric Association, 2013; World Health Organization, 2018). The 12-month global prevalence of major depressive disorder ranges from 5% to 7% (Ferrari et al., 2013; Lim et al., 2018), with a lifetime prevalence of 11% (Kessler et al., 2015). Similar 12-month (4.9%) and lifetime (11.7%) prevalence rates have been reported among Australian residents aged 16 to 85 years (Australian Bureau of Statistics, 2020-2022), although higher rates have been observed in some other high-income countries (Kessler et al., 2015). Females experience depression at higher rates than males, with 12-month prevalence estimates in Australia ranging from 5.1% to 6.3% for females and 3.5% to 4.7% for males (Australian Bureau of Statistics, 2020-2022). Australian prevalence estimates are largely consistent with findings in other regions (Ferrari et al., 2013). Sex differences in depression may be due to various factors, including biological influences such as hormonal fluctuations and differences in brain structure and function, as well as psychosocial stressors and cultural norms that affect symptom recognition and reporting (Altemus et al., 2014; Di Benedetto et al., 2024).

Anxiety disorders constitute the most common group of mental disorders (Craske & Stein, 2016; Slade et al., 2009). This category includes a range of conditions characterised by fear, anxiety, and avoidance behaviours, including generalised anxiety disorder, social anxiety disorder, panic disorder with or without agoraphobia, and specific phobia, as well as disorders with a predominant childhood onset including separation anxiety disorder and selective mutism (American Psychiatric Association, 2013; World Health Organization, 2018). Globally, anxiety disorders have a point prevalence of 5% to 10% (Baxter et al., 2013) and a lifetime prevalence of up to 34% (Bandelow & Michaelis, 2015). Annual prevalence estimates for anxiety disorders range from 10% to 14% (Penninx et al., 2021), with specific phobia (5.5%), social anxiety disorder (2.4%), generalised anxiety disorder (1.8%), and panic disorder (1.0%) among the most prevalent conditions (De Jonge et al., 2016; Ruscio et al.,

2017; Stein et al., 2017; Wardenaar et al., 2017). In Australia, 17.2% of people aged 16 to 85 years meet criteria for an anxiety disorder each year, and 28.8% experience an anxiety disorder during their lifetime (Australian Bureau of Statistics, 2020-2022). Differences in prevalence estimates across studies may be due to the inclusion of different disorders in these studies (e.g., some include posttraumatic stress disorder and obsessive compulsive disorder and exclude specific phobia) (McEvoy et al., 2011). Similar to depression, there are sex differences in the prevalence of anxiety disorders, with 19.9% to 22.3% of females in Australia experiencing an anxiety disorder each year compared to 12.2% to 14.4% of males (Australian Bureau of Statistics, 2020-2022). Factors contributing to sex differences in anxiety disorders are similar to those in depression and include biological, psychosocial, and cultural influences (Farhane-Medina et al., 2022).

Depression and anxiety disorders can occur at any age, although most cases begin in adolescence and early adulthood (Kessler et al., 2007). A recent meta-analysis of 192 population-based studies reported a median age of onset for depressive disorders of 30 years, with the highest incidence observed at ages 19 to 20 (Solmi et al., 2022). Anxiety disorders generally emerge earlier than depression, although the age of onset varies depending on the specific disorder (Lijster et al., 2017). Roughly half of all cases occur by age 13 for social anxiety disorder, by age 26 for panic disorder, and by age 32 for generalised anxiety disorder (Solmi et al., 2022). Each year, approximately 25% of adolescents aged 10 to 19 years experience a depressive or anxiety disorder (Silva et al., 2020), with comparable rates reported among young adult populations (e.g., university students) (Auerbach et al., 2018; Sheldon et al., 2021). Depression and anxiety disorders often follow a chronic course (Solis et al., 2021; ten Have et al., 2022), and early onset of symptoms has been associated with greater functional impairments over time (Clayborne et al., 2019; Gollan et al., 2005; Ramsawh et al., 2011; Rosellini et al., 2013; Wickersham et al., 2021). These findings point to the importance of prevention and early intervention efforts targeted at young people to mitigate the impact of depression and anxiety disorders. Addressing symptoms early may potentially reduce the severity of illness trajectories and improve overall health outcomes.

Studies conducted since the onset of the COVID-19 pandemic generally suggest an increase in the prevalence of depression and anxiety symptoms among young people and adults, due both to its direct (e.g., infection and fear of the virus) and indirect effects (e.g., increased financial hardship and social isolation) (Batterham et al., 2021a; Pompili et al., 2022; Taquet et al., 2021a; Taquet et al., 2021b; Zhao et al., 2020). Research conducted by the COVID-19 Mental Disorders Collaborators (2021) estimated that the COVID-19 pandemic led to 53.2

million additional cases of major depressive disorder and 76.2 million additional cases of anxiety disorders in 2020. More recently, an umbrella review of 338 systematic reviews (including 158 meta-analyses) conducted from late 2019 to early 2022 found increased prevalence rates of probable depression (28.1%), anxiety (30.8%), and psychological distress (44.2%) compared to pre-pandemic levels (Bower et al., 2023). Similar to other reviews (COVID-19 Mental Disorders Collaborators, 2021; Madigan et al., 2023), the review by Bower et al. (2023) reported that adolescents and young people were among those most vulnerable to the effects of the pandemic, with a higher prevalence of probable depression (32.1%) and anxiety (32%) compared to other populations. However, the review also noted that the accuracy and validity of these estimates were limited by the low quality of the source data, most of which was derived from convenience samples where participants self-selected into the studies.

1.2.1.2 Burden of Depression and Anxiety Disorders

Depression and anxiety disorders impose a significant burden on individuals and society. These disorders are associated with reduced quality of life (Hohls et al., 2021), high comorbidity with other mental health conditions (Kessler et al., 2005; Plana-Ripoll et al., 2019), and an increased incidence of various chronic health conditions (e.g., diabetes, heart disease, stroke, and cancer) (Clarke & Currie, 2009; Mersha et al., 2022). Individuals with depression or anxiety disorders have an increased risk of mortality compared to those without mental disorders (Walker et al., 2015), due predominantly to the presence of physical comorbidities such as cardiovascular and metabolic disease (Fiorillo & Sartorius, 2021; Härter et al., 2007), as well as elevated rates of suicide (Chesney et al., 2014; Gili et al., 2019; Kanwar et al., 2013). Depression and anxiety are also associated with a range of adverse psychosocial outcomes, including lower levels of occupational functioning (Hendriks et al., 2015; Johnston et al., 2019; Plaisier et al., 2010), increased rates of unemployment (Jefferis et al., 2011), interpersonal difficulties (McEvoy et al., 2013), high levels of marital dissatisfaction (Whisman, 1999), and reduced educational attainment among those with early onset disorders (Leach & Butterworth, 2012). Additionally, these disorders carry a substantial economic cost. Lee et al. (2017) analysed data from the 2007 National Study of Mental Health and Wellbeing and estimated the annual cost of high prevalence mental disorders (including both depression and anxiety-related disorders) in Australia at AUD 12.8 billion, including costs borne by the healthcare sector (AUD 974 million) and lost productivity (AUD 11.8 billion). On a global scale, depression and anxiety contribute an estimated USD 1 trillion in lost productivity each year (Lancet Global Health, 2020). In 2010, the global economic impact of poor mental health, including both lost productivity and healthcare costs, was

around USD 2.5 trillion annually, with projections indicating that this figure could rise to USD 6 trillion by 2030 (Lancet Global Health, 2020).

Depression and anxiety also contribute to a significant burden of disease, as measured by years of life lived with disability (YLDs) and disability-adjusted life years (DALYs). YLDs quantify the non-fatal health burden due to living with illness or disability, while DALYs combine YLDs with years of life lost due to premature mortality (YLLs) to provide a measure of overall disease burden (Devleesschauwer et al., 2014). According to the Global Burden of Disease Study, both groups of disorders consistently rank among the top ten causes of YLDs worldwide (Ferrari et al., 2024; Vos et al., 2017; Vos et al., 2016; Vos et al., 2015). The latest Global Burden of Disease Study in 2021 found that depression accounted for 6.2% of all YLDs, while anxiety disorders accounted for 4.7% (Ferrari et al., 2024). In Australia, depressive disorders rank second and anxiety disorders fifth among the leading causes of non-fatal health loss (Islam et al., 2023). In 2019, depressive disorders accounted for 1.8% of all global DALYs, equal to conditions such as lung cancer and chronic kidney disease (Vos et al., 2020). Anxiety disorders, while less impactful than depression, still represent a significant burden, contributing to 1.1% of DALYs. Both depression and anxiety disorders are among the top ten causes of DALYs among adolescents and young adults (aged 10 to 24 years), with depressive disorders accounting for 3.7% and anxiety disorders for 3.3% of total DALYs in this age group (Vos et al., 2020). These figures reflect the high prevalence, often chronic course, and severe impact of these disorders on quality of life and functioning.

1.2.1.3 Summary of Depression and Anxiety Disorders

In summary, depression and anxiety disorders are highly prevalent and disabling conditions, affecting a significant number of individuals each year and contributing to substantial personal and societal costs. Research conducted since the onset of the COVID-19 pandemic has indicated an increase in the probable prevalence of these conditions. At least half of all cases of depression and anxiety disorders emerge by early adulthood. Earlier onset of symptoms is associated with a range of adverse outcomes, including increased disorder severity (e.g., heightened risk of recurrence or persistence) and adverse psychosocial outcomes. These insights underscore the urgent need for effective prevention and intervention strategies to address the burden of depression and anxiety disorders on public health, particularly among young people.

1.2.2 Cognitive Behavioural Therapy for Depression and Anxiety

A range of effective interventions are available for the treatment and prevention of depression and anxiety disorders. These include pharmacological interventions such as antidepressant or anti-anxiety medications (Arroll, 2016; Chawla et al., 2022; Garakani et al., 2020); psychotherapeutic approaches such as cognitive behavioural therapy (CBT), interpersonal therapy, and psychodynamic therapy (Cuijpers et al., 2016a; Cuijpers et al., 2016b; Driessen et al., 2015; Keefe et al., 2014); and therapeutic lifestyle changes such as exercise, diet, and sleep interventions (Singh et al., 2023; Wong et al., 2021; Wong et al., 2022). Among the psychotherapies, CBT is the most prominent and widely researched approach (Hofmann et al., 2012). CBT has a robust evidence base supporting its effectiveness and is recommended as a primary treatment option for both depression and anxiety disorders in clinical practice guidelines (Ellis, 2004; Szuhany & Simon, 2022).

CBT is a structured psychotherapy focused on identifying and modifying dysfunctional thought patterns and behaviours through strategies such as cognitive restructuring, exposure therapy, and behavioural activation (Beck & Clark, 1997; Foa & Kozak, 1986; Lewinsohn & Graf, 1973). Other techniques taught in CBT may include problem-solving, social skills training, relaxation, and goal setting (López-López et al., 2019). Numerous randomised controlled trials and meta-analyses have demonstrated the efficacy and effectiveness of CBT for depression and anxiety disorders (Cuijpers et al., 2023; Öst et al., 2023; Szuhany & Simon, 2022). For depression, the largest meta-analysis of any type of psychotherapeutic treatment to date (N = 409 trials including 52,702 participants) showed that CBT had a moderate to large effect on symptoms compared to control conditions such as care as usual or waitlists (g = 0.79), with evidence that CBT remained effective at 6- to 12-month follow-ups (Cuijpers et al., 2023). CBT has also demonstrated equivalence to other psychotherapies for depression (Cuijpers et al., 2021; Smith & Hewitt, 2024), is comparable to pharmacotherapies in the short term, and may be more effective than pharmacotherapies over long term follow-up (Cuijpers et al., 2023).

For anxiety disorders, a meta-analysis of 41 randomised placebo-controlled trials including 2,835 participants indicated small to large short-term effects of CBT relative to placebos for generalised anxiety disorder (Hedges g = 1.01), social anxiety disorder (g = 0.41), and panic disorder (g = 0.39) (Carpenter et al., 2018). Long-term effects have also been demonstrated, with evidence to indicate small to moderate reductions in symptoms of generalised anxiety disorder (Hedges g = 0.40), social anxiety disorder (g = 0.34), and panic disorder (g = 0.35) at 6 to 12 months post-treatment compared to controls (van Dis et al., 2020).

CBT has also been found effective for depression and anxiety among young people, including for specific populations such as university students. A recent meta-analysis reported medium to large effects of CBT for depression relative to control conditions (e.g., waitlist or usual care) among adolescents (g = 0.54) and young adults (of which the majority were university students; g = 0.93) (Cuijpers et al., 2020). Notably, however, effect sizes tended to be smaller for adolescents compared to both young adult and older adult populations (Cuijpers et al., 2020; Zhou et al., 2020). Similar results have been reported for anxiety. A meta-analysis of psychological therapies for anxiety disorders in adolescents, of which the majority were CBT-based, reported that these treatments were more likely to be effective (standardised mean difference = 0.45) and to result in remission than controls (Baker et al., 2021). Importantly, there is also evidence to support the effectiveness of CBT among those with subthreshold symptoms and for the prevention of depression and anxiety disorders among both young people and adults (He et al., 2022; Rasing et al., 2017; Werner-Seidler et al., 2021).

1.2.3 Help-Seeking and Treatment Access

Despite the availability of effective treatments such as CBT-based therapies, many individuals experiencing mental disorders do not receive timely or appropriate care. Recent data from Australia's National Study of Mental Health and Wellbeing 2020-2022 showed that only 45.1% of adults with a 12-month mental disorder sought assistance from a health professional (Australian Bureau of Statistics, 2020-2022). This proportion represents a slight increase since Australia's last national survey in 2007 (Burgess et al., 2009), and surpasses previous rates reported in other high-income countries (ten Have et al., 2013; Wang et al., 2005), where only about one-third of adults sought professional help. Despite this, treatment rates remain below optimal levels, and only a minority of those who do seek treatment receive adequate levels of care. Analysis of data from Australia's 2007 National Survey of Mental Health and Wellbeing indicated that just 16% of individuals with a 12-month affective or anxiety disorder who sought help from a health professional received treatment that met the threshold for being minimally adequate, and only 26% received an evidence-based treatment (Harris et al., 2015).

Rates of help-seeking also vary by different mental disorders. Wang et al. (2007) analysed data from 15 countries in the World Mental Health Survey Initiative and found that the percentage of respondents in high-income countries who sought treatment within the first year of experiencing symptoms ranged from 28.8% to 52.1% for mood disorders and 11.2% to 36.4% for anxiety disorders. Similar patterns are observed among adolescents (Wang et al., 2023), although rates are considerably lower in low- and middle-income countries (Wang

et al., 2007). Substantial delays in treatment initiation are common across people with both groups of disorders, with median delays ranging from 1 to 6 years for mood disorders and 3 to 28 years for anxiety disorders (Wang et al., 2007). Longer duration of untreated illness is associated with a range of negative outcomes, including poorer treatment response, lower rates of remission, and increased risk of chronicity (Ghio et al., 2014).

Several factors contribute to treatment delay and under-utilisation of services among individuals with mental health conditions. These factors can be broadly categorised into two groups: those influencing treatment demand, such as beliefs and attitudes affecting the individual's willingness to seek help, and those influencing treatment supply, including limitations in the availability or accessibility of mental health services. Low perceived need for treatment is a common factor impacting on treatment demand, particularly among those with mild to moderate symptoms (Andrade et al., 2014). This may be due to a lack of awareness or education about mental health problems, although some researchers suggest it could also indicate that not all individuals who meet current diagnostic criteria require formal treatment services (Patel, 2014; Roberts et al., 2018). Other factors affecting treatment demand include a preference for self-managing symptoms, concerns about treatment effectiveness, and fear of stigma associated with mental disorders or help-seeking (Andrade et al., 2014; Gulliver et al., 2010; Mojtabai et al., 2011; Radez et al., 2021; Schnyder et al., 2017). Individuals also report that treatment supply barriers can impede help-seeking, including high treatment costs, inadequate insurance coverage, long waiting lists, and limited or inflexible operating hours of services (Andrade et al., 2014). Shortages in the number of appropriately trained providers and gaps in the distribution of services may also reduce access to care, particularly in regional and remote areas and among ethnic minority groups (Carbone et al., 2011; Green et al., 2012; Kazdin, 2017; Ohtani et al., 2015). The COVID-19 pandemic compounded many of the existing challenges people face in accessing mental health care by severely limiting access to in-person services due to physical distancing and stay-at-home orders (World Health Organization, 2020; Zangani et al., 2022). This highlights a critical need for alternative methods of delivering mental health care (Bennett et al., 2020).

1.3 Digital Mental Health Interventions

1.3.1 Definition of Digital Mental Health Interventions

Digital Mental Health Interventions (DMHIs) have been developed as a potential solution to improve access to evidence-based mental health care. A recent taxonomy categorised DMHIs into two broad types: (1) provider-administered interventions, which may or may not include digital adjuncts, and (2) self-help interventions delivered outside the formal

healthcare system (Pineda et al., 2023). This thesis focuses on the latter. These interventions are defined as psychotherapeutic interventions delivered through technology to either treat existing mental disorders or prevent their onset (Barak et al., 2009; Pineda et al., 2023). DMHIs typically draw from therapeutic models that have demonstrated efficacy in face-to-face treatment settings (Lattie et al., 2022). They vary based on several key factors, including the specific technologies or platforms used to implement the intervention (e.g., websites, smartphone apps, video games, virtual reality, or conversational agents), the degree of human support provided (ranging from fully automated self-help to guided interventions with support provided by a clinician, coach, or peer), and the therapeutic model employed (e.g., CBT, acceptance and commitment therapy, or psychodynamic approaches). The majority of DMHIs investigated in the research literature to date are CBT-based interventions delivered via the internet with or without guidance (Andersson & Titov, 2014; Lattie et al., 2022), although there is growing interest in the utility of smartphone apps (Goldberg et al., 2022), virtual reality (Cieślik et al., 2020), and chatbots (Abd-Alrazaq et al., 2020).

1.3.2 Advantages of Digital Mental Health Interventions

DMHIs offer several advantages relative to face-to-face treatments (Marcu et al., 2022). These interventions are typically more cost-effective, as they eliminate the need for physical office space and reduce operational costs, resulting in lower expenses for providers and service users. DMHIs can also be scaled to reach a large audience, further enhancing their affordability by spreading costs across more users. In Australia, publicly available DMHIs are typically offered at minimal or no cost to individuals (Australian Government Department of Health, 2023). This is significantly less than average out-of-pocket costs for individual sessions with a clinical psychologist, which can be as high as AUD 169.15 per session, based on the Australian Psychological Society's (2024) suggested standard consultation fee of AUD 311 and current Medicare rebates (i.e., Australia's public health system providing free or subsidised healthcare services) (Australian Government, 2023). From a societal perspective, recent evidence from a meta-analysis suggests that DMHIs may be a more cost-effective option for improving health-related quality of life than wait-list or treatment-as-usual conditions (Rohrbach et al., 2023).

DMHIs also offer convenient and flexible access to care and have considerable potential to expand the reach of evidence-based treatment and prevention services. By enabling users to access interventions from virtually any location with internet access, DMHIs can reduce geographical barriers and provide support to individuals in regional or remote areas where traditional services are limited (Graham et al., 2021b). Moreover, DMHIs enable individuals

who face challenges leaving their homes due to factors such as physical illness or disability to access support at their convenience and without the need for travel. These interventions also provide continuous access to resources on demand and outside of traditional service hours, enabling support at times when it is needed (Casey et al., 2014). Finally, DMHIs enable individuals to seek mental health support privately and often anonymously, which has been suggested to reduce experiences of stigma or shame associated with accessing face-to-face services (Barney et al., 2009).

Despite their promise, DMHIs also face challenges. Many individuals with mental health conditions prefer face-to-face therapy (Casey et al., 2014; Klein & Cook, 2010; Renn et al., 2019), perhaps because DMHIs lack the level of human interaction desired or needed by some individuals. These interventions also have limited capacity to provide personalised support tailored to the individual's presenting issues or concerns (Patel et al., 2020), and accessibility issues, such as low digital literacy or privacy concerns, can impede widespread adoption (Beatty & Binnion, 2016; Borghouts et al., 2021). Moreover, unguided interventions in particular generally demand a high degree of self-motivation for effective use (Borghouts et al., 2021; Moshe et al., 2021), which can further limit their impact.

1.3.3 Effectiveness of Digital Mental Health Interventions

Numerous systematic reviews and meta-analyses have demonstrated the efficacy and effectiveness of DMHIs in treating and preventing depression and anxiety disorders (Andrews et al., 2018; Etzelmueller et al., 2020; Harith et al., 2022; Hollis et al., 2017; Karyotaki et al., 2021; Lehtimaki et al., 2021; Pauley et al., 2021; Rigabert et al., 2020). The majority of this evidence is drawn from studies evaluating CBT-based approaches. For depression, a comprehensive meta-analysis including 83 studies and 15,530 participants found that digital interventions (of which 74.4% were CBT-based) had a moderate effect on depression symptoms relative to control conditions (g = 0.52) (Moshe et al., 2021). Guided interventions (g = 0.63) and efficacy trials (g = 0.59) showed higher effect sizes than unguided interventions (g = 0.34) and effectiveness trials (g = 0.30), respectively (Moshe et al., 2021). For anxiety, a meta-analysis of 47 RCTs including 53 comparisons and 4,958 participants found that digital interventions (90% of which were CBT-based) had a large effect on symptoms of anxiety relative to controls (g = 0.80) (Pauley et al., 2021). Sub-group analyses demonstrated moderate to large effects favouring digital interventions for specific disorders, including generalised anxiety disorder (g = 0.62), social anxiety disorder (g = 0.76), panic disorder with or without agoraphobia (g = 1.08), and mixed anxiety samples (g = 0.68) (Pauley et al., 2021). Digital CBT has also shown superior long-term efficacy compared to control comparisons (Mamukashvili-Delau et al., 2023), and may be equivalent to face-to-

face CBT (Esfandiari et al., 2021; Hedman-Lagerlöf et al., 2023; Kambeitz-Ilankovic et al., 2022).

Among adolescents and young adults, digital CBT has demonstrated similar, though slightly smaller, positive effects compared to inactive control groups for symptoms of depression (g = 0.51) and anxiety (g = 0.44), although its effectiveness compared with active control comparisons has not yet been established (Christ et al., 2020). Studies have also highlighted the effectiveness of DMHIs among specific populations like university students (Farrer et al., 2013; Harrer et al., 2019), as well as their potential in universal or targeted prevention approaches (Conley et al., 2016; Rigabert et al., 2020; Werner-Seidler et al., 2021). Together, these findings underscore the potential of DMHIs in general, and digital CBT specifically, across diverse settings, populations, and levels of symptom severity. However, challenges remain in effectively engaging adults and young people with these interventions.

1.4 Engagement with Digital Mental Health Interventions

Despite the promise of DMHIs, not everyone who uses these interventions experiences substantial change or improvement in symptoms (Andersson et al., 2019; Karyotaki et al., 2018). These challenges are partly due to low levels of intervention completion, which is frequently observed in research studies and tend to be exacerbated when DMHIs are implemented in community settings. A review of 10 RCTs (including 2,705 participants) of unguided internet-based interventions for depression found that only 41% of adults complete half of these interventions, while just 17% complete an entire intervention (Karyotaki et al., 2015). Among adolescents, completion rates below 50% have been reported in research trials (Garrido et al., 2019). Guided interventions tend to improve completion rates, although the effects are modest (e.g., an average increase of only 12% in the number of individuals completing an intervention), and the scalability of unguided interventions has been suggested to outweigh these gains (Musiat et al., 2022). The rates of completion for DMHIs are often much lower in community or clinical settings, as research trials typically recruit participants who are motivated, have access to support from study personnel, and undergo structured assessment procedures (Baumel et al., 2019; Fleming et al., 2018). For example, a study of adolescent users of an open access internet-based depression and anxiety program found that 89% either did not start the intervention or only completed one module out of a possible five (Neil et al., 2009). Similar findings have been reported among adult users of publicly available anxiety and depression programs, with reported rates of completion or sustained use ranging from 0.5% to 28.6% (Fleming et al., 2018). These

findings underscore the need to enhance engagement with DMHIs in order to improve their effectiveness and facilitate their adoption into healthcare systems.

1.4.1 Existing Approaches to Defining and Measuring Engagement

Efforts to facilitate engagement with digital interventions face challenges due to a lack of consensus regarding how to define and measure engagement (Kelders et al., 2020; Nahum-Shani & Yoon, 2024; Perski et al., 2017). Most previous studies (such as those described above) have operationalised engagement through metrics related to program completion, usage, or adherence. This approach typically relies on data extracted from user activity logs to track usage patterns over time. Beintner et al. (2019) examined engagement reporting in trials of manualised internet-based interventions for common mental disorders and found that various metrics had been used to measure engagement, although the most common included rates of module or session completion (e.g., the number of participants completing all or a minimum number of modules), login frequency (e.g., the total number of logins), and the duration of program usage (e.g., total time spent using the program). Similar findings have been reported in at least two other reviews (Sieverink et al., 2017), including a recent review by Li et al. (2022) that reported on adherence among young people (aged 12 to 24 years).

Program usage indicators provide useful information on the degree to which users interact with or are exposed to intervention content. However, they may not capture other processes that may be more proximal to intervention outcomes (Beintner et al., 2019; Donkin et al., 2011), such as the quality or depth of engagement with intervention content or the practical application of skills learned from an intervention in daily life (Nahum-Shani & Yoon, 2024). Accordingly, there is limited evidence supporting a strong association between program usage indicators of engagement and mental or physical health outcomes (Michie et al., 2017). Moreover, available evidence suggests that the predictive value of these indicators may vary depending on the specific indicator being considered (Donkin et al., 2011). For example, a recent systematic review and meta-analysis by Gan et al. (2021) found that accessing a greater number of modules was associated with small to moderate improvements in mental health outcomes, but this association was not observed for other indicators such as time spent on the program or number of logins. Another systematic review that evaluated engagement among adolescents and young adults found little evidence to support an association between program usage and improvement in mental health outcomes, regardless of the measure considered (Li et al., 2022).

Chien et al. (2020) provided additional evidence to indicate that the degree of improvement in mental health outcomes may not correspond to levels of program usage or adherence. The authors used machine learning techniques to analyse automatically collected usage data from 54,604 users of an internet-based CBT intervention and found that users who exhibited a pattern of high engagement followed by rapid disengagement had greater reductions in both depression and anxiety scores than those who remained consistently engaged. These findings point to a need to consider the reasons why people choose to use, and stop using, digital interventions. Whereas some users may drop out of an intervention due to a poor user experience or lack of symptom improvement, others may discontinue because they have successfully achieved their desired goals or outcomes (Batterham et al., 2021b; Batterham et al., 2008; Davis & Addis, 1999). This latter group of users may disengage from a program but continue to be engaged with and use what they have learned from the program to manage their mental health (Yardley et al., 2016). Therefore, more comprehensive approaches to studying engagement are needed.

To address the limitations of existing indicators of engagement, studies are increasingly investigating measures of active participation (e.g., number of skills practice logs completed) (Hanano et al., 2022) and subjective user experiences of engagement (e.g., the perceived usefulness or usability of an intervention) (Graham et al., 2021a). Though useful, these efforts continue to focus on a user's direct interactions with and experiences of an intervention. What remains overlooked is the extent to which people implement their online learning to manage their mental health, both during and after their use of an intervention. To improve the impact of digital interventions, researchers have argued for extending the focus of engagement research to explore indicators that might better reflect effective engagement (i.e., the level and type of engagement required to achieve intended outcomes) (Nahum-Shani & Yoon, 2024; Yardley et al., 2016). The present thesis addresses this gap by conceptualising and investigating skill enactment as an additional aspect of user engagement with DMHIs. Skill enactment is defined throughout this thesis as the degree to which users implement strategies and techniques from an intervention in everyday life. Although predominantly focused on skill enactment, the thesis adheres to a broader definition of engagement that includes uptake, ongoing program use, and skill enactment (Davis et al., 2022; Piotrowska et al., 2017).

1.5 Skill Enactment

There is growing recognition of the importance of skill enactment in understanding the real-world impact of digital CBT interventions. Accordingly, several guidelines recommend

reporting on skill enactment when evaluating user engagement with digital interventions (Beintner et al., 2019; Li et al., 2022; Michie et al., 2017; Nahum-Shani & Yoon, 2024). The following sections summarise current theories and research related to changes in skill enactment, its association with mental health outcomes, and factors associated with or influencing skill enactment, with a focus on digital CBT interventions for depression and anxiety. Qualitative research on user experiences is also explored. These sections aim to illustrate important knowledge gaps and identify areas where further research is needed to advance understanding of these topics.

1.5.1 Skill Enactment and Mental Health Outcomes

The importance of skill enactment for health and mental health outcomes in digital and face-to-face interventions is illustrated in various conceptual frameworks of engagement. These frameworks include the pragmatic model of engagement (Nahum-Shani & Yoon, 2024); the user pathway framework (Baumel, 2022); the CAPE (Connect, Attend, Participate, Enact) model of engagement with parent support interventions (Piotrowska et al., 2017); the conceptual framework of engagement with digital behaviour change interventions (Perski et al., 2017); and the micro- and macro-levels of engagement with digital interventions proposed by Yardley et al. (2016). Collectively, these frameworks conceptualise program usage as a mechanism that facilitates the acquisition of knowledge and skills for managing symptoms and achieving health-related goals. Positive outcomes are believed to result when a user applies these skills in daily life. Within these frameworks, skill enactment is defined either as a component (Nahum-Shani & Yoon, 2024; Piotrowska et al., 2017; Yardley et al., 2016) or an outcome (Baumel, 2022; Perski et al., 2017) of engagement, depending on whether engagement is viewed as a momentary state or an ongoing process (Kelders et al., 2020; Nahum-Shani & Yoon, 2024). This thesis adopts the perspective of skill enactment as a component of engagement, as it reflects the degree of engagement with cognitive and behavioural change and is considered to be an essential step towards achieving the target outcomes of DMHIs (Nahum-Shani et al., 2022; Nahum-Shani & Yoon, 2024).

Conceptual models of engagement draw support from studies on the mechanisms of change in face-to-face CBT, which suggest that the effectiveness of these interventions depends, at least in part, on the acquisition and use of skills by clients during and outside of therapy (Adler et al., 2015; Hundt et al., 2013; Schmidt et al., 2019b). This research generally suggests two key pathways through which skill enactment may improve outcomes: the frequency with which the individual uses CBT skills (i.e., frequency) and the proficiency with which they apply these skills in accordance with how they were taught (i.e., quality) (Hundt et al., 2013; Southward et al., 2021). Additionally, a distinction is often made between formal

skill enactment (i.e., completing structured exercise during or between sessions) and informal skill enactment (i.e., spontaneously applying skills in everyday contexts without formal prompts) (Hundt et al., 2013). Formal practice may help individuals develop the proficiency and confidence needed to apply and generalise skills in daily life. However, to the author's knowledge, this relationship has yet to be formally investigated. A review by Hundt et al. (2013) found that skill enactment increases during CBT, with both frequency and quality of skill enactment found to be associated with greater reduction in symptoms and reduced risk of relapse. Subsequent studies have generally confirmed these relationships (Hundt et al., 2016; Schmidt et al., 2019b; Strunk et al., 2014). The broader literature on emotion regulation and adaptive coping extends this idea, indicating that greater use of adaptive skills may be relevant not only for symptom change but also for supporting ongoing mental health and wellbeing (Adler et al., 2013; Aldao et al., 2010). This may be particularly pertinent in interventions targeting prevention or addressing mild symptoms (where change in mental health outcomes may be minimal) and suggests the importance of evaluating skill enactment as a distinct measure of intervention effects. However, despite sharing similar therapeutic content, findings from studies on face-to-face CBT may not directly translate to digital CBT due to differences in delivery methods and user engagement dynamics.

No previous systematic review has comprehensively investigated skill enactment in digital CBT interventions for depression and anxiety. Domhardt and colleagues (2021a; 2021b) conducted two recent reviews focusing on therapeutic processes within digital interventions for adults with depression (*N* = 26 studies) or anxiety (*N* = 26 studies). Both reviews found some evidence that skills (categorised as a broad group of mediators) facilitated reductions in symptoms of depression or anxiety. However, these reviews included various therapeutic approaches (e.g., CBT, mindfulness-based cognitive therapy, acceptance and commitment therapy) and mediators (i.e., cognitive, affective, and behavioural processes were considered alongside skills), potentially obscuring the specific contributions of CBT skills. Additionally, neither review considered the effectiveness of DMHIs in improving skill enactment as a standalone outcome, nor did they explore skill enactment among young people specifically. Another systematic review by Davis et al. (2022) included 16 studies to explore how women engage with DMHIs during the perinatal period. This review highlighted inadequate reporting on skill enactment as a component of engagement; however, it did not consider the impact of skill enactment on mental health outcomes. Furthermore, the focus on women during the perinatal period highlights the need for a review to address broader gaps in the literature beyond this specific population.

1.5.2 Factors Influencing Skill Enactment

Enhancing user engagement with intervention skills represents an important research priority given that the effectiveness of DMHIs may depend on whether and how effectively users are able to implement these skills in practice. Current efforts to improve user engagement—typically measured through program usage—focus on two main approaches: optimising intervention design by incorporating user-centred, gamified, or therapeutically persuasive features (Baumel et al., 2023; Fleming et al., 2016), and deploying adjunct engagement strategies—such as reminders, coaching, and personalised feedback—separately from the main intervention (Batterham et al., 2021b; Gan et al., 2022). However, evidence for the effectiveness of these approaches remains mixed (Lipschitz et al., 2023), and a recent systematic review found inconclusive support for existing strategies in promoting program usage engagement (Gan et al., 2022). Moreover, the impact of these efforts on skill enactment has yet to be explored. Research focused on identifying user-specific and intervention-related characteristics that facilitate or hinder engagement could inform the development of targeted strategies to improve engagement. Such efforts could also support the personalisation of interventions to accommodate diverse user groups (Borghouts et al., 2021; Gulliver et al., 2021).

Numerous studies and several systematic reviews have explored factors influencing engagement and dropout in DMHIs (Batterham et al., 2008; Beatty & Binnion, 2016; Christensen et al., 2009; Garrido et al., 2019; Gulliver et al., 2021; Karyotaki et al., 2015; Neil et al., 2009; Waller & Gilbody, 2009). Borghouts et al. (2021) conducted the most comprehensive review to date, including 208 studies utilising quantitative or qualitative methods. Their findings suggest that engagement is generally higher among females, younger people, those with higher levels of education, those with less severe mood-related or fatigue symptoms at baseline, and those who hold positive attitudes towards help-seeking and DMHIs. Moreover, sustained engagement was more likely when users found the intervention content to be enjoyable and relevant, received clear guidance on usage, and perceived positive outcomes such as symptom improvement. Privacy concerns were found to discourage engagement, whereas a sense of anonymity and perceived social support facilitated engagement with the intervention. These findings are useful for developing targeted strategies to facilitate program usage and uptake. However, the extent to which they clarify the factors underpinning skill enactment remains unclear. The limited research available suggests that skill enactment in DMHIs is not significantly associated with age, gender, education level, baseline symptoms, or personality factors (Kuosmanen et al., 2017; Schmidt et al., 2019a). Furthermore, although some level of program usage is likely to be a

prerequisite for skill enactment (Yeager & Benight, 2018), other theoretically relevant predictors of behaviour change such as levels of learning and motivation, self-efficacy, or environmental cues may also influence skill enactment (Atkins et al., 2017). These factors are shaped not only by a user's engagement with an intervention program but also by broader psychological, social, and environmental influences. Accordingly, effectively promoting skill enactment may require tailored strategies that address these influences (Nahum-Shani et al., 2022). However, further research is first needed to comprehensively explore the factors influencing skill enactment.

1.5.2.1 Knowledge Acquisition

One factor that may be important for skill enactment is gaining knowledge about mental health and strategies for managing symptoms (hereafter referred to as knowledge acquisition) (Piotrowska et al., 2017; Yeager & Benight, 2018). In addition to providing practical strategies and techniques designed to address symptoms, comprehensive CBT-based interventions also include psychoeducation to improve knowledge and understanding of mental health issues and help individuals identify the underlying cognitive and behavioural patterns that contribute to distress (Käll & Andersson, 2023). Digital CBT interventions aim to facilitate knowledge acquisition through interactive modules, self-guided exercises, and multimedia formats such as video tutorials and text-based instructions (Linardon et al., 2022). Users are encouraged to engage with these resources more or less independently to learn and apply therapeutic strategies aimed at managing symptoms and improving mental health outcomes. Consequently, poor recall or understanding of the strategies and recommendations provided within an intervention may hinder the application of these skills in practice, potentially reducing the effectiveness of treatment. Indeed, research has linked poor memory for treatment with worse clinical outcomes (Lee & Harvey, 2015).

Recent research on face-to-face therapy suggests that the acquisition and retention of knowledge may indirectly predict improvements in symptom severity and overall impairment via changes in a client's use of skills. For instance, Dong et al. (2017) analysed data from a pilot trial of cognitive therapy delivered with or without adjunctive memory support and demonstrated that improved client recall was associated with greater adherence to treatment recommendations and improved use of strategies between sessions. Extending on these findings, a study by Sarfan et al. (2023) showed that the use of memory support strategies (considered here as a proxy for knowledge acquisition) was indirectly linked to improved treatment outcomes and overall impairment through more frequent use of therapy skills during and after treatment. Although no research has directly investigated these relationships in digital or web-based interventions, the findings highlight the importance of investigating

knowledge acquisition given its potential implications for both skill enactment and treatment outcomes.

Some previous studies have explored the specialised knowledge that individuals gain through participation in digital CBT interventions for depression and anxiety. These studies suggest that digital CBT interventions can enhance declarative knowledge (i.e., knowledge about facts and information that can be explicitly stated) (Andersson et al., 2012; Berg et al., 2020; Berg et al., 2019); however, these improvements may not translate into better mental health outcomes. This might suggest that other forms of knowledge, such as practical knowledge of how to apply skills or experiences of insight, play a more important role in the enactment of skills and overall treatment effectiveness. However, these relationships remain underexplored, and the role of knowledge acquisition in skill enactment is still not well understood. Furthermore, no systematic review has synthesised the existing evidence on knowledge acquisition within digital CBT interventions specifically. Previous reviews have evaluated the effectiveness of digital interventions in improving general mental health literacy (Brijnath et al., 2016; Tay et al., 2018). These reviews suggest that structured interventions that provide evidence-based content and interactive learning components may enhance mental health literacy and reduce stigma (Brijnath et al., 2016; Tay et al., 2018). However, these reviews covered a range of programs (e.g., online support groups, role playing games, or web-based information) and did not explore the specific content and knowledge related to CBT-based interventions. Given these gaps, further investigation is needed to understand how knowledge acquisition might influence skill enactment and treatment effectiveness in digital contexts. Moreover, exploring factors that may be associated with knowledge may be useful for identifying effective approaches to enhance knowledge acquisition and understand who is most likely to benefit from these interventions.

1.5.3 Qualitative Research on User Experiences and Perspectives

Studies described in previous sections predominantly employed quantitative research designs to investigate skill enactment, knowledge acquisition, and mental health outcomes. These methods provide a structured way to measure and analyse relationships between variables. However, they may not capture rich or detailed information about factors influencing these processes. Qualitative methods offer a complementary approach by exploring the experiences, motivations, and contextual influences that contribute to and shape quantitative findings. This approach can be valuable for clarifying and explaining why quantitative findings apply in some cases but not others (Brannen, 2005; Hammarberg et al., 2016). Few studies have qualitatively explored experiences of skill enactment and knowledge acquisition in DMHIs in general or digital CBT programs specifically. Existing studies in this

area primarily focus on understanding immediate user experiences and perspectives regarding the acceptability and usability of DMHIs. Broadly, these studies suggest that DMHIs may appeal to users as they offer improved accessibility, convenience, and reduced stigma compared to in-person services (Patel et al., 2020). However, they also highlight disadvantages or challenges associated with these interventions, such as lack of personalisation, privacy concerns, technical challenges, varying user perceptions of effectiveness, and difficulties in sustaining motivation due to the self-guided nature of DMHIs (McCashin et al., 2019; Patel et al., 2020; Peng et al., 2024).

The studies described above provide useful insights to guide the refinement of DMHIs. In particular, they suggest the importance of ensuring privacy, security, and providing adequate support mechanisms to foster trust and acceptance among users. Additionally, they point to a need for personalised content and features to support engagement by addressing individual differences in preferences and expectations. However, these studies do not directly address the processes involved in acquiring and using knowledge and skills from these interventions, nor do they consider the factors that might affect these processes. Furthermore, previous research has been conducted almost exclusively with participants in research trials. This limits the applicability of findings to users of DMHIs in the community who may vary in terms of their motivations, engagement, and responses to these interventions. Qualitative research that specifically targets experiences of learning and applying skills from DMHIs among community users is needed.

1.6 The Present Thesis

This chapter highlights skill enactment as a key consideration for research on user engagement with DMHIs. However, despite the proposed importance of skill enactment, there is currently a lack of evidence on skill enactment in the context of DMHIs in general, and digital CBT programs specifically. Therefore, the overarching aim of this thesis is to contribute new knowledge regarding the role of skill enactment within digital CBT interventions for depression and anxiety. The scope of the thesis is limited to digital CBT-based interventions for depression and anxiety disorders due to their well-established efficacy in treating and preventing these conditions. Evidence presented in this chapter also suggests the importance of knowledge acquisition in facilitating effective skill enactment. Therefore, a secondary aim of this thesis is to improve understanding of the processes underpinning knowledge acquisition and its implications for both skill enactment and mental health outcomes. These aims are addressed across four discrete studies that examine skill enactment and knowledge acquisition across a range of populations, using various data sets

and methods, including narrative synthesis within a systematic review, quantitative and mixed methods analysis of data collected in trial settings, and qualitative exploration of experiences and perspectives among community users of digital CBT interventions.

The thesis begins with a systematic review (Chapter 2) of the evidence on skill enactment and knowledge acquisition in controlled trials of digital CBT interventions for depression and anxiety among adolescents (aged ≥12 years) and adults (Jackson et al., 2023a). The objective of this of this study is to examine measurement approaches, post-intervention changes in skill enactment and knowledge acquisition, associations between mental health outcomes and skill enactment or knowledge acquisition, and predictors of skill enactment and knowledge acquisition. An additional purpose of this review is to identify critical knowledge gaps to inform the development of the subsequent studies within the thesis.

In Chapter 3 (Jackson et al., 2023b), a secondary analysis of data from a cluster randomised controlled trial (cRCT) of a school-based online depression prevention program is presented. The objective of this study is to investigate predictors of skill enactment and its association with mental health outcomes and explore how predictors of skill enactment might differentially affect program usage indicators of engagement in an adolescent sample.

Chapter 4 (Jackson et al., 2024a) builds on the findings presented in Chapters 2 and 3 and uses a mixed-methods study embedded within an RCT to prospectively evaluate the effects of a brief video-based intervention on skill enactment among university students with mild to moderate psychological distress. Additionally, this study investigates the association between skill enactment and mental health outcomes and qualitatively explores student experiences of and motivations for implementing intervention skills.

Finally, Chapter 5 (Jackson et al., 2024b) extends the focus of the thesis beyond trial settings and reports results from a qualitative interview study conducted with community-based adults who have used publicly available digital CBT interventions. The objective of this study is to qualitatively explore user experiences of learning and implementing skills from digital CBT programs in everyday life, and investigate the perceived factors influencing their selection and enactment of skills.

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Chapter 2. Skill Enactment and Knowledge Acquisition in Digital Cognitive Behavioral Therapy for Depression and Anxiety: Systematic Review of Randomized Controlled Trials

2.1 Foreword

Chapter 1 provided an overview of the prevalence of depression and anxiety disorders among both adults and young people. It reviewed existing evidence on the effectiveness of face-to-face interventions for these conditions and identified structural and attitudinal barriers that impede access to these services. The chapter then explored the potential of DMHIs to improve access to evidence-based mental health care. However, it also highlighted challenges in facilitating engagement with these interventions, partly due to a lack of consensus on how to define and operationalise engagement. Importantly, despite extensive research on program usage as a proxy for engagement, there have been few studies and no systematic reviews specifically investigating skill enactment as an additional aspect of engagement in DMHIs. This represents a significant gap in the literature, as skill enactment is considered an important outcome in its own right and may be central to achieving therapeutic benefit in DMHIs. Additionally, Chapter 1 emphasised that knowledge acquisition may be a necessary condition for skill enactment. Yet research on knowledge acquisition following participation in DMHIs is limited, and no systematic review has specifically examined this in the context of digital CBT interventions. Accordingly, Chapter 2 presents the first systematic review to investigate skill enactment and knowledge acquisition during or following participation in digital CBT interventions targeting depression and anxiety. The review aimed to address the following objectives in trials of digital CBT interventions for depression and anxiety: (1) to investigate the methods used to measure skill enactment and knowledge acquisition, (2) to assess changes in skill enactment and knowledge acquisition at post-intervention measurement, (3) to examine whether mental health outcomes are associated with skill enactment and/or knowledge acquisition, and (4) to evaluate evidence for predictors of skill enactment and knowledge acquisition.

Review

Skill Enactment and Knowledge Acquisition in Digital Cognitive Behavioral Therapy for Depression and Anxiety: Systematic Review of Randomized Controlled Trials

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Abstract

Background: Digital cognitive behavioral therapy (CBT) interventions can effectively prevent and treat depression and anxiety, but engagement with these programs is often low. Although extensive research has evaluated program use as a proxy for engagement, the extent to which users acquire knowledge and enact skills from these programs has been largely overlooked.

Objective: This study aimed to investigate how skill enactment and knowledge acquisition have been measured, evaluate postintervention changes in skill enactment and knowledge acquisition, examine whether mental health outcomes are associated with skill enactment or knowledge acquisition, and evaluate predictors of skill enactment and knowledge acquisition.

Methods: PubMed, PsycINFO, and Cochrane CENTRAL were searched for randomized controlled trials (RCTs) published between January 2000 and July 2022. We included RCTs comparing digital CBT with any comparison group in adolescents or adults (aged ≥12 years) for anxiety or depression. Eligible studies reported quantitative measures of skill enactment or knowledge acquisition. The methodological quality of the studies was assessed using the Joanna Briggs Institute Critical Appraisal Checklist for RCTs. Narrative synthesis was used to address the review questions.

Results: In total, 43 papers were included, of which 29 (67%) reported a skill enactment measure and 15 (35%) reported a knowledge acquisition measure. Skill enactment was typically operationalized as the frequency of enacting skills using the completion of in-program activities (ie, formal skill enactment; 13/29, 45%) and intervention-specific (9/29, 31%) or standardized (8/29, 28%) questionnaires. Knowledge measures included tests of CBT knowledge (6/15, 40%) or mental health literacy (5/15, 33%) and self-report questionnaires (6/15, 40%). In total, 17 studies evaluated postintervention changes in skill enactment or knowledge acquisition, and findings were mostly significant for skill enactment (6/8, 75% of the studies), CBT knowledge (6/6, 100%), and mental health literacy (4/5, 80%). Of the 12 studies that evaluated the association between skill enactment and postintervention mental health outcomes, most reported ≥1 significant positive finding on standardized questionnaires (4/4, 100%), formal skill enactment indicators (5/7, 71%), or intervention-specific questionnaires (1/1, 100%). None of the 4 studies that evaluated the association between knowledge acquisition and primary mental health outcomes reported significant results. A total of 13 studies investigated predictors of skill enactment; only type of guidance and improvements in psychological variables were associated with increased skill enactment in ≥2 analyses. Predictors of knowledge acquisition were evaluated in 2 studies.

Conclusions: Digital CBT for depression and anxiety can improve skill enactment and knowledge acquisition. However, only skill enactment appears to be associated with mental health outcomes, which may depend on the type of measure examined. Additional research is needed to understand what types and levels of skill enactment and knowledge acquisition are most relevant for outcomes and identify predictors of these constructs.

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Trial Registration: PROSPERO CRD42021275270; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=275270

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KEYWORDS

cognitive behavioral therapy; technology; engagement; skill enactment; knowledge acquisition; depression; anxiety; adults; young people; systematic review; mobile phone

Introduction

Background

Depression and anxiety are common mental disorders [1,2], with estimated 1-year global prevalence rates ranging from 5% to 7% for major depressive disorder and 5% to 10% for anxiety disorders [3-5]. Despite the high level of burden associated with these disorders, many people do not seek professional help [6,7]. The provision of evidence-based digital mental health interventions (DMHIs) such as cognitive behavioral therapy (CBT) is proposed as a strategy to address this unmet need. Relative to in-person interventions, DMHIs can improve the reach and accessibility of care, are often available for free or at a lower cost, and may overcome several attitudinal barriers (eg, concerns about stigma and a preference for self-management) [8,9]. These programs also offer scalable solutions when traditional mental health services are displaced or demand for support increases, such as during public health crises [10]. Digital CBT programs deliver cognitive and behavioral skills and information via websites, smartphone apps, virtual reality, video games, or conversational agents [11]. There is considerable evidence showing that guided and unguided digital CBT can be effective in preventing and treating symptoms of depression and anxiety in adults [12-14] and young people [15,16].

Despite the promise of DMHIs, limited or low engagement with these programs is common. A systematic review of self-guided interventions for depression (most of which were based on CBT) found that >80% of research trial participants failed to complete all intervention modules, and only approximately 40% completed half of all modules [17]. Engagement with these programs in community settings is often much lower [18,19] as research trials typically recruit motivated participants, include human contact, and use explicit assessment procedures. Developing a better understanding of program engagement represents an important goal for research on DMHIs as there is meta-analytic evidence indicating that greater engagement is associated with better postintervention mental health outcomes [20,21]. However, notably, there is also limited evidence regarding what level of engagement, or dosage, is sufficient to achieve the intended outcomes [22], and some studies have demonstrated that outcomes are not always linearly related to engagement [23]. Nevertheless, research aimed at identifying the characteristics of individuals and interventions that influence engagement may enable the targeted development of strategies to facilitate engagement.

However, challenges remain regarding how to define and measure engagement with DMHIs [22]. Beintner et al [24] found that a range of indicators can be used to quantify engagement or adherence, the most common of which include indicators of module progression (eg, the percentage of participants completing a full intervention or completion of a minimum number of modules), log-ins, and time spent using the program. These metrics capture the extent to which individuals are exposed to intervention materials or progress through an intervention but may not elucidate engagement with other relevant behaviors that may also be important for mental health outcomes (eg, enactment of skills or accessing crisis support) [25]. Accordingly, there is current evidence suggesting that, although improvements in mental health outcomes are modestly associated with the number of modules accessed, they may not be associated with other use indicators [21,22]. The limitations of existing program use measures are further reinforced by observations that some individuals do not need to complete a full intervention to achieve symptom benefits (ie, e-attainers or early completers) [26,27].

Skill Enactment and Knowledge Acquisition

Recognizing the need to improve how engagement with DMHIs is measured and reported, recent recommendations have proposed the use of multiple approaches [24,25,28], with a particular focus on measures that may be more indicative of effective engagement (ie, engagement necessary to produce outcomes) [29]. Evaluating whether individuals implement the strategies and techniques they have learned from a DMHI in their daily lives (hereafter referred to as skill enactment) may be especially important [30]. For example, Donkin et al [31] recommended using measures to assess the real-world implementation of skills taught during web-based interventions and suggested that this may be central to understanding the impact of engagement on mental health outcomes. Similar recommendations were provided in at least 3 subsequent reviews [24,25,28].

The importance of skill enactment for positive outcomes has also been instantiated in several frameworks of engagement with face-to-face and digital health interventions [32-34], which broadly correspond to some cognitive behavioral theories of the mechanisms of action in CBT [35,36]. These frameworks generally characterize enacting skills as an important causal mechanism by which interventions produce outcomes and, in particular, that program use (or attendance at in-person sessions) results in improvements in relevant health or mental health outcomes when an individual implements the strategies taught in a program effectively [32-34]. The literature on CBT skill use and emotion regulation extends this idea, suggesting that improvements in outcomes may occur through improvement in one of several skill enactment domains, including the frequency (ie, how often a person uses skills, regardless of the skill type), quantity (ie, the range of strategies used), or quality (ie, how well a person enacts skills in line with how they were taught) of skill enactment [35,37]. A further distinction is made between

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formal skill enactment (eg, completing a thought record) and informal skill enactment (eg, briefly reviewing the evidence against a negative automatic thought) [35]. However, questions remain regarding how program participation can produce changes in skill enactment and what factors might affect this process.

A factor that has been suggested to be important for both skill enactment and mental health outcomes is the acquisition of knowledge about mental health and awareness of strategies to address symptoms (hereafter referred to as knowledge acquisition) [33,38]. In comprehensive CBT interventions for depression and anxiety, psychoeducational components in the form of text, video, or audio tutorials are usually introduced early in the intervention process to improve knowledge and understanding of the signs and symptoms of depressive or anxiety disorders. Psychoeducation may help improve an individual's ability to recognize and appropriately manage symptoms of depression or anxiety and has been shown to result in small improvements in symptoms even in the absence of other strategies [39]. In addition, information and instructions on the rationale for CBT and strategies for actively managing symptoms (eg, cognitive restructuring and behavioral activation) are provided throughout an intervention. If an individual does not acquire or understand the information related to these strategies, effective implementation and, thus, improvement in mental health outcomes are unlikely [38,40].

Although there is robust evidence for the effectiveness of digital CBT and the logical and theoretical importance of knowledge acquisition and skill enactment in achieving these outcomes, little is known about whether users acquire knowledge or enact skills from these interventions. Consequently, it is unclear whether skill enactment and knowledge acquisition are important for mental health outcomes or which factors influence skill enactment and knowledge acquisition. Although several reviews have investigated the predictors and outcomes of engagement or adherence [17,21,22,41,42], these studies have focused predominantly on indicators of program use (eg, module completion). Some reviews have also been conducted to evaluate the effectiveness of digital interventions in improving mental health literacy and its impact on mental health–related outcomes [43-45]. However, these previous reviews have not examined specialized knowledge acquired during participation in digital CBT interventions. Moreover, it is also important to examine how skill enactment and knowledge acquisition have been measured and reported in the literature to examine the extent to which measurement approaches align with theoretical conceptualizations of these concepts and to identify recommendations for future research on engagement with DMHIs.

This Review

This systematic review builds on previous reviews by investigating skill enactment as a component of engagement with digital CBT interventions for depression and anxiety. Although we focused on skill enactment, the review adhered to a broader definition of engagement that includes initial uptake, ongoing use of a program, and enactment of skills in everyday life [33]. Given that knowledge acquisition is proposed to be essential for the enactment of skills and may itself be an important determinant of outcomes, we also reported data on knowledge acquisition as a secondary objective. Our specific review questions were as follows: (1) What methods have been used to measure skill enactment and knowledge acquisition in randomized controlled trials (RCTs) of digital CBT interventions for depression and anxiety? (2) Are digital CBT programs effective in improving skill enactment and knowledge acquisition? (3) Is there an association between mental health outcomes and skill enactment or knowledge acquisition? and (4) What predictors of skill enactment and knowledge acquisition have been identified?

Methods

Protocol

This review was reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [46] (refer to Multimedia Appendix 1 [46] for a PRISMA checklist) and was prospectively registered in PROSPERO (registration CRD42021275270). The review team originally intended to investigate skill enactment and knowledge acquisition in technology-based skills training interventions for depression and anxiety from any therapeutic orientation. However, we subsequently limited the scope of the review to digital CBT programs to facilitate comparisons across studies and because of the established evidence base for CBT in the treatment of depression and anxiety [16,47]. We added a criterion to exclude studies targeting people with physical illnesses given the potential for these programs to target specific types of knowledge and skills associated with the target condition. These decisions were made before the completion of screening and were added to the registered protocol as an amendment on March 24, 2022. No other substantive changes were made to the original protocol.

Search Strategy

We searched the Cochrane CENTRAL, PubMed, and PsycINFO databases for peer-reviewed articles published between January 1, 2000, and July 26, 2022. The start date was selected to coincide with the publication of RCTs related to the first digital interventions for depression and anxiety [48,49]. The search strategy used combinations of relevant Medical Subject Heading terms and keywords for "technology-based intervention," "randomized controlled trial," and "depression" or "anxiety." The full search strategy for each database is provided in Multimedia Appendix 2. Searches were rerun before final analyses. In addition, we supplemented the electronic search with forward citation searching of published self-report measures of CBT skill use to identify studies that may have been missed in the text-based searches. Citation searching is an effective way to retrieve studies when central concepts are difficult to capture using keyword searches [50]. Forward searching was carried out in Scopus on July 26, 2022, and included the following skill use measures: the Behavioral Activation for Depression Scale [51] and its short form [52], Cognitive Behavioral Therapy Skills Questionnaire [53], Skills of Cognitive Therapy [54], Competencies of Cognitive Therapy

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Scale [55], Frequency of Actions and Thoughts Scale [56], and Ways of Responding Scale [57].

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were developed using the participants, intervention, comparator, outcome, and study design framework [58]. Only peer-reviewed articles published in English between 2000 and 2022 were included in this review.

Participants

Studies targeting adolescent or adult samples with a mean age of ≥12 years were eligible for inclusion. Articles were excluded if the mean age of the sample was <12 years or if the study primarily targeted people with a physical health condition. Primary studies were not required to screen participants for the presence of elevated anxiety or depressive symptoms to be eligible for inclusion given evidence that prevention programs can result in symptom improvements among people who do not have clinical levels of depression or anxiety [59,60].

Intervention

Articles were eligible for inclusion if they tested a stand-alone CBT intervention delivered via a digital platform that was designed to reduce or prevent symptoms of depression or anxiety. Interventions were classified as CBT if they were described as such by the study authors and included cognitive restructuring as a core component. Interventions could be delivered with or without guidance. Articles were excluded if the intervention (1) was not CBT (eg, behavioral activation, acceptance and commitment therapy, or cognitive behavioral stress management), (2) did not include depression or anxiety as the main intervention target (eg, a program that primarily focused on chronic pain but also included a depression outcome), (3) used technology but was delivered at a clinic or in the laboratory (ie, not a distal intervention), (4) was delivered as part of stepped care or as adjunctive therapy, or (5) was primarily delivered by a health professional in person or via videoconference or email (eg, the main intervention was in person, but an SMS text message component was included).

Comparator

Eligible interventions could be compared with an active (eg, other intervention or attention placebo) or inactive (eg, waitlist or no-intervention) control group. Uncontrolled studies were excluded.

Outcomes of Interest

Articles were included if they reported a quantitative measure of skill enactment or knowledge acquisition. The selection of eligible measures for this review was based on definitions provided within existing engagement frameworks [33,34]. In terms of skill enactment, articles were eligible for inclusion if they (1) included a measure designed to assess the implementation of treatment strategies and techniques (eg, self-reported frequency of practicing cognitive and behavioral skills) or (2) captured data on the practice of techniques and strategies within the intervention program (eg, thought record completion or tracking of exposures conducted in reality). We excluded general measures of coping, emotion regulation, and self-efficacy as these measures do not specifically target CBT skills and may include concepts and strategies not targeted for change in CBT [35]. We also excluded papers that only reported indicators of active engagement (eg, the number of program activities, exercises, or tools used) as these measures do not provide direct information on skill enactment.

Regarding knowledge acquisition, articles were eligible for inclusion if they reported a measure of (1) actual learning via a knowledge test or (2) self-reported learning. For this review, measures of general mental health literacy (ie, measures targeting awareness of the causes, epidemiology, symptoms, diagnosis, and treatment of mental disorders [61]) were included in addition to measures explicitly aimed at assessing knowledge of CBT principles, as CBT programs typically include psychoeducational content aimed at increasing knowledge and understanding. Indicators of program satisfaction or acceptability (eg, how understandable an intervention was) and treatment self-efficacy (eg, confidence or perceived ability to learn intervention content) were excluded.

Study Design

Primary and secondary reports of RCTs were eligible for inclusion. Cluster and factorial designs were eligible for inclusion, as were pilot and feasibility trials. Non-RCTs and observational studies (eg, cross-sectional, cohort, and case-control designs) were excluded.

Study Selection

The search results were uploaded to EndNote (version 20; Clarivate Analytics), and duplicate records were removed automatically and through hand searching. Study selection was completed in 3 stages. At stage 1, titles and abstracts were screened by 1 of 2 reviewers (HJ or AT) and discussed with the last author (LF) to exclude irrelevant records. A third reviewer (GF) screened 10% of the abstracts to confirm that the review criteria had been applied consistently (percentage of agreement=99.6%; Cohen κ=0.97). At stage 2, full-text articles were uploaded to the Covidence systematic review software (Veritas Health Innovation) and coded by the first author (HJ) according to whether the studies (1) evaluated a CBT-based program and (2) reported a measure of skill enactment or knowledge acquisition (“yes,” “no,” or “unclear”). Relevant construct definitions and inclusion criteria were piloted with 50 full-text articles and refined through discussion within the review team before completion of this stage. A second reviewer screened 10% of the full-text articles to check for coder bias at stage 2, which did not result in the inclusion of any additional manuscripts (percentage of agreement=98.4%; Cohen κ=0.90). At stage 3, all articles coded as “yes” or “unclear” were referred to a third stage for double screening by 2 reviewers (HJ and GF) against all inclusion criteria. Discrepancies were resolved through discussion, and a third author (LF) was consulted if an agreement could not be reached.

Data Extraction and Coding

A data extraction form was developed in Microsoft Excel (Microsoft Corp) and pilot-tested on 5 papers. Data extraction was completed by the first author (HJ), and accuracy was confirmed by a second author (GF). The key data elements extracted included skill enactment and knowledge acquisition

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data to address the objectives of the review (described in the *Strategy for Data Synthesis* section). In addition, we extracted the following descriptive data: country where the study was conducted, study design and type of comparison, participant characteristics and recruitment setting, intervention details and the type of technology, the length of the treatment period and intervention structure, the presence of guidance, and adherence or use data. We only extracted information for eligible interventions, and data for all eligible interventions were extracted if more than one eligible intervention was evaluated in the study. We accessed and cited primary reports or protocol papers to retrieve information if relevant data were not available in the paper under review.

The presence of guidance was categorized as guided (support related to treatment content was provided), unguided (no support related to treatment content provided), or supported (support was provided by educational staff for interventions delivered in educational settings, but this support was not related to treatment content). We included a *supported* category as interventions delivered in school settings involve a captive audience. Studies were also categorized according to the age group of the sample. Age classifications were established based on the mean age of the trial sample and included adolescents (aged 12-17 years), young adults (aged 18-24 years), and adults (aged ≥25 years). These classifications are consistent with the age categorizations used by the Australian Institute of Health and Welfare [62] and the legal age in Australia.

Risk of Bias

The methodological quality of the included studies was independently assessed by 2 reviewers (HJ and LF) using the Joanna Briggs Institute Critical Appraisal Checklist for RCTs [63]. The checklist includes 13 items to evaluate randomization procedures, allocation concealment, selection bias, blinding, postassignment attrition, outcome measurement, and appropriateness of the statistical analyses and trial design. Items were scored as “Yes,” “No,” “Unclear,” or “Not applicable” according to the guidelines provided by Tufanaru et al [63]. For secondary reports, we referred to primary outcome papers to obtain ratings where necessary. Disagreements between reviewers were resolved through discussion until a consensus was reached. A score of 1 was awarded for each item adequately addressed in the paper, with possible scores ranging from 0 to 13.

Strategy for Data Synthesis

The studies were not pooled for meta-analysis because of methodological diversity related to the measurement tools used to evaluate skill enactment and knowledge acquisition, as well as the use of different statistical approaches to determine the associations among skill enactment, knowledge acquisition, and mental health outcomes. Instead, descriptive narrative synthesis was conducted to address the review questions per our PROSPERO registration (CRD42021275270). All eligible measures of skill enactment and knowledge acquisition were recorded and tabulated, with tables ordered by symptoms or disorder targeted. In addition, we recorded any data on change in skill enactment or knowledge acquisition outcomes at postintervention measurement or follow-up (eg, between- or within-group comparisons or assessments of self-reported skill practice or learning), any analysis of the association between skill enactment or knowledge acquisition and primary or secondary mental health outcomes (eg, via correlation, regression, or mediation analyses), and any investigation of potential predictors of skill enactment or knowledge acquisition (eg, via regression or between-group analyses).

Definitions provided in the literature on CBT skill use [35], knowledge [64,65], and DMHI engagement [24] and information provided by the study authors were used to classify and summarize methods of measuring skill enactment and knowledge acquisition (review question 1). These classifications were used to group studies to address the subsequent review questions. Descriptive information regarding whether the study reported a significant between- or within-group effect for skill enactment or knowledge acquisition at postintervention measurement was reported to examine the effectiveness of digital CBT programs in improving skill enactment and knowledge acquisition (review question 2). Between-group analyses comparing intervention and control conditions within studies were prioritized in reporting as they provide greater certainty regarding the relationship between intervention exposure and subsequent skill enactment or knowledge change. Where possible, effect sizes using the pretest n value were calculated as the mean difference between treatment and control groups at postintervention measurement or follow-up divided by the pooled SD of the baseline scores. All estimates were adjusted using a Hedges *g* correction [66]. Consistent with Luo et al [67], imputed data values were used if both complete case and imputed values were provided. Negative effect sizes indicated that the comparison group performed better than the treatment group on skill enactment or knowledge acquisition.

Significant and nonsignificant findings were also summarized to examine the association between mental health outcomes and skill enactment or knowledge acquisition (review question 3) and investigate predictors of skill enactment or knowledge acquisition (review question 4). Predictor variables could include participant characteristics (eg, age and sex), disease-specific effects (eg, baseline symptom levels), intervention characteristics (eg, presence of guidance), and components of intervention engagement (eg, module completion). Previous systematic reviews of predictors of adherence or engagement [68] were used to establish broad categories of predictors. For each synthesis, all indicators of skill enactment or knowledge acquisition were summarized if multiple indicators were reported in the study. For studies reporting both intention-to-treat (ITT) and completer analyses, only ITT results were reported. In addition, if studies reported results for subscale scores in addition to total scores on skill enactment or knowledge acquisition measures, we only reported total scores to aid interpretation of the results, although changes in subscales are noted in Multimedia Appendix 3 [36,61,64,69-114]. Relevant results for follow-up time points are also summarized in Multimedia Appendix 3.

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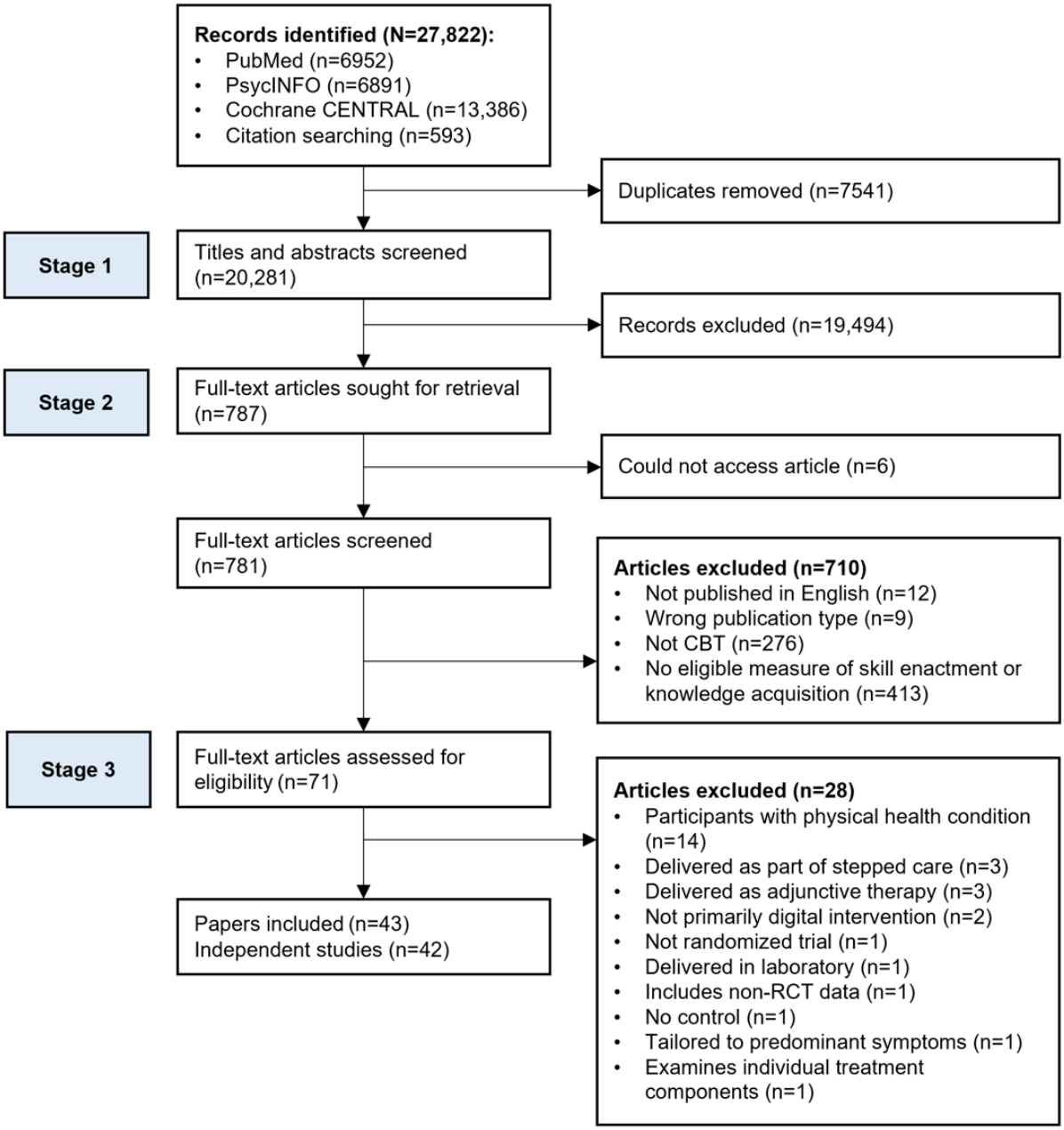
Results

Study Selection Process

A total of 27,822 records were retrieved from the database and forward citation searches. After removing duplicates, 20,281 titles and abstracts were screened. Full texts were retrieved for 781 articles, and 43 (5.5%) papers [36,61,64,69-108] were included in the review (Figure 1). A study that appeared to meet the inclusion criteria was excluded as the trial was designed to test individual treatment components rather than an entire program of treatment, resulting in a 32-condition design [115]. On 2 occasions, more than one paper was published from a single trial, and both provided data on our outcomes of interest [89,90,101,102]. These manuscripts are reported together to describe study characteristics. In addition, one of these papers included 2 distinct trials [101]. These trials are reported separately. Therefore, 42 independent studies (reported in 43 papers) were included in the review.

Figure 1. Flow diagram of study screening and inclusion. CBT: cognitive behavioral therapy; RCT: randomized controlled trial.



Study Characteristics

Study characteristics and outcomes of the review are reported in Multimedia Appendix 3. The studies were conducted in Europe (16/42, 38%), Australia (13/42, 31%), the United States (10/42, 24%), and Asia (3/42, 7%). Most studies (38/42, 90%) were parallel RCTs, although 5% (2/42) were cluster RCTs, 2% (1/42) were factorial design studies, and 2% (1/42) were described as intervention studies. Control groups were classified as waitlist (14/42, 33%), usual care (5/42, 12%), attention control (4/42, 10%), or enhanced usual care (2/42, 5%). In 21% (9/42) of the studies, participants were assigned to a waitlist

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control group but also received access to usual care, attention control materials, enhanced usual care, or a web-based discussion group. A total of 19% (8/42) of the studies compared ≥2 active treatments only.

Sample Characteristics

A total of 10,078 participants were included in the 42 studies (ie, the number analyzed). Among the 41 studies that reported the number of participants by group assignment, 5881 participants received a stand-alone digital CBT intervention. The sample sizes ranged from 43 to 1236 (mean 239.95, SD 278.91; median 149.50). Most studies (30/42, 71%) recruited participants from the community, although 14% (6/42) recruited from educational settings, 10% (4/42) recruited from health care settings, and 5% (2/42) recruited from occupational settings. Studies (36/42, 86%) were typically conducted with adults, although 10% (4/42) included adolescents, and 5% (2/42) included young adults. Among the 31 studies where the mean age of the total sample was reported, the mean participant age ranged from 15.00 to 51.60 years (mean 31.90, SD 8.21 years). The proportion of female participants in the study samples ranged from 16.1% to 100% (median 76.59%), and 17% (7/42) of the studies included only female or pregnant participants, all of which focused on maternal or perinatal mental health.

Intervention Characteristics

Symptoms or Disorders Targeted

Studies were categorized according to the symptoms or disorders targeted, as specified by the study authors. The most common conditions or symptoms targeted were depression (14/42, 33%), social anxiety (9/42, 21%), or depression and anxiety (5/42, 12%). Other symptoms or disorders targeted included panic disorder and agoraphobia (3/42, 7%), postnatal depression (3/42, 7%), perinatal anxiety and depression (2/42, 5%), and anxiety (1/42, 2%). A total of 12% (5/42) of the interventions targeted multiple mental health concerns. Almost half (19/42, 45%) of the trials focused on symptom reduction (ie, the study screened for and targeted individuals with elevated symptom levels not yet meeting diagnostic criteria), 38% (16/42) focused on treatment (ie, the study screened for and targeted individuals meeting diagnostic criteria for a depressive or anxiety disorder), and 17% (7/42) focused on prevention (ie, the study did not screen participants for elevated symptom levels). A total of 57 eligible interventions were tested in the 42 studies.

Type of Technology

Most studies (33/42, 79%) evaluated internet-based interventions, with access primarily provided via a computer. The remaining studies tested smartphone apps (3/42, 7%), internet-based programs with an adjunct smartphone app (2/42, 5%), a computerized intervention (delivered via CD-ROM; 1/42, 2%), a conversational agent (1/42, 2%), a multiplatform intervention (1/42, 2%), and an internet-based intervention delivered via a smartphone app versus a computer (1/42, 2%).

Presence of Guidance

A nearly equal number of studies evaluated only guided (19/42, 45%) or unguided (17/42, 40%) interventions, and 5% (2/42) of the studies tested supported interventions (self-guided interventions delivered in a supported environment such as a classroom). In addition, 5% (2/42) of the studies compared digital CBT delivered with and without guidance, 2% (1/42) compared digital CBT delivered with different types of guidance, and another study (1/42, 2%) tested unguided digital CBT compared with 2 types of guidance.

Intervention Length

Intervention length ranged from 2 weeks to 4 months (mean 8.21, SD 3.78; median 8.00). Among the 34 studies that specified the number of modules or sessions, the number of core modules ranged from 3 to 17 (mean 7.21, SD 2.46; median 7.50).

Methodological Quality of the Included Studies

The number of studies that satisfied each of the quality items is shown in Table 1, and full information is provided in Multimedia Appendix 4 [36,61,64,69-108,116]. Overall, the quality of the included studies was good, with most studies (36/42, 86%) meeting ≥8 criteria (mean 8.81, SD 1.31). Most studies described adequate randomization (31/42, 74%) and allocation concealment procedures (33/42, 79%). The treatment groups were typically similar at baseline, or the subsequent analyses clearly accounted for any observed differences. Blinding was the primary issue in the included studies, with no study meeting the blinding of participants or blinding of outcome assessors criteria as all included participant-reported scales. In addition, only approximately one-third (15/42, 36%) of the studies met the blinding of those delivering treatment criterion as they evaluated unguided interventions. All studies (42/42, 100%) treated compared groups identically and measured outcomes in the same way across the groups. Most studies (33/42, 79%) reported incomplete follow-up, although patterns of loss to follow-up were generally adequately described and analyzed, and most studies (35/42, 83%) used ITT analyses. Despite all studies using validated outcome measures, close to half (22/42, 52%) did not provide clear information to determine whether outcomes were measured reliably in the study. Most studies (39/42, 93%) described appropriate statistical procedures, and the trial design was considered appropriate in all studies, with 2/2 (100%) of cluster RCTs using analytical techniques to account for clustering in the analyses.

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Table 1. Number (and percentage) of the included studies meeting the criteria on the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Randomized Controlled Trials (n=42).

Item number	JBI checklist item	Studies, n (%)
1	True randomization	31 (74)
2	Allocation concealment	33 (79)
3	Treatment groups similar at baseline[a]	36 (86)
4	Participants blind to treatment assignment	0 (0)
5	Those delivering the intervention blind to treatment assignment[b]	15 (36)
6	Outcome assessors blind to treatment assignment	0 (0)
7	Treatment groups treated identically	42 (100)
8	Follow-up complete or differences between groups adequately described and analyzed	33 (79)
9	Participants analyzed in the groups to which they were randomized	35 (83)
10	Outcomes measured in the same way for treatment groups	42 (100)
11	Outcomes measured reliably	22 (52)
12	Appropriate statistical analysis	39 (93)
13	Appropriate trial design and any deviations accounted for	42 (100)

[a]In 26% (11/42) of the studies, observed differences between treatment groups were accounted for in the analyses.

[b]Studies testing unguided programs wherein treatment was delivered entirely on the web met this criterion by default.

Studies Reporting a Measure of Skill Enactment or Knowledge Acquisition

Of the 43 papers, 28 (65%) reported ≥1 measure of skill enactment [36,74,77-82,84,85,88,90,92-106,108], fourteen (33%) reported ≥1 measure of knowledge acquisition [61,64,69-73,75,83,86,87,89,91,107], and 1 (2%) reported a measure of both skill enactment and knowledge acquisition [76].

Of the 29 studies reporting a measure of skill enactment, 26 (90%) were conducted with adults, 2 (7%) were conducted with adolescents, and 1 (3%) was conducted with young adults. The studies evaluated guided (15/29, 52%), unguided (10/29, 34%), or supported (2/29, 7%) interventions, and 7% (2/29) compared ≥1 guided and unguided intervention.

Of the 15 studies reporting a measure of knowledge acquisition, most (n=11, 73%) were conducted with adults, although 3 (20%) included adolescent samples, and 1 (7%) included a young adult sample. The studies evaluated guided (5/15, 33%), unguided (8/15, 53%), or supported (1/15, 7%) interventions, and 7% (1/15) compared guided and unguided interventions.

Review Question 1: What Methods Have Been Used to Measure Skill Enactment and Knowledge Acquisition?

Skill Enactment

The methods used to measure skill enactment varied across the studies. These included formal skill enactment measures captured via log data (13/29, 45%) and standardized (8/29, 28%) or intervention-specific (9/29, 31%) questionnaire measures. Among the studies reporting an indicator of formal skill enactment, most targeted social anxiety (7/13, 54%) or panic disorder and agoraphobia (2/13, 15%). Of the studies reporting a standardized or intervention-specific questionnaire, studies typically evaluated interventions for depression (7/17, 41%), perinatal mental health (4/17, 24%), or depression and anxiety (2/17, 12%). Regardless of the measure used, skill enactment was assessed as frequency (eg, how often a person performed skills over the past week or the number of in-program activities completed) or time spent practicing skills in all studies except 1 (28/29, 97%), which also assessed quality of skill enactment. See Table 2 for a breakdown of the specific ways in which skill enactment was measured in the included studies.

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Table 2. Summary of methods used to investigate skill enactment in the included studies (n=29).

Type of skill enactment measure and measure of skill enactment	Times reported[a], n (%)
Formal skill enactment	
Tracked exposures	7 (24)
Cognitive restructuring exercises	6 (21)
Anxiety diaries	4 (14)
Activity planning	2 (7)
Behavioral experiments	2 (7)
Attentional training exercises	1 (3)
Relaxation exercises	2 (7)
Global indicators	4 (14)
Standardized questionnaire[b]	
Behavioral activation skills	6 (21)
Cognitive skills	1 (3)
Cognitive and behavioral skills	2 (7)
Intervention-specific questionnaire[b]	
Time spent practicing skills (single item)	5 (17)
Frequency of practicing skills (single item)	2 (7)
Frequency of practicing specific skills (multi-item)	3 (10)
Successful use of skills[c]	1 (3)

[a]Numbers do not add up to 29 as some studies include more than one indicator of skill enactment.

[b]All standardized and intervention-specific questionnaires relied on participant self-reports unless otherwise stated.

[c]On the basis of coach reports.

Knowledge Acquisition

Methods used to measure knowledge acquisition included objective tests (9/15, 60%) designed to measure declarative knowledge about CBT principles or mental health literacy, as well as questionnaire measures (6/15, 40%) to assess perceived learning or knowledge. Studies that reported a measure of knowledge acquisition typically targeted symptoms of depression (8/15, 53%) or anxiety and depression (2/15, 13%). Table 3 provides a breakdown of the ways in which knowledge acquisition was measured in the included studies.

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Table 3. Summary of methods used to investigate knowledge acquisition in the included studies (n=15).

Type of knowledge acquisition measure and measure of knowledge acquisition[a]	Times reported[b], n (%)
CBT[c] knowledge test	
Multiple-choice items[d]	3 (20)
True-or-false items	2 (13)
Multiple-choice + true-or-false items[d]	1 (7)
Mental health literacy test	
Multiple-choice items	1 (7)
True-or-false items	1 (7)
Helpfulness ratings	1 (7)
Multiple-choice items + helpfulness ratings	1 (7)
True-or-false items + vignettes	1 (7)
Questionnaire measure	
Perceived learning (single item)	4 (27)
Perceived knowledge of specific treatment components (multi-item)	2 (13)

[a]Knowledge tests and questionnaire measures were completed by the participants in all studies.

[b]Numbers do not add up to 15 as some studies include more than one measure of knowledge acquisition.

[c]CBT: cognitive behavioral therapy.

[d]In addition to the total number of correct answers, 50% (3/6) of the studies reporting CBT knowledge tests reported weighted scores based on the level of certainty associated with a given response.

Review Question 2: Are Digital CBT Programs Effective in Improving Skill Enactment and Knowledge Acquisition?

Skill Enactment

A total of 8 studies evaluated skill enactment from baseline to postintervention measurement, all of which used standardized questionnaire measures to assess the frequency of enacting skills. Of these 8 studies, 6 (75%) reported significant findings in favor of the intervention group at postintervention measurement [36,76,84,94,101], whereas 2 (25%) did not [95,98]. Significant findings were reported for 4 (80%) out of 5 studies that evaluated interventions for symptoms of depression, 1 (50%) out of 2 studies that evaluated interventions for postnatal depression, and 1 study that evaluated an intervention for symptoms of anxiety and depression. The Hedges *g* ranged from 0.09 to 2.08 (median 0.76). Effect sizes could not be calculated for 1 study because of insufficient data regarding the direction of the effect [95].

Knowledge Acquisition

A total of 10 studies evaluated knowledge acquisition from baseline to postintervention measurement. The results are grouped by type of knowledge measure.

CBT Knowledge

A total of 6 studies on 10 eligible interventions examined whether CBT knowledge improved at postintervention measurement, and all (6/6, 100%) reported significant improvements across all eligible interventions using between-group [61,64,69,73,76] or within-group analyses [72]. The studies evaluated interventions targeting symptoms of depression (n=4), social anxiety (n=1), or anxiety and depression (n=1). For studies with available data (4/6, 67%), the Hedges *g* ranged from 0.17 to 0.74 (median 0.67). Effect sizes could not be calculated for 2 studies because of insufficient data or a lack of a control condition [64,72].

Mental Health Literacy

A total of 5 studies on 7 eligible interventions examined whether mental health literacy improved at postintervention measurement. Of these 5 studies, 2 (40%) reported significant findings in favor of the intervention group at postintervention measurement across all eligible interventions [75,91], 2 (40%) reported mixed findings (where significant findings were associated with some but not all interventions or measures of literacy) [61,64], and 1 (20%) reported no significant findings [70]. Significant or mixed findings were reported for 3 studies that evaluated interventions for symptoms of depression and 1 study for stress, depression, anxiety, and substance abuse. Nonsignificant findings were reported in 1 study, which targeted anxiety, depression, and well-being. The Hedges *g* ranged from −0.17 to 0.92 (median 0.07). Effect sizes could not be calculated for 1 study because of insufficient data [64].

Self-reported Knowledge Acquisition

A total of 2 studies examined whether self-reported knowledge improved at postintervention measurement, with 1 (50%) reporting significant findings in favor of the intervention group across all learning areas [86], whereas the other (n=1, 50%) found no significant change [87]. Both studies evaluated interventions for symptoms of depression. The Hedges *g* ranged from −0.03 to 0.49 (median 0.32).

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Review Question 3: Is There an Association Between Mental Health Outcomes and Skill Enactment or Knowledge Acquisition?

Skill Enactment

A total of 12 studies evaluated the relationship between skill enactment and postintervention mental health outcomes, of which most (n=7, 58%) examined indicators of formal skill enactment and all but 2 (17%) were conducted with adult samples. The results in the following sections are grouped by type of skill enactment measure.

Standardized Questionnaire Measures

Four studies examined whether frequency of skill enactment mediated the effect of the intervention on postintervention mental health outcomes using standardized questionnaire measures. Of these 4 studies, 3 (75%) found that skill enactment significantly mediated improvements in mental health outcomes at postintervention measurement [36,101], and 1 (25%) found that frequency of enacting cognitive but not behavioral activation skills mediated subsequent change in mental health outcomes [84]. All 4 studies investigated reductions in depressive symptoms, with 1 study also investigating improvements in anxiety and life satisfaction.

Formal Skill Enactment Measures

A total of 7 studies on 11 eligible interventions investigated the association between indicators of formal skill enactment and mental health outcomes at postintervention measurement. As some studies included multiple analyses (eg, multiple skill enactment measures investigated or >1 eligible intervention evaluated), results are organized around the specific measure used to predict mental health outcomes and summarized in terms of the number of analyses. We focus on indicators showing significant results in ≥2 analyses, although Table 4 summarizes all analyses.

Table 4. Summary of formal skill enactment indicators used to predict postintervention mental health outcomes (n=7).

Formal skill enactment indicator	Studies[a], n/N (%)	Positive analyses[b], n/N (%)
Tracked exposures	3/3 (100)	4/5 (80)
Global indicator	2/3 (67)	2/5 (40)
Cognitive restructuring exercises[c]	1/4 (25)	1/6 (17)
Anxiety diaries	1/2 (50)	1/4 (25)
Activity planning	0/1 (0)	0/1 (0)
Relaxation tools	0/2 (0)	0/3 (0)

[a]Number of studies reporting ≥1 significant positive associations between a formal skill enactment indicator and mental health outcomes over the total number of studies investigating that indicator.

[b]Number of analyses reporting a significant positive association between a formal skill enactment indicator and mental health outcomes over the total number of analyses.

[c]One analysis showed a negative association between cognitive restructuring exercises and improvement in stress at postintervention measurement, although this indicator was associated with significant improvements in anxiety and stress at follow-up.

Overall, at least one positive finding was reported in 71% (5/7) of the studies. However, only the number of exposure exercises completed (4/5, 80% of analyses in 3/3, 100% of the studies) and global indicators (2/5, 40% of analyses in 2/3, 67% of the studies) were positively associated with improvement in mental health outcomes at postintervention measurement in ≥2 analyses. At least 1 significant positive finding was reported in each of the 4 studies evaluating improvements in social anxiety symptoms [77,79,100,105] and in 1 study evaluating improvements in depression, anxiety, and stress [85]. Nonsignificant or negative findings were reported in studies evaluating improvements in depression [108] or anxiety, depression, and stress [96]. A total of 1 study provided insufficient detail to determine the exact number of significant analyses [74] and was excluded from the synthesis.

Intervention-Specific Questionnaire

A total of 1 study examined whether frequency of enacting intervention-specific skills was associated with improvement in mental health outcomes at postintervention measurement. Results were largely nonsignificant; skill enactment was associated with improvements in support-seeking coping but not in depression, anxiety, well-being, or emotion regulation [90].

Knowledge Acquisition

A total of 4 studies evaluated the association between knowledge acquisition and mental health outcomes at postintervention measurement. The results in the following sections are grouped by type of knowledge measure.

CBT Knowledge

A total of 3 studies on 6 eligible interventions examined whether CBT knowledge acquisition was associated with improvement in mental health outcomes at postintervention measurement. None of the studies reported significant findings for the primary outcomes of depression (n=2), anxiety (n=1), or social anxiety (n=1) [69,72,73], although 1 study reported a small significant correlation between knowledge acquisition and improvement in the secondary outcome of social anxiety [69].

Mental Health Literacy

A total of 1 study on 2 eligible interventions investigated whether improvements in mental health literacy were associated with the primary outcomes of depression, anxiety, and mental

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well-being at postintervention measurement, with no significant findings reported [70].

Review Question 4: What Predictors of Skill Enactment and Knowledge Acquisition Have Been Identified?

Skill Enactment

Overview

In total, 13 studies investigated potential predictors of frequency or time spent using skills, of which 6 (46%) examined formal skill enactment measures, 4 (31%) examined intervention-specific questionnaires, and 3 (23%) examined standardized questionnaire measures. The results in the following sections are grouped according to type of predictor and focus on significant findings. As with review question 3, the results are reported in terms of the number of studies and analyses.

Intervention Content

In total, 2/13 (15%) studies examined whether factors related to intervention content were associated with time spent using skills (ie, CBT with or without exposure and CBT with or without mindfulness), and the results were not significant [88,99].

Intervention Features

A total of 2/13 (15%) studies on 4 eligible interventions examined whether the presence of specific intervention features was associated with frequency of enacting skills, and there were mixed results. The delivery of an adjunct skills-based app during an internet-based intervention (compared with sequential delivery of the same app; 1/1, 100% of the analyses) [77] and the absence of a group news feed and accountability features (compared with the presence of these features; 1/2, 50% of the analyses) [81] were associated with increased skill enactment.

Therapeutic Approach

A total of 2/13 (15%) studies examined whether the therapeutic approach was associated with frequency or time spent using skills (ie, cognitive restructuring vs self-compassion intervention and internet-based CBT vs internet-based exposure therapy), and the results were largely nonsignificant (1/5, 20% of the analyses) [103,104].

Presence and Type of Guidance

In total, 2/13 (15%) studies on 5 eligible interventions investigated whether the presence and type of guidance were associated with skill enactment frequency. Individual therapist guidance, compared with group-based guidance, was found to be positively associated with skill enactment (2/2, 100% of the analyses) [100], but the presence or option of guidance was not [74].

Psychological Factors

A total of 2/13 (15%) studies examined whether psychological factors were associated with frequency of enacting skills, with both studies finding that improvements in skill enactment were associated with improvements in negative thinking (2/2, 100% of the analyses) and savoring (2/2, 100% of the analyses) [101].

Baseline Symptoms

A total of 2/13 (15%) studies investigated whether baseline symptoms predicted the frequency of skill enactment, with neither study reporting significant findings [90,96].

Program Use

A total of 1/13 (8%) studies examined whether completion of a fixed number of modules was associated with skill enactment frequency [98], and the results were not significant.

Knowledge Acquisition

A total of 2 studies examined predictors of knowledge acquisition. The results are grouped according to the type of predictor.

Learning Support

In total, 1/2 (50%) studies examined whether learning support integrated into a web-based program predicted CBT knowledge acquisition, and the results were significant (1/1, 100% of the analyses) [72].

Presence of Guidance

A total of 1/2 (50%) studies investigated whether weekly therapist support was associated with improvements in CBT knowledge, and the results were not significant [72].

Group Assignment

A total of 1/2 (50%) studies evaluated whether assignment to the active intervention condition was associated with higher levels of perceived learning relative to an attention control program, and the results were significant (1/1, 100% of the analyses) [71].

Discussion

Principal Findings

This review aimed to systematically examine the literature on skill enactment and knowledge acquisition in the context of digital CBT interventions for symptoms of depression or anxiety. In total, 43 papers (reporting on 42 independent trials) were included, of which 29 (67%) reported a measure of skill enactment and 15 (35%) reported a measure of knowledge acquisition.

Methods Used to Measure Skill Enactment

Most of the research on engagement with digital CBT interventions for depression and anxiety has not measured skill enactment. Despite the use of broad inclusion criteria to identify skill enactment measures, only approximately 6.4% (29/456) of eligible papers reported a quantitative measure of skill enactment and were included in this review. In contrast, a previous review of adherence to manualized web-based interventions found that 85% of primary publications included information on program use [24]. Eligible measures of skill enactment were also difficult to identify in many cases, either because the measures were insufficiently described in the study methods and results or because they were not reported under engagement or adherence headings. Nevertheless, we identified 3 broad approaches to measuring skill enactment: formal skill enactment indicators, standardized questionnaire measures, and

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intervention-specific questionnaires. Formal skill enactment measures were used more frequently than standardized or intervention-specific questionnaire measures. Furthermore, the reporting of each of these measures appeared to vary depending on the symptoms or disorders targeted. More than half (7/13, 54%) of the studies that examined formal skill enactment measures evaluated interventions for symptoms of social anxiety disorder, whereas most studies (13/17, 76%) that reported standardized or intervention-specific questionnaires targeted symptoms of depression, perinatal mental health, or depression and anxiety.

This review identified some weaknesses in current methods of measuring skill enactment. Only standardized questionnaires of behavioral activation skills, single items measuring "global" skill enactment, and adherence measures derived from exposure diaries or cognitive restructuring exercises were examined in ≥5 studies. As digital CBT programs target a range of adaptive skills, the use of unidimensional measures may not sufficiently capture the multifaceted nature of these interventions or enable examination of the differential impact of enacting specific skills. A related issue is the relatively common use of automatically captured log data (ie, formal skill enactment measures) as a proxy for skill enactment (although we do not suggest that this was the intention of the study authors). Although these measures provide helpful information on the frequency of using specific intervention tools, they cannot capture the various ways in which people can engage with skills outside their interaction with a program. For example, people might schedule pleasant events or achievement activities on their phones or personal calendars rather than using the tools provided in the program itself. Therefore, it is important to implement measures that reflect the breadth of recommended skills and the various ways in which people can enact them.

The studies also varied in the methods used to report skill enactment data (eg, the number of formal exercises completed and percentage of participants able to regularly perform exercises), and nearly all studies (28/29, 97%) reported the frequency or amount of time spent practicing skills based on retrospective self-reports. These approaches overlook key aspects of skill enactment outlined in the literature on CBT and emotion regulation [35,37], including the competence with which skills are enacted by participants (ie, skill enactment quality) and the number or range of skills used (ie, skill enactment quantity), and they may be susceptible to social desirability and memory biases that hinder accurate recall or reporting. It will be important for studies to examine skill enactment quality and quantity, and in the case of guided interventions, it may be possible for therapists or other supporters to observe and rate the quality of skill enactment indirectly via evaluations of thought records, web-based practice sessions, or other homework materials. Hundt et al [35] provide a review of existing therapist-rated measures of skill enactment quality used in face-to-face CBT. The literature would also benefit from ecological momentary assessment methods that capture skill enactment as it occurs in real time to overcome reliance on retrospective reporting and improve measurement precision. Together, these methods may help address several important research questions, such as "what type of skill enactment is necessary for outcomes" (eg, frequent use of skills, use of a broad range of skills, or competent use of skills) and "which skills are most important for change?"

Changes in Skill Enactment and Association With Mental Health Outcomes

The number of studies that examined changes in skill enactment (n=8) or effects on mental health outcomes (n=12) was small and, again, limited to assessments of skill enactment frequency using questionnaire measures or log data. Nevertheless, some promising findings were reported. Most studies that evaluated changes in skill enactment (6/8, 75%) found that levels of skill enactment increased at postintervention measurement among participants exposed to interventions relative to the comparison groups. Estimated effect sizes were generally medium to large. Overall, these data suggest that interventions targeting depression are effective in improving the frequency of skill enactment. Interventions for postnatal depression or anxiety and depression combined may also be effective, but the findings were mixed [94,95] or limited to only 1 study [36]. One or more significant positive findings were also reported in 83% (10/12) of the studies that examined the relationship between skill enactment and mental health outcomes at postintervention measurement. In particular, each of the studies (4/4, 100%) reporting standardized measures provided evidence for an association between intervention exposure, greater frequency of enacting skills, and postintervention improvement in mental health outcomes [36,84,102], although the outcomes were almost exclusively limited to improvement in depressive symptoms. Overall, these findings are generally consistent with engagement models that propose that participation in an intervention will produce improvements in skills and outcomes [32-34], as well as with some cognitive behavioral theories on the mechanisms of action in CBT [35].

In contrast, studies that addressed mental health outcomes in relation to formal skill enactment measures provided mixed evidence. Only the number of tracked exposures and global skill enactment indicators were positively associated with outcomes in ≥2 analyses, whereas other indicators (eg, cognitive restructuring and activity planning) were not found to be consistently related to outcomes or were addressed in only 1 analysis. This result is perhaps not surprising given the similarly mixed findings for comparable program use measures, such as number of diary entries, tools used, or activities [22], and further highlights the importance of adopting a comprehensive approach to measuring skill enactment that enables examination of what participants do offline. Intervention-specific questionnaires can provide a thorough assessment of skill enactment and may be particularly well suited to evaluating programs that target a range of therapeutic techniques and strategies when appropriate standardized measures are not available, but their utility in predicting mental health outcomes has not yet been elucidated, with only 1 pilot study exploring the association between intervention-specific skill enactment and mental health outcomes [90]. Future studies that use intervention-specific measures should explicitly examine change in skill enactment and its association with treatment outcome.

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Predictors of Skill Enactment

Similar to the selection of skill enactment measures, there was considerable variation in the predictors and types of skill enactment studied. The same predictor was only investigated in more than one study on 2 occasions. There was some evidence that participants used skills more often if they demonstrated improvements in negative thinking and savoring [101]. However, similar to some previous reviews on predictors of adherence [17,68], mental health symptoms at baseline were not found to predict skill enactment [90,96]. Other factors considered in 1 study each included program use [98] and various intervention-related factors such as comparisons between therapeutic approaches and the presence and type of support [74,77,81,88,99,100,103,104]. Given the small number of studies that considered individual predictors of skill enactment, the findings described in this review could be related to the specific study samples or methods. Research has also neglected to examine theoretically relevant predictors of skill enactment. Some level of knowledge acquisition is likely to be a prerequisite for enacting skills, but this still needs to be investigated. In addition, there may be a range of factors that influence the likelihood of enacting skills once users have acquired knowledge. For example, the theory of planned behavior states that behavior change depends not only on an individual's ability to carry out a behavior but also on their readiness or motivation to do so, which in turn depends on attitudes, social influences, and self-efficacy [117]. Future studies that use a theory-driven approach are warranted to clarify the preliminary relationships described in this review and examine the influence of underlying motivational variables.

Methods Used to Measure Knowledge Acquisition

Only 3.3% (15/456) of eligible articles reported a quantitative measure of knowledge acquisition. Among these studies, objective tests (eg, multiple-choice or true-or-false tests and objectively scored helpfulness ratings) designed to measure declarative knowledge about CBT or mental health literacy comprised almost two-thirds (9/15, 60%) of the measures. Self-report questionnaires on perceived learning were also reported, although these measures were typically limited to single items. Regardless of the type of measure reported, more than half (8/15, 53%) of the included studies evaluated interventions for depression. Some limitations of existing approaches to measuring knowledge acquisition include the fact that most studies (9/15, 60%) only considered declarative knowledge (ie, knowledge of facts and information) measured using recognition-based tasks (eg, multiple-choice questions). Other forms of learning and knowledge may also be important to consider, such as more implicit and procedural knowledge (ie, knowledge of how to perform a skill), as well as the ability to generalize and apply learning to novel situations [118,119]. Possible ways to capture these constructs include the use of open-ended items to measure free recall performance, reviews of homework, hypothetical scenarios, and vignette designs [40,73,120].

Changes in Knowledge Acquisition and Association With Mental Health Outcomes

Most studies (8/10, 80%) that evaluated changes in knowledge found that intervention group participants significantly improved their levels of knowledge at postintervention measurement. The studies that found at least one positive effect included all the studies (6/6, 100%) that used a test of CBT knowledge, 80% (4/5) of the studies evaluating mental health literacy, and 50% (1/2) of the studies evaluating perceived knowledge acquisition. Overall, these findings indicate that participants can learn and recognize novel information about mood and anxiety disorders and underlying therapeutic principles in digital CBT. These interventions may also be effective in improving perceived knowledge and learning, but the findings were mixed [86,87]. As would be expected given the focus of the included interventions on CBT principles and information, effect sizes were generally the largest for measures of CBT-specific knowledge. However, even for these measures, the magnitude of change was generally modest (ie, intervention group participants answered, on average, only 1 to 2 more items correctly than at baseline [61,69,73]), perhaps because of relatively high levels of preexisting knowledge.

There was no evidence that knowledge acquisition, assessed using tests of CBT knowledge or mental health literacy, was associated with improved mental health outcomes at postintervention measurement. Thus, participants can learn the treatment content, but they do not necessarily benefit in terms of symptom reduction. Overall, this pattern of results is in line with studies evaluating digital CBT interventions targeting other common mental disorders such as eating disorders [121,122], as well as with suggestions that knowledge acquisition alone may not be sufficient to improve symptoms [34]. Instead, it is the active application of skills (ie, skill enactment), which may depend not only on knowledge change but also on an individual's motivation to implement mental health actions, that has been suggested to be important for mental health outcomes [34,73], an idea that is largely supported by the results of this review. However, we advise caution in interpreting the findings in this way. Some research from other areas has shown that knowledge acquisition can predict symptom improvements in certain instances, for example, for individuals with low levels of preexisting CBT knowledge and in cases where changes in knowledge confidence, not accuracy, are correlated with outcomes [122]. Furthermore, some of the included studies demonstrated that improvements in both CBT knowledge and mental health literacy can be maintained at the 6- to 12-month follow-ups [61,72]. It is possible that these enduring improvements facilitate ongoing recovery from current episodes of depression and anxiety or confer a protective effect against future episodes via improvements in an individual's ability to recognize symptoms within themselves or others and respond to challenges or by facilitating timely help seeking.

Predictors of Knowledge Acquisition

Only 2 studies on knowledge acquisition examined potential predictors of knowledge acquisition. Significant predictors included the use of learning support strategies and assignment to the active intervention rather than the attention control group,

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whereas therapist guidance was nonsignificant [71,72]. However, the small number of studies that considered predictors of knowledge acquisition makes it challenging to draw conclusions about the reliability of these findings, and further research is warranted. The potential role of learning support may be especially important to consider as Berg et al [72] found that building pedagogical techniques into program modules led to small improvements not only in CBT knowledge but also in mental health outcomes despite a nonsignificant relationship between these outcomes. These findings suggest that developing a better understanding of how best to support people in learning treatment strategies and techniques may help improve outcomes. Harvey et al [38] provide an overview of cognitive support strategies that may enhance memory for psychological treatments.

Research Gaps and Future Directions

This review highlighted several gaps in the current state of knowledge in this area. Overall, there was a lack of research that examined skill enactment and knowledge acquisition in the context of digital CBT. Very few studies (6/42, 14%) reported on skill enactment and knowledge acquisition among adolescents and young adults, and most studies (33/42, 79%) evaluated internet-based interventions accessed via a computer. Similar to other authors [24,25,73], we encourage researchers to measure and report skill enactment and knowledge acquisition in future studies of digital CBT and examine outcomes and predictors related to these constructs.

However, future research must go beyond simply measuring skill enactment and knowledge acquisition to also address measurement issues. A key limitation of the literature identified by this review is the heterogeneity in how knowledge acquisition, and especially skill enactment, was measured and analyzed. Heterogeneity was evident not only in the specific construct examined (eg, skill enactment frequency vs quality and CBT knowledge vs mental health literacy) but also in the mode of assessment and the way in which data were reported and analyzed. This heterogeneity hinders the pooling of data for quantitative synthesis and may be due in part to a lack of specific theoretical guidance or standards available to inform the selection, analysis, and reporting of skill enactment and knowledge acquisition measures in DMHIs. To facilitate consistency going forward, we recommend that definitions of skill enactment and knowledge acquisition in DMHIs and the subsequent selection of measures are theory-driven. For example, the literature on CBT skill use and emotion regulation provides clear conceptual definitions of skill enactment and its distinct components (eg, frequency, quantity, and quality) that can inform the selection of appropriate measures [35,37]. A theory-driven approach will be aided by developing robust and broadly applicable scales to measure skill enactment and knowledge acquisition in DMHIs more consistently and considering how these scales are related to outcomes. In the context of skill enactment, recent work by Titov et al [123] and Bisby et al [124] to develop and test a measure of daily actions associated with psychological health may align well with conceptual definitions of skill enactment frequency. In addition, psychometric research comparing different methods of measuring skill enactment and knowledge acquisition is needed to examine whether each is measuring a unitary construct or whether there are distinct types of skill enactment and knowledge acquisition beyond those highlighted within conceptual frameworks.

In addition, although the overall quality of the included studies was good, some methodological issues were evident, with most or all studies not meeting quality assessment criteria related to blinding of participants (0/42, 0%), outcome assessors (0/42, 0%), or those delivering treatment (15/42, 36%). This is an inherent problem with RCTs of psychological interventions [125]. However, it is possible to implement blinding in these interventions in some cases (eg, by not informing participants of which treatment is expected to be most effective in studies including active treatment or attention control comparisons) [125]. It is also notable that more than half (22/42, 52%) of the studies did not provide sufficient information to determine whether outcomes were measured reliably (eg, reporting the Cronbach α for the collected data) despite many reporting estimates from external sources. Unreliable measurement of outcomes can weaken the validity of inferences made about statistical relationships [63]. It is essential that studies explain in sufficient detail the methods used to allow for accurate assessments of study quality.

Limitations of This Review

This review has some limitations. The inclusion of an English-language restriction and single screening of titles, abstracts, and initial full texts may have increased the risk of selection bias. Although double screening of 10% of the records at each stage did not result in the inclusion of any additional papers, it is possible that some publications were excluded erroneously. It is also possible that some studies were excluded because of insufficient or unclear reporting of the study methods or results. The review was further limited to RCTs of stand-alone digital CBT interventions for depression and anxiety. Thus, our findings cannot be generalized to open-access settings, other mental health problems, stepped-care interventions, or psychotherapeutic treatments other than CBT. Nevertheless, the examination of knowledge acquisition and skill enactment is likely to be important in any skills training intervention, and this review can inform the development of future studies in this area. In addition, we could not conduct a quantitative synthesis of skill enactment and knowledge acquisition because of methodological diversity in the included studies, meaning that we could not estimate the average effect of skill enactment or knowledge acquisition on depression and anxiety outcomes, nor could we examine the factors that modify these effects. Future meta-analytic studies will be essential to understand therapeutic mechanisms in digital CBT and advance future interventions but will require greater methodological consistency.

Conclusions

In digital interventions for mental health problems, it is essential to consider engagement as a concept that extends beyond program use to encompass actions that are implemented outside initial engagement with an intervention. Given that most studies on engagement with DMHIs focus on program use, this review addresses a substantial gap by focusing on skill enactment and

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knowledge acquisition during or following program use. This review demonstrated that digital CBT interventions for depression and anxiety appear to be effective in improving skill enactment frequency; levels of CBT knowledge; and, to a lesser extent, mental health literacy. However, only skill enactment frequency was found to be associated with positive mental health outcomes. Few studies have investigated predictors of skill enactment and knowledge acquisition, and those that have done so have mostly been limited to investigations of intervention-related factors and reported null results. This review calls for a more systematic and theory-based approach to studying the role of skill enactment and knowledge acquisition in DMHIs for depression and anxiety. The findings of this review can inform the development and selection of skill enactment and knowledge acquisition measures and promote the inclusion of these types of measures in future studies evaluating DMHIs.

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Authors' Contributions

HMJ conceived and designed the research in consultation with LMF, PJB, ALC, and JLO. HMJ and GMF completed screening and data extraction, and HMJ and LMF conducted the risk-of-bias assessment. HMJ performed the synthesis with input from LMF, PJB, ALC, and JLO. HMJ prepared the first draft of the manuscript. All the authors were involved in the revision of earlier versions of and approved the final manuscript.

Conflicts of Interest

PJB, ALC, and LMF are codevelopers of FitMindKit, which was evaluated in one of the included trials [71]. All other authors declare no other conflicts of interest.

Multimedia Appendix 1

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist.
[PDF File (Adobe PDF File), 57 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Search strategies for PubMed, PsycINFO, and Cochrane CENTRAL.
[PDF File (Adobe PDF File), 126 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Results of the review.
[XLS File (Microsoft Excel File), 115 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Quality assessment.
[XLS File (Microsoft Excel File), 39 KB-Multimedia Appendix 4]

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Abbreviations

CBT: cognitive behavioral therapy
DMHI: digital mental health intervention
ITT: intention-to-treat
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT: randomized controlled trial

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Chapter 3. Predictors and Outcomes of Engagement in an Online Depression Prevention Program for Final Year Secondary School Students

3.1 Foreword

The systematic review in Chapter 2 demonstrated that digital CBT interventions can improve skill enactment at post-intervention among adults with elevated symptoms or formal diagnoses, with these improvements associated with reductions in symptoms of depression and anxiety based on standardised questionnaire measures. However, the chapter also highlighted a gap in research regarding skill enactment among young people. Furthermore, it found that few studies have explored factors associated with skill enactment during or after participation in digital CBT programs, particularly in relation to user characteristics and other theoretically relevant predictors of behaviour change. By identifying factors that affect the application of skills, it may be possible to refine and personalise digital CBT interventions to better address individual needs, enhance skill enactment, and ultimately improve intervention effectiveness. To this end, Chapter 3 conducted a secondary analysis of data from a cRCT of an online depression prevention program for final-year secondary school students. This analysis investigated predictors of skill enactment and examined their potentially differential effects on program usage indicators of engagement (indexed as number of modules completed). The study also aimed to investigate the effect of skill enactment on the trial's primary outcome (depression symptoms) and secondary outcomes (generalised anxiety symptoms, social phobia symptoms, and personal depression stigma).

Note: The Trial for the Prevention of Depression (TriPoD), which provided the data for this secondary analysis, is described in the primary outcomes paper presented in Appendix A.

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Predictors and outcomes of engagement in an online depression prevention program for final year secondary school students

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ABSTRACT

Although school-based delivery of online interventions can effectively prevent depression and other common mental disorders, little is known about the characteristics of students who engage with these programs. This study aimed to identify predictors of two indicators of adolescent engagement (program usage and skill enactment) with a school-based online depression prevention program. The study also explored the association between skill enactment and mental health outcomes. Participants were 204 final-year secondary school students (M = 16.7 years, SD = 0.51 years; 111 females) from the intervention condition of a cluster randomized controlled trial conducted in 10 selective and partially selective government schools in Australia between 2015 and 2016. Program usage was measured as number of modules completed and skill enactment was assessed using a self-report questionnaire at post-intervention to determine the frequency of implementing program strategies (e.g., cognitive restructuring, activity scheduling). Predictors of engagement included demographics, mental health-related variables, and psychological factors (e.g., mastery). Regressions indicated that possible history of depression predicted fewer modules completed, whereas higher baseline anxiety, mastery, and higher perceived level of learning from the program predicted greater skill enactment. Mixed models did not show a significant effect of skill enactment on symptoms of depression, generalized anxiety, social phobia, or personal stigma. Future work is needed to investigate whether the results apply to students enrolled in non-selective programs and examine the effects of skill enactment and other possible mechanisms on outcomes in order to guide the refinement of future interventions.

1. Introduction

The implementation of digital mental health interventions (DMHIs) in schools is increasingly recognized as an effective way to prevent and treat depression and other common mental disorders among young people [1]. When delivered in schools, DMHIs preserve the benefits of school-based programs in terms of improved reach and accessibility while also providing key advantages over in-person delivery methods. These advantages include reduced demands on teaching staff who are not necessarily trained to support student mental health, decreased stigma associated with receiving mental health support, and high fidelity in intervention delivery [2]. However, challenges remain regarding how best to engage students with these programs. Relative to entirely self-guided approaches, school-based DMHIs have been associated with improved engagement among adolescents [3], [4]. Yet even in monitored settings, completion rates are often modest, and previous trials have indicated that only 30–60 % of adolescents fully complete these programs [5], [6], [7]. Given that engagement is a key factor in the effectiveness of DMHIs [8], [9], research that focuses on identifying the relationship between user characteristics and engagement may help guide the development of strategies to improve program effectiveness [10].

Abbreviations: DMHIs, Digital mental health interventions.

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However, inherent in this line of research is a broader challenge regarding how to define and operationalize engagement with digital interventions. Typically, studies have used system usage data, such as the number of modules, sessions, or within-program activities completed, as a proxy for engagement [11]. Indicators of program usage can provide useful information about the rate of progress through an intervention or the depth of engagement with specific intervention components. Higher rates of program usage have also been associated with small to moderate improvements in mental health outcomes, irrespective of the type of intervention or symptoms targeted [8]. However, when collected in school settings, these indicators may depend not only on how motivated the student is but also on classroom and teacher characteristics [12]. In addition, they may not account for other behaviors that might be more proximal to outcomes, such as the application of knowledge and strategies learned from an intervention [9], [11].

Several studies have conceptualized the application of skills in everyday life (referred to as skill enactment hereafter) as an additional aspect of engagement in both digital and face-to-face interventions [13], [14], [15]. This definition extends the boundary of engagement research beyond technology usage to include the degree to which users engage with and apply intervention content in their daily lives. Evaluating skill enactment and its predictors may be especially relevant to research aimed at improving intervention effectiveness, given that it has been suggested to be more important for mental health outcomes than program usage measures [11], [16], is often only weakly correlated with technology usage [17], and may be a better indicator of active and meaningful engagement than automated usage data in school settings.

Relatively few studies of school-based DMHIs have attempted to identify user characteristics that are associated with either program usage or skill enactment indicators of engagement. Some studies have shown that greater program usage was predicted by living in a rural location, lower year level, higher pre-intervention depression, lower pre-intervention anxiety, and higher self-esteem [12], [18], [19], [20]. However, only one previous evaluation of an online depression program based on cognitive behavioral therapy (CBT) delivered in an educational setting has examined predictors of skill enactment among young people. This study found no evidence to suggest that skill enactment was associated with baseline symptoms [21]. Some studies have investigated predictors of skill enactment among adult users of DMHIs, but these have predominantly focused on the relationship between skill enactment and intervention-related factors (such as the presence of guidance) in the absence of considering other theoretically prescribed predictors of behavior [22]. Other factors that may be important for DMHI engagement, but which have been overlooked in school-based studies, include beliefs about the effectiveness of DMHIs, social influences, and in the case of skill enactment, the degree to which users interact with and acquire knowledge from an intervention program [14], [22], [23]. Thus, further research is needed to examine a more comprehensive array of predictors of both program usage and skill enactment indicators of engagement among users of school-based DMHIs.

The present study builds on previous studies of engagement with school-based DMHIs by investigating two indicators of engagement in the Trial for the Prevention of Depression (TriPoD). The TriPoD trial used a cluster randomized controlled trial (cRCT) design to test the effectiveness of a gamified online CBT intervention (SPARX-R) for the prevention of depression among final year secondary school students attending selective and partially selective government secondary schools in Sydney, New South Wales. In Australia, selective and partially selective schools use an entrance examination to admit students or place them in specialist streams (as is the case in partially selective schools) based on academic merit. The intervention was trialed in selective schools because, along with other known risk factors for mental health problems among young people (e.g., exposure to poverty or discrimination [24]), students attending high-achieving schools are increasingly recognized as a group at elevated risk for mental health problems [25]. Risk factors implicated in the development of mental health difficulties among this group include pressure to succeed from parents, schools, and peers, as well high levels of perfectionism and the competitive academic nature of the school environment [25], [26]. The intervention was trialed with students in their final year, as final course examinations represent a significant school-related stressor that may exacerbate these challenges and precipitate mental health problems [27].

The methods and primary outcomes of the trial have been published [7], [28], and indicated that the program was effective in reducing symptoms of depression relative to a control condition at post-intervention and 6-month follow-up. Furthermore, sub-group analyses showed that the intervention was effective in reducing depressive symptoms at post-intervention and 6 months for participants who completed 4 or more modules, but not for those who completed fewer modules [7]. Therefore, identifying factors associated with engagement may help guide the development of strategies to enhance effectiveness through improved program engagement. This study sought to extend on these initial findings and aimed to identify predictors of module completion and skill enactment in the active intervention condition. The study also aimed to explore the effect of skill enactment on primary (depression) and secondary (anxiety and personal depression stigma) outcomes.

2. Materials and methods

2.1. Overview

We performed a secondary analysis of data from the TriPoD trial, which used a cRCT design to test the effectiveness of an online CBT intervention (SPARX-R) for the prevention of depression among final year secondary school students relative to an attention-matched control condition. Assessments took place at baseline, post-intervention, and six- and 18-months after the baseline assessment. Full details on the methods and primary outcomes for the trial have been published elsewhere [7], [28]. The trial received ethics approval from the University of New South Wales (HC14105), the Australian National University Human Research Ethics Committee (protocol 2014/325), and the New South Wales Department of Education and Training (SERAP2014001).

2.2. Participants

Selective and partially selective government secondary schools from Sydney, New South Wales, Australia, participated in the trial between February 2015 and August 2016. All students at participating schools who were enrolled in their final year of high school (year 12) were invited to participate. For partially selective schools, enrollment status (selective or non-selective) was recorded. There were no exclusion criteria as the study tested a universal prevention program. Written informed consent was obtained from students and their parents prior to the start of the trial. Students who did not provide consent were offered access to the assigned intervention but did not complete research questionnaires.

2.3. Intervention: SPARX-R

The SPARX-R program was adapted from SPARX [29], a fully automated CBT-based program which teaches skills to adolescents experiencing mild to moderate symptoms of depression using an unguided, interactive fantasy game format. SPARX-R delivers the same content as SPARX but is framed in preventive terms. For example, whereas in the original program participants are informed that “SPARX was made to help young people who feel down or depressed”, SPARX-R informs participants that “this version of SPARX was made to help young people who are having hassles and feeling down, stressed or angry a lot of the time. Even if you are doing fine, SPARX-R can help strengthen your skills for dealing with problems when they do come along” [30]. The program

is delivered across seven modules. Users navigate through a series of challenges and activities within a fantasy world that has been invaded by gloomy, negative automatic thoughts (GNATs). Their mission is to restore balance to the world. The challenges and activities are designed to help the user understand and apply CBT skills via play-based learning and the use of a virtual guide character who provides context and relates the content back to the user's real-world experiences [30]. The modules and core skills focus on: (1) finding hope (negative automatic thoughts, controlled breathing), (2) being active (activity scheduling and behavioral activation, progressive muscle relaxation, communication and interpersonal skills), (3) dealing with strong emotions (assertiveness, listening, and negotiation), (4) overcoming problems (problem-solving, cognitive restructuring), (5) recognizing unhelpful thoughts (cognitive restructuring), (6) challenging unhelpful thoughts (cognitive restructuring, negotiation skills), and (7) bringing it all together (summary, mindfulness). Each module takes 20–30 min to complete. For more information on the original and revised versions of SPARX, see Merry et al. [29] and Fleming et al. [30].

Schools scheduled curriculum time for students to complete 1–2 modules per week over the course of 5–7 weeks, with supervision provided by classroom teachers. Research personnel were not directly involved in the delivery of the intervention.

2.4. Attention-matched control condition: lifeSTYLE

Participants assigned to the attention control condition received access to the online educational program, lifeSTYLE. This program is a modified version of an online program originally developed as a control intervention for a trial targeting reduction in suicidal thoughts [31]. The program was designed to match SPARX-R in terms of duration without providing skills to prevent or manage mental health difficulties. The program is delivered in seven modules (lasting 20–30 min), each of which provides knowledge and information on topics related to general health: (1) independence, (2) participating in your community, (3) work skills, (4) mobile phone safety and hygiene, (5) healthy skin, (6) sustainable eating and (7) maintaining a healthy home environment. Interactive activities are designed to reinforce knowledge and learning (e.g., quizzes, myth busters). Control group participants were excluded from this study.

2.5. Measures

2.5.1. Engagement

Indicators of engagement included number of modules completed (ranging from 0 to 7) and frequency of enacting skills from the SPARX-R program. Module completion was automatically recorded within the program software, with modules marked as complete if the participant reached the end of the module. Skill enactment was assessed at post-intervention using a list of 13 strategies and techniques specific to the SPARX-R program. Respondents rated how often they had tried each of the skills on a 3-point scale (Never = 0, Sometimes = 1, Often = 2). Example items include: "Challenging GNATS (unhelpful thoughts)" and "Mindfulness (tolerating distress)". These questions were based on items used in a previous trial of an online anxiety prevention program and adapted for SPARX [32]. Given the range of skills examined, exploratory factor analysis was conducted on the 13 skill enactment items. This analysis was consistent with the scale representing a single factor (see Supplementary material for further details). Therefore, we used the total scale (ranging from 0 to 26) as a measure of overall skill enactment, with higher scores indicating more frequent skill enactment. Cronbach's alpha for the total scale at post-intervention was excellent (α = .92).

2.5.2. Predictors of engagement

Predictors of engagement (i.e., program usage and skill enactment) included demographic variables, baseline mental health symptoms, and psychological factors. Each of the predictor variables described below were assessed at pre-intervention, except for perceived level of learning, which was assessed at post-intervention. Demographic variables were gender (female = 0, male = 1) and language spoken at home (English = 0, other = 1).

Mental health-related variables included depression symptoms measured by the Major Depression Inventory (MDI) [33] (α = .88 in the present sample) and the Generalized Anxiety (α = .80 in the present sample) and Social Phobia (α = .76 in the present sample) subscales of the Spence Children's Anxiety Scale (SCAS) [34]. Subscale scores on the SCAS were summed to produce a total anxiety severity score (α = .85 in the present sample). The MDI has acceptable sensitivity and specificity for the diagnosis of depression according to ICD-10 and DSM-IV criteria [33], and the SCAS has been demonstrated to be a valid and reliable indicator of anxiety in adolescent samples [35]. Two standalone screening questions from the Structured Clinical Interview for DSM-IV disorders–Mood module were also included to provide an indication of possible history of depression [36]. The questions assess mood and anhedonia symptoms (α = .76 in the present sample), with respondents answering 'yes' or 'no' to whether they have ever experienced each symptom for two weeks or longer.

Psychological factors included personal depression stigma, sense of mastery, social support, confidence to learn skills, and perceived level of learning. Personal depression stigma was measured with the 9-item Personal Stigma subscale of the Depression Stigma Scale (DSS-Personal) [37], with each item rated on a 4-point scale from 0 (strongly disagree) to 4 (strongly agree). Total scores range from 0 to 36, with higher scores indicating greater stigma (α = .79 in the present study). Perceived mastery over life outcomes was measured with the 5-item version of the Pearlin Mastery Scale [38]. Each item is rated on a 4-point scale from 1 (strongly agree) to 4 (strongly disagree). Total scores range from 5 to 20, with higher ratings indicating a higher level of self-mastery (α = .75 in the present study). The 5-item scale was used in place of the original 7-item scale given evidence to support improved reliability and model fit for the shortened version [39], [40]. Positive social support from family and friends was measured using the supportive interactions subscales (4 items in total) from the Schuster Social Support Scale [41]. Each item was rated on a 4-point scale, from 0 (never) to 3 (often). Scores are computed separately for family (α = .81 in the present study) and friends (α = .71 in the present study), with item scores averaged to compute total scores.

Pre-intervention confidence to learn skills and perceived level of learning at post-intervention were assessed using single items that asked participants whether they were confident that people could learn skills to enhance wellbeing from an online program (rated on a 5-point scale, ranging from strongly disagree to strongly agree) and how much they perceived they had learnt from the program (rated on a 4-point scale, ranging from almost nothing to a great deal). These questions are also based on those used in previous research [32].

2.5.3. Intervention outcomes

The primary outcome was symptoms of depression measured by the MDI. Secondary outcomes included symptoms of generalized anxiety disorder and social anxiety disorder measured using the SCAS and personal depression stigma measured by the DSS.

2.6. Analyses

Data were analysed using SPSS *v28*, and significant effects were determined at $p < 0.05$. Mixed effects ordinal logistic regression (GENLINMIXED command) was used to examine predictors of module completion, with a random intercept term included to account for the clustering of students within schools. Fixed effects linear regression analysis was used to identify predictors of skill enactment. A random effect for school was omitted from the regression on skill enactment, as the estimated intraclass correlation coefficient (ICC) and design effect (ICC = 0.009, design effect = 1.42) indicated the absence of a multilevel

structure to the data. Some predictors were dichotomized for analysis: confidence to learn skills was re-coded into not confident (strongly disagree or disagree) and confident/neutral (strongly agree, agree or neither agree nor disagree), and perceived level of learning was re-coded into no/minimal learning ('almost nothing' or 'not very much') and some/considerable learning ('a fair bit' or a 'great deal').

Evidence for moderation of the primary and secondary outcomes by skill enactment was evaluated using mixed model repeated measures (MMRM) analysis of variance (ANOVA) with a two-way interaction term (i.e., skill enactment×time). The interaction term provides information on whether changes in outcome over time differed more for those who had higher levels of skill enactment. School was included as a random factor to reflect the clustered sampling of students within schools. An unstructured covariance matrix was used to model relationships between observations at different occasions, and error degrees of freedom were estimated using the Satterthwaite method.

3. Results

3.1. Participants

Table 1 presents the baseline characteristics and engagement data for the study sample. Module completion was both a predictor and outcome variable. Ten selective and partially selective government secondary schools participated in the trial during February 2015 and August 2016. A total of 540 final year secondary students (341 female, 199 male) with a mean age of 16.7 years ($SD = 0.51$) consented to participate and were randomized at the school-level to the intervention group ($n = 242$) or control group ($n = 298$). Of this group, the majority ($n = 469$, 54.4 %) returned post-intervention surveys, 341 (63.1 %) completed 6-month follow-up surveys, and 104 (19.3 %) completed 18-month follow-up. Sample size ranged from 7 to 126 participants from each school. Control group participants were excluded from the current analysis. After excluding a further 38 participants who did not have complete data on the included variables, data from a final sample of 204 participants were analysed ($n = 4$ students enrolled in non-selective programs). Chi-square analyses and *t*-tests demonstrated that there were no significant differences between those who did and did not have complete data on the basis of language spoken at home ($\chi^2_1 = .07$, $p = 0.796$), confidence to learn skills ($\chi^2_1 = .18$, $p = 0.674$), possible history of depression ($\chi^2_1 = .48$, $p = 0.490$), pre-intervention depressive symptoms ($t_{240} = -1.09$, $p = 0.276$), anxiety ($t_{240} = -1.00$, $p = 0.320$), personal stigma ($t_{240} = 0.11$, $p = 0.910$), self-mastery ($t_{240} = -1.44$, $p = 0.150$), or supportive interactions with friends ($t_{240} = 0.68$, $p = 0.500$) or family ($t_{240} = 1.16$, $p = 0.246$). However, males ($\chi^2_1 = 3.96$, $p = 0.047$) and participants who completed fewer modules ($t_{240} = -5.47$, $p < 0.001$) were more likely to have incomplete data.

Table 1
Baseline characteristics and engagement data for participants included in the study ($N = 204$).

	Intervention group (SPARX-R)
Demographics	
Gender, *n* (%)	
Male	93 (45.6)
Female	111 (54.4)
Language spoken at home, *n* (%)	
English	112 (54.9)
Other	92 (45.1)
Mental health status	
Depression severity (MDI), *M* (*SD*)	15.36 (8.23)
Anxiety severity (SCAS), *M* (*SD*)	13.97 (6.02)
Depression history, *n* (%)	48 (23.5)
Psychological factors	
Depression stigma (DSS-Personal), *M* (*SD*)	10.11 (5.29)
Mastery (PMS), *M* (*SD*)	14.22 (2.52)
Social support friends (SSS-friends), *M (SD)*	2.38 (0.57)
Social support family (SSS-family), *M (SD)*	2.50 (0.66)
Confidence to learn skills	
Not confident	32 (15.7)
Confident/neutral	172 (84.3)
Post-intervention learning	
Learning, *n* (%)	
Some/considerable learning	77 (37.7)
No/minimal learning	127 (62.3)
Engagement	
Modules completed, *M* (*SD*)	4.05 (2.13)
Skill enactment, *M* (*SD*)	9.64 (6.26)

3.2. Module completion and skill enactment

On average, participants completed approximately 4 program modules ($M = 4.05$, $SD = 2.13$), with a majority (106/204, 52.0 %) completing 4–6 modules and 26 (12.7 %) completing all 7 modules. However, almost one-third of participants (57/204, 27.9 %) completed only 1–3 modules and 15 participants (7.4 %) did not complete any modules. The mean for skill enactment was 9.64 ($SD = 6.26$), and the average number of skills tried (at least sometimes) was approximately 8 out of a total 13 ($M = 7.69$, $SD = 4.31$). One-fifth of participants (19.1%) reported trying all 13 skills, although 19 (9.3 %) had not practised any skills and a further 23 (11.3 %) practised only 1–3 skills. The most frequently practised skills included listening skills ($M = 1.06$, $SD = 0.70$; 78.4 % practised), activity scheduling ($M = 0.94$, $SD = 0.68$; 73.5% practised) and keeping busy ($M = 0.85$, $SD = 0.68$; 70.6 % practised). The least used skills were identifying positive and realistic thoughts ($M = 0.47$, $SD = 0.64$; 38.7 % practised), engaging in progressive muscle relaxation ($M = 0.49$, $SD = 0.64$; 40.7 % practised), and using problem-solving strategies ($M = 0.55$, $SD = 0.68$; 44.6 % practised).

3.3. Predictors of module completion

The mixed-effects ordinal logistic regression presented in Table 2 demonstrated that module completion was significantly related to possible history of depression, with possible history of depression being associated with a 54% decrease in the odds of completing an additional program module, after adjusting for the effects of other variables. There were no other significant predictors of module completion.

3.4. Predictors of skill enactment

Table 3 presents the results of the linear regression on skill enactment. Greater levels of skill enactment were significantly associated with higher baseline anxiety, greater mastery, and greater perceived level of post-intervention learning. Perceived level of learning was the strongest predictor, with the model indicating that after controlling for all other factors, those who reported higher perceived learning from the program reported an average increase in skill enactment of 3.40 points, compared to those who reported learning little from the program. There

Table 2
Mixed-effects ordinal multinomial logistic regression model on number of modules completed ($N = 204$).

	Coefficient	*SE*	*OR*	95% CI	*p* value
Gender (Female)	0.51	0.56	1.67	0.55–5.09	0.364
Language (English)	-0.01	0.27	0.99	0.58–1.68	0.966
Depression	-0.02	0.02	0.98	0.94–1.02	0.319
Anxiety	0.00	0.03	1.00	0.95–1.06	0.965
Depression history	**-0.79**	**0.37**	**0.46**	**0.22–0.94**	**0.033***
Depression stigma	-0.01	0.03	0.99	0.94–1.05	0.794
Perceived mastery	-0.11	0.06	0.90	0.80–1.01	0.066
Social support–friends	0.40	0.26	1.49	0.90–2.49	0.123
Social support–family	-0.21	0.22	0.81	0.52–1.25	0.342
Confidence to learn skills (not confident)	-0.25	0.35	0.78	0.39–1.55	0.480

Note:
* $p < 0.05$

Table 3
Linear regression model on skill enactment ($N = 204$).

	Coefficient	*SE*	*t*	95% CI	*p* value
Gender (Female)	-1.24	0.96	-1.29	-3.14–0.65	0.198
Language (English)	-1.33	0.87	-1.52	-3.05–0.39	0.129
Depression	-0.01	0.07	-0.18	-0.15–0.12	0.856
Anxiety	**0.21**	**0.09**	**2.39**	**0.04–0.38**	**0.018***
Depression history	0.14	1.21	-0.12	-2.52–2.24	0.905
Depression stigma	-0.11	0.09	-1.16	-0.29–0.08	0.247
Perceived mastery	**0.57**	**0.20**	**2.90**	**0.18–0.96**	**0.004****
Social support–friends	-0.31	0.83	-0.37	-1.96–1.33	0.710
Social support–family	0.41	0.73	0.56	-1.03–1.85	0.579
Confidence to learn skills (not confident)	-2.08	1.17	-1.78	-4.38–0.23	0.077
Modules completed	-0.17	0.22	-0.77	-0.59–0.26	0.445
Post-intervention learning (Some/ considerable learning)	**3.40**	**0.96**	**3.55**	**1.51–5.28**	**< 0.001*****

Note:
* $p < 0.05$,
** $p < 0.01$,
*** $p < 0.001$.

were no other significant factors associated with skill enactment in the model.

3.5. Association between skill enactment and mental health outcomes

There were no significant overall interaction effects between post-intervention skill enactment and measurement occasion for any of the primary or secondary outcomes based on MMRM ANOVAs, including for depression ($F_{3108.59} = 1.82$, $p = 0.148$), generalized anxiety ($F_{3,88.43} = 1.29$, $p = 0.282$), social phobia ($F_{3,87.87} = 1.31$, $p = 0.277$), or personal depression stigma ($F_{3106.04} = 2.44$, $p = 0.069$). Contrasts demonstrated no significant interaction effects between time and skill enactment on symptoms of depression or anxiety at post-intervention and follow-up, although there was a significant interaction between time and skill enactment for depression stigma at post-intervention ($t_{202.00} = -2.62$, $p = 0.009$, 95 % CI = −.26 to −.04), such that participants with higher levels of post-intervention skill enactment had greater reductions in depression stigma from baseline to post-intervention. The effect remains significant using a conservative alpha of $p < 0.01$ to account for multiple comparisons. The effect was not maintained at 6- ($t_{134.40} = -1.60$, $p = 0.111$, 95 % CI = −.20 to.02) or 18-month ($t_{49.09} = -1.13$, $p = 0.264$, 95% CI = −.25 to.07) follow-ups.

4. Discussion

This study built on previous research on adolescent engagement with DMHIs by investigating predictors of engagement, measured using modules completed and skill enactment, among a sample of final-year secondary school students participating in a school-based online depression prevention program. The study also explored whether skill enactment moderated the effect of the intervention on primary and secondary outcomes. The findings point to several considerations for future program design and delivery, as possible history of depression predicted fewer modules completed, whereas self-reported perceived level of learning from the program, higher levels of baseline mastery, and more severe baseline anxiety symptoms predicted skill enactment, suggesting that unique factors may underlie different aspects of adolescent engagement with school-based DMHIs. In addition, unlike evidence presented in the main trial paper, which showed a significant effect of module completion on reduction in depression symptoms, skill enactment was not shown to be related to reductions in either depressive or anxiety symptoms. However, despite a non-significant omnibus test, skill enactment was related to reductions in stigma at post-intervention.

The findings for module completion indicated that participants with a possible history of depression (i.e., those who reported prolonged experiences of mood or anhedonia symptoms) tended to complete fewer modules than those who did not. This finding warrants further investigation. Students with past depression have higher rates of school nonattendance than their peers [42], which may suggest that they had fewer opportunities to use the program during class time. However, it could also suggest that this group may not have found the program to be relevant to their situation or needs, perhaps because they had already received mental health support or because the content was focused on prevention rather than addressing their specific concerns. Personalized intervention content, and the availability of choice, has been suggested to be critical for motivation and engagement with DMHIs [43], [44]. Although this approach has potential to contribute to stigma when school-based programs are delivered in person [45], the relative confidentiality offered by self-directed online programs may allow for a greater degree of tailoring to student needs and preferences. We did not identify any other significant predictors of module completion. This contrasts with previous studies on adolescent engagement with online interventions in school-based and community settings, which have found baseline depression and levels of social support to predict program usage [18], [46]. The absence of findings related to these variables could be due to the delivery setting, as well as differences in how program usage was defined in this study as compared with previous studies (i.e., as modules, rather than activities, completed). Our decision to enter all predictors simultaneously into the predictive model to account for any possible confounding may also have contributed.

Unlike module completion, greater skill enactment was predicted by higher perceived learning from the program, higher levels of mastery, and more severe pre-intervention anxiety symptoms. The finding for perceived learning is broadly consistent with models of intervention engagement and behavior change [14], [47], both of which highlight having knowledge to perform a target behavior as an essential condition for actual behavioral enactment. This might provide an opportunity to improve skill enactment through the development of strategies to facilitate knowledge acquisition and memory for intervention materials. Recent studies have highlighted the potential of learning support strategies to improve engagement and outcomes [48], [49]. For example, Berg et al. [50] demonstrated a small but significant positive effect of learning support strategies (e.g., knowledge quizzes and pedagogical media such as pictures and video) on both knowledge acquisition and anxiety symptoms when integrated in an online CBT intervention for adolescent anxiety, relative to online CBT alone. However, the fact that we measured learning using participant self-reports could also suggest that participants who were more satisfied with the program, or perceived it to be more valuable, were more likely to try the skills compared with those who were less satisfied. To address this limitation, future studies should employ measures of declarative and procedural knowledge (e.g., multiple choice tests, reviews of homework, hypothetical scenarios) to confirm the findings reported here.

A greater sense of mastery was also associated with increased skill enactment, suggesting that young people who perceive an enhanced sense of agency over outcomes are more likely to implement program strategies. This finding supports research that has found sense of mastery to predict positive health behaviors and outcomes [51], and is consistent with evidence that a feeling of being in control of one's health facilitates engagement with DMHIs [23]. As mastery captures a generalized sense of control over outcomes, future investigation of related control beliefs, such as task-specific self-efficacy to implement program strategies, may provide additional information on possible targets to facilitate skill enactment [52]. A range of strategies can be used to target self-efficacy beliefs, including enactive mastery, peer modeling, and social influence, and in the context of physical health, studies have demonstrated that self-management programs are associated with better outcomes when these strategies are incorporated [53]. In addition, the finding that more severe anxiety symptoms predicted greater skill enactment suggests that

young people who were more anxious may have been more motivated or aware of their need for strategies to support their mental health or may have found the strategies provided in the program to be useful in addressing their symptoms, as treatment and prevention approaches for anxiety and depression can be similar.

Notably, there was no evidence that skill enactment was associated with number of modules completed, suggesting that usage of an online program delivered in schools is a poor indicator of what young people subsequently do offline. Universal programs face a challenge, as intervention recipients include both those who are experiencing symptoms of mental illness as well as many young people who are not currently experiencing mental health challenges. Consequently, factors such as the young person's awareness of and need for mental health support are likely to influence whether program usage translates into skill enactment [45]. Furthermore, the fact that we identified few significant predictors of modules completed could suggest that factors related to the delivery setting (e.g., teacher and classroom characteristics) may be more important for engagement with mandatory program components than student characteristics in school-based DMHIs, consistent with Calear et al. [12]. As the trial on which this study is based demonstrated a positive association between module completion and improvement in depression symptoms [7], future research is needed to clarify how delivery setting impacts program usage. Moreover, focused research that explores student perspectives and predictors of non-participation among young people who choose not to participate in digital programs is needed to help improve engagement among this group, as they may face unique challenges to engaging with DMHIs. Examination of barriers to participation may also extend to parents, as many cases of non-participation in this study were due to non-return or refusal of parental consent."

There was also no evidence to support a relationship between skill enactment and reductions in either depression or anxiety symptoms. This null finding is consistent with findings reported in a study targeting depression prevention among young people attending alternative education [54], but contrasts with evidence from treatment studies of DMHIs among adults [55], [56], [57], suggesting that the pattern of results described here may be related to the preventive nature of the program. Prevention studies often require significant long-term follow-up in order to demonstrate genuine prevention effects [1], and it may be that the length of the study period, paired with substantial loss to follow-up, was not sufficient to demonstrate benefits of skill enactment [45]. Alternatively, improving the frequency with which adaptive strategies are implemented may not be what helps produce symptom improvements in a prevention context. Instead, the program may have helped individuals to reduce their use of maladaptive strategies or improve the quality with which skills are enacted (i.e., how effectively the young person uses strategies in line with how the strategy was taught; [58]), such that ongoing use of specific adaptive strategies was not needed. The literature on emotion regulation and CBT skills use points to a range of possible mechanisms through which treatment strategies can reduce symptom severity [59], [60], and exploring these in future studies may help illuminate mechanisms of action in DMHIs targeting prevention. This research can help guide the targeted refinement and optimization of these interventions to be more efficacious and cost-effective. Finally, despite a non-significant overall finding for personal stigma, contrasts indicated an association between greater skill enactment and stigma reduction at post-intervention. This result should be regarded tentatively given the lack of an overall significant result, but it nevertheless warrants further investigation.

This study has several limitations. There are likely to be other engagement indicators not examined here that are also relevant for outcomes, such as the number of in-program activities completed or the extent to which students accessed additional supports [11]. Examining multiple aspects of engagement is essential to understanding the multifaceted nature of engagement with DMHIs. This may be aided in future trials by recent guidelines on collecting and reporting engagement data, such as those provided by Li et al. [11] and Beintner, Vollert [60]. In addition, our skill enactment measure was based on retrospective self-reports collected at post-intervention from the intervention group, meaning that participants may have over- or under-reported their use of strategies and we could not ascertain changes in skills from baseline to post-intervention or compare these changes against the control group. Collecting skill enactment data can be challenging as items measuring specific cognitive or behavioral strategies may not be readily understood by participants without previous exposure to CBT [61], but future trials should do so using measures that do not assume previous or current treatment engagement [61], [62]. Further, there are likely to be a range of other factors, including motivational (e.g., self-efficacy) and contextual factors (e.g., transitioning through final examinations and out of secondary education), which may have influenced the findings.

Our focus on high-achieving students enrolled in selective classes is also a limitation. Although this group of students may experience unique stressors that make them vulnerable to developing mental health difficulties [25], they may also be more self-motivated and proactive in their approach to engagement than students enrolled in non-selective programs. For example, some established predictors of academic success, such as individual differences in motivation, conscientiousness, and openness to experience [63], have also been shown to predict interest in and engagement with digital interventions [23]. Although no previous studies have investigated skill enactment following DMHIs among young people in mainstream schooling, our finding that more severe baseline anxiety symptoms predicted greater skill enactment contrasts with a previous study among youth in alternative education, which found no effect of initial symptom levels [21]. This might suggest that different factors may be important for DMHI engagement among different groups of young people. Consequently, future work is needed to understand how the findings described in this study apply to young people enrolled in mainstream and alternative education programs. Finally, our use of two screening questions from the Structured Clinical Interview for DSM-IV disorders–Mood module to provide an indication of past depression was not sufficient to establish a formal diagnosis of lifetime presence of depression. Future studies should include a comprehensive evaluation of past symptoms and functional impairment according to established classification systems (e.g., DSM-IV criteria).

5. Conclusions

This study identified several factors associated with engagement in a school-based depression prevention program among final-year secondary school students. These factors were differentially related to our engagement indicators. Adolescents with a possible history of depression tended to use the program less, whereas those with more severe baseline anxiety symptoms, higher levels of mastery, and those who reported learning more from the program enacted the skills they learned from the program more often. In addition, although module completion was shown to be related to improvement in the primary outcome of depression [7], there was no evidence to suggest that skill enactment moderated improvements in symptoms of depression or the secondary outcomes of anxiety and depression stigma. School-based prevention programs delivered online have considerable potential to reduce the prevalence and disease burden of depression and other common mental disorders, but limited understanding of what constitutes effective or meaningful engagement undermines our ability to design better interventions. Understanding processes of behavior change within DMHIs, including factors related to capability (e.g., learning processes, skill acquisition and practice) and motivation (e.g., self-efficacy beliefs and outcome expectancies), but also the dynamic environmental and social context within which engagement occurs, may provide a more rigorous and meaningful approach to studying engagement and guide the development of more appropriate services.

Declaration of Competing Interest

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

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.xjmad.2023.100027.

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Chapter 4. Skill Enactment Among University Students Using a Brief Video-Based Mental Health Intervention: Mixed Methods Study Within a Randomized Controlled Trial

4.1 Foreword

The findings presented in Chapter 3 indicated that different factors predicted skill enactment and module completion in a cRCT of an online depression program for adolescents. History of possible depression predicted fewer modules completed, while higher baseline anxiety, greater mastery, and a higher perceived level of learning from the program predicted greater skill enactment. However, skill enactment was not found to be associated with change in symptoms of depression, anxiety, or personal stigma. A methodological limitation in the study presented in Chapter 3 was the absence of available baseline or control group data from the RCT to include in the analysis, which prevented comparison of potential changes over time and across groups, possibly obscuring important effects. Accordingly, Chapter 4 addressed this limitation by prospectively analysing data from an RCT of a brief video-based mental health intervention for university students with mild to moderate psychological distress. This study involved the development and preliminary psychometric testing of a novel measure designed to assess the application of the specific skills taught in the intervention in everyday life. The study used mixed methods with the aims of: (1) evaluating the effects of a low-intensity video-based intervention on skill enactment relative to an attention-control condition, (2) examining whether skill enactment influences mental health outcomes (symptoms of depression and generalised anxiety disorder), and (3) qualitatively exploring participant experiences of, and motivations for, applying skills from the intervention in their everyday lives. The qualitative component was designed to provide in-depth insights into the personal and contextual factors influencing skill enactment, building on the quantitative findings in Chapter 3.

Note: The primary outcomes paper for the Uni Virtual Clinic-Lite (UVC-Lite) trial is presented in Appendix B.

Original Paper

Skill Enactment Among University Students Using a Brief Video-Based Mental Health Intervention: Mixed Methods Study Within a Randomized Controlled Trial

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Abstract

Background: Mental health problems are common among university students, yet many students do not seek professional help. Digital mental health interventions can increase students' access to support and have been shown to be effective in preventing and treating mental health problems. However, little is known about the extent to which students implement therapeutic skills from these programs in everyday life (ie, skill enactment) or about the impact of skill enactment on outcomes.

Objective: This study aims to assess the effects of a low-intensity video-based intervention, Uni Virtual Clinic Lite (UVC-Lite), in improving skill enactment relative to an attention-control program (primary aim) and examine whether skill enactment influences symptoms of depression and anxiety (secondary aim). The study also qualitatively explored participants' experiences of, and motivations for, engaging with the therapeutic techniques.

Methods: We analyzed data from a randomized controlled trial testing the effectiveness of UVC-Lite for symptoms of depression and anxiety among university students with mild to moderate levels of psychological distress. Participants were recruited from universities across Australia and randomly assigned to 6 weeks of self-guided use of UVC-Lite (243/487, 49.9%) or an attention-control program (244/487, 50.1%). Quantitative data on skill enactment, depression, and anxiety were collected through baseline, postintervention, and 3- and 6-month follow-up surveys. Qualitative data were obtained from 29 intervention-group participants through open-ended questions during postintervention surveys (n=17, 59%) and semistructured interviews (n=12, 41%) after the intervention period concluded.

Results: Mixed model repeated measures ANOVA demonstrated that the intervention did not significantly improve skill enactment ($F_{3,215.36}$=0.50; P=.68). Skill enactment was also not found to influence change in symptoms of depression ($F_{3,241.10}$=1.69; P=.17) or anxiety ($F_{3,233.71}$=1.11; P=.35). However, higher levels of skill enactment were associated with lower symptom levels among both intervention and control group participants across time points (depression: $F_{1,541.87}$=134.61; P<.001; anxiety: $F_{1,535.11}$=73.08; P<.001). Inductive content analysis confirmed low levels of skill enactment among intervention group participants. Participants were motivated to use techniques and skills that were perceived to be personally relevant, easily integrated into daily life, and that were novel or had worked for them in the past.

Conclusions: The intervention did not improve skill enactment or mental health among students with mild to moderate psychological distress. Low adherence impacted our ability to draw robust conclusions regarding the intervention's impact on outcomes. Factors influencing skill enactment differed across individuals, suggesting that it may be necessary to tailor therapeutic

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skills and engagement strategies to the individual user. Theoretically informed research involving collaboration with end users is needed to understand the processes underlying skill enactment in digital mental health interventions.

Trial Registration: Australian New Zealand Clinical Trials Registry ACTRN12621000375853; https://tinyurl.com/7b9ar54r

(JMIR Ment Health 2024;11:e53794) doi: 10.2196/53794

KEYWORDS

university students; young people; internet; computer-assisted therapy; engagement; skill enactment; depression; anxiety; randomized controlled trial; mobile phone

Introduction

Background

University students are a population in need of mental health support. Before the COVID-19 pandemic, findings from the World Health Organization World Mental Health International College Student initiative indicated that approximately one-third of students met the criteria for a mental disorder each year [1,2]. Mood and anxiety disorders are the most common diagnoses [1]. Research conducted since the beginning of the pandemic has generally indicated an increase in the prevalence of mental health problems among university students [3,4]. It is estimated that 30% to 40% of students experienced elevated levels of depression and anxiety symptoms during the first 2 years of the pandemic alone [5,6], with the highest rates reported for students in low- and middle-income countries [4]. Mental health problems among students have been associated with a range of negative outcomes, including reduced academic performance, lower engagement in campus life, poorer interpersonal relationships, and higher dropout rates [2,7-9]. However, evidence from upper-middle and high-income countries suggests that only 25% of students with a mental disorder receive treatment in a given year [2]. Common barriers to accessing mental health services include lack of time, stigma, high treatment costs, and insufficient capacity of university counseling centers to meet student demand [10,11]. Some of these barriers may be addressed through the provision of evidence-based digital mental health interventions (DMHIs) [2,12].

University students from various countries and regions have indicated a willingness to use digital tools for mental health–related information and support, highlighting benefits in improved access, privacy, confidentiality, and reduced costs [13]. Moreover, several systematic reviews have indicated that DMHIs targeting tertiary students can be effective for symptoms of depression and anxiety when delivered under trial conditions [12,14,15], with the most robust support for programs based on cognitive behavioral therapy (CBT) [12]. However, there is also evidence to suggest that the benefits of DMHIs are diminished in real-world settings [16,17], with high rates of dropout and a lack of sustained engagement frequently reported as key challenges to program effectiveness and successful implementation in both the general and student populations [15,18]. Although strategies such as the use of reminders, coaching, and engagement facilitation interventions offer the potential to redress suboptimal levels of engagement [19-21], their effectiveness has so far been variable, and a recent systematic review concluded that more research is needed to ensure that engagement strategies are effective and acceptable for end users [22].

Efforts to improve engagement with DMHIs are further complicated by a lack of consensus regarding how to define and measure engagement [22]. Most previous studies have focused on program use indicators of engagement (eg, number of logins or modules accessed) [23,24], reflecting the extent to which users are exposed to or interact with intervention materials. These indicators provide relatively objective information on use patterns and have been associated with small to moderate improvements in mental health outcomes in some instances [25,26]. However, they may not account for other factors that might be more closely related to positive outcomes, such as the degree to which users integrate and apply the therapeutic techniques from an intervention into their daily lives (ie, skill enactment) [27]. Recent recommendations, such as those provided by Li et al [24], Beintner et al [23], and Baumel [27], underscore the importance of investigating skill enactment as a distinct aspect of engagement that goes beyond the technology used to capture the cognitive and behavioral changes a user makes in their everyday life because of intervention [27-30]. Evaluating the strategies and techniques individuals implement from digital interventions is likely to be important both as a stand-alone outcome following intervention and because of its potential role as a mediator of treatment outcomes [31,32]. Skill enactment is likely to be an important outcome to consider in itself given suggestions that adopting healthy actions and routines may help maintain mental health or prevent future problems by improving the individual's ability to cope with stressors [31,32]. This may be especially relevant in interventions targeting relatively mild distress or symptoms where improvements in mental health outcomes may be small. Moreover, skill enactment has also been argued to be critical to understanding the impact of an intervention on symptom reduction [27,33]. This is because most therapeutic programs are predicated on the theoretical understanding that positive change occurs by facilitating the uptake of adaptive cognitive and behavioral skills [27].

The proposed importance of skill enactment has some support from recent studies that have demonstrated that DMHIs can effectively increase levels of skill enactment among adults with at least clinically mild symptoms of depression or anxiety at mid or postintervention assessments [34-36]. These studies also tend to indicate that improvements in skill enactment (ie, increase in the use of cognitive or behavioral skills, such as cognitive reframing and behavioral activation) are associated with small to moderate improvements in depression and anxiety [35-38]. However, a recent systematic review of digital CBT

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programs targeting depression and anxiety identified a gap in the literature on skill enactment among young people [30], and none of the included studies explored changes in skill enactment among a university student sample. Furthermore, qualitative or mixed methods investigations of skill enactment in digital interventions are rare [39], and we are not aware of any studies specifically exploring experiences of skill enactment among university students. As little is known about skill enactment in this population, there is a need for research examining skill enactment, its potential implications for mental health outcomes, and experiences among university students participating in DMHIs.

This Study

This mixed methods study investigated skill enactment among university students with mild to moderate distress who participated in a randomized controlled trial (RCT) of the Uni Virtual Clinic Lite (UVC-Lite), a low-intensity internet-based program designed to address depression, anxiety, and other mental health problems that commonly affect university students. The results from the trial have been submitted for publication [40] and indicated no differences between the UVC-Lite intervention and an attention-control program on any of the primary (symptoms of depression and generalized anxiety disorder) or secondary outcomes at postintervention measurement, 3-month, or 6-month follow-ups. Despite these nonsignificant results, understanding patterns and experiences related to skill enactment remains pertinent due to its potential relevance in maintaining mental health and improving future interventions. The primary aim of this study was to investigate whether the UVC-Lite intervention led to improvements in skill enactment. As per the study protocol, we also intended to investigate whether improvements in skill enactment mediated change in mental health outcomes (secondary aim). Although the intervention was not shown to be effective, we retained statistical analyses to explore the association between skill enactment and mental health outcomes. As there was a significant reduction in symptoms of depression and anxiety at posttest assessment across both conditions, there remained the potential to observe whether change in mental health outcomes was associated with skill enactment. We restricted our analysis to investigate the primary outcomes of depression and anxiety symptoms. We supplemented the quantitative component with partial data set analysis of semistructured interviews and free-text response data from participants who received access to UVC-Lite to examine patterns of skill enactment and explore participants' motivations for using the techniques delivered in the program. By collecting feedback from participants, it may be possible to refine the content and features of the intervention to enhance engagement and skill enactment.

We hypothesized that skill enactment would be higher in the UVC-Lite intervention condition than the attention-control condition at postintervention, 3-month, and 6-month follow-up assessments.

Methods

Overview

The CONSORT-EHEALTH (Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth) is presented in Multimedia Appendix 1 [41]. Data for this study were collected as part of an RCT that examined the effectiveness of UVC-Lite in reducing depression and anxiety symptoms among university students with mild to moderate levels of psychological distress. Participants were randomly assigned to either the UVC-Lite intervention or an attention-control program for a period of 6 weeks. A full description of the trial methods and primary outcomes, including information on allocation concealment, randomization procedures, and blinding, is provided in the main trial paper [40].

Participants

RCT Data

Trial participants were 487 undergraduate and postgraduate students, recruited and randomized into the trial between August 2021, and May 2022. Follow-up data were collected by January 2023. Students from all universities in Australia were invited to participate in the trial using a range of recruitment methods. These included targeted social media advertising, posts in university-related social media groups, and advertisements in university newsletters. In addition, assistance was sought from student associations and advocacy departments, student housing services, university marketing teams, survey management departments, university counseling and well-being clinics, and academic course coordinators to disseminate information about the trial to students via email and flyers. A total of 2865 students clicked on the study invitation and were screened for eligibility. Of these, 523 (18.25%) participants were initially screened into the trial, completed baseline measures, and were randomized to the UVC-Lite intervention (n=261, 49.9%) or attention-control group (n=262, 50.1%). A further 6.9% (36/523) of the participants were excluded after randomization due to being older than the eligible age range. Respondents were eligible for inclusion if they were (1) enrolled at an Australian university and resided in Australia, (2) aged between 18 and 25 years, and (3) scored between 8 and 17 on the Distress Questionnaire-5, indicating mild to moderate levels of psychological distress [42]. Students diagnosed with bipolar disorder, schizophrenia, posttraumatic stress disorder, or a personality disorder could participate if they met eligibility criteria and were receiving support or treatment for their disorder. Students who were ineligible due to high levels of psychological distress were provided with help-seeking resources.

Follow-Up Interviews

Purposive sampling was used to recruit participants for interview. All participants (131/243, 53.9%) randomized to the intervention condition who completed the postintervention survey were invited to provide additional feedback by telephone or videoconference about their experience with the modules. Of these, 38.9% (51/131) of the respondents indicated a

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willingness to provide their feedback. From this group, 33% (17/51) of the participants responded to the subsequent email invitation and 24% (12/51) participated in an interview. Reasons for not participating included loss of contact (3/51, 6%) and being overseas (2/51, 4%). In addition, 1 follow-up email was sent to participants if there was no response to the initial email. No incentives were offered for participation in the interview.

Intervention and Attention-Control Conditions

Intervention Condition: UVC-Lite

The UVC-Lite is a low-intensity internet-based intervention comprising 12 modules that target the common mechanisms underlying mental health problems in university students. Content for the intervention was drawn from the Uni Virtual Clinic, an web-based mental health intervention for university students that was shown to be effective in reducing symptoms of social anxiety and improving academic self-efficacy compared to a waitlist control group in a previous trial [43,44]. Each UVC-Lite module comprises a 3- to 6-minute video presenting psychoeducation about a mental health problem and a therapeutic technique designed to address the problem. The videos provide practical examples and guidance on how to apply the techniques in daily life. The modules also include optional exercises designed to encourage the practice of therapeutic techniques, self-monitoring quizzes (included in modules 1, 3, 4, 5, 7, and 11), and links to help-seeking resources provided at their university or in the community if necessary. The twelve modules include (1) dealing with depression and low mood (behavioral activation), (2) tackling negative and anxious thoughts (cognitive reframing), (3) dealing with anxiety (cognitive reframing, breathing, and grounding techniques), (4) managing study issues: procrastination and time management (practical strategies for time management), (5) perfectionism (challenging perfectionistic thoughts and behaviors), (6) coping with stress (mindfulness practice), (7) managing sleep issues (sleep hygiene), (8) social anxiety and shyness (behavioral experiments and exposure techniques), (9) relationships and loneliness (communication skills and social support), (10) social media use (practical strategies for reducing social media use), (11) body image (body functionality appreciation), and (12) thoughts of suicide (safety planning). Modules were delivered twice weekly over the 6-week intervention period.

Attention-Control Condition: General Health Information

Participants assigned to the attention-control condition received 2 emails per week containing a web link to a PDF document providing information on topics related to general health rather than mental health, approximately matched for completion time with the active intervention. A total of 12 topics were covered, including bone health, sun exposure, food hygiene, dietary supplements, kidney health, microbes, household burns, respiratory viruses, heart health, allergens, posture, and pancreas health. A similar program has previously been shown to be associated with no therapeutic reductions in depression [45].

Data Collection

Overview

At baseline, the following demographic data were collected: age, gender, ethnicity, living situation, employment status, study discipline and year of degree, study load, and international or domestic student status. Quantitative data on skill enactment, depression symptoms, and generalized anxiety symptoms were obtained using web-based self-report questionnaires at baseline, postintervention assessment (emailed to participants 6 weeks after completion of the baseline survey), and 3- and 6-month follow-ups (emailed to participants 3 and 6 months after receiving the postintervention survey). Participants received 2 email reminders to finish the postintervention and follow-up surveys. Qualitative data were collected at postintervention assessments (free-text responses) and through interviews conducted with participants following the completion of postintervention assessments between April and August 2022.

Skill Enactment

We assessed skill enactment using a list of 14 items developed to assess the frequency of enacting therapeutic techniques from the UVC-Lite program (eg, “I made time for activities that make me feel better” and “I challenged my thinking to be more realistic and helpful”). At each time point, participants rated how often they used each of the skills over the past 2 weeks on a 5-point scale using the following response options: 0 (never), 1 (rarely), 2 (sometimes), 3 (often), and 4 (very often). Item development was informed by existing CBT skills use questionnaires [46,47]. Exploratory factor analysis was conducted on the skill enactment items before computing total scores. The results of this analysis indicated that the scale could be treated as a single factor. One item was dropped from the measure due to a low factor loading, resulting in a 13-item measure (Multimedia Appendix 2 [48-50]). The internal consistency of the scale was acceptable (Cronbach α=0.84). The 13 items yielded a summed total score ranging from 0 to 52. Higher scores indicate more frequent skill enactment.

Mental Health Outcomes

Primary mental health outcomes were symptoms of depression, measured by the Patient Health Questionnaire-9 (PHQ-9) [51], and generalized anxiety disorder, measured by the Generalized Anxiety Disorder-7 (GAD-7) scale [52]. The PHQ-9 comprises 9 items rated on a 4-point scale, ranging from 0 (not at all) to 3 (nearly every day). Item scores are summed to produce an overall severity score ranging from 0 to 27, with higher scores indicating greater symptom severity (0-4: no symptoms, 5-9: mild symptoms, 10-14: moderate symptoms, and 15-27: severe symptoms). The GAD-7 comprises 7 items rated on the same 4-point scale as the PHQ-9. Summed scores produce an overall severity score ranging from 0 to 21 (0-4: no symptoms, 5-9: mild symptoms, 10-14: moderate symptoms, and 15-21: severe symptoms). Higher scores indicate greater symptom severity. Both scales have demonstrated robust psychometric properties in general population and university student samples [53-56]. In the current sample, internal consistency was acceptable at baseline (PHQ-9: Cronbach α=0.80; GAD-7: Cronbach α=0.84).

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Program Use

JavaScript code was used to track intervention group participants' uptake and use behaviors. We report specific indicators in this study to provide an indication of exposure to the therapeutic content, including the number of modules accessed (ie, whether participants clicked to open each module), number of videos started (ie, >0% of the video watched), and number of therapeutic activities accessed (based on whether participants clicked through to access the exercise). For the control group, we tracked the number of modules accessed.

Qualitative Data

Semistructured interviews were conducted by the first author (HMJ), with ongoing supervision provided by the senior author (LMF). Overall, 7 interviews were conducted via Zoom (Zoom Video Communications), a web-based teleconferencing platform, and the remaining 5 interviews were conducted via telephone. The interview guide was developed by the researchers to investigate participants' thoughts about and use of the video modules and exercises, their suggestions for implementation in universities, and any barriers to the modules being used by university students. The full list of interview questions is provided in Multimedia Appendix 3, although only a subset of questions was the focus of investigation in this paper. Interviews were audio-recorded and transcribed verbatim using a speech-to-text transcription application (Otter.ai; Otter.ai, Inc). Transcripts were corrected by the first author while listening to the audio-recorded interviews.

Participants' satisfaction with and views of the intervention were also assessed during postintervention surveys by asking participants open-ended questions regarding whether there was anything they liked about the program, whether there was anything they disliked about the program, and whether they would change anything about the program.

Data Analysis

Quantitative Data

Quantitative data were analyzed using SPSS for Windows (version 28.0; IBM Corp), and significance was set at $P<.05$. Primary analyses were undertaken on an intention-to-treat basis. Mixed model repeated measures (MMRM) ANOVA was conducted to compare mean scores on skill enactment between the intervention and control groups, with measurement occasion as a within-groups factor and condition as a between-groups factor. MMRM techniques incorporate all available data under the assumption that data are missing at random [57]. Within-person variation was modeled using unstructured covariance matrices, and *df* was estimated using Satterthwaite correction. Subgroup analyses of intervention group participants who started ≥1 videos versus all of the control group were conducted to estimate the effectiveness of UVC-Lite among participants who accessed at least some of the therapeutic content. We opted to use this indicator of program use in the analyses as use of the videos was considered sufficient to promote acquisition and enactment of the therapeutic skills in this intervention and because the module exercises were optional. The influence of skill enactment on primary outcomes (PHQ-9 and GAD-7) was explored using MMRM ANOVA, including 3-way interaction terms for time×condition×skill enactment, as well as all main effects and 2-way interactions. Time-varying skill enactment, measured simultaneously with mental health outcomes, was used in the models. The 3-way interaction tested whether changes in outcome over time differed more for those in the intervention group with greater skill enactment, relative to the control group. The time × skill enactment interaction tested how a change in skill enactment was related to symptoms across different time points.

Qualitative Data

Qualitative data were analyzed using inductive content analysis [58,59], as per the analytic steps outlined by Vears and Gillam [60]. This approach is well suited to answering applied research questions [60]. After reading each of the interviews and free-text responses, the first author extracted all data potentially relevant to the research question to develop a working data set (ie, extracts referring to any aspects of in-program exercises or skill enactment) [61]. Data extracts were drawn from all (12/12, 100%) interview participants and 16.5% (17/103) of the participants who provided free-text responses during the postintervention survey, resulting in the analysis of data from 11.9% (29/243) of intervention group participants. The data then went through several iterations of inductive coding and similar codes were clustered together into content categories. Reporting was structured around the categories, drawing on illustrative quotes from interview transcripts and open-ended responses. Data extracts are presented verbatim, though some words (eg, "like" and "um") were removed to improve readability. Participants are identified by their gender, a coded number, and the type of data provided (eg, M1, interview=male, interview participant 1). Quirkos (offline version; Quirkos Software) was used to analyze qualitative data.

Ethical Considerations

The trial was registered at the Australian New Zealand Clinical Trials Registry (ACTRN12621000375853) and the ethical aspects of the research were approved by the Australian National University Human Research Ethics Committee (protocol #2020/412). All participants provided informed consent by ticking a checkbox on the web after viewing an information sheet containing key details about the study. To protect participant privacy, all data were deidentified. Participants who completed all 4 surveys were entered into a prize draw to win 1 of 10 Aus $100 (US $66.7) gift vouchers.

Results

Sample Characteristics and Participation Rates

The flow of participants through the study is presented in Figure 1 [40,62]. Of the 487 students who were eligible, randomized, and completed baseline measures, 265 (54.4%) completed postintervention surveys, 105 (21.6%) completed 3-month follow-up surveys, and 172 (35.3%) completed 6-month follow-up surveys. Table 1 presents the demographic data for the full sample by trial condition. Students from 40 academic institutions across Australia participated. Most participants were female (355/487, 72.9%), with an average age of 20.62 (SD 2.12) years. Participants were predominantly domestic students

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(411/487, 84.4%) living either with family (209/487, 42.9%) or in on-campus accommodation (152/487, 31.2%). Most (328/487, 67.4%) participants were in some form of paid employment. Most students were studying full time (449/487, 92.2%) for an undergraduate degree (416/487, 85.4%); *t* tests (2-tailed) and chi square analyses demonstrated that there were no significant differences between the intervention and control conditions on any of the baseline demographic variables. Similarly, we found no significant differences between conditions on each of the outcomes of interest at baseline: skill enactment (t_{483}=−1.06; *P*=.29), depression ($t_{471.98}$=1.59; *P*=.11), and anxiety (t_{485}=1.41; *P*=.16). At preintervention, skill enactment was negatively correlated with both depression (*r*=−0.35; *P*<.001) and generalized anxiety (*r*=−0.21; *P*<.001) symptoms.

Figure 1. Flow of participants through the study. This figure is an abbreviated version of the flow diagram presented in the main trial paper by Farrer et al [40], which is published under Creative Commons Attribution 4.0 International License [62]. The figure has been adapted to include numbers on interview participation. DQ5: Distress Questionnaire-5; UVC-Lite: Uni Virtual Clinic Lite.

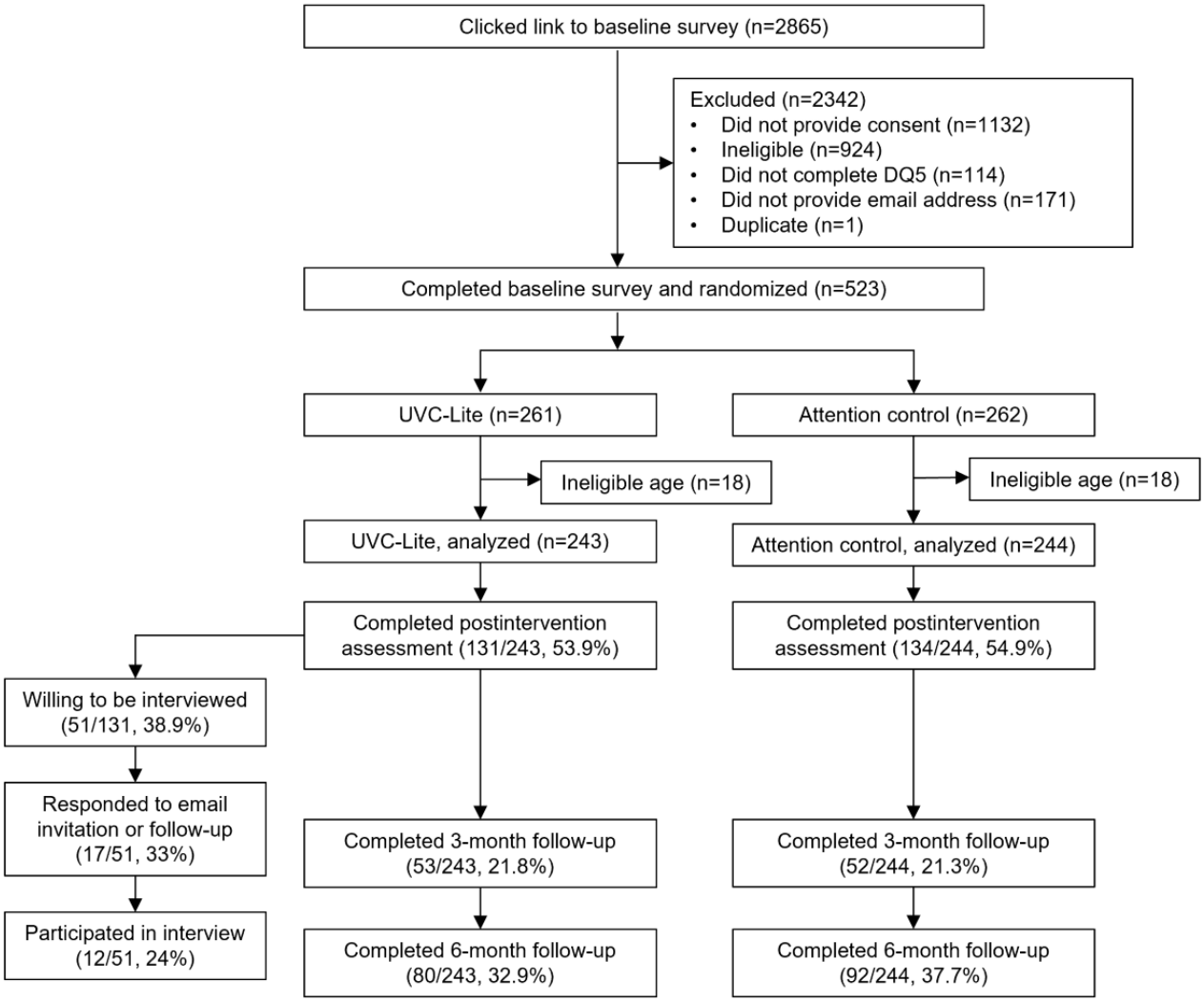

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Table 1. Sample characteristics by condition.

Characteristic	UVC-Lite[a] (n=243)	Attention control (n=244)	Chi-square (*df*)	*t* test (*df*)	*P* value
Gender, n (%)			0.4 (2)	—[b]	.82
Male	52 (21.4)	58 (23.8)			
Female	180 (74.1)	175 (71.7)			
Other	11 (4.5)	11 (4.5)			
Ethnicity, n (%)			3.2 (4)	—	.53
Aboriginal and/or Torres Strait Islander, or Pacific Islander	6 (2.5)	2 (0.8)			
African or Middle Eastern	6 (2.5)	6 (2.5)			
Asian or Indian	65 (26.7)	75 (30.7)			
Caucasian or European	154 (63.4)	152 (62.3)			
Other	11 (4.5)	8 (3.3)			
Current living situation, n (%)			4.6 (6)	—	.59
With parents or family	100 (41.2)	109 (44.7)			
On-campus housing	82 (33.7)	70 (28.7)			
Friends off-campus	24 (9.9)	21 (8.6)			
Others off-campus	19 (7.8)	18 (7.4)			
With partner, children, or both	10 (4.1)	17 (7)			
Alone	7 (2.9)	9 (3.7)			
Other	1 (0.4)	0 (0)			
Hours per week in paid employment, n (%)			6.1 (5)	—	.30
None	89 (36.6)	70 (28.7)			
1-9	53 (21.8)	58 (23.8)			
10-19	68 (28)	67 (27.5)			
20-29	24 (9.9)	33 (13.5)			
30-39	8 (3.3)	15 (6.1)			
≥40	1 (0.4)	1 (0.4)			
Discipline of degree studied, n (%)[c]			5.5 (7)	—	.60
Health/medicine	83 (38.4)	71 (32)			
Arts/social sciences	37 (17.1)	42 (18.9)			
Science	39 (18.1)	45 (20.3)			
Engineering/computing	21 (9.7)	28 (12.6)			
Business/economics	11 (5.1)	14 (6.3)			
Law/criminology	14 (6.5)	15 (6.8)			
Education	11 (5.1)	6 (2.7)			
Tertiary preparation course	0 (0)	1 (0.5)			
Year of degree, n (%)[d]			4.3 (3)	—	.23
First-year undergraduate	93 (38.4)	86 (35.4)			
Later-year undergraduate	107 (44.2)	112 (46.1)			
Honors	5 (2.1)	13 (5.3)			
Postgraduate	37 (15.3)	32 (13.2)			
Study load, n (%)			0.4	—	.51

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Characteristic	UVC-Lite[a] (n=243)	Attention control (n=244)	Chi-square (*df*)	*t* test (*df*)	*P* value
Full time	226 (93)	223 (91.4)			
Part time	17 (7)	21 (8.6)			
Student status, n (%)			0.1	—	.79
Domestic	204 (84)	207 (84.8)			
International	39 (16)	37 (15.2)			
Age (y), mean (SD)	20.67 (2.15)	20.57 (2.09)	—	−0.55 (485)	.58

[a]UVC-Lite: Uni Virtual Clinic Lite.

[b]Not applicable.

[c]Discipline of degree data provided by 216 participants in the UVC-Lite condition and 222 participations in the attention-control condition.

[d]Year of degree data provided by 242 participants in the UVC-Lite condition and 243 participants in the attention-control condition.

Program Use

The use of the UVC-Lite intervention among intervention group participants was low. Although 69.1% (168/243) of the participants accessed ≥1 (mean 5.10, SD 5.08) modules, more than half (129/243, 53.1%; mean 2.48, SD 3.89) of the participants did not start any of the videos, 28.8% (70/243) started 1 to 5 videos, 12.3% (30/243) started 6 to 11 videos, and only 5.8% (14/243) started all 12 videos. Engagement with the therapeutic activities was lower than engagement with the videos. Most participants (157/243, 64.6%; mean 1.31, SD 2.66) did not access any of the therapeutic activities; 27.2% (66/243) accessed 1 to 5 activities, and only 8.2% (20/243) of participants accessed ≥6 activities. Participants who received access to the attention-control program accessed a mean of 4.78 (SD 5.05) modules. More information on patterns of program use is provided in the study by Farrer et al [40].

Change in Skill Enactment

Table 2 presents the observed means and SDs for the outcomes of interest at each measurement occasion across the 2 conditions, and Table 3 provides the estimates of fixed effects from the MMRM ANOVA models. There was no significant overall interaction effect between measurement occasion and condition for skill enactment ($F_{3,215.36}$=0.50; *P*=.68) based on MMRM analyses. Planned contrasts demonstrated no significant interactions between time and condition on skill enactment scores at postintervention, 3-month, or 6-month follow-up assessments, indicating no differences in skill enactment between conditions. When subgroup analyses among those who started ≥1 videos (vs. the control group) were conducted, the overall effect of the intervention on skill enactment scores remained nonsignificant ($F_{3,179.78}$=2.08; *P*=.11). However, exploratory post hoc contrasts demonstrated that intervention group participants who accessed ≥1 videos had higher levels of skill enactment than participants in the control condition at postintervention ($t_{231.96}$=1.99; *P*=.048; 95% CI 0.02-4.01) and 6-month follow-up assessment ($t_{186.84}$=2.09; *P*=.04; 95% CI 0.13-4.64), though not at 3-month follow-up ($t_{132.85}$=0.58; *P*=.57; 95% CI –2.07 to 3.77). We also explored whether a change in skill enactment over time was modified by reliable improvement (reliable improvement vs no reliable improvement. Reliable improvement was defined as a decrease of ≥4 points on either the PHQ-9 or GAD-7 scales from pre to postintervention). The interaction between time, condition, and improvement was not significant ($F_{3,207.14}$=1.13; *P*=.34), but there was a significant 2-way interaction between time and improvement ($F_{3,207.14}$=8.78; *P*<.001). Post hoc contrasts indicated that, regardless of condition, participants demonstrating reliable improvement reported greater skill enactment at postintervention assessment ($t_{282.72}$=3.97; *P*<.001; 95% CI 2.53-7.52) and 3 months ($t_{133.09}$=2.02; *P*=.045; 95% CI 0.09-8.23) than those who did not. This was not significant at the 6-month follow-up ($t_{216.90}$=1.81; *P*=.07; 95% CI –0.23 to 5.39).

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Table 2. Observed means for skill enactment, depression, and anxiety scores at baseline, postintervention, and at 3- and 6-month follow-up.

Outcome	UVC-Lite[a]		Attention control	
	Participants, n (%)	Scores, mean (SD)	Participants, n (%)	Scores, mean (SD)
Skill enactment				
Baseline	243 (100)	27.25 (8.24)	242 (99.2)	26.46 (8.09)
Postintervention	124 (51.0)	27.76 (7.31)	129 (52.9)	26.57 (8.14)
3-month follow-up	52 (21.4)	26.52 (8.97)	50 (20.5)	27.00 (9.14)
6-month follow-up	78 (32.1)	27.47 (7.12)	91 (37.3)	26.27 (6.54)
Depression (PHQ-9[b])				
Baseline	243 (100)	9.70 (5.11)	244 (100)	9.02 (4.34)
Postintervention	131 (53.9)	9.04 (5.31)	134 (54.9)	8.24 (4.80)
3-month follow-up	53 (21.8)	9.06 (5.92)	52 (21.3)	8.13 (4.57)
6-month follow-up	80 (32.9)	9.58 (6.10)	92 (37.7)	9.02 (5.60)
Generalized anxiety (GAD-7[c])				
Baseline	243 (100)	7.84 (4.53)	244 (100)	7.28 (4.13)
Postintervention	130 (53.5)	6.75 (4.19)	134 (54.9)	6.03 (3.90)
3-month follow-up	53 (21.8)	7.21 (4.84)	52 (21.3)	6.60 (4.36)
6-month follow-up	80 (32.9)	8.15 (5.52)	92 (37.7)	7.20 (4.77)

[a]UVC-Lite: Uni Virtual Clinic Lite.

[b]PHQ-9: Patient Health Questionnaire-9.

[c]GAD-7: Generalized Anxiety Disorder Scale-7.

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Table 3. Estimates of fixed effects from mixed model repeated measures models.

Outcome and source	*F* test (*df*)	*P* value
Skill enactment		
Intercept	5607.77 (1, 357.91)	<.001
Time	0.72 (3, 215.36)	.54
Condition	1.10 (1, 357.91)	.29
Time×condition	0.50 (3, 215.36)	.68
Depression score (PHQ-9[a])		
Intercept	644.17 (1, 567.48)	<.001
Time	0.36 (3, 229.22)	.78
Condition	3.30 (1, 567.48)	.07
Skill enactment	134.61 (1, 541.87)	<.001
Time×condition	1.68 (3, 229.22)	.17
Time×skill enactment	1.19 (3, 241.10)	.31
Condition×skill enactment	1.36 (1, 541.87)	.24
Time×condition×skill enactment	1.69 (3, 241.10)	.17
Generalized anxiety score (GAD-7[b])		
Intercept	419.26 (1, 544.66)	<.001
Time	2.05 (3, 221.68)	.11
Condition	0.23 (1, 544.66)	.63
Skill enactment	73.08 (1, 535.11)	<.001
Time×condition	1.13 (3, 221.68)	.34
Time×skill enactment	1.16 (3, 233.71)	.32
Condition×skill enactment	0.15 (1, 535.11)	.70
Time×condition×skill enactment	1.11 (3, 233.71)	.35

[a]PHQ-9: Patient Health Questionnaire-9.

[b]GAD-7: Generalized Anxiety Disorder Scale-7.

Influence of Skill Enactment on Primary Outcomes

In MMRM models testing the effect of skill enactment on mental health outcomes, the 3-way interaction between time, condition, and skill enactment was not significant (PHQ-9: $F_{3,241.10}$=1.69; *P*=.17; GAD-7: $F_{3,233.71}$=1.11; *P*=.35), indicating no differential effects of the intervention for those with greater skill enactment. The 2-way interactions between time and skill enactment were also nonsignificant (PHQ-9: $F_{3,241.10}$=1.19; *P*=.32; GAD-7: $F_{3,233.71}$=1.16; *P*=.32). Planned contrasts confirmed these null results. However, a significant main effect of skill enactment was demonstrated on both depression ($F_{1,541.87}$=134.61; *P*<.001) and anxiety ($F_{1,535.11}$=73.08; *P*<.001) scores, indicating that higher levels of skill enactment were associated with lower symptom levels among both intervention and control group participants across time points. We also examined the influence of skill enactment among intervention group participants who started ≥1 videos (compared against all of the control group). While the main effect of skill enactment remained significant (PHQ-9: $F_{1,492.97}$=130.47; *P*<.001; GAD-7: $F_{1,501.66}$=071.95; *P*<.001), the 3-way interaction (PHQ-9: $F_{3,211.95}$=1.47; *P*=.23; GAD-7: $F_{3,204.92}$=0.9; *P*=.44) and the 2-way interaction effects between time and skill enactment (PHQ-9: $F_{3,211.95}$=1.28; *P*=.28; GAD-7: $F_{3,204.92}$=0.9; *P*=.44) was not significant.

Qualitative Analysis

Description of Participants

Students from 18 academic institutions were represented in the qualitative analysis, 79% (23/29) of whom were female. The mean age of participants who provided qualitative data was 20.97 (SD 2.23) years. Most participants were domestic students (26/29, 90%) studying at the undergraduate level (21/29, 72%) across a range of disciplines (eg, Health and Medicine and Arts and Social Sciences). Unlike most participants randomized to the intervention, engagement among this group was very high; participants accessed a mean of 10.86 (SD 2.37) modules, started a mean of 8.28 (SD 4.33) videos, and accessed a mean of 4.14 (SD 3.62) exercises.

Qualitative Categories

One category was identified from the interviews and open-ended survey responses regarding patterns of skill enactment among

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participants: (1) limited initial and ongoing skill enactment. Three categories were identified regarding the factors that influenced participants' use of the program techniques: (1) relevance and perceived fit, (2) practicality and ease of implementation, and (3) exploring novel approaches and reinforcing familiar ones.

Limited Initial and Ongoing Skill Enactment

Overall, participants' initial engagement with the exercises designed to facilitate the practice of the therapeutic techniques was limited. Where participants did engage, most stated that they tried only some of the exercises, and several participants described a pattern of engagement that lacked depth in terms of the time, effort, or attention they gave to the exercises. For some, this involved reading through the exercises without any or limited further engagement:

> *Like the exercises and things like that, like I read through them. I didn't really, I didn't do any of the exercises myself, but I did...I did read through them and look at them and they seemed pretty, pretty good.* [M1, interview]

Others described completing the exercises, but not in a "fully focused" way [M3, interview], and some commented that their engagement did not go beyond their initial interaction with the exercise in the web-based platform, especially if the exercise included a writing component:

> *For ones that required actually writing things down, if I had something in the moment that I wanted to...that I thought of as I was, like, reading through the exercises then I put them down. But I didn't, like you know, take it as homework and adopt it within my lifestyle.* [F2, interview, writing exercises]

In general, participants did not describe continuing to enact skills from the program after initially interacting with the web-based exercises, and one student noted that they were not "consistent" in their use of skills (F5, interview). At the same time, participants described finding the techniques they did try, which included a mixture of thought records, pleasant events schedules, behavioral experiments for social anxiety, procrastination strategies, body functionality appreciation, or mindfulness exercises, to be practical and useful, and several stated that they would use them in the future if needed:

> *But I can probably look back at that. So, I've downloaded all of them though, for like later reference if I need them.* [F6, interview, behavioral experiments for social anxiety]

Relevance and Perceived Fit

Several participants described the relevance of certain strategies or techniques to their specific symptoms or challenges as a key influence on their decisions to initially engage with the exercises. Techniques that were not seen to be relevant to students' symptoms were less likely to be used, whereas those that were more relevant were more likely to be used:

> *I think at the time, it probably applied to me a bit more. I think that I was probably feeling a bit low in the social skills area of life. Yeah.* [F8, interview, behavioral experiment for social anxiety]

Perceived compatibility between an individual's personal characteristics, their goals, and the techniques taught in the intervention was also mentioned by some participants as positively or negatively influencing their use of specific techniques. For example, one participant commented on the fit between a cognitive exercise (a thought record) and their personal characteristics:

> *And it...it kind of...I am a very logical and, like, a person who likes to process things. So, like, I liked the layout of it, that you could fill in a table and see...work it out.* [F1, interview, thought record exercise]

Although mentioned less often, another participant stated that their use of the techniques was motivated by their preexisting mental health goals:

> *Okay, so pretty much like I'd already been wanting to meditate. And I feel like the videos just like reinforced it.* [M4, interview, mindfulness exercise]

To address issues of relevance and fit, participants recommended tailoring or personalizing program content, for example, by modifying content according to the needs of the student or by highlighting that users can work through the exercises based on their needs and preferences. One participant suggested that "the exercises might be improved by having a few variations by which one might manage their issues" within each module [M5, free-text response].

Practicality and Ease of Implementation

The degree to which participants perceived the strategies to be practical and easy to implement in everyday life also affected their initial willingness to engage with and enact techniques. For example, techniques that were seen as enjoyable, rewarding, and having a tangible impact on mood (such as the pleasant events schedule) were easier to implement for some participants:

> *So then incorporating, I think it was like one achievable task that will give you a sense of achievement and one task for fun. And I'm not used to like scheduling in things just for fun. So that felt really rewarding.* [F4, interview, pleasant events schedule]

Conversely, some participants stated that they were less likely to use exercises that had a significant web-based writing component or that involved multiple steps (such as the thought records):

> *Yeah, there were...there was a lot to like write down and it was maybe if it was like a thought exercise like with just like a couple of steps to do I maybe would have done it more but just because I'm not at my laptop all day.* [F3, interview, thought record exercise]

Other factors that made it challenging to implement the exercises, in general, and in terms of particular topics, included forgetting and lack of time due to other demands:

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> *Ah, time, I suppose...But I've had a very kind of busy schedule, which means I probably should have prioritized it, but I didn't as much as I should have.* [F6, interview, body functionality appreciation exercise]
>
> *...I did download them, but I just forgot about them.* [F13, free-text response]

Participants indicated that changing the presentation of the thought records to be less cognitively demanding (such as by breaking down the exercise into smaller steps) and providing calls to action (eg, using weekly reminders) could facilitate engagement. Several participants also suggested that the exercises should be more interactive:

> *Possibly make them a bit more interactive—maybe add a challenge for the week or something (to help with motivation for these exercises/activities).* [F19, free-text response]

Exploring Novel Approaches and Reinforcing Familiar Ones

Participants also stated that their use of certain strategies or techniques was shaped by previous exposure. Several participants commented that they used strategies that were new to them because the concepts sparked curiosity and motivated them to try out new ways of coping or relating to themselves:

> *And I don't know why I practiced that one in particular, because I'm happy with my body image. But it was just a really interesting notion of 'don't think about, like how your body looks, think about how it performs,' and things like that.* [F5, interview, body functionality appreciation exercise]

In contrast, some participants indicated that they used strategies with which they were already familiar because this reinforced previous knowledge and behaviors:

> *There was like, there was one of them...that is like, you know, I think I've heard it before. I think it's like a common thing. But it was just good to reinforce it. I guess.* [M2, interview, behavioral experiments for social anxiety]
>
> *Improving sleep...yeah, yeah so, I already kind of try and do some of that but it's helpful to kind of have a refresher.* [F6, interview, sleep hygiene exercise]

Discussion

Principal Findings

This mixed methods study aimed to examine skill enactment among university students participating in an RCT of a low-intensity video-based intervention (UVC-Lite). The intervention was not found to be effective in improving self-reported skill enactment. There was also no evidence to indicate that participants who reported greater skill enactment experienced greater improvement in symptoms. This finding is not surprising given that skill enactment remained relatively stable over time and because we did not observe an overall effect of the intervention on primary mental health outcomes in the main trial [40]. These results raise the possibility that it may be difficult to facilitate changes in skill enactment via the unguided use of brief transdiagnostic modules in a sample of university students with mild to moderate levels of distress. Several previous studies have demonstrated that DMHIs can lead to improvements in skill enactment, with some evidence indicating that these improvements mediate improvements in symptoms of depression and anxiety [35,36,38,63]. These factors may provide users with more opportunities to consolidate, practice, and benefit from program skills through increased repetition and reinforcement.

Use of the materials was also low in this trial (ie, approximately half of the participants either did not start any of the videos or accessed any of the activities). These results are comparable to previous studies of DMHIs for students and young people [64-66], including a recent study by Bolinski et al [67], which found that although most students started at least 1 session of an automated transdiagnostic intervention, they completed an average of only 2 (25%) out of the 8 mandatory modules. The low rates of program use in this study suggest that a key explanation for our null results may be insufficient exposure to the therapeutic content. Our subgroup analyses lent some support to this explanation, as contrasts indicated that the program may be effective in improving skill enactment at postintervention and 6-month follow-up for participants who accessed at least some of the intervention materials. However, this result should be interpreted with caution given that the analyses were post hoc and represented small effects, the overall model was not significant, and an effect was not observed at 3-month follow-up. Furthermore, improvements in skill enactment among this group also did not translate to improvements in depression or anxiety, perhaps because the analysis was not sufficiently powered to detect small effects that have been observed in other studies [36].

It is also possible that relatively high baseline levels of self-reported skill enactment (49.1%-83.6% of participants indicated that they used each of the skills, at least sometimes; median 70.8%, IQR 62.4%-78.5%) and low baseline severity of depression and anxiety symptoms affected our ability to detect change. We did find partial support for this idea in our post hoc analysis comparing skill enactment among participants who reported reliable improvement against those who did not. Higher skill enactment was reported at postintervention and 3-month follow-up among those who demonstrated reliable improvement in symptoms. However, there was no evidence to suggest that the intervention led to greater improvements in skill enactment in this group. Further investigation is needed to examine the conditions under which this intervention may be effective and to explore the relationship between skill enactment and outcomes in a larger sample of students with a higher need or more severe symptoms (ie, those with greater potential to experience reliable or clinically significant change).

The results of our qualitative analysis help to further elucidate the processes underlying skill enactment. Participants who provided qualitative data constituted a unique subset of users, as most had high levels of program use. However, even among this group, skill enactment was limited and often did not extend beyond students' initial interactions with the web-based exercises. Instead, participants tended to highlight that they

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planned to use the skills if they experienced a worsening of symptoms. Similar experiences were expressed by participants in 2 previous studies of adolescent and adult users of DMHIs, wherein the authors observed that some users adopt a passive and reactive approach to applying treatment principles [39,68]. Both in these previous studies and our study, this approach appeared to be underpinned by participants' judgments concerning their current and potential future need for strategies to address various mental health concerns, suggesting that tailoring intervention content and activities based on an initial assessment of symptoms may improve skill enactment. However, other studies have reported that students are not more likely to choose content matched to their symptoms based on clinical assessment [69,70], and some research has linked choice to improved outcome [71], which suggests that tailoring approaches may need to strike a balance between student-identified concerns and clinical recommendations.

In addition, participants also highlighted that they were motivated to use skills that were easily integrated into daily routines rather than those that involved a significant writing component (eg, thought record exercises). These findings are consistent with past research on the co-design and evaluation of DMHIs among young people, which found that this group has a preference for practical and easy to use information and an aversion to text-heavy content [72-74]. This might suggest that behavioral activities (eg, pleasant events scheduling) may be more useful among students with mild to moderate distress than cognition-focused exercises, consistent with the suggestions offered by Titov et al [32] that different actions may be important at different levels of mental health. Yet individual differences also appeared to have a substantial influence on participants' decisions to enact certain skills, for example, some participants highlighted that their engagement decisions were underpinned by judgments regarding whether the approach was consistent with their personal characteristics (eg, approach to problem-solving and preexisting goals), and others pointed to the newness or, conversely, the familiarity of the strategy as positively influencing skill enactment.

Suggestions offered by participants to improve engagement with the therapeutic activities included changing the presentation of writing-based activities to be less cognitively demanding (eg, using tunneling features), providing reminders, and enhancing interactivity (eg, using weekly challenges). These results align broadly with the recommendations for persuasive system design provided by Baumel et al [27], who suggested that calls to action (eg, reminding and inspiring users to use a technique) and load reduction (eg, gradual presentation of information to reduce cognitive load) may help encourage users of digital interventions to integrate therapeutic activities in everyday life. Gamification elements, such as the use of points and reward systems or leaderboards, might also be used to enhance interactivity and support motivation among students who face barriers to skill enactment, with a previous RCT of an internet-based intervention finding that adult participants who received concurrent access to a smartphone app encouraging the completion of small challenges in daily life had greater skill enactment than those who did not have concurrent access to the app [75].

Implications

This study was motivated by calls for research to measure and report indicators of meaningful and active engagement such as skill enactment in digital interventions [23,24,27]. However, low rates of program use made it challenging to draw meaningful conclusions regarding whether low-intensity interventions such as the UVC-Lite have the capacity to improve skill enactment among students, or about the potential effects of skill enactment on outcomes. Our results related to low program use and high dropout are common in several trials of digital CBT interventions for young people with relatively mild symptoms [18,76]. They suggest that a low perceived need for intervention among students with mild to moderate symptoms may undermine their motivation to fully engage with CBT-based programs. Lack of perceived need can reduce program uptake and participation [77], but it may also result in a lack of active engagement with therapeutic skills and limited ongoing behavior changes among those who do participate. This suggests that an important priority for future research would be to establish whether low-intensity programs can effectively improve levels of skill enactment and mental health outcomes among students with more severe symptoms. In addition, the potential for the large-scale implementation of unguided interventions in university settings suggests that another direction for future research would be to ascertain the most effective approaches for prevention and early intervention among students. Alternative approaches such as those that focus on preparation for difficult times or establishing healthy routines may be needed with this population. This might include not only mental health education to promote appropriate support seeking, but also well-being interventions (eg, mindfulness-based and positive psychological interventions), stress management programs, strength-based planning, lifestyle interventions, and CBT-based programs targeting less stigmatized challenges such as sleep disturbance.

The study also points to potential pathways for improving intervention design to promote skill enactment. Our qualitative findings related to individual differences in skill enactment suggest that 1 promising approach may be to tailor therapeutic content to the needs and preferences of individual users. For instance, real-time analysis of user behaviors could be used to dynamically tailor therapeutic recommendations and feedback [27], continuous engagement with certain activities might trigger recommendations for more complex activities, while a lack of engagement could trigger recommendations for alternative activities or feedback to address barriers. Tailoring therapeutic recommendations based on other user characteristics is also likely to be beneficial (eg, through assessment of user-identified concerns, goals, or existing mental health knowledge). However, this will require a better understanding of the processes underlying skill enactment among users of DMHIs, including factors that influence initial and ongoing cognitive and behavioral change in everyday life, as well as factors that affect the enactment of different types of skills, especially among different student groups. Qualitative methods involving consultation with end users and the application of structured frameworks of behavior change during data collection and

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interpretation (eg, theoretical domains framework [78]) may help address these aims.

Strengths and Limitations

Strengths of the study include the large sample relative to other trials testing web-based interventions in tertiary student populations [79-81], recruitment of participants from universities across Australia rather than a single institution, and a focus on maximizing ecological validity. However, high ecological validity was also a limitation due to high rates of attrition and low adherence. This may have led to inaccurate estimates of the treatment effect, although we used rigorous MMRM models to account for all available data. Our use of qualitative data to supplement the quantitative analysis represents an additional strength. However, we relied on a self-selected sample of students to provide these data, nearly all of whom were highly engaged. This may have resulted in a sample skewed toward those who had predominantly positive experiences of the intervention, and our findings may not apply to students who did not use or only minimally used the intervention. Questions regarding skill enactment were also asked as part of a larger qualitative study designed to examine students' views on implementing the program within universities, and thus we may not have captured other experiences related to skill enactment. Furthermore, we did not ask participants about potential factors other than the program that may have influenced skill enactment during the measurement period.

In addition, participation among males, gender-diverse students, and international students was low, which may limit the generalizability of the results to other populations. Although this reflects differences in the help-seeking and participation in mental health research more generally [82-84], ongoing efforts to improve participation are important to ensure DMHIs are acceptable and effective for these groups. Given the high number of international students attending university in Australia [85], future studies might also consider the utility of offering interventions in multiple languages to maximize accessibility for international and culturally and linguistically diverse students. We also relied on brief self-report scales to measure outcomes. Although assessments included validated measures of depression and anxiety, a bespoke scale was used to assess skill enactment as none of the standardized measures available at the time of trial design adequately captured the range of techniques covered in the UVC-Lite intervention [46,47,86]. Titov et al [32] have since developed and evaluated a comprehensive self-report questionnaire of mentally healthy actions that is not tied to a specific therapeutic approach and which may assist other researchers to evaluate skill enactment using a standardized approach. However, it will also be important for future studies to assess the fidelity of skill enactment (ie, the extent to which individuals enact skills in line with how they are taught), for example, through evaluations of homework or therapist ratings [30]. Moreover, delivery of the 3-month follow-up assessments was delayed by approximately 1 month for a proportion of participants due to an administrative error.

Conclusions

This study indicated that a transdiagnostic low-intensity video-based program was not effective in improving skill enactment among university students with mild to moderate levels of psychological distress. Our null results may be due to several factors, including characteristics of the intervention, low program use, low baseline severity of participants' symptoms, and high levels of baseline skill enactment. The results of our qualitative analysis suggested that initial and ongoing skill enactment was limited even among participants with high program use, and individual differences appeared to have a substantial influence on decisions to enact skills. Ongoing research with university students is needed to determine who can benefit from low-intensity digital interventions, what types of digital interventions may be most effective, and how we can improve engagement, both in terms of program use and skill enactment, to ensure that the potential benefits of DMHIs are realized. Qualitative and theory-informed research may lead to a better understanding of the mechanisms underlying skill enactment.

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Authors' Contributions

LMF, PJB, and ALC obtained project funding and designed the trial. HMJ developed the research goals and aims and designed the skill enactment measure in consultation with all other authors. LMF and HMJ implemented the study. HMJ analyzed the data. HMJ drafted the manuscript. All authors provided critical revisions to and approved the final manuscript.

Conflicts of Interest

PJB, ALC, and LMF are codevelopers of the Uni Virtual Clinic Lite (UVC-Lite) intervention. LMF was involved in the development of the original UVC-Lite intervention. The other authors declare no conflicts of interest.

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Multimedia Appendix 1

CONSORT-eHEALTH checklist (V 1.6.1).
[PDF File (Adobe PDF File), 92 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Results of the exploratory factor analysis on skill enactment items.
[DOCX File , 18 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Interview questions.
[DOCX File , 17 KB-Multimedia Appendix 3]

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Abbreviations

CBT: cognitive behavioral therapy
CONSORT-eHEALTH: Consolidated Standards of Reporting Trials of Electronic and Mobile Health Applications and Online Telehealth
DMHI: digital mental health intervention
GAD-7: Generalized Anxiety Disorder-7
MMRM: mixed model repeated measures
PHQ-9: Patient Health Questionnaire-9
RCT: randomized controlled trial
UVC-Lite: Uni Virtual Clinic Lite

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Chapter 5. Skill Enactment and Knowledge Acquisition Among Community Users of Digital Mental Health Interventions: Qualitative Study with Thematic Analysis

5.1 Foreword

The studies presented in previous chapters were conducted within the framework of RCTs, which can enhance the internal validity of findings and enables a rigorous evaluation of intervention effects. However, RCTs may not fully capture how DMHIs are used and experienced by people in the community outside of research trials, where program engagement is often lower. Additionally, inconclusive evidence regarding the role of skill enactment—evident in studies within this thesis—and knowledge acquisition in influencing mental health outcomes highlights the need for further investigation. Quantitative methods may not fully address the complexity of these constructs, and qualitative research may offer more in-depth understanding of the experiences and contextual factors that affect skill enactment, knowledge acquisition, and mental health outcomes. Qualitative methods may also provide a more nuanced understanding and can help clarify why quantitative results may vary across different contexts. Accordingly, the study presented in Chapter 5 involved semi-structured qualitative interviews with 13 Australian adults to explore: (1) how community users learn and apply information and skills from DMHIs in daily life, (2) the factors influencing their selection and use of therapeutic strategies, and (3) perceived changes in mental health resulting from their use of a DMHI.

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Skill enactment and knowledge acquisition among community users of digital mental health interventions: qualitative study with thematic analysis

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Abstract

Background The acquisition of knowledge and use of skills from digital mental health interventions (DMHIs) are considered important for effectiveness. However, our understanding of user experiences implementing skills learned from these interventions is limited, particularly outside of research trials. This qualitative study aimed to investigate how community users learn and apply knowledge and skills from DMHIs based on cognitive behavioural therapy (CBT) in daily life. The study also examined factors influencing the selection and use of skills and explored perceived changes in mental health resulting from the intervention.

Methods Thirteen adults aged 26 to 66 years (10 females) were recruited using social media advertising and participated in semi-structured interviews by telephone or videoconference. All participants were living in Australia and had used a digital CBT program within the past 3 months. Interviews lasted on average 45 min. Transcripts were analysed using theoretical thematic analysis.

Results Participants demonstrated high levels of program engagement. Findings were organised into three topics with six major themes. Participants reported that their chosen intervention reinforced existing knowledge and fostered new skills and insights (Topic 1, Theme 1: knowledge consolidation). Most described actively applying skills (Topic 1, Theme 2: active approach to skill enactment), although the extent of learning and range of skills enacted varied across participants. Influences on skill selection included the perceived relevance of intervention strategies to the user's needs and personal characteristics (Topic 2, Theme 1: relevance of intervention strategies), as well as the perceived or experienced effectiveness of those strategies (Topic 2, Theme 2: perceived and experienced benefit). Challenges to ongoing skill enactment included time scarcity, prioritisation difficulties, and lack of motivation (Topic 2, Theme 3: navigating time constraints and low motivation). Improvements in mental health were generally modest and attributed mainly to participants' proactive efforts (Topic 3, Theme 1: perceived changes).

Conclusions DMHIs may reinforce existing understanding of psychotherapeutic strategies, offer new knowledge, and encourage the application of skills in everyday life among community users who actively engage with these

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interventions. Future research should prioritise personalising DMHIs and investigating methods to optimise the acquisition, retention, and sustained application of knowledge and skills.

Keywords Internet, Computer-assisted therapy, Engagement, Skill enactment, Qualitative

Background

Approximately one in five adults meet the diagnostic criteria for a mental health disorder each year [1]. Many of these individuals do not receive timely or appropriate care [2]. Digital mental health interventions (DMHIs) have emerged as potential solutions to improve access to evidence-based services [3]. These interventions are delivered through internet websites or smartphone apps and can be used with or without human support [4]. Meta-analyses have demonstrated the effectiveness of DMHIs in reducing symptoms associated with a range of common mental health problems such as depression and anxiety disorders [5, 6]. Interventions based on cognitive behavioural therapy (CBT) have the most robust evidence supporting their effectiveness [7]. However, not all individuals who use these interventions will experience benefits [8]. This is due in part to levels of user engagement [9], which have frequently been found to be suboptimal in research settings [10] and tend to be even lower among free-range users in the community [11].

Existing literature suggests that user engagement is influenced by several factors, including the perceived relevance of an intervention to user needs, levels of personalisation and interactivity, and the availability of external support or guidance [12]. Individual and demographic differences have also been found to influence engagement, with higher engagement generally observed among females, younger people, those with less severe depression at baseline, and those with more positive beliefs about DMHIs [12]. A limitation of this evidence is that most previous studies have considered these factors in relation to program usage indicators of engagement, such as the number of modules or exercises completed [13]. Recommendations in user engagement research increasingly highlight the need to consider the application of strategies and techniques learned from an intervention in everyday life (i.e., skill enactment) as an additional dimension of engagement [14, 15]. Skill enactment is thought to play an important role in producing treatment effects following CBT and other digital interventions that involve skills training [14, 16]. These programs aim to facilitate improvements by providing users with cognitive and behavioural skills that can be used to cope with and manage symptoms [17]. However, there is currently inconclusive evidence regarding the role of skill enactment in symptom reduction during and after participation in digital CBT. Although some studies have demonstrated improvements in skill enactment alongside mental health outcomes [18, 19], others have failed to show such changes [20, 21]. Additionally, some studies report a non-significant association between skill enactment and post-intervention mental health outcomes [22]. These differences may be attributed to various factors, including differences in intervention length and duration, the presence or absence of tailoring and other engagement features, as well as the availability of guidance [23]. Different skills may also be relevant across different symptom severities and user groups [24]. However, few studies have investigated the processes or factors that underpin successful skill enactment.

One factor that is thought to be necessary for effective skill enactment is the acquisition of knowledge about mental disorders and strategies to address symptoms (referred to as knowledge acquisition hereafter). This is particularly pertinent in self-help programs, where independent learning and self-directed use of intervention materials are emphasised. Psychoeducation is a common component of CBT programs and is typically incorporated with the aim to improve knowledge and understanding of mental disorders, their symptoms, and the underlying cognitive and behavioural patterns contributing to distress. Psychoeducation has been shown to produce small improvements in health outcomes, even in the absence of therapeutic strategies [25]. There is also evidence that digital CBT interventions can produce improvements in explicit recall of CBT principles [14]. However, existing evidence suggests that neither CBT-specific knowledge gain nor improvements in general mental health literacy are related to treatment outcomes following digital CBT [14, 26], and limited research has investigated how improvements in knowledge are related to skill enactment.

Inconclusive evidence regarding the role of skill enactment and knowledge acquisition may be partly attributed to the limitations of quantitative measures in capturing the complexities of these constructs. Qualitative research enables a deeper exploration of the experiences, perspectives, and contextual factors influencing skill enactment and knowledge acquisition. This information is important for driving innovation in the design and implementation of digital interventions. Two previous studies investigated user experiences of learning and applying knowledge gained during digital CBT interventions using qualitative interview methods [27, 28]. Both observed a distinction between participants who actively engage with and apply knowledge and skills versus those who adopt a more passive or reactive approach. Both studies also focused on user experiences following participation

in randomised controlled trials. These settings differ from community-based contexts in ways that may have implications for engagement (e.g., use of explicit assessment protocols and researcher contact). Moreover, interviews took place after an extended time frame, potentially making it difficult for participants to accurately recall initial treatment experiences. The studies also lacked a thorough exploration of factors impacting on initial and ongoing skill enactment or on the use of specific strategies. Addressing these gaps can enhance our understanding of engagement with DMHIs in real-world contexts and guide future intervention design to better account for user experiences and perspectives.

This study used a critical realist paradigm [29] to explore community users' experiences and perspectives of digital CBT programs within 3 months of intervention use, with a focus on skill enactment and knowledge acquisition. Critical realism asserts the existence of an objective reality, while acknowledging that our understanding of this reality is fallible and influenced by social, cultural, and historical contexts [30]. The approach has been applied across various domains of health research, including digital mental health [31–33], aiming to identify and explain complex health phenomena [34]. In this study, we sought to investigate: (1) how community users learn and apply information and skills from DMHIs in daily life, (2) the factors influencing their use of different therapeutic strategies, and (3) perceived changes in mental health and wellbeing resulting from the intervention.

Methods

Overview

The present study reports the results of semi-structured interviews conducted with 13 Australian adults who had used a CBT-based DMHI within the past 3 months. The research team approached the project with an interest in understanding experiences of learning and skill enactment among community users of DMHIs in order to inform future research and intervention design. The first author (HMJ) led the study and conducted and analysed the interviews. HMJ is a female doctoral researcher with training in psychology whose PhD research focuses on engagement with DMHIs. She has previous experience conducting interviews and analysing qualitative data (see [35]). She was interested in new insights and perspectives from the participants, acknowledging the potential impact of her own worldview on the interpretation of findings. Ongoing supervision was provided by the senior author (LMF), a psychologist and researcher in digital mental health. The study is reported according to the COnsolidated criteria for REporting Qualitative Research (COREQ) checklist [36] (refer to Appendix 1).

Recruitment and screening procedure

Participants were purposively sampled into the study over a period of approximately three weeks, from 3 October to 20 October 2023, using targeted social media advertising on Facebook and Instagram. Advertisements targeted Australian adults who were identified as having an interest in mental health and wellbeing based on keywords and community interests associated with their social media profile. Individuals who clicked on the study advertisement were taken to an online Qualtrics survey containing study information and a question to obtain informed and voluntary consent. Respondents were eligible for inclusion if they were aged 18 years or older, currently residing in Australia, and had used a CBT-based DMHI (i.e., online program or smartphone app) within the past 3 months. To confirm eligibility, participants were asked to select from a list of interventions (derived from e-Mental Health in Practice [37] and Beacon [38]) or state the name of the intervention they used most often within the past 3 months. Fictitious program names were listed alongside legitimate programs in an effort to minimise data quality issues. Where participants stated the name of the intervention they used (rather than selecting from the listed interventions), the program was manually screened by the first and senior authors to confirm that it was based on CBT before inviting the participant to interview. CBT-based programs were classified as interventions that included cognitive restructuring as a core component. Respondents who selected a fictitious program ($n=1$) or who had not participated in a CBT-based program ($n=5$) were excluded and provided with help-seeking resources.

Participants

Table 1 presents the characteristics of study participants. Sixteen people were eligible and consented to participate in the study. Of these, three were subsequently unable to be contacted, either to schedule or complete the interview. Therefore, 13 participants aged 26 to 66 years ($M=39.69$ years, $SD=11.09$) participated in the study. Of these, 10 (77%) identified as female and three as male. Most participants had a university degree, and the majority were living in Victoria or New South Wales. Participants reported various mental health concerns, including depression or low mood, anxiety, sleep problems, and a general dissatisfaction with their current mental health. For some participants, these problems were self-described as severe or protracted, and a couple described experiencing significant trauma or stressful life events that contributed to the development of these issues. All participants had used a CBT-based DMHI within the past three months, and three were still working with the program at the time of the interview.

Table 1 Characteristics of the participants

ID[a]	Age[b]	Gender	Ethnicity[c]	State	Education[b]	Program(s)	Presence of guidance	Primary concern[e]
F1	25–34	Female	South Asian	Victoria	Undergraduate degree	THIS WAY UP Social Anxiety Program; Health Anxiety Program[d]	Unguided	Health anxiety, social anxiety
M2	35–55	Male	Chinese	New South Wales	Postgraduate degree	HeadGear	Unguided	Sleep issues, generalised mental health concerns
M3	≥65	Male	Northern European/ Caucasian/ Anglo	New South Wales	Undergraduate degree	THIS WAY UP Health Anxiety Program	Unguided	Health anxiety
F4	25–34	Female	None	Victoria	Vocational education	THIS WAY UP Generalised Anxiety Program; Depression Program[d]	Unguided	Anxiety
F5	25–34	Female	Indian	Victoria	Undergraduate degree	MumMoodBooster	Coach supported	Depression
F6	35–44	Female	Australian	New South Wales	Secondary education	THIS WAY UP Mixed Anxiety and Depression Program	Unguided	Depression, Anxiety
M7	25–34	Male	Indian	Victoria	Postgraduate degree	MoodMission, CBT Companion, What's Up?[d]	Unguided	Low mood
F8	35–44	Female	Asian	New South Wales	Undergraduate degree	THIS WAY UP Insomnia Program	Unguided	Sleep issues
F9	25–34	Female	Caucasian/ New Zealander	New South Wales	Vocational education	MindSpot Wellbeing Course	Unguided	Multiple mental health concerns, low quality of life
F10	35–44	Female	South Asian	Victoria	Postgraduate degree	MumMoodBooster	Coach supported	Generalised mental health concerns
F11	45–54	Female	New Zealander	Victoria	Undergraduate degree	MindSpot Wellbeing Course	Therapist supported	Generalised mental health concerns
F12	45–54	Female	White Australian	Queensland	Undergraduate degree	moodgym	Unguided	Anxiety, low mood
F13	25–34	Female	Asian	Victoria	Undergraduate degree	THIS WAY UP Depression Program	Unguided	Depression

[a]Participants are identified by their gender and a coded number

[b]Broad classifications are reported to hide the exact age and qualifications of the participants

[c]Self-identified ethnicity is reported

[d]Participant used two or more eligible interventions

[e]Self-identified concerns are reported

Data collection

Semi-structured interviews were conducted to capture variability in the experiences of DMHIs among community users, while covering the key topics of interest with all participants. Participants were given the choice of participating in an interview via telephone or Zoom, as research suggests that offering multiple interview formats can improve participant recruitment and data quality [39]. Eight interviews were conducted by telephone, with the remaining five conducted on Zoom. The interviews lasted between 21 and 65 min, with an average length of 46.2 (SD=14.9) minutes. Participants were informed that the interviewer was a PhD student researching user engagement with DMHIs prior to participating. They were advised to choose a quiet space away from others to maintain confidentiality and encourage open discussion. The interview questions were developed by the research team to explore the following topic areas: (1) how participants learned and applied information and skills from the DMHI in their daily lives; (2) factors influencing their selection and use of therapeutic techniques; and (3) perceived changes in their mental health or wellbeing and their thoughts regarding what may have brought about these changes. The full list of interview questions is provided in Appendix 2. Example questions include: "Did you learn anything new from the program/app?" and "Have you continued to use anything from the program/app in your everyday life? If so, in what way?". No substantive changes were made to the interview guide during the study. Prompts and follow-up questions were used to encourage participants to clarify or elaborate on their responses, and to delve deeper into specific areas of interest as they arose during conversation. Demographic information was collected at the beginning of each interview, and usage levels were determined by asking

participants how much of the program or app they had completed.

We used an information power approach to guide sample size decisions [40], considering the study aims, sample characteristics, quality of participant interactions, and analytic method during both study design and data collection. Data were reviewed during data collection, and the number of participants was adjusted downwards from 15 (estimated during study design) to 13 due to the high quality of participant dialogue and high relevance of data to the research questions. This sample size was deemed sufficient to yield rich and experientially diverse data [41]. The interviewer had no prior relationship with the participants, and repeat interviews were not conducted. Field notes were recorded after each interview to document important observations and contextual information.

Transcription and analysis

Data were managed using Quirkos (desktop version). Interviews were audio-recorded and transcribed verbatim using Otter.ai, an automated speech-to-text transcription application. Transcripts were corrected and de-identified by the first author (HMJ) while listening to the audio-recordings. All participants were offered the opportunity to review their transcript; de-identified copies were provided to six participants, and four returned their transcript following review. No changes were suggested. For the remaining two participants, consent to use their transcript was assumed when no communication was received within two weeks, per the ethics protocol. This process was communicated to participants through the study information sheet, on conclusion of the interview, and in email correspondence containing the corrected transcript. Transcripts were analysed using theoretical thematic analysis [42]. This approach was chosen as it provides a systematic method to identify repeated patterns of meaning, guided by analytical interests. A broad coding frame, centred on the key topic areas addressed during the interviews—namely, (1) experiences of knowledge acquisition and skill enactment, (2) factors influencing skill enactment, and (3) perceived change in mental health—was used to address our research questions. Following data familiarisation, codes were developed and applied to the data under each topic by the first author (HMJ). Similar codes were grouped together to form initial themes using a primarily inductive approach. This approach was used to capture a broad range of participant experiences and perspectives, providing a useful foundation for understanding the outcomes studied. The themes were refined through review against the coded data extracts and interview transcripts. Themes are reported under each pre-determined topic area. Verbatim quotes are utilised to illustrate themes, although filler words such as "like" and "um" were removed for readability. Participants are identified using self-reported gender and a coded number (e.g., F1 = female, participant 1).

Table 2 Overview of topics, themes, and sub-themes

Topic/ Theme	Sub-themes
Topic 1: Knowledge acquisition and skill enactment	
Knowledge consolidation	i. Reinforcing existing knowledge ii. Enhanced comprehension and understanding
Active approach to skill enactment	i. Variability in skill selection
Topic 2: Factors influencing skill enactment	
Relevance of intervention strategies	i. User needs and characteristics ii. Lack of tailoring and customisation
Perceived and experienced benefit	–
Navigating time constraints and low motivation	–
Topic 3: Impact on mental health	
Perceived changes	i. Factors driving change

Ethical considerations

All participants provided written informed consent after reading an information sheet in accordance with the Declaration of Helsinki. Electronic gift cards valued at $30 (AUD) were distributed to thank participants for their time. The study received ethical approval from the Australian National University Human Research Ethics Committee (protocol number 2023/561).

Results

The themes and sub-themes are described within the broad topic areas targeted during the interviews and are presented in Table 2. We observed several contexts relevant to understanding experiences of skill enactment and knowledge acquisition among the participants. Firstly, participants were generally quite knowledgeable about mental health. About half of the participants had prior contact with mental health services either through their own treatment or by supporting a family member's treatment, such as accessing services for a child or attending sessions as a partner. Others had used self-help resources in the past and a few had worked in or held qualifications in related fields. Secondly, this group demonstrated high program engagement, with all participants completing most, if not all, of their selected program. Participants had diverse motivations for using digital tools. Several cited the affordability of digital programs, while others preferred using digital tools or felt their concerns did not warrant more intensive support. Two participants signed up for a digital intervention due to barriers in accessing face-to-face services, with both beginning in-person treatment during their use of the digital intervention.

Lastly, participants reported generally positive experiences with their selected intervention. Key benefits cited by participants included the provision of practical strategies to reduce distress, along with a general sense of being supported.

Topic 1: knowledge acquisition and skill enactment

Two themes were developed to describe the data in relation to Topic 1: (1) knowledge consolidation (subthemes: (i) reinforcing existing knowledge and (ii) enhanced comprehension and insight) and (2) active approach to skill enactment (subtheme: (i) variability in skill selection). The first, knowledge consolidation, highlights how digital CBT programs enable users to revisit, strengthen, and build on their existing knowledge and skills related to mental health. The second theme, active approach to skill enactment, demonstrates how participants actively engage with intervention skills, both initially and over time. Differences were evident in the range and types of skills used among participants.

Topic 1, theme 1: knowledge consolidation

Subtheme 1: reinforcing existing knowledge

Most participants highlighted that the information presented in their selected intervention was "*…not new*" (F10). Instead, it felt familiar or aligned with what they already knew or had encountered previously. For example, one participant remarked, "*there's not necessarily a huge amount of novel information*" (M3), while another simply stated, "*I don't think I learnt anything new at all*" (F8). Others commented that although they may not have explicitly known or articulated the concepts presented in the intervention, the information was not surprising because it was "*common sense*" (F1). Revisiting familiar concepts was generally viewed positively, with one calling the program a "*…good little refresher*" (F12) that helped reinforce their existing knowledge, and another stating, "*It doesn't have to be rocket surgery. It's just a reminder…*" (M3). This was important as some participants had forgotten things they previously knew, "*All these years. I was enough busy. I forgot all these things*" (F10). These reminders boosted participants' confidence in their existing knowledge, with one participant commenting that it reminded them of some things they knew "*…and confirmed that that was a good coping strategy*" (F12). Others emphasised that the intervention reminded them to "*look out for*" (F5) themselves first. However, one participant whose mental health issues significantly impacted their daily life found these reminders distressing because they reminded them of their perceived inadequacies, "*I think maybe something to aspire to. Maybe somewhat more distressing though. Maybe just a reminder of how inadequate I am or how stuck I am*" (F8).

Subtheme 2: enhanced comprehension and insight

Most participants described gaining some knowledge or skills from their chosen intervention, although the degree of perceived learning appeared to vary based on their existing levels of knowledge. Many participants who were already quite knowledgeable pinpointed specific gains, "*ways to relax and… practice mindfulness… so there was some new things*" (M2). Conversely, those with limited knowledge emphasised broader insights, with two participants stating they "*learned a lot of things*" (F13, F5). Although participants were already familiar with some concepts, they also highlighted the "*…difference between having knowledge of something and then having that in an applicable form*" (M7). Many found that the accessible and structured format of the programs aided them in developing this knowledge, with one participant commenting that having the information and activities "*broken down into steps was really kind of helpful*" (F4), underscoring the value of this approach in fostering problem-solving skills:

"…the whole problem-solving thing was really important. So, the problem solving, how to break things down into different steps, and how to approach things at a different level or slower." (F4).

In several cases, the interventions also led to a shift in the way the participants perceived and interpreted their emotions and experiences, "*the key takeaway… was that sometimes we really overthink our interactions with others, and that module really made me reflect on that… So, I keep that in mind even now*" (F1). Others described a shift in focus away from external factors beyond their control to their actions and internal thought processes:

"A lot of it has to do with how we perceive and go about things. And so, you know, I guess the management side of it. We can manage it ourselves. So yeah, it was good to learn about that." (M2).

Topic 1, theme 2: active approach to skill enactment

Participants generally demonstrated an active approach to applying the intervention skills, engaging with online activities initially and making concerted efforts to apply these strategies beyond their initial engagement. One participant stated, "*I'm trying to use those strategies. You know, I'm trying to sort of rewire my brain*" (F12, referring to cognitive restructuring). Another shared that they, "*… tried to practice the same things*" (M2, referring to lifestyle and sleep hygiene) after finishing their selected intervention, highlighting ongoing efforts to enact skills. Some participants also described developing personalised approaches to applying the skills, as highlighted by one participant when describing their efforts to achieve a balanced state of mind integrating both rational and emotional aspects:

"So, it was sort of sort of as I was practicing wise mind. You know, within that unit sort of practicing it … And I was like, 'Oh, yeah. I can talk to so and so. And I can talk to this person too. And they're really good for sound boarding. Oh, yeah. So, I can use these people as wise mind soundboards." (F6).

For some, implementing the strategies demanded less effort over time, with one participant stating that it had become "*really easy*" to think differently and commenting, "*…it is like a part of me now*" (F5). Others described it as a "*work in progress*" (F1) and challenges persisted for some, as indicated by one participant who remarked, "*as much as I know about sleep hygiene, implementing it has always been hard*" (F6). Sometimes, participants attributed these difficulties to their own capabilities or perceived shortcomings:

"…sometimes I get really frustrated with my unhelpful thoughts and think well, 'cause I'm 50, so it's a bit different…to like a 20-year-old, where you're able to kind of interrupt the patterns before it gets too ingrained. So sometimes I think…maybe I'm just too far gone." (F11, referring to cognitive restructuring).

Despite challenges, many participants intended to continue practicing the skills acquired from their selected intervention, with one noting, "*…obviously, I will just keep practicing it*" (F4, referring to problem-solving). Others had already revisited, or intended to revisit, the treatment materials in order to further develop their skills, "*I think it'd be good to probably revisit it…and go through, maybe do the challenge again*" (M2). However, one participant questioned how sustainable these changes would be over time, "*…at the moment, because it's still quite recent and fairly fresh in my memory, I am quite aware of it, conscious of it. If that's going to be sustainable long term, I don't know*" (F1).

Subtheme 2: variability in skill selection

Although all participants engaged with the intervention skills, differences emerged in the number and types of skills used. Nearly half of the participants described trying most or all of the online activities initially, with one stating, "*I used everything*" (F5). However, others took a more selective approach, "*I tried some of them*" (M7). These differences persisted regarding skill enactment beyond participants' initial engagement. Those with existing knowledge typically concentrated on integrating select skills. Many of these participants also described using various strategies to support their mental health prior to intervention, such as physical activity, hobbies, or social connections. Some among this group focused on integrating newly acquired skills, such as problem-solving techniques or fostering social connections, whereas others aimed to strengthen existing skills. Among those focused on improving existing skills, cognitive restructuring emerged as a prominent strategy, with one participant commenting, "*…managing thoughts is the key one for me*" (M3) and another stating that they were "*trying to do that a lot more*" (F12). Conversely, participants with limited knowledge or skill enactment prior to intervention generally adopted a broader range of strategies, emphasising a focus on establishing healthy habits and routines, "*I'm taking a lot of care of my diet…I started doing yoga. And I think it's more like, peaceful for my mind. And kind of like connecting with nature*" (F13).

Topic 2: factors influencing skill enactment

Three themes were developed in relation to Topic 2: (1) relevance of intervention strategies (subthemes: (i) user needs and characteristics and (ii) lack of tailoring and customisation), (2) perceived and experienced benefit, and (3) navigating time constraints and low motivation. The first theme, relevance of intervention strategies, underscores how the alignment of intervention strategies to the users' unique needs and characteristics can facilitate or hinder skill enactment decisions. The second theme, perceived and experienced benefit, highlights how participants' perceptions and experiences influence their judgments regarding the effectiveness of intervention strategies, which in turn shape initial and ongoing skill enactment. The final theme, navigating time constraints and competing priorities, emphasises the practical challenges participants encounter to integrating intervention skills into their daily routines amidst busy schedules and competing responsibilities.

Topic 2, theme 1: relevance of intervention strategies

Subtheme 1: user needs and characteristics

All participants demonstrated an understanding of their unique symptoms and challenges. Recognising these challenges motivated participants to seek change and work towards personal growth and improvement, "*I always felt like I had this issue…and I thought that I should change…this bad habit. Obviously, it is kind of a habit*" (F5). Underlying participants' motivation was a belief that these concerns could be addressed through psychotherapeutic intervention, with some preferring it over medication, "*…because the doctor kind of recommended me, okay, you should take antidepressants…but I wasn't into pills or anything. I want to do it naturally*" (F5). The desire for change prompted participants to prioritise strategies that directly addressed their needs or concerns. Several focused on cognitive restructuring because it targeted their "*biggest problems*" (F12), while others integrated sleep hygiene and lifestyle practices or mindfulness, "*My thing is breathing, regulating my breathing, because that helps my heart rate*" (F6). Conversely, strategies perceived as less relevant were often

disregarded, "*…I just didn't wanna go right into that because I didn't think that was relevant at the time*" (F4).

Participants' decisions to enact skills were further influenced by the alignment between their perceived personal characteristics or abilities and the intervention strategies, as illustrated by one participant who found cognitive exercises suitable because they enjoyed introspective and analytical thinking: "*…I really like thinking about things. So, in kind of analysing my thoughts, why I might think a certain way…*" (F11). Less alignment reduced skill enactment, as illustrated by one participant who expressed doubts about their ability to maintain focus during mindful breathing practice:

"…maybe my concentration and attention is not the best. And also, sometimes I kind of can get distracted very quickly, very easily. And that, I guess you need to have a lot of patience and be able to concentrate on that in order for it to work." (F1).

Subtheme 2: lack of tailoring and customisation

Several participants felt their selected intervention lacked tailoring to their individual needs, with some noting that this impacted their engagement with the online activities and motivation to apply skills. Some older participants noted that the interventions seemed to be "*…pitched to the younger age group*" (M3). Others highlighted a lack of tailoring to their current symptom levels or existing knowledge. For instance, one participant, who was experiencing severe mental health difficulties, felt overwhelmed by the amount of information provided in each module and suggested breaking it down over several weeks "*…to focus on week one, engaging in exercise, week two, engaging with food in a more kind of healthy way… rather than trying to look at the picture as a whole*" (F9). Another participant, a trained counsellor, observed, "*the course does seem to be tailored to people who maybe have never done CBT before*" (F11). Some participants commented that the lack of personalisation "*…kind of felt demotivating*" (M7), and several underscored the importance of providing tailored content to maintain engagement, "*it would be good to have a bit more tailoring or personalisation so you can kind of choose your focus areas. I think that would…enable me to feel more like I would keep using it on a more consistent basis*" (M2). Similarly, others suggested adapting content to the user's existing levels of knowledge or skills, "*…maybe having something that's geared towards somebody who's had a lot of experience…maybe having that in the resources as well*" (F11).

Topic 2, theme 2: perceived and experienced benefit

Participants' initial evaluations of the potential value or benefit of a skill influenced enactment, with one participant stating, "*I'm always willing to give things a go when I can sort of see the value*" (F6) and another commenting, "*I did everything that I thought would be useful*" (F12). Others tried strategies despite initial scepticism as they were desperate to find relief from their symptoms:

"At first… I'm not really believing in the progressive muscle relaxation, because I was thinking, what's the point of tensing your body before you go to sleep…but because I was already frustrated, I'm trying it anyway. I'm thinking there's no harm. I cannot sleep anyway." (F8).

Participants were motivated to persist with strategies that were experienced as helpful, whereas negative experiences reduced motivation. For example, one participant shared how encountering challenges with an online activity designed to identify cognitive distortions discouraged ongoing use:

"…Like, there was this activity where it gave you a situation and you had to identify what kind of warped thinking it was. Was it catastrophizing? Was it this? Was it that? But that just annoyed me a bit. I felt I don't need to be able to identify all those things." (F12).

Past experiences also informed participants' judgements. Some favoured strategies that had been helpful in the past, while previous unsuccessful attempts deterred others from implementing similar strategies, "*I do remember, when I read some of the things, thinking, 'I just can't be bothered, this just doesn't work'*" (F11). Concerns that engaging with certain strategies could lead to negative emotional consequences also influenced strategy selection among some participants, with one questioning whether engaging with certain strategies would "*have brought up other things*" (F4).

Topic 2, theme 3: navigating time constraints and low motivation

Difficulty integrating the strategies into everyday life due to time constraints was mentioned by many participants as a barrier to both initial and sustained skill enactment. Busy work schedules and domestic responsibilities were both highlighted as getting in the way of consistently implementing skills. One participant succinctly summarised this challenge, "*You know, it's just life…there's too many things going on for you to do all those things and have that same routine every single day.*" (M2). This struggle was particularly relevant when implementing time-consuming strategies like exercise, though it was less relevant to strategies that were easily integrated into existing routines, such as those that "*… didn't involve having to move or go somewhere*" (M7) or "*didn't sort of take too much…time*" (M2). One participant suggested that prioritising other tasks over time-consuming and effortful activities like exercise was perhaps "*…a way of me subconsciously trying to get out of it*" (F11), suggesting issues related not just to lack of time but also motivation and prioritisation. Difficulties with motivation were often described as an ongoing challenge requiring

perseverance and self-discipline, as expressed by one participant:

"…I find it quite draining to just keep tapping into that parental aspect of my psyche that says, 'Come on, you know what you need to do.' But just the child part of me goes, 'No, I'm sitting here watching my favourite show. Go away." (M3).

Participants described various techniques to overcome challenges due to lack of time or motivation. Some embraced a "*just do it*" (F6) attitude, while others described using cognitive strategies to remind themselves of the benefits of action or the consequences of inaction:

"If I have an unhelpful thought, like, for example, 'I can't be bothered going on my bike ride.' Then thinking about… the consequences of not doing it, and then thinking about alternative ways I can think of it…like, instead of 'I don't want to go for a bike ride, I'm too tired.' Think, 'Well, yesterday, I went for a bike ride. I was tired, but I made myself do it. When I came home, I felt much better." (F11).

One participant described actively planning actions into their daily routine to facilitate ongoing engagement: "*…two days I do yoga and two days I do gym workout… and two days I go for swimming. So, I've kind of divided the time*" (F13). Reminders to engage with the intervention skills were also recommended by some participants because "*sometimes you listen to something and you totally forget*" (F13). Another participant suggested that online programs could incorporate "*time sensitive prompts*" (F8) to remind users to engage with adaptive actions when they are most needed.

Topic 3: changes in mental health and wellbeing

One theme was developed in relation to topic 3: (1) perceived changes (subtheme: (i) factors driving positive change). Participants generally perceived some positive change in their mental health associated with use of the programs and enacting the skills they learned, although this was typically modest. Key factors contributing to change varied across participants but included factors related to improvements in skill enactment and knowledge acquisition.

Topic 3, theme 1: perceived changes

Most participants described experiencing some positive changes in their mental health or wellbeing as a result of using their selected intervention. The changes encompassed reductions in anxiety or worry, improved mood and relationships, better sleep quality, increased emotional resilience, and improved coping. For many, these changes were modest, with one participant commenting, "*…maybe I'm a little less worried*" (F1) and another stating, "*I think I can sleep easier*" (F8), despite some ongoing difficulties. However, a couple of participants described more substantial changes, with one remarking, "*…it kind of changed my whole life*" (F5), while another stated, "*I feel great. I feel better than before*" (F13). Notably, two participants, both of whom were seeking more intensive support, noted a decline in their mental health. In both cases, this was attributed to external factors rather than the intervention (e.g., difficulty scheduling regular appointments with a new therapist).

Subtheme 1: factors driving positive change

Participants identified several factors contributing to the described improvements. Common across most accounts was the importance of applying the strategies presented in everyday life. Several participants emphasised the need for ongoing practice and "*sticking to routines*" (M2), recognising that consistency in implementing skills played an important role in their improvement. For instance, one participant commented, "*My biggest takeaway from all of it was that I need to keep doing it. It's not something that you just do every now and again, or you just do when your health flares…it's a maintenance job…*" (F6). Improvements in knowledge and understanding were also highlighted, with some noting that new insights led to a shift in their perspective or approach to situations, such as "*…about how you think in social situations about maybe not, kind of taking a step back and not overthinking*" (F1). Several participants underscored the importance of these factors alongside other elements such as engaging supportive social networks and a commitment to growth and change, as one participant commented:

"But the most important thing is…if I am ready, then everything will work out. But if I'm not ready, I'm doing it forcefully…I will not be happy and there will be no change. Nothing can work out if you don't want to." (F10).

Together, several participants described how these factors contributed to an enhanced feeling of control and empowerment through participation in these programs. For instance, one participant remarked, "*I think my anxiety has sort of calmed down, because…when I think okay, so this is why it might be happening, and this is what I can do. I think it's down*" (F4), while another commented, "*I feel like I am more in control of my situation and how I respond to it*" (F6). Additionally, two participants highlighted the importance of human support or guidance, with one emphasising the value of shared experience, "*… she [the therapist] moved to Australia, maybe 15 years ago, so she knows what it's like to kind of move countries and yes, so, I found that really helpful*" (F11).

Discussion

This study explored the perspectives and experiences of adults utilising publicly available digital CBT programs in Australia, with a focus on skill enactment and knowledge acquisition. The study aimed to understand how community users learn and apply knowledge and skills, identify

factors influencing skill enactment, and explore perceived changes in mental health. Thirteen adults who had utilised 13 interventions from eight different service providers participated. All of the participants demonstrated high program usage. Overall, the findings suggest that DMHIs can reinforce existing knowledge, facilitate the acquisition of new insights, and encourage a proactive approach to implementing practical strategies in everyday life, particularly among users who actively engage with these interventions.

Participants emphasised that revisiting familiar concepts and information in these interventions helped reinforce their existing knowledge and improve their confidence to manage their mental health. This is in line with previous trials of DMHIs, which have indicated improvements in knowledge confidence following intervention [43, 44]. In the area of health education, repetition of health messages is considered crucial to improve retention and knowledge confidence [45], especially considering patient recall of health information is frequently poor [46]. These insights underscore the importance of ongoing education and reinforcement in promoting effective self-management and self-efficacy among users. The finding that these interventions offered participants new skills and insights is generally consistent with a study by Berg et al. [28], which found that adolescents who actively engaged with a digital CBT intervention for depression gained new perspectives and strategies to manage their mental health. Our study also extends on these findings by highlighting variability in the degree of learning based on pre-existing knowledge: participants with less prior knowledge tended to emphasise substantial gains, while those with more knowledge typically reported specific improvements in particular areas or skills.

Overall, the findings highlight that participants generally adopt an active approach to applying intervention skills, evident in their engagement with online activities and ongoing efforts beyond the initial intervention period. Similar to the findings for knowledge acquisition, differences also emerged in the number and range of skills enacted, with some participants integrating a broad range of skills into their routines while others focused on specific strategies. Research on emotion regulation highlights different aspects of skill enactment that may be relevant for outcomes, including the range or breadth of skills employed (i.e., quantity), how often skills are used (i.e., frequency), and the proficiency with which skills are implemented (i.e., quality or fidelity) [47]. Results of this study suggest that a user's baseline level of knowledge or skills use may play a key role in the impact of interventions on skill enactment. Individuals who already possess a diverse repertoire of skills before intervention may prioritise mastering a smaller subset of skills, whereas those with fewer skills may concentrate on learning and exploring a broad range of skills, identifying skills that work best for them, or establishing healthy routines.

Our finding that participants generally adopted an active approach to learning and applying skills differs from results reported in previous qualitative studies conducted in trial settings [27, 28]. These earlier studies identified a subset of users exhibiting a more passive approach to learning and engaging with skills, despite also interviewing participants with relatively high levels of program engagement. Methodological differences, such as the use of trial procedures, variations in sampling strategies, and the timing of interviews, may account for these differences. For instance, Halmetoja et al. [27] used a criterion-based sampling approach based on the degree of symptom improvement, and both previous studies interviewed participants 6 months to 4 years post-intervention. Similar to these studies, our study also does not capture the experiences of the majority of individuals who drop out of digital interventions early [11]. Our recruitment method primarily attracted highly engaged, motivated, and relatively knowledgeable participants. Experiences of skill enactment among this group are likely to differ from those who have limited previous experience with mental health, less readiness or motivation to change, or a more passive approach to learning. Future studies should recruit specifically for people facing challenges in engaging with and using information from these interventions, such as those who report a poor user experience or have low levels of mental health literacy.

Decisions to enact certain strategies were influenced by their perceived alignment with participants' mental health needs and personal characteristics, as well as their perceived or experienced effectiveness. This is similar to a previous study by Eilert et al. [48], which found that in a pragmatic randomised controlled trial of internet-based CBT for anxiety and/or depression, the selection of skills was partly driven by perceived symptoms and strategy effectiveness. These findings are in line with the common-sense model of self-regulation [49], suggesting that the selection and maintenance of skills is guided by an individual's cognitive representations of their mental health concerns and beliefs about how effective different interventions will be in addressing those concerns. The findings suggest the importance of considering the beliefs, experiences, and goals of users when designing, targeting, or tailoring intervention programs. Failure to personalise interventions to these experiences may reduce the feeling of being personally connected to the intervention and diminish participants' motivation to engage, as seen in this study. Personalisation of digital interventions can be achieved through user or provider choice, rule-based algorithms (e.g., presenting content relevant to clinical symptoms), and data-driven

approaches that tailor therapeutic recommendations based on a user's previous interactions and behaviour within an intervention [23, 50]. However, there is currently a lack of published research investigating these approaches based on user knowledge and skills.

Time constraints due to paid employment and domestic responsibilities were emphasised as barriers to the maintenance of skills. These factors were especially pronounced for time-consuming strategies like physical activity, whereas activities that were easy to implement in everyday life presented fewer barriers. Research consistently identifies lack of time as a key barrier to both engagement with DMHIs [12] and health-related behaviours such as exercise participation [51]. However, recent studies suggest that perceived time scarcity may obscure more important barriers, such as difficulties with prioritisation or motivation [52]. It was evident that sustaining motivation could be challenging for participants. Maintaining health actions over time involves recognising their importance for mental health and wellbeing and choosing to prioritise them over other activities or commitments that may be less essential. Consistent with existing behavioural theories and evidence-based behaviour change techniques [53, 54], the participants observed that this process could be facilitated by various factors, including adopting a "just do it" attitude, creating action plans, and reminding themselves of the benefits of engaging in mentally healthy actions. These frameworks also recommend additional strategies not explicitly mentioned by the participants, such as goal setting, leveraging social support features, and implementing rewards systems, to sustain adaptive behaviours over time [53].

The findings show that most participants perceived positive changes in their mental health and wellbeing because of the intervention, including reduced anxiety, improved mood, better sleep quality, and enhanced relationships. Although many described these changes as modest, some participants reported substantial improvements. Importantly, two participants who were seeking more intensive support noted a decline in their mental health. This was attributed to external factors but could suggest that existing programs may not be sufficient for individuals with higher levels of need. Understanding the factors driving change in psychotherapies is crucial for developing more effective intervention packages, but evidence on causal factors remains largely uncertain [55]. Participants highlighted various factors as relevant to the observed improvements, including the consistent application of skills, experiences of learning, and a commitment to personal development and growth. Together, these factors contributed to a sense of empowerment and control among the participants over their mental health and wellbeing. The findings are consistent with recent research on the mechanisms of change in DMHIs [56], and suggest the importance of active coping and self-management in intervention effectiveness. These concepts extend beyond skill enactment to capture a wide range of activities undertaken to actively manage mental health and wellbeing, including not just the implementation of specific strategies but also factors such as adherence to treatment protocols, social support, and symptom monitoring. Continued research into mechanisms underlying these interventions is essential for program optimisation and addressing the diverse needs of individuals seeking support through digital tools.

Implications

This study provides valuable insights for future research and intervention design. Although participants generally responded positively to the interventions, the findings also suggest the importance of personalised content that targets the primary concerns of users and is relevant to their existing levels of knowledge and skills. Individual differences in existing knowledge and skills suggest a need for separate program paths that include both introductory CBT programs offering step-by-step guidance, as well as more advanced programs that assume a level of knowledge based on previous intervention or ongoing face-to-face services. Providing options for users experiencing high levels of need or chronic impairment—such as relapse prevention programs or adapting models of chronic illness management—may also be needed given that these challenges were observed among some participants in our study. Future studies could also explore the effectiveness of advanced personalisation techniques such as adaptive learning models that dynamically adjust therapeutic content recommendations and feedback based on analysis of the user's previous interactions within the intervention. Concerns about the sustainability and long-term maintenance of skills underscores the need to explore effective approaches for providing ongoing support and resources (e.g., periodic booster sessions, self-monitoring tools, and peer support networks) to support skill enactment beyond the intervention period. Additionally, findings related to knowledge acquisition suggest the importance of integrating learning support strategies and offering opportunities for ongoing education to support knowledge retention and confidence. Future trials are warranted to examine the relevance of key constructs identified in this study, such as knowledge confidence, practical knowledge, and active coping, for mental health outcomes.

Limitations

This study has several limitations. Data were collected from a sample of participants who self-selected into the study. The participants generally demonstrated high levels of insight, several had previous experience with

mental health services, and most described predominantly positive views of their selected intervention. Consequently, the findings may be biased towards individuals who are relatively knowledgeable and have had positive experiences with these interventions. Results might differ among a more naïve sample of users or those who have negative experiences. Additionally, although the sample varied in demographic characteristics such as age and self-reported ethnicity, most participants were female, and there was limited representation of participants with lower levels of education. Males tend to have lower rates of mental health service utilisation than females [57], and those with lower levels of education often face challenges with mental health literacy [58] and overall health outcomes. Future studies should prioritise the inclusion of these underrepresented groups using strategies such as maximum variation sampling to recruit participants with different levels of mental health knowledge and varying demographic characteristics [59]. Personalised recruitment invitations (e.g., targeting those with negative user experiences) and offering different options for participation (e.g., offering interviews via email or other online platforms) may help ensure representation among individuals who are less likely to engage.

In addition, many of the interventions used by participants in this study were only available to users in Australia [60], most had government funding, and all were accessible at low or no cost to users at the time of study. The availability and characteristics of digital interventions are likely to vary across countries due to differences in healthcare systems, cultural contexts, and support structures. These factors may influence how users engage with and benefit from DMHIs, suggesting the need for further research to explore these questions across different geographical contexts. Insights from this study are further limited to exploring relatively short-term effects on knowledge acquisition and skill enactment based on participant self-report. Studies conducted over longer time frames are needed to understand how skill enactment evolves over time and influences longer-term mental health outcomes. Participants may also not have complete insight into their motivations or the mechanisms through which interventions improve outcomes. Supplementing the results with ecological momentary assessment studies could help better understand temporal relationships between motivations, program use, skill enactment, and health outcomes. Moreover, although our study considered the impact of pre-existing knowledge on the outcomes studied, it did not explicitly investigate the influence of current or previous engagement in treatment services. Additionally, we did not explore in detail the specific features or components of digital interventions that might contribute to learning and skill enactment (e.g., interactive features or feedback mechanisms). Future studies exploring how treatment histories and the features of digital interventions may affect engagement with and responses to digital interventions are warranted. Future studies should seek feedback from participants on study findings to ensure that their unique meanings and perspectives are accurately represented and not constrained by the researchers' own knowledge or goals.

Conclusions

Better understanding of skill enactment and knowledge acquisition can help foster innovation in the design and implementation of DMHIs. This study addresses an important gap in the literature by employing qualitative methods to explore skill enactment and knowledge acquisition with a sample of community users. Among a group of engaged and motivated users, our findings suggest that DMHIs are valuable, in part, because they help reinforce and strengthen existing knowledge and confidence, offer new insights and skills, and encourage the proactive application of skills. Variability among participants in their existing levels of knowledge, skills, and preferences for therapeutic strategies underscores the need for adaptive interventions based on user choice or machine learning algorithms that dynamically tailor therapeutic content based on user behaviours within an intervention. Future research should focus on establishing effective approaches for personalising DMHIs, and explore how to best support the acquisition, retention, and sustained use of knowledge and skills.

Abbreviations

CBT	Cognitive behavioural therapy
DMHI	Digital mental health intervention
RCT	Randomised controlled trial
COREQ	Consolidated Criteria for Reporting Qualitative Research

Supplementary Information

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Supplementary Material 1

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Author contributions

All authors contributed to the conception and design of the study. H.M.J. and L.M.F. conducted the analysis, and all authors contributed to the interpretation of the results. H.M.J. drafted the manuscript and P.J.B., J.L.O., A.L.C., and L.M.F. critically revised the work. All authors were involved in the revision of earlier versions of and approved the final manuscript.

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Data availability
The datasets generated and/or analysed during the current study are not publicly available due to their sensitive nature but deidentified data are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study received ethical approval from the Australian National University Human Research Ethics Committee (protocol number 2023/561). All participants gave written informed consent to participate in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Chapter 6. General Discussion

There is considerable evidence supporting the effectiveness of DMHIs across various mental health problems and age groups. However, not all individuals who undertake DMHIs experience benefits. This discrepancy may be partly attributed to low levels of user engagement, which are often observed in research trials (Garrido et al., 2019; Karyotaki et al., 2015), tend to be particularly pronounced in community settings (Baumel et al., 2019; Fleming et al., 2018), and have been linked to reduced mental health benefits (Donkin et al., 2011; Gan et al., 2021). Engagement is a complex and multifaceted concept. In research, it has been defined and operationalised in various ways depending on factors such as the discipline or field of study, the goals of the individual project, and practical considerations such as data availability (Kelders et al., 2020; Perski et al., 2017). Common approaches to measuring engagement in DMHIs include program usage metrics such as the number of modules accessed or time spent using an intervention (Beintner et al., 2019; Li et al., 2022; Sieverink et al., 2017). The present investigation builds upon this work by investigating skill enactment an additional aspect of engagement that may be more proximal to the cognitive and behavioural changes necessary for symptom improvement compared to program usage measures (Gan et al., 2022; Yardley et al., 2016). In so doing, the thesis aimed to provide new knowledge regarding the role of skill enactment in digital CBT interventions for depression and anxiety. Knowledge acquisition was examined as a secondary aim, given its logical and theoretical significance for skill enactment. Using systematic review, quantitative, and qualitative approaches, four discrete studies were conducted to investigate how skill enactment and knowledge acquisition change following intervention, explore factors that might influence these changes, and examine their associations with and implications for mental health outcomes. The qualitative component of the thesis also explored user experiences of learning and implementing the skills and strategies taught in DMHIs.

The systematic review in Chapter 2 (Jackson et al., 2023a) highlighted a lack of research on skill enactment and knowledge acquisition in RCTs of digital CBT interventions for depression and anxiety, especially among young people and in early intervention or prevention programs. Narrative synthesis indicated that digital CBT interventions can improve both skill enactment and knowledge acquisition, although most evidence came from studies involving adults with diagnosed or elevated symptoms of depression and anxiety disorders. Only improvements in skill enactment were associated with improvements in mental health outcomes; no significant effects were found for knowledge acquisition on primary mental health outcomes. Few studies examined factors associated with skill

enactment or knowledge acquisition, and most potential predictors were either not significant or investigated in only a single study, limiting the conclusions that could be drawn.

Chapter 3 (Jackson et al., 2023b) sought to address knowledge gaps identified by the systematic review by investigating predictors and outcomes of engagement (module completion and skill enactment) in a trial of a school-based online depression prevention program for final-year secondary school students. A history of possible depression predicted fewer modules completed, whereas higher pre-intervention anxiety, mastery, and higher self-reported learning from the program predicted greater skill enactment. No overall effect was found for skill enactment on changes in symptoms of depression, generalised anxiety, or social phobia.

Chapter 4 (Jackson et al., 2024a) expanded on Chapter 3 by prospectively analysing data from an RCT of a brief video-based intervention (UVC-Lite) for university students experiencing mild to moderate psychological distress. The intervention did not significantly improve skill enactment, nor was skill enactment found to influence change in symptoms of depression or generalised anxiety disorder. These findings align with the null effects observed in the main trial (Farrer et al., 2024), and may be due to floor effects resulting from low levels of program usage among intervention group participants (e.g., 53.1% of participants did not start any videos and only 18.1% started 6 or more). Qualitative analyses suggested that low skill enactment among participants who engaged with the intervention may have been due to low perceived need. Participants preferred strategies that were relevant, easy to implement, and either novel or previously effective. Barriers to skill enactment included lengthy or complex strategies and practical constraints like lack of time and forgetting.

Chapter 5 (Jackson et al., 2024b) built upon earlier studies by qualitatively exploring the experiences of Australian adults using publicly available digital CBT interventions outside trial settings. Analysis of semi-structured interviews showed that these interventions can reinforce existing knowledge, foster new skills, and encourage skill enactment among motivated users. However, variability was observed in learning and the range of skills enacted by participants, which was connected to levels of pre-existing knowledge and skills. Factors influencing skill selection included the relevance and perceived benefit of strategies. Barriers to ongoing skill enactment included time constraints and challenges with prioritisation or motivation. Participants generally reported modest improvements in their mental health following their engagement with a DMHI, and attributed this to factors such as the application of skills and learning, and a sense of control and commitment to personal development and growth.

In the present chapter, the thesis findings are integrated and contextualised within the existing literature. Additionally, this chapter outlines future directions for research and intervention design, addresses methodological limitations, and synthesises conclusions across studies.

6.1 Integration of Findings and Implications

6.1.1 Skill Enactment and Mental Health Outcomes

Findings varied across studies regarding the relationship between changes in or experiences of skill enactment and mental health outcomes. Among adults with elevated symptoms or those actively seeking support (Chapters 2 and 5), the results showed that digital CBT interventions can facilitate improvements in skill enactment, and that this may contribute to improved outcomes. The findings align with the literature on face-to-face therapy (Hundt et al., 2016; Hundt et al., 2013; Schmidt et al., 2019; Strunk et al., 2014), suggesting that similar mechanisms may contribute to symptom improvement in both traditional and digital treatment settings. However, digital interventions introduce unique elements, such as technology-related challenges and differences in the therapeutic relationship, which may influence outcomes differently compared to face-to-face therapy (Domhardt et al., 2021b). The findings also support existing engagement frameworks (Nahum-Shani & Yoon, 2024; Piotrowska et al., 2017; Yardley et al., 2016), which propose that positive health or mental health outcomes may depend on the integration of skills learned from an intervention into daily life. However, qualitative findings from Chapter 5 also highlight differences in participant experiences based on pre-existing knowledge and skills, suggesting the need to target interventions to individual needs and past experiences. Furthermore, results indicate additional factors beyond skill enactment, such as commitment to change and perceived control, that may be associated with treatment outcomes. Recent reviews suggest that cognitive mediators such as perceived control may play a role in the effectiveness of digital interventions (Domhardt et al., 2021a; Domhardt et al., 2021b), but few studies have clearly established the sequence in which changes in these mediators and related outcomes occur, and more research is needed to clarify these temporal relationships.

The research also adds complexity to existing engagement models by suggesting that skill enactment and the mechanisms driving intervention effects may vary based on factors such as the severity of initial symptoms and the specific context of the intervention. For instance, findings from Chapter 4 suggested that low need for intervention due to relatively mild symptomatology may have driven low program usage and skill enactment among university students, ultimately resulting in an ineffective intervention. By contrast, awareness of

symptoms and recognition of a need for change motivated adult users of publicly available digital CBT programs to engage with DMHIs and use the skills learned from these interventions (Chapter 5). These findings imply that skill enactment and broader decisions to use self-guided interventions may be influenced by current symptoms and readiness for change, which could impact the effectiveness of interventions in improving mental health outcomes. This idea aligns with recent suggestions by Eilert et al. (2023) of a circular relationship between skill enactment and outcomes, where increased symptoms may lead to greater skill enactment, potentially contributing to symptom reduction. There is a need to formally test these relationships. Additionally, in Chapter 3, the absence of a significant association between skill enactment and mental health outcomes, despite a positive overall effect of the intervention, is consistent with a previous study of an online depression prevention program for young people in alternative education (Kuosmanen et al., 2017). Together, the results suggest that skill enactment may be less relevant in prevention contexts where most participants have low levels of distress and potentially less motivation to engage with the skills taught. It is possible that other mechanisms such as offering general support, increasing mental health awareness, or improving self-monitoring may be important in prevention programs, as they have different therapeutic targets compared to treatment programs (Moreno-Peral et al., 2020).

The results also highlight the impact of the delivery setting on program usage metrics of engagement. Although students participating in a school-based intervention showed relatively high intervention usage (Chapter 3), university students had very low usage of a self-guided video-based intervention (Chapter 4). This discrepancy may be due to the structured support and accountability provided by DMHIs delivered in more controlled, monitored settings such as schools, which may enhance adherence (Achilles et al., 2020; Garrido et al., 2019; Neil et al., 2009). The absence of these elements in self-guided interventions may lead to lower engagement, particularly if users do not perceive a strong need for intervention. Low program usage is common among young people with mild distress participating in self-guided interventions (Becker & Torous, 2019), and the thesis findings suggest that low perceived need may hinder engagement both at the level of program usage and skill enactment. This is similar to Borghouts et al. (2021), who found that individuals with higher levels of symptoms are generally more motivated to engage with DMHIs. However, the authors also found that those with more severe symptoms tended to exhibit lower actual program use. This suggests that while some level of distress may be necessary to drive engagement in self-guided interventions, symptoms that are too severe may interfere with sustained participation.

6.1.2 Factors Influencing Skill Enactment

This research is the first to comprehensively explore factors influencing skill enactment in DMHIs. It identifies several key factors that may impact whether users engage with and apply the skills taught in digital CBT interventions targeting depression and anxiety. These include the relevance of strategies to individual users, perceptions of potential benefits, and practical challenges such as time constraints and difficulties with motivation or prioritisation. The acquisition and reinforcement of knowledge also appear to play a role, supporting previous studies and engagement frameworks that suggest that gaining therapeutic knowledge from an intervention is important for effectively applying intervention skills (Käll & Andersson, 2023; Piotrowska et al., 2017; Yeager & Benight, 2018). However, further exploration is needed to determine whether perceived or actual knowledge gain is more influential in this process. Some of the factors identified, such as perceived relevance and expected benefits, are similar to those influencing program usage indicators of engagement (Borghouts et al., 2021). However, these factors refer specifically to how users perceive the relevance and effectiveness of individual strategies in their daily lives, rather than the intervention as a whole, highlighting the need to consider specific aspects of an intervention when designing it to facilitate skill enactment (Baumel, 2022). Furthermore, skill enactment involves additional challenges, such as translating newly acquired knowledge into everyday actions and overcoming motivational or practical barriers to maintaining these actions. The findings suggest a need for interventions to support users in consistently applying skills in their daily routines, especially in treatment-focused contexts.

Some differences in factors influencing skill enactment were observed across samples. University students with mild symptoms (Chapter 4) generally preferred simple, easy-to-use strategies such as behavioural activation over more complex cognitive approaches like thought records. In contrast, adults actively seeking help (Chapter 5) showed less distinct preferences and often highlighted their use of cognitive restructuring. These variations suggest that different skills may be relevant for people with different levels of mental health symptoms, treatment needs, motivation to change, and sociodemographic backgrounds, consistent with Titov et al. (2022). However, individual differences in preferences for strategies also highlight the need for enhanced personalisation of these interventions. Participant feedback reinforces this need, emphasising the importance of tailored interventions, along with reminders or notifications and gamified elements such as rewards or challenges to encourage strategy use. These strategies aim to make interventions more engaging, relevant, and supportive, thereby increasing the likelihood of successful skill enactment. The results align with the user pathway framework (Baumel, 2022), which

suggests that for therapeutic interventions to be effective, they should incorporate prompts (calls to action), provide opportunities to practice strategies (load reduction), and adapt to individual needs based on real-time user data or activity (data-driven approach). However, previous studies have not tested the effects of these strategies on subsequent skill enactment. Additionally, most studies on personalisation in DMHIs have focused on providing pre-defined content options or applying if-then rules that adjust content based on factors such as symptom severity or inactivity (Hornstein et al., 2023), rather than examining personalisation approaches tailored to users' pre-existing knowledge or skills.

Findings from the current investigation also suggest the need for strategies that go beyond the intervention to help sustain skill enactment over time. Strategies suggested by users include taking immediate action without overthinking (i.e., adopting a "just do it" attitude), creating specific action plans, and considering the benefits of engaging in adaptive actions or the consequences of not doing so. These suggestions align with behaviour change frameworks and evidence-based principles for intervention design (Atkins et al., 2017; Michie et al., 2013), which suggest that individuals are more likely to engage with a behaviour when they have clear goals or plans and understand the benefits or consequences associated with their actions. The results suggest that incorporating interactive tools for goal setting and action planning, as well as educational content and reflection tools that help users link their actions to outcomes, may support skill enactment. Integrating techniques such as motivational interviewing could further enhance skill enactment by addressing users' readiness to change and reinforcing their motivation to apply skills. Digitised motivational interviewing has shown promising effects on behaviour change in the context of physical health (Nurmi et al., 2020), but studies are needed to assess its impact on skill enactment in DMHIs. Furthermore, a recent review by Li et al. (2022) on adherence reporting in digital CBT interventions for young people found that only half of the studies described features that prompted homework activities, and none reported features designed to promote skill enactment outside the intervention. This might suggest that existing programs lack explicit strategies to help users apply the skills learned in the intervention to their everyday lives.

6.1.3 Knowledge Acquisition

The current investigation indicated that digital CBT programs targeting depression and anxiety can improve knowledge, based either on tests of declarative knowledge (Chapter 2) or user perceptions of learning (Chapter 5). However, qualitative insights from Chapter 5 also suggested that the extent of learning varies with pre-existing mental health knowledge. Most participants, who had prior knowledge from previous treatments or self-help materials, generally reported that the interventions mainly reinforced their existing knowledge while

offering some new skills or insights. In contrast, a few participants with less prior knowledge reported more substantial gains. This observation aligns with quantitative studies (Andersson et al., 2012; Farrer et al., 2012), which generally show only minimal improvements on knowledge tests compared with baseline. The implications of this finding for user experiences and perceptions are complex. Participants generally reported that revisiting familiar information helped them retain knowledge and build confidence. This is somewhat consistent with a study by Andersson et al. (2023), which found that while internet-based CBT for depression initially increased knowledge, this improvement tended to diminish over time. More broadly, research shows that people often struggle to remember health advice (Flocke & Stange, 2004), and this difficulty may be more pronounced among individuals with mental health issues (Harvey et al., 2014; Kessels, 2003). Taken with the findings of the current investigation, this suggests that it may be necessary to review and reinforce previously learned information to improve retention and recall of therapeutic content in CBT-based interventions. However, it may also be necessary to evaluate more advanced programs for users with high levels of pre-existing knowledge, as some expressed concerns about a lack of tailoring to their current knowledge. Future research should also explore learning and knowledge acquisition among individuals with low levels of existing mental health or CBT-related knowledge, as their experiences may differ from those with previous exposure to treatment concepts.

The findings of the thesis suggest that explicit declarative knowledge may not be sufficient to produce measurable changes in mental health outcomes. This aligns with recent studies on knowledge acquisition in digital interventions for other mental health or psychosocial concerns, such as loneliness and eating disorders (Käll & Andersson, 2023; Linardon et al., 2022). The findings also support some engagement theories (Yeager & Benight, 2018), which propose that learning alone may not lead to symptom improvement. However, the results contrast with evidence from face-to-face therapy, which has shown that better memory for treatment correlates with improved outcomes (Dong et al., 2017; Lee & Harvey, 2015). This discrepancy may be due to differences in measurement approaches. Studies on face-to-face therapy generally use free recall tests to assess knowledge and memory for treatment points, whereas research on knowledge acquisition in DMHIs typically employs multiple-choice tests (Jackson et al., 2023a). Free recall tests may be more closely related to mental health outcomes as they require participants to retrieve and articulate information from memory without external cues, potentially providing a better measure of how individuals internalise and apply therapeutic information. However, while a minimum level of knowledge is likely ta necessary precondition for symptom improvement, further increases may have a diminishing impact on outcomes. Once a certain baseline is reached, factors such as

perceived control and skill enactment may become more significant in driving outcomes, as they help users apply and sustain the skills they have acquired. Additionally, participants in digital interventions might have higher pre-existing mental health knowledge, as these relatively novel interventions may attract individuals who are already well-informed. Higher levels of baseline knowledge could mean that the additional knowledge gained from an intervention has a smaller incremental effect on mental health outcomes.

The findings of the research also point to the importance of considering other types of knowledge that may be relevant for mental health outcomes, such as procedural knowledge (i.e., knowledge of how to apply skills), knowledge confidence (i.e., the belief in one's own ability to effectively use knowledge and skills in practice), and experiences of insight or meta-cognitive knowledge (i.e., an individual's experience and understanding of their own cognitive processes) (Andersson, 2025; Berg, 2021). Additionally, knowledge acquisition may be an important outcome to consider in itself, particularly as digital CBT can be viewed "as a form of online patient education" (Andersson, 2025, p. 50). Improvements in knowledge during digital CBT have been suggested to reduce risk of relapse and support ongoing recovery by helping individuals to recognise and detect symptoms or by facilitating help-seeking behaviour (Andersson, 2025; Jackson et al., 2023a). However, despite the proposed importance of knowledge acquisition, the systematic review in Chapter 2 identified a lack of research on both predictors of and strategies for enhancing knowledge acquisition in digital CBT interventions. A study by Berg et al. (2020) demonstrated that learning support strategies—such as pedagogical pictures, quizzes, and knowledge summaries—had a modest effect on explicit knowledge and mental health outcomes immediately post-treatment among adolescents participating in an online intervention for anxiety. However, no studies have been conducted since the review was undertaken to explore the effects of these strategies in other populations or contexts. Additionally, there is a need to investigate the effects of learning support on knowledge retention over longer-term follow-ups. Developing effective strategies to support the acquisition and retention of knowledge may be aided by a more comprehensive examination of user, program-related, and contextual factors that influence knowledge acquisition and retention.

6.2 Contribution to the Research Area

The thesis makes several important contributions to research on DMHIs and user engagement. It is the first to synthesise and consolidate evidence on skill enactment and knowledge acquisition within digital CBT interventions, highlighting a notable gap in the research on these constructs, despite their logical and theoretical importance for intervention

effectiveness. Additionally, it provides a comprehensive examination of skill enactment among young people, particularly in the context of prevention and interventions targeting relatively mild symptoms. Furthermore, it extends previous research by exploring user experiences with learning and applying skills from publicly available DMHIs, thereby broadening our understanding of how these interventions function and are experienced in real-world settings. In so doing, the investigation highlights that both acquiring knowledge and implementing skills may be important for achieving positive mental health outcomes from DMHIs. However, it also suggests that the relationship between these factors and intervention effectiveness is complex and influenced by various factors, such as motivation, pre-existing symptoms, and personal characteristics.

6.3 Future Directions

The findings presented in the thesis highlight important implications for future research and offer pathways for improving the design and implementation of DMHIs. Overall, the research suggests a need for more widespread measurement and reporting on skill enactment and knowledge acquisition in digital CBT interventions, and DMHIs more broadly. Several specific research questions require investigation in future studies. The absence of significant findings on skill enactment and mental health outcomes among young people with low symptom levels participating in digital CBT programs indicates the need to investigate these relationships in more highly symptomatic samples. Future prospective analyses should also explore factors impacting the effectiveness of programs targeting prevention or mild symptoms, given suggestions that different factors may account for intervention effects in these contexts (Moreno-Peral et al., 2020). Additional comparative studies are also needed to explore other factors, such as perceived control, motivation to change, and active coping, that may impact intervention effectiveness in treatment-focused contexts. Various aspects of knowledge acquisition, such as procedural knowledge, meta-cognitive knowledge, and confidence in one's knowledge are also important to consider. Exploring these factors may help provide a better understanding of the mechanisms underlying intervention effects across contexts. To address these questions, future research should employ pragmatic effectiveness trials and analytic methods such as structural equation modelling to simultaneously evaluate multiple mediators and comprehensively explore the processes contributing to the effectiveness of digital interventions. This approach will help in identifying which factors are most influential across different contexts, and enhancing these factors may help make existing interventions more targeted and effective. Studying the processes contributing to intervention effectiveness in real-world settings can enhance the

generalisability of research findings to the experiences of everyday users and provide insight into how digital interventions perform outside controlled settings.

Future studies should also seek to develop standardised approaches for measuring skill enactment and knowledge acquisition to facilitate comparison of results across studies. These measures should be grounded in theoretical frameworks of skill enactment and knowledge acquisition and capture the multi-faceted nature of these constructs. For assessing the frequency of skill enactment, there may be a need for new standardised measures that better reflect the diverse skills presented in digital programs, which often do not adhere to a single theoretical orientation. Titov et al. (2022) recently developed the Things You Do Questionnaire to evaluate how frequently people use various actions associated with psychological health in their daily lives. Unlike previous measures that focus on traditional cognitive and behavioural skills (Kanter et al., 2007; Strunk et al., 2014; Terides et al., 2016), this questionnaire covers a broader range of skills, making it more suitable for capturing the diverse skills targeted in many digital interventions.

There is also a need to develop and test measures that evaluate other theoretically relevant aspects of skill enactment and knowledge acquisition, such as the quality or range of skills enacted, as well as procedural knowledge, confidence in knowledge, and meta-cognitive knowledge. The quality of skill enactment and procedural knowledge could be evaluated through external evaluations by therapists or independent raters based on user performance in interactive tasks or exercises requiring the application of skills (Hundt et al., 2013). Knowledge confidence might be measured using self-report scales assessing confidence in using learned skills, similar to existing studies (Andersson et al., 2012; Berg et al., 2019). Reflective journaling or self-assessment questionnaires on cognitive processes could be used to evaluate meta-cognitive knowledge. Furthermore, psychometric research is needed to compare different approaches to measuring skill enactment and knowledge acquisition. This research would help determine whether these methods assess a single, unified concept or if they capture distinct aspects of skill enactment and knowledge acquisition that go beyond current conceptual frameworks.

The research also points to the importance of diversifying digital interventions to accommodate varying preferences and needs. For young people with low levels of symptomatology participating in self-guided interventions, there may be a need to evaluate alternative approaches that are potentially more engaging or suitable compared to CBT-based interventions targeting depression and anxiety. This may include mental health education to encourage symptom monitoring and appropriate support-seeking, as well as

wellbeing interventions that focus on building resilience, stress management, or healthy lifestyle habits (Jackson et al., 2024a). Interventions that target modifiable risk factors for depression and anxiety disorders—such as sleep disturbance, perfectionism, and loneliness or social connections (Alvarez et al., 2024; Bourke et al., 2022; Galloway et al., 2022)—may also be useful, as these concerns may be less stigmatised and more relevant for young people with mild symptoms. Additionally, the observation that some participants using publicly available interventions were experiencing severe distress or impairment raises ethical concerns about the suitability of existing interventions, which are generally designed for mild to moderate symptoms. DMHIs targeting higher levels of need are increasingly recognised as feasible and acceptable options for those with severe mental health problems (Ehrt-Schäfer et al., 2023; Naslund et al., 2015). However, these interventions are not yet widely available, and more research is needed to establish their effectiveness and address issues related to treatment safety and crisis management protocols. This work is essential to ensure the availability of appropriate services during times of crisis and to potentially prevent further deterioration in symptoms.

The need for personalised content within interventions was a recurring theme across studies. Future research should investigate effective approaches for personalising interventions based on users' existing knowledge and skills. This could involve offering both introductory and advanced programs, with introductory programs offering a broad range of skills and concepts, while advanced programs focus on helping users master specific skills. Users could choose their preferred program, or the most appropriate program could be determined based on an assessment of their existing knowledge or previous exposure to treatment principles. Additionally, more advanced personalisation techniques could be tested to make interventions more responsive to the immediate needs of users by tailoring therapeutic recommendations to real-time user behaviour or feedback, or adapting content based on situational factors such as the time of day (e.g., suggesting calming exercises in the evening to help with sleep) or recent life events (e.g., offering stress management strategies during examination periods). Just-in-time adaptive interventions (JITAIs) are designed to deliver appropriate support by optimising the timing, type, and intensity of interventions or strategies to address specific challenges or behaviours as they occur in real time (Nahum-Shani et al., 2018). Unlike traditional interventions, JITAIs use a data-driven approach to adapt to individual needs based on real-time user data or activity. However, there are currently few clinical implementations of JITAI mechanisms in mental health (Smith et al., 2023; Teepe et al., 2021), and future research is warranted to investigate the efficacy of these mechanisms for skill enactment. Incorporating persuasive system design and gamification features, such as prompts and challenges, into interventions may further motivate users to practice and

apply skills (Baumel, 2022; Fleming et al., 2023). Additionally, future studies should assess the effectiveness of learning support strategies to further facilitate knowledge acquisition and retention in digital interventions. Harvey et al. (2014) identify several strategies to aid memory for psychological treatment, including using expressive language and multimedia to highlight key points, organising information into themes, repeating and revisiting key concepts, and encouraging users to practice recalling information.

Post-intervention support and resources may be needed to sustain learning and skill enactment beyond the intervention period due to challenges with knowledge retention and concerns about the prioritisation of skills in everyday life. This could include strategies such as providing continued access to resources that users can revisit at any time, offering periodic booster sessions to reinforce key knowledge and skills, and creating online communities to enable users to connect with one another and provide encouragement. Additionally, providing adjunct resources such as action planning or goal setting tools may help address motivational challenges and enhance the prioritisation of adaptive actions. Research on the use of post-intervention support such as booster sessions remains limited, and studies that are available generally indicate low rates of uptake and variable effectiveness (Andersson et al., 2014; Hadjistavropoulos et al., 2022; Peynenburg et al., 2022). Involving end users during the design of strategies to facilitate the acquisition, retention, and use of knowledge or skills may improve their acceptability and effectiveness. However, co-design methods have also shown mixed success (Gan et al., 2022), potentially due to inadequate representation of user perspectives or because users may not fully understand what will work for them in practice (Gan, 2024). A research process that integrates user input with relevant theory may yield more acceptable, engaging, and effective interventions (Bevan Jones et al., 2020), with evidence to indicate that greater use of theory is associated with larger effect sizes in internet-based behaviour change interventions (Webb et al., 2010).

6.4 Strengths and Limitations

This thesis had several notable strengths, including the exploration of skill enactment and knowledge acquisition across various user groups and intervention types (e.g., treatment, prevention, and early intervention) using systematic review, quantitative, and qualitative research methods. This approach helped mitigate the inherent limitations of individual methods and allowed for cross-verification of findings across data sources and methodologies. Additionally, individual studies adhered to relevant reporting guidelines (e.g., PRISMA guidelines, CONSORT-EHEALTH checklist, and COREQ checklist) and followed

methodological standards appropriate for each study type (e.g., use of validated instruments, risk of bias assessments, and return of interview transcripts to participants). Moreover, investigating the research questions through both highly controlled RCTs and ecologically valid community-based studies enhances the internal and external validity of the findings.

Despite these strengths, several limitations warrant consideration. The thesis primarily relied on retrospective self-report data to assess skill enactment. These data may be influenced by social desirability and memory biases, and they may not capture real-time variations in skill enactment, potentially leading to inaccurate recall or incomplete data. Future research should address this limitation by incorporating ecological momentary assessment or experience sampling methods to collect real-time data on skill enactment and mental health outcomes. This would also enable exploration of bidirectional relationships between perceived symptoms and skill implementation. Using multiple data sources, such as therapist reports or ratings from other supporters, could also strengthen the validity of self-reported information. Moreover, Chapters 3 and 4 used bespoke measures of skill enactment due to the absence of suitable existing instruments, which may limit the comparability of results with other studies. Suggestions for addressing these measurement challenges are discussed in the 'Future Directions' section.

The current investigation was also predominantly limited to exploring the frequency of skill enactment. Future research should expand this focus to examine other aspects of skill enactment and emotion regulation, such as the quality or range of skills enacted, as well as reductions in the use of maladaptive coping strategies. These factors may be significant for outcomes in both treatment and prevention settings (Hundt et al., 2013; Southward et al., 2021). Additionally, investigations into skill enactment and knowledge acquisition in the current thesis concentrated on their associations with symptom reduction. This focus may have overlooked other important impacts, such as improvements in quality of life and self-efficacy. Future studies should consider how skill enactment and knowledge acquisition may relate to these additional outcomes, as well as sustained improvements in mental health over time and reductions in the use of maladaptive coping strategies. Furthermore, there may be other factors influencing skill enactment that were not identified in the present research, such as environmental and contextual factors like social support and variations in intervention features or delivery. Future research should explore these variables to achieve a more comprehensive understanding of the factors influencing skill enactment.

Some characteristics of the study samples may also affect the generalisability of the results. The systematic review predominantly included studies conducted in Western countries,

subsequent studies were conducted in an Australian context, and the majority of participants were female. This raises questions about the applicability of findings to males and individuals in different geographical or cultural contexts. Additionally, the findings in Chapter 4 regarding skill enactment and its associations with mental health outcomes may be constrained by floor effects. Most participants either did not engage with the intervention or used it only minimally, which may have limited the study's capacity to detect improvements in skill enactment, symptoms, or a relationship between skill enactment and symptom improvements. Future research within higher engagement settings may be needed to further explore changes in skill enactment and its impact on mental health outcomes among young people. Furthermore, qualitative data were largely derived from highly engaged users. This may have led to an overestimation of the acceptability or effectiveness of the interventions and might not fully capture the experience or challenges of less engaged or disengaged users. Chapters 4 and 5 propose strategies to improve participation among these underrepresented groups, such as employing maximum variation sampling methods, utilising personalised recruitment approaches, and offering flexible participation options. These strategies aim to engage users whose perspectives are underrepresented or who may be reluctant to participate. Finally, the thesis focused on skill enactment and knowledge acquisition in standalone digital CBT interventions for depression or anxiety disorders, limiting the generalisability of the findings to other mental health issues or treatments. However, skill enactment and knowledge acquisition are important to consider in any psychotherapeutic or skills training intervention. The present research identifies key questions and insights for future research on these constructs, which could be applied to a broader range of digital interventions beyond CBT.

6.5 Conclusions

Most existing research on engagement in DMHIs primarily focuses on the frequency of intervention use or interaction with different program components. This thesis addresses a substantial gap in the literature by focusing on skill enactment and knowledge acquisition during and following participation in digital CBT programs designed to address depression and anxiety. The results indicate that these interventions can reinforce existing knowledge, introduce new information and skills, and facilitate the application of skills in daily life for adults with elevated symptoms or those who recognise a need for treatment. Although skill enactment appears relevant for outcomes in these contexts, the effectiveness of treatment-focused programs may also depend on additional factors such as motivation to change, perceived control, active coping abilities, and various aspects of knowledge, including procedural knowledge and confidence in one's knowledge. However, similar effects on skill

enactment and mental health outcomes were not observed among younger users with lower levels of symptomatology, possibly due to a lack of perceived need to engage with the intervention or apply skills. The thesis highlights several key factors that may influence whether users apply skills from digital CBT interventions, both initially and over time. These include factors such as the relevance and perceived benefit of intervention strategies, knowledge acquisition and retention, as well as practical challenges such as time constraints and difficulties with prioritisation.

This thesis advances understanding of engagement with digital CBT interventions by consolidating and generating new evidence on skill enactment and knowledge acquisition. It further contributes to the evidence base by examining skill enactment across different groups of young people and exploring user experiences of learning and implementing skills from these interventions beyond trial settings. Looking ahead, there is a need to clarify which factors contribute to benefits across diverse groups and contexts to make DMHIs more targeted and effective. Future research should prioritise diversifying and personalising these interventions to accommodate individual differences in preferences, needs, and levels of existing knowledge and skills. Additionally, further investigation is needed into how factors such as gamification, therapeutic persuasiveness, learning support, and post-intervention resources contribute to, and enhance, the acquisition, retention, and application of knowledge and skills. Improving the acquisition of knowledge and skills in DMHIs may be critical to make these interventions more effective and impactful, but further research is needed to understand the mechanisms by which these constructs influence mental health outcomes.

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Appendices

Appendix A. Primary Outcomes Paper for Paper 2 (Chapter 3)

Original Paper

Preventing Depression in Final Year Secondary Students: School-Based Randomized Controlled Trial

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Abstract

Background: Depression often emerges for the first time during adolescence. There is accumulating evidence that universal depression prevention programs may have the capacity to reduce the impact of depression when delivered in the school environment.

Objective: This trial investigated the effectiveness of SPARX-R, a gamified online cognitive behavior therapy intervention for the prevention of depression relative to an attention-matched control intervention delivered to students prior to facing a significant stressor—final secondary school exams. It was hypothesized that delivering a prevention intervention in advance of a stressor would reduce depressive symptoms relative to the control group.

Methods: A cluster randomized controlled trial was conducted in 10 government schools in Sydney, Australia. Participants were 540 final year secondary students (mean 16.7 [SD 0.51] years), and clusters at the school level were randomly allocated to SPARX-R or the control intervention. Interventions were delivered weekly in 7 modules, each taking approximately 20 to 30 minutes to complete. The primary outcome was symptoms of depression as measured by the Major Depression Inventory. Intention-to-treat analyses were performed.

Results: Compared to controls, participants in the SPARX-R condition (n=242) showed significantly reduced depression symptoms relative to the control (n=298) at post-intervention (Cohen *d*=0.29) and 6 months post-baseline (*d*=0.21) but not at 18 months post-baseline (*d*=0.33).

Conclusions: This is the first trial to demonstrate a preventive effect on depressive symptoms prior to a significant and universal stressor in adolescents. It demonstrates that an online intervention delivered in advance of a stressful experience can reduce the impact of such an event on the potential development or exacerbation of depression.

Trial Registration: Australian New Zealand Clinical Trials Registry ACTRN12614000316606; https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=365986 (Archived by WebCite at http://www.webcitation.org/6u7ou1aI9)

(J Med Internet Res 2017;19(11):e369) doi: 10.2196/jmir.8241

KEYWORDS

prevention; depression; adolescent; digital cognitive behavior therapy

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Introduction

Depression carries the greatest burden of disease in young people, with an annual prevalence in adolescence of 8% and approximately 80% of these cases experiencing a moderate to severe impact on functioning [1]. It has been estimated that, at most, only 36% of the burden of depression could potentially be alleviated using current knowledge and therapies [2]. Prevention represents an important alternative pathway to reducing this burden, with evidence suggesting that preventive efforts may result in a further 21% to 22% reduction [3]. A number of recent reviews and meta-analyses have found small but consistent effects for the prevention of depression in young people [4]. These reviews indicate mixed findings regarding the relative superiority of universal prevention programs (which target all individuals in a given population regardless of risk) compared to targeted programs (which are directed at high-risk individuals on the basis of the presence of existing risk factors or subthreshold symptoms). However, universal programs may offer additional advantages as they may be easier to implement, are less stigmatizing, and provide greater scope and catchment of individuals who may be on the trajectory toward developing depression but do not yet display symptoms.

The incidence of depression increases monotonically throughout adolescence [5]. However, stressful life events are precursors of and possible causal factors for the onset of depression [6]. Final school examinations are a significant stressor for most adolescents, with exams and academic outcomes endorsed most strongly among school-related stressors [7]. In the Australian context, these final exams determine tertiary education entrance scores, rendering their outcome critically important. More than 40% of final year secondary students report elevated symptoms of depression, anxiety, and stress [8]. In extreme cases, exam stress has been linked to suicidal ideation, behavior, and completion [9]. To date, the potential for prevention has not been examined in the context of school-based stressors. Schools are an ideal location in which to deliver mental health interventions that address these difficulties, not only because young people spend more time in these institutions than any other, but also because of the integral role schools play in students' social, academic, cognitive, emotional, and behavioral development. While school-based prevention programs have typically taken the format of face-to-face, group-based interventions, online interventions in the school setting are becoming increasingly appealing [10]. Automated online programs guarantee fidelity, since the information cannot be distorted, diluted, or contaminated during delivery [11]. Consequently, implementation of an online universal depression prevention program in the context of a stressor widely experienced in the target sample represented a unique opportunity to evaluate the effectiveness of such an approach.

Our cluster randomized controlled trial (RCT) was designed to test the effectiveness of SPARX-R, an online, cognitive behavioral gamified intervention, in preventing the development or exacerbation of depressive symptoms in final year secondary students relative to an online active control program (lifeSTYLE). SPARX was originally designed as a treatment intervention for depression; however, it was subsequently adapted for use as a universal preventive intervention, known as SPARX-R. SPARX has been shown to result in a decline in symptoms of depression and improved remission rates in a help-seeking sample of adolescents and was found to be non-inferior to treatment as usual (consisting primarily of face-to-face therapy with a counselor, general practitioner, or clinical psychologist) [12]. However, in a recent school trial for individuals with subthreshold depression, SPARX failed to demonstrate effects superior to a control condition despite having a positive impact on depressive symptoms [13]. The authors suggest that the absence of an intervention effect may have been due to the effectiveness of the control condition, which essentially operated as a self-monitoring intervention and may have been sufficient to improve those with mild depressive symptoms. The effectiveness of self-monitoring has been demonstrated in other trials (see, for example, Kauer et al [14]). In our trial, it was predicted that students assigned to the SPARX-R condition would report lower levels of depressive symptoms immediately following the intervention and at 6-month follow-up relative to participants in the attention control condition.

As well as evaluating the impact of this novel intervention on depressive symptoms, this study also examined the effect of SPARX-R on secondary outcomes including anxiety, stigma, academic performance, and suicidal ideation. Given the substantial comorbidity of anxiety and depression and the fact that anxiety symptoms can decline in the context of some depression prevention programs [15], it was expected that participants in the SPARX-R group would also experience reduced anxiety. There is evidence that increased knowledge regarding depression is associated with reduced stigma [16]. Therefore, it was predicted that stigma would also be decreased in the SPARX-R group. Outcomes of final examinations for participants were sought from schools to evaluate whether any impact of the intervention flowed through to academic performance, an expectation arising from the association of depression with poor academic outcomes [17]. Although depression and suicidality are associated [18], they may not follow the same trajectory and so the examination of outcomes pertaining to suicidal ideation and behavior was exploratory.

Methods

Study Design

A cluster RCT was conducted with 2 parallel arms consisting of an experimental condition (SPARX-R) and an attention-matched control condition (lifeSTYLE). The trial was designed for implementation in schools in accordance with the Australian academic calendar: baseline assessments were conducted at the start of the academic year (February), followed by a 5-week intervention phase and post-intervention assessments. Six-month follow-up assessments were conducted midyear, just prior to a significant period of academic assessments that contribute to students' final secondary school grade (the exam period). The final follow-up assessment was conducted 18 months after baseline. At this time, participants had graduated from high school, and the majority were engaged in post-secondary studies. This trial received ethics approval

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from the New South Wales Department of Education and Training (SERAP2014001), the University of New South Wales (HC14105), and the Australian National University (2014/325). The study protocol is published [19].

Participants

The trial was conducted in selective and partially selective government secondary schools in metropolitan Sydney. Selective schools use an entry exam to enroll students with superior academic ability, while partially selective schools offer both selective and comprehensive (non-selective) streams. Academically gifted students were selected because final school exam outcomes are critical to them. They are particularly sensitive to the stressful nature of exams, with studies finding they experience adverse stress reactions to academic failures coupled with pressure to succeed from parents, schools, the media, and students themselves [20]. The academic workload and considerable number of hours spent studying in a demanding educational program is likely to compound this pressure and act as an additional stressor [21]. These attributes made this group a particularly relevant sample in which to test the stress-diathesis model of depression.

All adolescents enrolled in their final year of secondary school in participating schools were invited to participate in the trial. All students at participating partially selective schools were eligible to participate in the trial; however, streaming status (ie, selective or comprehensive) was recorded and evaluated in analyses. Due to the universal nature of the study, there were no exclusion criteria. Written, informed consent was sought from students and their parents prior to the start of the trial. Students who did not provide consent were able to access the assigned intervention; however, only those with consent completed the research questionnaires.

Interventions

SPARX-R

SPARX-R is a revised version of SPARX, which was developed as an unguided, interactive program using the format of a fantasy game providing cognitive behavioral skills to treat mild to moderate symptoms of depression in help-seeking adolescents.

SPARX-R provides users with the same skills as those in SPARX [12]; however, the revised version is framed in preventive terms. For example, participants are told that "this version of SPARX was made to help young people who are having hassles and feeling down, stressed, or angry a lot of the time. Even if you are doing fine, SPARX-R can help strengthen your skills for dealing with problems when they do come along." Further, for the version of SPARX-R used, care was taken to ensure that terminology and local helplines and services were suitable for Australia. SPARX-R users choose and personalize an avatar and are led through the program by a virtual guide who provides context and links the content of the program to their real-life experiences. The user navigates their way through a series of challenges within a fantasy world that has been overrun by GNATs (gloomy, negative, automatic thoughts), with the mission of restoring balance in the game world. The program has 7 modules (levels), each of which takes approximately 20 to 30 minutes to complete. Participating schools scheduled curriculum time for participants to complete 1 to 2 modules per week, allowing a few days in between modules for students to process what they learned and practice new skills before beginning the next module. The intervention was completed over the course of 5 to 7 weeks in class under teacher supervision. The modules cover the following topics: finding hope, being active, dealing with strong emotions, overcoming problems, recognizing unhelpful thoughts, challenging unhelpful thoughts, and bringing it all together. Key skills taught by the program were relaxation, activity scheduling and behavioral activation, emotion regulation, interpersonal skills, problem solving, cognitive restructuring, and distress tolerance [12]. SPARX-R was delivered to students on desktop computers via the Internet in school classrooms and supplemented with a paper notebook for students to review key messages from each module and record personal comments. A trailer for how SPARX works can be found at sparx.org.nz.

lifeSTYLE

lifeSTYLE is an adaptation of an interactive, online program originally developed as a control intervention for a trial targeting adults with suicidal thoughts [22]. The format and structure of the program was retained, but the content was adapted to suit adolescents. This active comparison was used to control for the large placebo effect commonly seen in depression prevention and treatment trials, which has been cited as a key methodological weakness in many studies. The aim of the intervention was to provide an engaging and useful resource for young people that matched the intervention in terms of duration and attention without providing any direct mental health content. As with SPARX, lifeSTYLE consisted of 7 modules, each of which took 20 to 30 minutes to complete. The program covers the following topics: independence, participating in your community, work skills, mobile phone safety and hygiene, healthy skin, sustainable eating, and maintaining a healthy home environment. Each module includes information about the specified topic as well as interactive activities such as quizzes, mythbusters, videos, and scenarios to which students can respond. As with SPARX-R, the intervention was delivered online to students in school classrooms.

Randomization and Masking

Each participating school (cluster) was randomized to SPARX-R or lifeSTYLE by a statistician not involved in the implementation of the trial and blind to the identity of the schools. All study staff remained blind to condition except for the 2 trial managers involved in the communication of the materials and instructions to the schools (YP, AWS). The method of Carter and Hood [23] sought to ensure balance between arms. Balance variables were gender, number of enrolled students, Index of Community Socio-Educational Advantage for each school, and language background other than English.

No research personnel were directly involved in the delivery of the prevention interventions. Schools were not informed whether their assigned program represented the experimental or control condition. All outcome measures were self-report and were completed privately via an online portal. The trial statistician was blind to school allocation.

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Procedure

Following school-level randomization, participants completed baseline assessments and their allocated intervention modules. Program sessions were scheduled at each school's convenience. For the most part, students collectively completed the sessions during the first 20 to 30 minutes of a designated class period and then resumed their regular lessons for the remainder of the period. The majority of participants completed their post-intervention assessments in scheduled class sessions within 1 week of the intervention period. A follow-up assessment session was scheduled approximately 6 months after the baseline assessment (July; approximately 2 weeks prior to the exam period). A final follow-up assessment was scheduled 18 months after the baseline assessment; approximately 7 to 8 months after participants had completed their final exams. Exam results were provided by school administrators approximately 6 weeks after the final exam period ended (November-December).

Outcome Measures

Primary Outcome Measure

The Major Depression Inventory (MDI) is a 12-item self-report measure of depressive symptoms [24]. The items of the MDI evaluate the presence and duration of depressive symptoms according to both *International Statistical Classification of Diseases and Related Health Problems, 10th Revision*, (ICD-10) and *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition*, (DSM-IV) criteria. Respondents rate the degree to which they have experienced each of 10 symptoms over the preceding 2 weeks on a 6-point scale, ranging from 0 (at no time) to 5 (all of the time). The MDI has the following cut-off points: 21 to 25 for mild depression, 26 to 30 for moderate depression, and 31 to 50 for severe depression [25]. The MDI has acceptable sensitivity and specificity for the diagnosis of depression according to the ICD-10 and DSM-IV [24]. In this trial, Cronbach alpha, assessed at baseline, was .88.

Secondary Outcome Measures

The Spence Children's Anxiety Scale (SCAS) is a 44-item measure comprising 6 subscales. The scale was designed to measure the severity of children and adolescents' anxiety symptoms based broadly on DSM-IV criteria for anxiety disorders [26]. Respondents rate the degree to which they experience each symptom on a 4-point frequency scale, ranging from 0 (never) to 3 (always). Only items on the social phobia and generalized anxiety subscales were administered. The scale has demonstrated high reliability [26]. In this trial, Cronbach alphas for the social phobia and generalized anxiety scales were .76 and .81, respectively.

Three items from the Youth Risk Behavior Survey concerning suicidal thoughts, plans, and attempts over the previous month were used to assess suicidality. Endorsement of any of these items triggered the trial risk management protocol. Studies have shown that the suicidality items demonstrate reliability [27].

The Depression Stigma Scale (DSS) is an 18-item measure that assesses personal and perceived stigma toward depression. In this study, only the 9-item personal stigma subscale was used, as this subscale was most relevant. Items require the participant to rate how strongly they agree with a statement about depression (eg, "people with depression are unpredictable") on a 5-point Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree). The sum of each of the items yields a total stigma score, where higher scores indicate greater stigma. For this sample, Cronbach alpha was .77.

Final exam results were also collected and standardized using the Australian Tertiary Admission Rank such that the 2 groups could be compared on academic outcomes.

Sample Size

Based on previous depression prevention research using an online intervention [15], a post-intervention Cohen *d* effect size for the primary outcome measure of .20 was used for sample size calculations. Power was set at 80%, alpha=.05 (2-tailed), and a correlation of .5 assumed between baseline and endpoint scores. To allow for possible clustering effects, a design effect was calculated assuming an intraclass correlation (ICC) of .02 and an average class size of 25. The estimate of the ICC was derived from a previous Australian school-based study that found a nonsignificant ICC of .02 [15]. The estimated sample size was 1166. The total target size sample size was set at 1600, 800 students per condition, in order to accommodate possible attrition at a rate up to 20% [28].

The protocol [19] specified 2 stages of recruitment over consecutive years, with a planned analysis conducted using data from the first cohort as soon as available. In addition to evaluating effectiveness of the intervention, a review of first cohort outcomes was planned, aimed at identifying any refinement of content and mode of delivery required before proceeding to the second stage of recruitment. Schools recruited to the first cohort had an enrollment of 1677 eligible students. Under the assumptions outlined above, for this cohort alone, there was 80% power to detect an effect size of 0.40 standard deviations between groups.

Data Analysis

Primary analyses were undertaken on an intent-to-treat (ITT) basis. Effectiveness of SPARX-R was established using a planned contrast of change from baseline to post-intervention in the active compared to placebo condition on the MDI using a mixed-model repeated measures (MMRM) analysis that incorporates all available data under the missing-at-random assumption [29]. School was included in analyses as a random effect to evaluate and accommodate clustering effects. Variables used in determining allocation balance were evaluated and retained in 2 sensitivity analyses, 1 adjusting for characteristics differing at baseline and 1 excluding non-selective students. An unconstrained variance-covariance matrix was used to model within-individual dependencies, and degrees of freedom were estimated using Satterthwaite's method [30]. Between-group effect sizes (Cohen *d*) were calculated using observed mean loss/gain scores from pre-intervention to post-intervention, from pre-intervention to 6-month follow-up, and from pre-intervention to 18-month follow-up, divided by pooled standard deviation at the later time-point. Positive effect sizes indicate changes in favor of the intervention condition.

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Although our MMRM analytic approach was conducted under the robust assumption that data were missing-at-random, we also conducted a completer analysis, excluding participants who did not complete a follow-up assessment. This analysis was conducted to provide evidence for whether findings were consistent across alternative assumptions about missingness. Due to high attrition from the trial at follow-up, consistency across multiple analytical approaches may provide added confidence in the findings. Outcomes of the completer analysis are briefly summarized with comparison to the ITT analyses, as completer analyses may be more prone to bias [31].

Prevalence rates of major depressive disorder and suicidal ideation between the 2 treatment arms at post-intervention, 6 months, and 18 months were compared using Fisher exact test. Analyses of secondary variables also used MMRM methods. Subsidiary analyses of students who completed post-test evaluations (protocol compliers) were used to estimate the efficacy of SPARX-R in participants who completed sufficient modules from the program to have a potential clinical impact (estimated to be 4 or more modules) [12]. Separate analyses for completer subgroups (eg, completed 0 to 3 modules vs 4 to 7 modules) were also undertaken, and clinically significant change (improvement and decline) was assessed in program completers. Due to scheduling difficulties, 2 participants in lifeSTYLE and 22 in SPARX-R completed a 6-month assessment after completion of exams. As the stressor of interest had consequently passed, the 6-month data from these participants were excluded from analyses. All analyses were undertaken using SPSS version 23 (IBM Corp). The trial was registered with the Australian New Zealand Clinical Trials Registry [ANZCTRN12614000316606].

Results

A total of 23 secondary schools were approached between August 1 and November 28, 2014, to participate in the trial. Of 14 schools who initially agreed to participate, 4 dropped out prior to randomization leaving 10 schools contributing 7 to 126 participants each. A total of 540 students provided personal consent and obtained parental consent to participate. The Consolidated Standards of Reporting Trials (CONSORT) flowchart outlines recruitment, randomization, and participation (see Figure 1). Baseline assessments commenced in February 2015 with 6-month follow-up assessments completed by August 2015 and 18-month follow-up assessments completed by August 2016.

Sample characteristics are shown in Table 1. There were no differences between the SPARX-R and lifeSTYLE conditions on the basis of country of birth, language primarily spoken at home, age, depression symptoms, generalized anxiety disorder symptoms, social phobia symptoms, or subjective health. However, males, students from selective programs, and students living with both parents together had significantly greater representation in the SPARX-R condition relative to lifeSTYLE. Participants in SPARX-R completed fewer intervention modules than those in lifeSTYLE. Estimated marginal means and standard errors were derived from models fitted for primary and secondary continuous outcomes at each time point by condition (see Table 2).

Table 1. Sample characteristics for the SPARX-R and lifeSTYLE conditions.

Characteristic		SPARX-R n=242 n (%)	lifeSTYLE n=298 n (%)	Chi-square	*P* value
School program					
	Non-selective	4 (1.7)	72 (24.2)	55.9	<.001
	Selective	238 (98.3)	226 (75.8)		
Sex					
	Male	117 (48.3)	82 (27.5)	24.9	<.001
	Female	125 (51.7)	216 (72.5)		
Country of birth					
	Australia	195 (80.6)	236 (79.2)	0.2	.69
	Other	47 (19.4)	62 (20.8)		
Language spoken at home					
	English	132 (54.5)	175 (58.7)	1.0	.33
	Other	110 (45.4)	123 (41.3)		
Live with both parents together					
	Yes	216 (89.3)	235 (78.9)	10.5	<.001
	No	26 (10.7)	63 (21.1)		

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Table 2. Mean and standard error for continuous outcomes at each time point (estimated from mixed effect models).

Test	SPARX-R				lifeSTYLE			
	Baseline n=242 mean (SE)	Post n=206 mean (SE)	6 months n=140 mean (SE)	18 months n=40 mean (SE)	Baseline n=298 mean (SE)	Post n=200 mean (SE)	6 months n=201 mean (SE)	18 months n=64 mean (SE)
MDI[a]	14.9 (0.9)	11.9 (0.9)	13.3 (1.0)	10.0 (1.1)	14.4 (0.9)	14.7 (0.9)	15.3 (0.9)	11.9 (1.0)
SCAS GAD[b]	6.7 (0.4)	5.9 (0.4)	6.5 (0.6)	5.1 (0.5)	6.8 (0.4)	6.4 (0.4)	6.6 (0.4)	5.7 (0.5)
SCAS SA[c]	7.2 (0.5)	6.4 (0.5)	6.5 (0.5)	6.1 (0.6)	7.4 (0.4)	6.8 (0.5)	6.6 (0.5)	6.5 (0.5)
DSS[d]	9.4 (1.0)	8.9 (1.1)	8.4 (1.1)	8.1 (1.1)	8.8 (1.0)	8.8 (1.0)	8.1 (1.0)	7.8 (1.0)

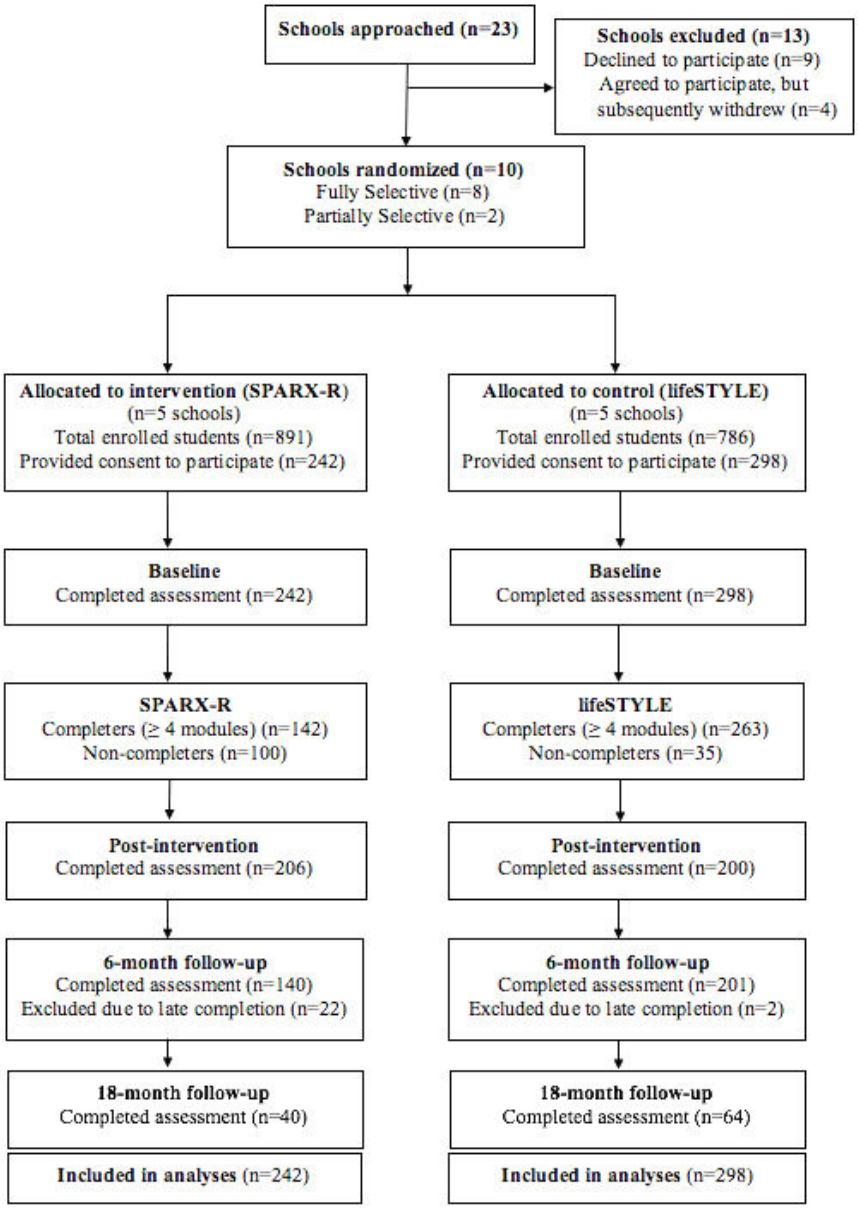
[a]MDI: Major Depression Inventory.

[b]SCAS GAD: Spence Child Anxiety Scale–Generalized Anxiety Disorder.

[c]SCAS SA: Spence Child Anxiety Scale–Social Anxiety.

[d]DSS: Depression Stigma Scale.

Figure 1. CONSORT Diagram.



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The ICC for depressive symptoms was 0.017. Primary analyses showed that participants in the SPARX-R condition had a significantly greater reduction in MDI scores than those in the lifeSTYLE condition both post-intervention ($t_{(416.1)}$=−4.78, P<.001) and at 6-month follow-up ($t_{(317.6)}$=−2.76, P=.01). The effect was not significant at 18-month follow-up ($t_{(132.1)}$=−1.82, P=.07). Effect sizes were small post-intervention (Cohen d=0.29, 95% CI 0.09 to 0.49), at 6-month follow-up (Cohen d=0.21, 95% CI −0.01 to 0.42), and 18-month follow-up (Cohen d=0.33, 95% CI −0.06 to 0.73).

When completer analyses were conducted, the effects of the intervention on depression scores remained significant ($F_{(3, 254.0)}$=8.00, P<.001), with significant effects at post-test ($t_{(410.4)}$=−4.84, P<.001) and 6-month follow-up ($t_{(368.1)}$=−2.82, P=.005) but not at 18 months ($t_{(132.4)}$=−1.93, P=.055), consistent with the ITT analysis. Secondary outcomes also remained nonsignificant in completer analyses.

For participants who completed 4 or more modules, the intervention was effective at both post-intervention ($t_{(328.3)}$=−4.55, P<.001) and 6 months ($t_{(313.6)}$=−2.68, P=.01) but not at 18-month follow-up ($t_{(116.4)}$= −1.54, P>.05). Conversely, those who completed fewer modules showed no significant intervention effect (P=.83 post-intervention, P=.57 at 6 months) except for at 18 months ($t_{(15.5)}$= −3.08, P=.01). A clinically significant improvement in depression, as indicated by the Reliable Change Index [32], was found in a larger proportion of completers of SPARX-R than controls at post-test (65/206, 31.6%, vs 26/200, 13.0%, P<.001) and 6-month follow-up (35/126, 27.8%, vs 33/202, 16.3%, P=.02) but not at 18-month follow-up (15/41, 37%, vs 17/64, 27%, P=.29).

No significant effects were found on any of the secondary outcomes. Generalized anxiety and social anxiety were significantly reduced at post-intervention relative to baseline for both groups, but there was no significant condition by time interaction effect for either anxiety outcome. There were no differences between conditions in the prevalence of depression at any time, based on MDI caseness criteria [24], with caseness of 4.9% (10/206) in SPARX-R and 8.5% (17/200) in lifeSTYLE at post-intervention (P=.17), 11.9% (15/126) and 9.4% (19/202), respectively, at 6 months (P=.46), and 2.4% (1/41) and 4.7% (3/64), respectively, at 18 months (P>.99). Few participants reported suicidal ideation at any time point, and no significant differences were found between groups: 3.4% (7/205) in SPARX-R and 4.1% (8/196) in lifeSTYLE at post-intervention (P=.80), 2.4% (3/126) and 4.0% (8/198), respectively, at 6 months (P=.54), and 3% (1/39) and 5% (3/62), respectively, at 18 months (P>.99). Notably, academic outcomes did not differ between the 2 groups (P=.41).

Discussion

Principal Findings

The online gamified prevention intervention, SPARX-R, was effective at reducing depression symptoms in secondary students prior to their final exams. The effect size was small but robust and corresponds to previous results from cognitive behavior therapy (CBT)–based school programs delivered face-to-face based on recent meta-analyses [4]. Effects remained significant after controlling for selective streaming status as well as characteristics found to differ substantially at baseline. Completion of the program was associated with clearly improved primary outcomes, such that SPARX-R completers reported fewer depressive symptoms postintervention and at 6-month follow-up than their lifeSTYLE counterparts, while no intervention effect was detected for noncompleters. Differences in rates of clinically significant change were demonstrated, implying that the intervention produces meaningful change in depressive symptoms under universal administration. Given that a small effect at the population level can have a substantial impact on overall mental health, we assess the impact of the magnitude of effect of the intervention as promising. This is an important finding as it highlights the effectiveness of SPARX-R in the context of a truly universal sample comprising those who are at elevated risk for developing depression and those who are not.

No intervention effects were found for generalized anxiety, a finding at variance with the use of SPARX as a treatment intervention in the initial study [12], although anxiety was not measured in the second SPARX study [13]. The overall reduction in anxiety observed in the course of the trial is somewhat surprising as it might be expected to increase with the approach of final exams.

No between-group differences were found in depression caseness, suicidality, or academic outcomes. Low base rates for caseness and suicidality would likely have obscured any effects that existed. It is unclear why decreased symptoms did not improve academic performance, (although findings were in the expected direction), but it is possible that due to the high achieving nature of the sample there was insufficient variability in academic performance to detect change or students may have already been performing at ceiling. This was also a universal group of relatively psychologically well students, so differences may be more likely to emerge in a clinical sample or at least at the more severe end of the spectrum [17]. This question will need to be addressed in future prevention research.

Strengths and Limitations

A key strength of the study is its implementation in school settings where the intervention will ultimately be delivered, directly supporting the translational capacity of this research into practice. The trial is noteworthy having been mounted in a sample faced with a meaningful, real-world stressor. Indeed, we believe that the anticipation of the stressor may have led to greater engagement, addressing a problem that has been identified in more recent digital trials [33]. Thus, the significant effects detected are of great potential importance, given that they were obtained under pragmatic, real-world conditions. The use of an active attention control condition, which was matched in terms of length, delivery format, and interactivity, means the effects are attributable to the intervention rather than involvement in a research trial or generic placebo effects.

Several limitations associated with this study warrant mention. In common with most Internet-delivered universal interventions, completion rates of the active intervention were modest (59%

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in the SPARX-R group; defined as completion of 4 or more of 7 modules) although substantially higher than comparable studies in secondary schools [15]. While this rate is lower than the 86% completion rate observed in the SPARX treatment trial [12], it is important to note that this sample was universal rather than help-seeking, which may account for differences in motivation. Completion may have also been compounded by technical difficulties. Several technical problems occurred during implementation (particularly in schools allocated to the SPARX-R intervention), which impacted some students' ability to complete all of their allocated modules during class time. This was largely due to the excessive load on the school information technology (IT) system associated with multiple students simultaneously accessing the online research platform and downloading the SPARX-R game files. Indeed, the completion rate of 4 or more modules in the lifeSTYLE group (which did not encounter the same degree of difficulty due to a smaller load on IT systems) was substantially higher (88%). In response to these issues, the stability and download size of the SPARX-R program has been reviewed with the assistance of software developers. A mobile app of the intervention is also being developed and will be tested in the future.

Our decision to recruit in academically selective schools means that caution must be exercised in generalizing results to the broader school population. However, approximately 80% of our sample was born outside Australia and over half did not speak English at home, suggesting this was a culturally, if not academically, diverse sample.

Resources and feasible sample size precluded mounting a trial with incidence of clinically diagnosed depressive disorder as its primary outcome. This limitation is shared by nearly all such school-based trials and might be precluded in any case due to the demands of the education curriculum in the last year of high school. Accordingly, this trial aimed to maximize ecological validity in order to determine the true effect of a prevention program under real-world conditions, although we acknowledge that a small proportion of participants may have met criteria for the disorder at baseline.

Prior Research

To date, the majority of school-based depression prevention trials have delivered material face-to-face in groups. Five published studies have examined the effectiveness of online prevention interventions in the school setting. Calear and colleagues [15] were the first to demonstrate the utility of an online CBT program (MoodGYM) in high school students, demonstrating a positive effect for the program at post-intervention and 6-month follow-up for anxiety (Cohen d=0.15 and 0.25, respectively) and depressive symptoms (in males only; d=0.43 and 0.31, respectively). Wong and colleagues [34] conducted an RCT investigating 2 separate, blended online/offline CBT interventions (Thiswayup Schools) targeting depression and anxiety compared to regular health classes. Students who received the depression intervention reported lower symptoms of both depression (d=0.14) and anxiety (d=0.29) at post-intervention. More recently, 2 trials have not shown significant effects, findings that have been interpreted as a failure to engage or attributed to the strength of the control group intervention [13,33]. Our study suggests that the context in which the intervention is offered must also be taken into consideration. Adult findings indicate the power of preparatory CBT in the context of a stressor. For example, in 1 study doctors in training were randomly assigned to 2 study groups, either MoodGYM or an attention control group, prior to taking up their medical internship, a period of high stress [35]. Results showed that suicide ideation was less frequently endorsed in the intervention group than the control over the course of the year. Therefore, interventions delivered prior to major transitions or major stressors may provide greater engagement (both from the students and the school administrators) and be more effective than those delivered at arbitrary times.

SPARX-R can be delivered without direct facilitation and requires only minimal supervision from teachers, reducing the human resources required to deliver face-to-face school-based programs, and may offer an effective and scalable universal prevention approach for students. Indeed, it could be the first step in a stepped care approach to mental health interventions, whereby young people within the school setting are provided with access to a universal, skills-oriented intervention, with those who require additional support being stepped up to more intensive care as needed.

Conclusion

This is the first trial to demonstrate a preventive effect on depression prior to a significant and universal stressor in adolescents. It extends the evidence base for appropriately developed CBT skills delivered through a gamified program as being broadly effective for young people regardless of whether their symptoms are minimal, elevated, or meet diagnostic criteria. Our results highlight the potential utility of delivering prevention interventions in advance of a key stressor and the program feasibility and effectiveness of using an engaging interactive tool for depression prevention. Major implementation studies of these types of digital interventions are now warranted.

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Conflicts of Interest

YP, AWS, ALC, AM, CK, JS, HC, and PB declare no conflicts of interest. The intellectual property rights for SPARX are owned by UniServices Ltd at the University of Auckland. In the event of commercialization, SM, TF, and KS, as developers of SPARX, could derive financial benefit from its operation.

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Abbreviations

ANZCTR: Australian and New Zealand Clinical Trials Registry
CBT: cognitive behavior therapy
CONSORT: Consolidated Standards of Reporting Trials
DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, 4th Edition
DSS: Depression Stigma Scale
GNAT: gloomy, negative, automatic thought
ICC: intraclass correlation
ICD-10: International Statistical Classification of Diseases and Related Health Problems, 10thRevision
IT: information technology
ITT: intention-to-treat
MDI: Major Depression Inventory
MMRM: mixed-model repeated measures
NHMRC: National Health and Medical Research Council
SCAS: Spence Child Anxiety Scale
RCT: randomized controlled trial

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Appendix B. Primary Outcomes Paper for Paper 3 (Chapter 4)

Original Paper

A Transdiagnostic Video-Based Internet Intervention (Uni Virtual Clinic-Lite) to Improve the Mental Health of University Students: Randomized Controlled Trial

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Abstract

Background: Numerous studies have demonstrated the effectiveness of digital interventions for improving the mental health of university students. However, low rates of engagement with these interventions are an ongoing challenge and can compromise effectiveness. Brief, transdiagnostic, web-based video interventions are capable of targeting key mental health and related issues affecting university students and may be more engaging and accessible for this population.

Objective: This study used a 2-arm randomized controlled trial to evaluate the effectiveness of Uni Virtual Clinic-Lite (UVC-Lite), a fully automated, transdiagnostic, web-based video intervention, relative to an attention-control condition. The primary outcomes were symptoms of depression and generalized anxiety disorder. The secondary outcomes included psychological distress, social anxiety symptoms, body appreciation, quality of life, well-being, functioning, general self-efficacy, academic self-efficacy, and help seeking. Program use (intervention uptake and engagement) and satisfaction were also assessed.

Methods: University students (n=487) with mild to moderate symptoms of distress were recruited from universities across Australia and randomly allocated to receive access to the UVC-Lite intervention or an attention-control condition targeting general health for a period of 6 weeks. UVC-Lite includes 12 modules, each comprising a brief animated video and an accompanying exercise. Of the 12 modules, 7 also included a brief symptom screening quiz. Outcomes were assessed at baseline, postintervention, and 3- and 6-months postintervention.

Results: The primary and secondary outcomes were analyzed on an intention-to-treat basis using mixed models repeated measures ANOVA. The intervention was not found to be effective relative to the control condition on any of the primary or secondary outcomes. While 67.9% (114/168) of participants accessed at least 1 module of the intervention, module completion was extremely low. Subgroup analyses among those who engaged with the program (completed at least 1 video) and those with higher baseline distress (Distress Questionnaire-5 score ≥15) did not reveal any differences between the conditions over time. However, uptake (accessing at least 1 video) and engagement (completing at least 1 video) were higher among those with higher baseline symptoms. Satisfaction with the intervention was high.

Conclusions: The UVC-Lite intervention was not effective relative to a control program, although it was associated with high satisfaction among students and was not associated with symptom deterioration. Given the challenges faced by universities in meeting demand for mental health services, flexible and accessible interventions such as UVC-Lite have the potential to assist students to manage symptoms of mental health problems. However, low uptake and engagement (particularly among students with lower levels of symptomatology) are significant challenges that require further attention. Future studies should examine the

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effectiveness of the intervention in a more highly symptomatic sample, as well as implementation pathways to optimize effective engagement with the intervention.

Trial Registration: Australian New Zealand Clinical Trials Registry ACTRN12621000375853; https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=380146

(J Med Internet Res 2024;26:e53598) doi: 10.2196/53598

KEYWORDS

university students; internet-based intervention; randomized controlled trial; mental health; transdiagnostic

Introduction

Background

There is growing concern about the mental health of university students worldwide. Most students commence university study during the transition from late adolescence to early adulthood, a time when the first onset of many common mental disorders is high [1,2]. In addition, this group faces numerous stressors such as transition to independent living, instability in relationships, financial stress, and academic pressure [3-6]; these stressors increase their risk of developing mental health problems [7]. Moreover, the COVID-19 pandemic and the associated mitigation measures severely disrupted the daily lives and educational experiences of university students around the world [8], with students reporting increased academic challenges due to a shift to remote learning, disruptions to paid work, concerns about their future academic and career prospects, and increased social isolation due to campus closures and physical distancing mandates [8-11].

Before the COVID-19 pandemic, research indicated that approximately one-third of university students met criteria for at least 1 mental disorder during a 12-month period, with generalized anxiety and mood disorders being the most prevalent diagnoses [12,13]. Furthermore, studies of the prevalence of psychological distress among university student populations have indicated that 19% to 48% of students experience high levels of psychological distress and that as many as 65% experience subsyndromal symptoms indicative of mild to moderate mental illness [14,15]. Research conducted since the onset of the pandemic has demonstrated an increase in the prevalence of mental health problems among university students [11,16,17], and approximately 30% to 40% of students are estimated to have experienced symptoms of depression or anxiety during the first 2 years of the pandemic [18-20].

Untreated mental disorders in young people place them at higher risk for developing comorbid mental disorders in later adulthood [21,22]. Moreover, mental health problems among university students can negatively impact academic performance [23] and have been associated with an increased risk of dropping out of university [24]. However, only approximately one-sixth of university students with a mental disorder receive minimally adequate treatment [12]. The most frequently reported barriers to using mental health services by students include a preference for self-management, concerns about stigma, high treatment costs, and scheduling difficulties [25]. Moreover, traditional models of delivering psychotherapy (ie, individual face-to-face sessions) are unlikely to be sufficient to meet the growing demand for services in universities and may not be feasible during times of crisis (such as during the COVID-19 pandemic). Therefore, there is an urgent need to reimagine existing models of mental health service delivery in tertiary education settings.

Internet-based and other digital mental health interventions are proposed as one solution to increase access to evidence-based treatment and prevention among the university student population. University students have indicated a willingness to use digital programs [26,27] and perceive numerous advantages in doing so, including increased treatment accessibility, anonymity, privacy, and confidentiality, as well as the potential to mitigate financial concerns by accessing support at a lower cost [28]. Moreover, several systematic reviews and meta-analyses have demonstrated that digital mental health interventions can be effective for university students [29-33]. In particular, these reviews have shown that interventions based on cognitive behavioral therapy (CBT) have been the most frequently used therapeutic approaches and demonstrate larger effects than other approaches [32]. However, the effectiveness of current interventions is also limited by low levels of adherence and high rates of dropouts [34].

Due to high rates of comorbidity between mental disorders in university student populations [35], transdiagnostic approaches that deliver therapeutic content targeting the common mechanisms that underlie mental disorders may have more clinical utility than disorder-specific approaches. Internet-based programs targeting the reduction of depression and anxiety symptoms using transdiagnostic approaches have generally been shown to be effective in improving one or more mental health outcomes among university students relative to control groups [36-38] although there are exceptions to this [7,39]. However, the potential of transdiagnostic internet-based interventions in university student populations has not yet been fully realized. Recent trials of transdiagnostic internet-based interventions with university students have predominantly focused on interventions delivered with guidance from a health professional or trained nonprofessional [7,40]. Although the provision of therapeutic guidance in an intervention can have small positive effects on the rates of intervention completion [38], this also requires increased resources, which substantially reduces the potential for scalability [41]. Moreover, sustained and active engagement with existing transdiagnostic interventions may be challenging for university students for different reasons. Those with few symptoms may not have much motivation for change or may not see a need to engage. Those who experience mental ill health or struggle to balance competing demands may find it challenging to engage with complex interventions that contain many pages of information; are predominantly text based; or

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include multiple components (eg, written text, audio and visual information, and exercises and worksheets) [42]. In addition, most previous randomized controlled trials have tested transdiagnostic interventions using relatively small sample sizes (eg, ≤100 participants), which have not been sufficiently powered to detect small, yet clinically meaningful, effects in mental health outcomes that may be present in this population [7].

There is a need to explore innovative methods of delivering transdiagnostic programs that are low intensity and use potentially more engaging methods (eg, videos) to deliver therapeutic content directly to the user. A previous trial of a brief video-based transdiagnostic intervention in a sample of adults from the general population with elevated levels of psychological distress demonstrated significant reductions in depression, panic, and social anxiety symptoms relative to an attention-control condition [43]. Video-based interventions may be particularly accessible for university students who have limited time or motivation, as videos require less reading, scrolling, or shifting between pages of text-based materials or different intervention components. A recent study found that university students show a preference for internet-based mental health interventions that contain video content [44]. However, there are currently no video-based internet interventions that have been developed for and trialed with the university student population. In recognition of the potential utility of a video-based transdiagnostic internet intervention for university students, our research group developed the Uni Virtual Clinic-Lite (UVC-Lite), a brief intervention designed to help university students manage mental health problems and related issues.

Objective

In this 2-arm randomized controlled trial, we compared the unguided use of the UVC-Lite intervention for 6 weeks with an attention-control condition among students recruited from universities across Australia. The primary aim of the trial was to assess the feasibility and effectiveness of the intervention in reducing the symptoms of depression and generalized anxiety disorder at immediate postintervention and longer term at 3- and 6-month follow-ups. A range of secondary outcomes, as well as satisfaction with and use of the intervention, were also examined.

Methods

Participants (Recruitment and Eligibility Criteria)

Undergraduate and postgraduate students from all 42 universities in Australia were targeted using the recruitment strategies outlined below. Recruitment took place between August 2021 and May 2022, and all the follow-up data were collected by January 2023. Multiple strategies were used to recruit students into the trial. Students were provided with information about the trial via targeted Instagram and Facebook advertisements; via posts to university-affiliated groups on social media sites (Facebook, Instagram, Reddit, and Discord); and through university media channels such as newsletters. Recruitment materials targeted students interested in learning more about mental health and well-being. Student advocacy departments and associations, student housing coordinators, marketing teams, survey management departments, university counselors and well-being staff, university psychology clinics, and academic course conveners were contacted via email and social media pages to request assistance in distributing information about the trial to students via emails and flyers. Individuals involved in distributing recruitment materials were not asked to target any specific student groups.

To be eligible for the trial, students were required to (1) be enrolled at an Australian university; (2) currently reside in Australia; (3) be aged between 18 and 25 years; and (4) score between 8 and 17 on the Distress Questionnaire-5 (DQ5), which indicates moderate levels of psychological distress [45]. UVC-Lite was designed to be a brief internet-based self-help intervention; thus, students with a moderate level of psychological distress were targeted, as these programs are thought to be most suitable for this group [46]. However, because of the concerns noted in the ethical review about offering this program to people with higher levels of distress, students with high psychological distress (DQ5 score of 18-25) were deemed ineligible and were instead provided with specific instructions on how to access resources for help seeking. Students with a diagnosis of bipolar disorder, schizophrenia, posttraumatic stress disorder, or a personality disorder could participate if they fulfilled the eligibility criteria and were also currently receiving support or treatment for their disorder.

Procedure

Students interested in participating in the trial were provided with a link to a Qualtrics survey (Qualtrics International Inc) containing the participant information sheet, a question to obtain informed consent, and self-report questions to determine trial eligibility. Eligible participants were asked to provide an email address and complete the baseline survey. Participants who completed the baseline survey were randomized to either the UVC-Lite intervention condition or an attention-control condition for a period of 6 weeks. An independent researcher who was not involved with the trial generated a random sequence of integers between the values of 1 and 2 using a web-based application [47] and manually allocated participants to the trial conditions according to this sequence to ensure allocation concealment. Trial allocations were sent to a research assistant (NK), who enrolled participants in the trial.

During the 6-week intervention period, participants were sent 2 automated emails per week containing a link to an intervention or control module hosted in Qualtrics software. Participants could not access modules until they received these emails. Emails contained information about the topic of each module. Participants were not restricted in their use of usual services or support during the intervention or follow-up periods. All participants received an email containing a link to the postintervention survey 6 weeks after completing the baseline survey, and links to the follow-up surveys were sent 3 and 6 months after the postintervention survey was distributed. Participants were sent 2 email reminders to complete the postintervention and follow-up surveys. Participants who completed all the assessments were entered into a prize draw to win one of ten AUD $100 (USD $67) electronic gift cards.

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In case of distress, participants could contact the research team and be followed up by the primary researcher (LMF), a registered psychologist, and provided with support and referral to relevant health, counseling, and crisis support services. No students in the trial contacted the research team in distress.

Ethics Approval

The trial was registered at the Australian New Zealand Clinical Trials Registry (ACTRN12621000375853), and ethical approval for the study was obtained from the Australian National University Human Research Ethics Committee (protocol #2020/412).

Intervention Condition: UVC-Lite

UVC-Lite is a brief internet-based intervention that comprises 12 modules targeting the common mechanisms that underlie mental health problems in university students (Multimedia Appendix 1). Each module includes a 3- to 6-minute video in which a series of animated characters introduce and share their lived experience of one or more mental health problems or issues affecting mental health in students. A therapist character presents relevant psychoeducation and therapeutic techniques, and a downloadable worksheet exercise designed to facilitate the practice of the therapeutic techniques presented follows each video. Additional features include self-monitoring quizzes for participants to track and receive feedback on their symptoms (included in modules 1, 3, 4, 5, 7, and 11) and links to additional help-seeking resources provided at their university or in the community if participants score above a certain symptom severity cutoff. Module transcripts and exercises were available for participants to download. The 12 modules covered the following topics and therapeutic strategies and were presented to participants in this order: (1) dealing with depression and low mood (behavioral activation: pleasant events scheduling); (2) tackling negative and anxious thoughts (cognitive reframing: thought diary), (3) dealing with anxiety (cognitive reframing, breathing, and grounding techniques); (4) managing study issues: procrastination and time management (practical strategies for time management); (5) perfectionism (challenging perfectionistic thoughts and behaviors); (6) coping with stress (mindfulness practice: focus on the present moment and mindful eating activity); (7) managing sleep issues (sleep hygiene); (8) social anxiety and shyness (behavioral experiments or exposure techniques); (9) relationships and loneliness (communication skills and social support); (10) social media use (practical strategies for reducing social media use); (11) body image (body functionality appreciation exercise); and (12) thoughts of suicide (safety planning exercise).

The content for the UVC-Lite program was drawn from a previously developed internet-based mental health intervention for university students, the Uni Virtual Clinic. Although this intervention was not effective in reducing the symptoms of depression, anxiety, or distress compared with a waitlist control group in a previous trial, it was shown to be effective in reducing the symptoms of social anxiety and improving academic self-efficacy [43]. The original Uni Virtual Clinic program, which was developed using extensive co-design processes involving students, university teaching and administrative staff, and service providers, was designed to be a comprehensive portal for student mental health [48]. We developed the UVC-Lite program based on the feedback from users of the original Uni Virtual Clinic program to ensure that it was focused primarily on the most critical issues affecting student mental health. The UVC-Lite incorporates key elements from the original program but is delivered in a more concise format involving brief videos containing student stories, tailored psychoeducation, and a range of psychotherapeutic strategies.

Attention-Control Condition: General Health Information

The attention-control condition received biweekly emails containing a link to the information pertaining to general health rather than mental health. The health information was delivered in a PDF document accessed through a weblink and was approximately matched to the UVC-Lite program on completion time. A similar program has previously been shown not to be associated with therapeutic reductions in depression [49]. A total of 12 general health topics were covered, including bone health, sun exposure, food hygiene, dietary supplements, kidney health, microbes, household burns, respiratory viruses, heart health, allergens, posture, and pancreas health. The general health information was derived from web-based public domain articles about general health topics published by the National Institutes of Health [50].

Measures

Overview

At baseline, the following demographic and study data were collected: age, sex, ethnicity, languages spoken, country of birth, living situation, state or territory of residence, hours in paid employment, financial stress, relationship status, study discipline and year of degree, study load, international or domestic student status, academic performance, and engagement with student life. Primary and secondary outcomes (described in subsequent sections) were assessed at the baseline, postintervention time point, and 3- and 6-month follow-ups. Satisfaction with the intervention program was assessed at the postintervention time point.

Primary Outcomes

Primary outcomes were symptoms of depression (measured by the Patient Heath Questionnaire-9 [PHQ-9]) [51] and generalized anxiety (measured by the Generalized Anxiety Disorder Scale-7 [GAD-7]) [52]. The PHQ-9 comprises 9 items rated on a 4-point scale, ranging from “not at all” to “nearly every day.” Item scores are summed to produce an overall severity score ranging from 0 to 27, with higher scores indicating greater symptom severity (0-4=no symptoms, 5-9=mild symptoms, 10-14=moderate symptoms, and 15-27=severe symptoms). The GAD-7 comprises 7 items rated on the same 4-point scale as the PHQ-9. Summed scores produce an overall severity score ranging from 0 to 21 (0-4=no symptoms, 5-9=mild symptoms, 10-14=moderate symptoms, and 15-21=severe symptoms). Higher scores indicate greater symptom severity. Both scales have been shown to have robust psychometric properties in general population samples and detect change over time [53,54]. In the current sample, internal consistency was acceptable at baseline (PHQ-9: α=.80; GAD-7: α=.84).

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Secondary Outcomes

The secondary outcomes included social anxiety symptoms, psychological distress, body appreciation, quality of life, well-being, functioning, general self-efficacy, academic self-efficacy, and help-seeking behavior.

Social Anxiety

Symptoms of social anxiety were assessed using the Social Anxiety Disorder Screener [55], a brief 4-item scale with symptom severity scores ranging from 0 to 16. This scale has been developed and validated using Australian community–based samples, has demonstrated good convergent and divergent validity with diagnostic measures [55], and had very good internal consistency in this sample (α=.90).

Psychological Distress

Psychological distress was measured using the DQ5 [45], which consists of 5 items rated on a 5-point scale that assess the symptoms of common mental disorders experienced over the last 30 days (range 5-25; 5-7-mild distress, 8-17=moderate distress, and 18-25=high distress). The DQ5 has been shown to accurately identify individuals at risk for specific mental disorders relative to the Kessler-6 and Kessler-10 screeners [45]. Previous studies have demonstrated that DQ5 displays high internal consistency and external validity [45,56]. Internal consistency in the current sample was α=.58; however, this is an artifact of the restricted range on the DQ5 of the recruited sample [57,58].

Body Appreciation

Body appreciation was assessed using the 10-item Body Appreciation Scale-2 (BAS-2) [59]. The BAS-2 comprises 10 items rated on a 5-point scale. Item responses are averaged to produce a total score ranging from 1 to 5, with higher scores indicating greater body appreciation. The BAS-2 has demonstrated good internal consistency, test-retest reliability, and construct validity [59]. The scale had good internal consistency in this sample (α=.95).

Quality of Life

Quality of life was assessed using the European Health Interview Survey-8 (EUROHIS-8), an 8-item measure designed to assess the psychological, physical, social, and environmental aspects of quality of life (range 0-32) [60]. The EURO-HIS 8 has satisfactory discriminant validity and acceptable internal consistency [61], and internal consistency was adequate in the current sample (α=.79).

Well-Being

Well-being was assessed using the 5-item World Health Organization Well-Being Index, a 5-item scale with item responses ranging from 0 to 6, which produces a raw well-being score ranging from 0 to 25. Raw scores are multiplied by 4 to provide a final score ranging from 0 (worst-imaginable well-being) to 100 (best-imaginable well-being) [62]. The 5-item World Health Organization Well-Being Index has demonstrated sensitivity and specificity in screening for depression and is sensitive to change in clinical trials [63]. The internal consistency of the scale in the current sample was adequate (α=.82).

Functioning

Functioning was measured by the Recovering Quality of Life scale, a 20-item measure assessing the dimensions of mental health functioning including activity, hope, belonging and relationships, self-perception, well-being, autonomy, and physical health. The items are rated on a 5-point scale ranging from 0 to 4, with total scores ranging from 0 to 80. The scale has acceptable internal consistency, test-retest reliability, and convergence with related measures [64]. Internal consistency in the current sample was good (α=.88).

General Self-Efficacy

Self-efficacy was measured using the 10-item General Self-Efficacy Scale, which measures perceived coping with daily hassles and adaptation to stressful life events on a 4-point scale (range 0-30) [65]. The 10-item General Self-Efficacy Scale has been validated in 31 countries and languages and has acceptable internal consistency and good discriminant and concurrent validity [66,67]. Internal consistency in this study was good (α=.88).

Academic Self-Efficacy

Academic self-efficacy (ie, confidence in one's ability to successfully complete university-related tasks) was assessed using the Study and Social subscales of the College Self-Efficacy Inventory (CSEI; 15 items, 5-point Likert scale ranging from very unconfident to very confident, range 0-60) [68]. The CSEI Course subscale measures self-efficacy to complete tasks associated with university study (eg, "How confident do you feel to keep up to date with your university work?"). The CSEI Social subscale measures self-efficacy related to social interactions at university (eg, "How confident do you feel to talk to your lecturers/tutors?"). Both subscales have demonstrated adequate internal consistency (α=.79-.86) and have been found to be negatively correlated with social anxiety and academic worry or concern and positively correlated with grade point average [69,70]. Internal consistency in this study was good (α=.87).

Help Seeking

Help seeking was measured with the Actual Help Seeking Questionnaire [71]. Participants were asked whether they had sought help from a range of formal (ie, general practitioner, psychologist, counselor, and helpline) and informal (ie, friends, family, and partner) help sources in the past month. The Actual Help Seeking Questionnaire has been found to adequately differentiate help-seeking behavior for different problems and help sources [71].

Intervention Satisfaction and Adherence

Program use was assessed using author-developed JavaScript embedded within Qualtrics to track clicks and percentage of videos watched. Measures included uptake (number of modules and videos started) and engagement (viewing at least 50% of each video, number of exercises accessed, and number of quizzes completed). Satisfaction was assessed by asking participants how satisfied they were with the intervention

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(5-point scale, *very unsatisfied* to *very satisfied*); whether they would recommend the intervention to other students (4-point scale, *definitely not* to *yes, definitely*); how much they learned from the intervention (4-point scale, from *almost nothing* to *a great deal*); and which modules they liked the best.

Blinding

Trial researchers were blinded to treatment allocation. Participants were blinded to whether they received the active or attention-control intervention. Specifically, participants were informed that they would be randomized to receive 1 of 2 programs: information and strategies for improving mental health (UVC-Lite) or information and strategies for improving general health (attention control). They were not provided with information about which program was expected to be more effective. Assessments were also blinded, as self-report questionnaires were delivered on the web.

Statistical Analyses

Statistical analyses were conducted by the primary author (LMF) and author PJB using SPSS (version 28; IBM Corp) for Windows [72]. Sample characteristics were described at baseline, and differences between the intervention and control groups were examined using 2-tailed *t* tests and chi-square statistics. Predictors of dropout (failure to complete trial assessments) were examined at postintervention and at 3- and 6-month follow-ups using logistic regression. Predictors of uptake and engagement with the UVC-Lite intervention were also examined using logistic regression. The primary and secondary outcome variables were analyzed on an intention-to-treat basis using mixed models repeated measures ANOVA, with measurement occasion as a within-groups factor and trial condition as a between-groups factor [73]. Mixed models incorporate all available data under the assumption that data are missing at random. Within-person variation was modeled using an unstructured covariance matrix. To examine whether intervention effectiveness was related to intervention adherence or baseline symptoms, analyses were re-estimated among participants who watched at least 1 video and those with higher levels of baseline distress (DQ5 score ≥15). Logistic regression was used to examine the relationship between trial condition and help-seeking behavior at postintervention and at 3- and 6-month follow-ups.

Power

A power calculation based on repeated measures ANOVA (conducted using G*Power) indicated that a target sample size of 418 would enable the detection of an effect of Cohen d=0.3 between conditions, with 90% power and a significance level of α=.01. The recruited sample size was 487, allowing the detection of an effect of Cohen d=0.3 at a significance level of .01 with slightly higher power (~95%). However, high attrition was observed in the trial, with a sample of 265 retained at postintervention, 105 at 3 months, and 172 at 6 months.

Results

Trial Flow and Survey Completion

The flow of participants through the trial is shown in Figure 1. A total of 2865 individuals clicked on the study invitation. Of them, 523 (18.25%) completed the baseline survey and were randomized into trial conditions. The most common reasons for not progressing to randomization were clicking on the link but not reading the study information and providing consent (n=1132, 39.5%) and scoring >17 on the DQ5 (n=640, 22.3%). After completing the baseline survey, 36 participants were identified as being outside the eligible age range for the trial and were excluded from analyses, leaving 487 eligible participants. A total of 265 participants (54.4%) completed the postintervention survey, 105 (21.6%) completed the 3-month follow-up survey, and 172 (35.3%) completed the 6-month follow-up survey. In total, 2 errors were discovered during the trial that resulted in a delay in participants receiving either their condition allocation after completing the baseline survey or their 3-month follow-up survey. As a result of administrative errors, 129 (26.5%) participants experienced a delay of >3 days between completing their baseline assessment and receiving confirmation of their allocated trial condition and instructions for accessing their materials. A technical error with the survey delivery platform resulted in 188 (38.6%) participants not receiving their 3-month follow-up survey on the date when it was due to be administered. Baseline depression and generalized anxiety symptoms, trial condition, and whether trial condition allocation or 3-month follow-up survey was administered on time were examined as predictors of survey completion at postintervention and at 3-and 6-month follow-ups. Baseline symptoms and trial condition were unrelated to survey completion at all time points. However, delay in the administration of the 3-month follow-up survey due to technical error was significantly associated with increased odds of survey completion at 3 months (B=2.61; P<.001).

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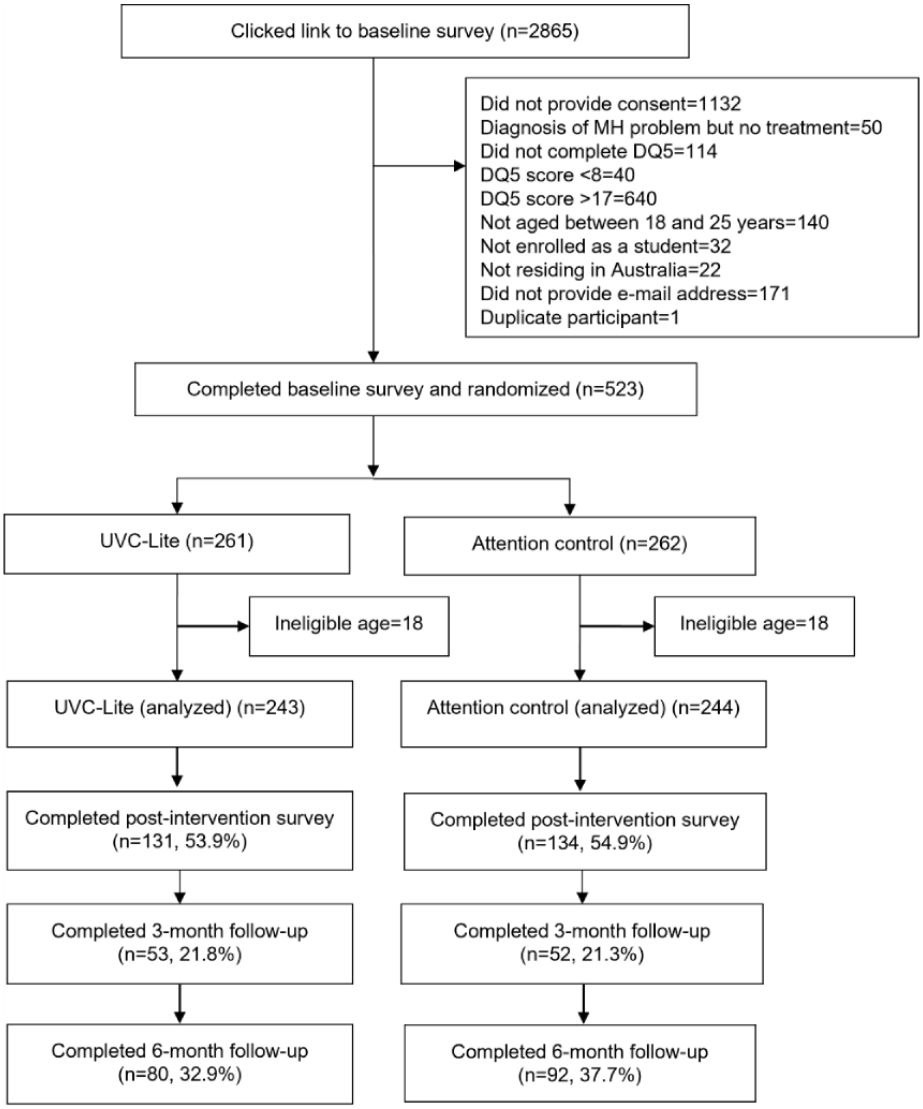
Figure 1. Trial flow. DQ-5: Distress Questionnaire; MH: mental health; UVC-Lite: Uni Virtual Clinic-Lite.



Sample Characteristics

Table 1 presents the baseline demographic and clinical characteristics of the sample. Students from 40 institutions in Australia participated in the study. The sample (n=487) was predominantly female (n=355, 72.9%), and participants were aged on average 21 (SD 2.1) years. Most participants were domestic students (411/487, 84.4%) studying full time (449/487, 92.2%) at the undergraduate level (416/485, 85.8%). Participants were studying degrees from a range of different disciplines. Most students were in some form of paid employment (328/487, 67.4%) and were living either with family (209/487, 42.9%) or on campus (152/487, 31.2%). There were no differences between participants randomized to the intervention or control conditions on any of the baseline demographic or symptom variables. As expected, due to screening, distress scores were moderate at baseline, whereas baseline depression and generalized anxiety symptoms were within the mild range.

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Table 1. Demographic and study characteristics of the sample.

	Intervention (n=243)	Control (n=244)	Total (n=487)	Chi-square (*df*)	*t* test (*df*)	*P* value
Categorical variables, n (%)						
Sex				0.4 (2)	—[a]	.82
Female	180 (74.1)	175 (71.7)	355 (72.9)			
Male	52 (21.4)	58 (23.8)	110 (22.6)			
Other	11 (4.5)	11 (4.5)	22 (4.5)			
Ethnicity				3.2 (4)	—	.53
Aboriginal and/or Torres Strait Islander and/or Pacific Islander	6 (2.5)	2 (0.8)	8 (1.6)			
African/Middle Eastern	6 (2.5)	6 (2.5)	12 (2.5)			
Asian/Indian	65 (26.7)	75 (30.7)	140 (28.7)			
White/European	154 (63.4)	152 (62.3)	306 (62.8)			
Other	11 (4.5)	8 (3.3)	19 (3.9)			
Current living situation				4.6 (6)	—	.59
With parents/family	100 (41.2)	109 (44.7)	209 (42.9)			
On-campus housing	82 (33.7)	70 (28.7)	152 (31.2)			
Friends off-campus	24 (9.9)	21 (8.6)	45 (9.2)			
Others off-campus	19 (7.8)	18 (7.4)	37 (7.6)			
With partner/children	10 (4.1)	17 (7)	27 (5.5)			
Alone	7 (2.9)	9 (3.7)	16 (3.3)			
Other	1 (0.4)	0 (0)	1 (0.2)			
Hours per week in paid employment				6.05 (5)	—	.30
None	89 (36.6)	70 (28.7)	159 (32.6)			
1-9	53 (21.8)	58 (23.8)	111 (22.8)			
10-19	68 (28)	67 (27.5)	135 (27.7)			
20-29	24 (9.9)	33 (13.5)	57 (11.7)			
30-39	8 (3.3)	15 (6.1)	23 (4.7)			
≥40	1 (0.4)	1 (0.4)	2 (0.4)			
Relationship status				2.50 (3)	—	.48
Single	170 (70)	165 (67.6)	335 (68.8)			
In relationship (not living together)	51 (21)	57 (23.4)	108 (22.2)			
In relationship (living together)	20 (8.2)	22 (9)	42 (8.6)			
Other	2 (0.8)	0 (0)	2 (0.4)			
Discipline of degree studied (n=438)				5.46 (7)	—	.60
Health/medicine	83 (38.4)	71 (32)	154 (35.2)			
Arts/social sciences	37 (17.1)	42 (18.9)	79 (18)			
Science	39 (18.1)	45 (20.3)	84 (19.2)			
Engineering/computing	21 (9.7)	28 (12.6)	49 (11.2)			
Business/economics	11 (5.1)	14 (6.3)	25 (5.7)			
Law/criminology	14 (6.5)	15 (6.8)	29 (6.6)			
Education	11 (5.1)	6 (2.7)	17 (3.9)			
Tertiary preparation course	0 (0)	1 (0.5)	1 (0.2)			
Year of degree				4.30 (3)	—	.23

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	Intervention (n=243)	Control (n=244)	Total (n=487)	Chi-square (*df*)	*t* test (*df*)	*P* value
First-year undergraduate	93 (38.3)	86 (35.2)	179 (36.8)			
Later-year undergraduate	107 (44)	112 (45.9)	219 (45)			
Honors	5 (2.1)	13 (5.3)	18 (3.7)			
Postgraduate	37 (15.2)	32 (13.1)	69 (14.2)			
Study load				0.44 (1)	—	.51
Full time	226 (93)	223 (91.4)	449 (92.2)			
Part time	17 (7)	21 (8.6)	38 (7.8)			
Student status				0.07 (1)	—	.79
Domestic	204 (84)	207 (84.8)	411 (84.4)			
International	39 (16)	37 (15.2)	76 (15.6)			
Average mark/grade achieved last semester (n=352)				0.86 (4)	—	.93
High distinction	41 (23.4)	44 (24.9)	85 (24.1)			
Distinction	79 (45.1)	76 (42.9)	155 (44)			
Credit	42 (24)	47 (26.6)	89 (25.3)			
Pass	12 (6.9)	9 (5.1)	21 (6)			
Fail	1 (0.6)	1 (0.6)	2 (0.6)			
Engagement with university life				1.40 (4)	—	.84
Not at all (only attend classes)	60 (24.7)	53 (21.7)	113 (23.2)			
Somewhat	80 (32.9)	80 (32.8)	160 (32.9)			
Moderate (participate in some university-based activities)	53 (21.8)	57 (23.4)	110 (22.6)			
High	29 (11.9)	27 (11.1)	56 (11.5)			
Extremely high (involved in student leadership activities within university)	21 (8.6)	27 (11.1)	48 (9.9)			
Continuous variables , mean (SD)						
Age (y)	20.67 (2.15)	20.57 (2.09)	20.62 (2.12)	—	0.55 (485)	.58
Depression (PHQ-9[b])	9.70 (5.11)	9.02 (4.34)	9.36 (4.75)	—	1.59 (485)	.11
Generalized anxiety (GAD-7[c])	7.84 (4.53)	7.28 (4.13)	7.56 (4.34)	—	1.41 (485)	.16
Social anxiety (SAD[d])	5.91 (3.69)	6.29 (3.89)	6.10 (3.79)	—	–1.12 (485)	.26
Psychological distress (DQ5[e])	14.10 (2.62)	13.92 (2.56)	14.01 (2.59)	—	0.77 (485)	.44
Body appreciation (BAS-2[f])	3.40 (0.90)	3.35 (0.87)	3.38 (0.88)	—	0.73 (485)	.47
Quality of life (EURO-HIS-8[g])	28.63 (5.16)	28.51 (4.87)	28.57 (5.01)	—	0.27 (485)	.79
Well-being (WHO-5[h])	47.00 (18.43)	47.57 (17.39)	47.28 (17.90)	—	–0.35 (484)	.72
Functioning (ReQoL[i])	45.24 (11.43)	45.64 (11.02)	45.44 (11.22)	—	–0.39 (484)	.70
Self-efficacy (GSE-10[j])	19.14 (5.21)	18.87 (4.64)	19.01 (4.93)	—	0.61 (484)	.54

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	Intervention (n=243)	Control (n=244)	Total (n=487)	Chi-square (*df*)	*t* test (*df*)	*P* value
Academic self-efficacy (CSEI[k])	34.53 (10.86)	33.97 (10.17)	34.25 (10.51)	—	0.59 (484)	.55

[a]Not applicable.

[b]PHQ-9: Patient Health Questionnaire-9.

[c]GAD-7: Generalized Anxiety Disorder Scale-7.

[d]SAD: Social Anxiety Disorder Screener.

[e]DQ5: Distress Questionnaire-5.

[f]BAS-2: Body Appreciation Scale-2.

[g]EURO-HIS-8: European Health Interview Surveys-8.

[h]WHO-5: 5-item World Health Organization Well-Being Index.

[i]ReQoL: Recovering Quality of Life.

[j]GSE-10: General Self-Efficacy Scale-10.

[k]CSEI: College Self-Efficacy Inventory.

Intervention Adherence and Use

Uptake of and engagement with the UVC-Lite intervention was low (Table 2). On average, participants (n=243) started (eg, clicked on the link directing them to the intervention) 5.1 (SD 5.08) of the 12 intervention modules, with 168 (69.1%) participants starting at least 1 module, and 51 (21%) participants starting all 12 modules. Among those who clicked through to the intervention modules, participants started an average of 3.58 (SD 4.23) of the 12 videos, with 114 (67.9%) participants starting at least 1 of the 12 videos and only 14 (8.3%) participants starting all 12 videos. Only 11 (6.5%) participants watched all 12 videos. Encouragingly, among those who started 1 or more videos, 92.6% of participants watched over half of the video once they started (on average). Engagement with the module exercises was lower than the completion of the quizzes. Participants accessed an average of 1.89 (SD 3.02) of the 12 module exercises, with 86 (51.2%) participants accessing 1 or more exercises, and only 1 (0.6%) participant accessing all 12. In contrast, participants completed an average of 4.14 (SD 2.73) of 7 quizzes, with 151 (89.9%) participants completing at least 1 quiz and 57 (33.9%) participants completing all 7. Age, gender, student status (domestic vs international), baseline distress (DQ5 score: 8-14 vs 15-17), receiving trial allocation information on time, and year of study (first year vs later year) were examined as predictors of uptake (starting at least 1 module) and engagement (watching at least 1 video). Those with higher levels of baseline distress (DQ5 score≥15) were more likely to start at least 1 module (B=2.18; *P*=.01) and watch at least 1 video (B=2.14, *P*=.007) compared with those with lower distress. In addition, those who were in a later year of their degree were more likely to engage (watch at least 1 video) than those in their first year (B=2.36; *P*=.008). Although it was not significant, there was a trend toward higher intervention uptake among those who received their trial condition allocation on time (within 3 days of completing the baseline assessment; B=1.78, *P*=.08). More detailed descriptive statistics for uptake and engagement with each intervention module are provided in Multimedia Appendix 2. The number of participants accessing each module declined over the order of modules. The most frequently accessed module was module 1 (145/243, 59.7%), and the least frequently accessed module was module 12 (83/243, 34.2%).

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Table 2. Uptake and engagement with the Uni Virtual Clinic-Lite intervention.

Uptake and engagement	Values
Participants who received the intervention (n=243), n (%)	
Started at least 1 module	168 (69.1)
Started all 12 modules	51 (21)
Participants who clicked through to the intervention modules (n=168), n (%)	
Started at least 1 video	114 (67.9)
Started all 12 videos	14 (8.3)
Watched ≥50% of at least 6 videos	42 (25)
Watched ≥50% of all 12 videos	11 (6.5)
Accessed at least 1 exercise	86 (51.2)
Accessed all 12 exercises	1 (0.6)
Accessed at least 1 quiz	151 (89.9)
Accessed all 7 quizzes	57 (33.9)
Modules started, mean (SD)	5.10 (5.08)
Videos started, mean (SD)	3.58 (4.23)
Exercises accessed, mean (SD)	1.89 (3.02)
Quizzes completed, mean (SD)	4.14 (2.73)

Primary Outcomes

Table 3 shows the estimated marginal means for the intervention and control groups on the primary outcomes at each measurement occasion. Significant decreases in depression ($F_{3,191.2}$=4.3; P=.006) and generalized anxiety ($F_{3,192.1}$=14.8; P≤.001) were observed over time in both trial groups, but no significant time-by-condition interactions were found, indicating that there was no significant difference in symptom reduction over time between conditions.

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Table 3. Estimated marginal means for the intervention (Uni Virtual Clinic-Lite; UVC-Lite) and control groups at each measurement occasion and results of the mixed models analysis.

	Intervention (UVC-Lite) condition, mean (SE)				Control condition, mean (SE)				Occasion×condition	
	Baseline	Postintervention time point	3 months	6 months	Baseline	Postintervention time point	3 months	6 months	*F* test (*df*)	*P*
Depression[a]	9.7 (0.3)	8.9 (0.4)	9.1 (0.6)	9.1 (0.6)	9.0 (0.3)	8.1 (0.4)	7.9 (0.6)	8.9 (0.5)	0.51(3)	.68
Generalized anxiety[b]	7.8 (0.3)	6.7 (0.3)	7.6 (0.5)	8.1 (0.5)	7.3 (0.3)	5.9 (0.3)	6.6 (0.5)	7.4 (0.5)	0.22 (3)	.88
Social anxiety[c]	5.9 (0.2)	5.6 (0.3)	6.3 (0.4)	5.9 (0.4)	6.3 (0.2)	5.5 (0.3)	5.3 (0.4)	5.8 (0.3)	1.65 (3)	.18
Distress[d]	14.1 (0.2)	12.0 (0.3)	12.5 (0.5)	12.4 (0.5)	13.9 (0.2)	12.0 (0.3)	11.3 (0.5)	12.5 (0.5)	1.21 (3)	.31
Body appreciation[e]	3.4 (0.1)	3.4 (0.1)	3.6 (0.1)	3.4 (0.1)	3.3 (0.1)	3.3 (0.1)	3.4 (0.1)	3.4 (0.1)	0.38 (3)	.77
Quality of life[f]	28.6 (0.3)	28.5 (0.4)	28.1 (0.5)	28.8 (0.5)	28.5 (0.3)	28.8 (0.4)	29.3 (0.5)	28.9 (0.5)	1.23 (3)	.30
Well-being[g]	47.0 (1.1)	50.0 (1.5)	50.3 (2.2)	53.5 (1.9)	47.6 (1.1)	49.8 (1.5)	50.5 (2.2)	49.9 (1.8)	0.99 (3)	.40
Functioning[h]	45.2 (0.7)	46.4 (1.0)	46.3 (1.4)	46.9 (1.3)	45.6 (0.7)	47.3 (1.0)	47.5 (1.4)	45.4 (1.3)	1.01 (3)	.39
Self-efficacy[i]	19.1 (0.3)	19.1 (0.4)	19.2 (0.6)	19.2 (0.5)	18.9 (0.3)	19.1 (0.4)	19.5 (0.6)	19.7 (0.5)	0.47 (3)	.71
Academic self-efficacy[j]	34.5 (0.7)	36.1 (0.9)	36.1 (1.2)	37.3 (1.0)	34.0 (0.7)	35.2 (0.8)	37.0 (1.2)	35.9 (1.0)	0.73 (3)	.53

[a]Patient Health Questionnaire-9; range 0 to 27.

[b]Generalized Anxiety Disorder Scale-7; range 0 to 21.

[c]SAD: Social Anxiety Disorder Screener; range 0 to 16.

[d]Distress Questionnaire-5; range 5 to 25.

[e]Body Appreciation Scale-2; range 1 to 5.

[f]European Health Interview Surveys-8; range 0 to 32.

[g]5-item World Health Organization Well-Being Index; range 0 to 100.

[h]Recovering Quality of Life; range 0 to 80.

[i]General Self-Efficacy Scale-10; range 0 to 30.

[j]College Self-Efficacy Inventory; range 0 to 60.

Secondary Outcomes

No significant differences were found between conditions over time on any secondary outcome variables (Table 3). However, both conditions showed significant reductions in distress ($F_{3,187.6}$=25.0; P≤.001) and significant increases in body appreciation ($F_{3,173.5}$=2.8; P=.04), quality of life ($F_{3,188.1}$=4.3; P=.006), and academic self-efficacy ($F_{3,175.3}$=5.6; P=.001) over time. Trial condition was not associated with help seeking from different sources at postintervention, 3-month follow-up, or 6-month follow-up.

Analyses Among Engagers and Those With Higher Distress

No significant differences were found between conditions over time on any of the primary or secondary outcomes among those who engaged with the intervention (watched ≥1 videos). However, one time-by-condition interaction approached significance; nonsignificant reductions in distress were observed at the postintervention time point and 6-month follow-up among intervention group participants who watched ≥1 videos, compared with those in the control group ($F_{3,161.1}$=2.3=; P=.08). No significant differences were found between conditions over time among those with higher levels of distress (DQ5 ≥15; n=260, 53.4%) at baseline.

Satisfaction

Most participants who returned a postintervention survey reported being satisfied with the intervention; 81.3% (100/123) of the participants were either “very satisfied” or “somewhat satisfied” following the use of the UVC-Lite. Most participants (115/124, 92.7%) also reported that they would be willing to recommend the UVC-Lite to other students, and 75.6% (93/123) reported that they learned either “a lot” or “a fair bit” from the program. In terms of specific modules, 41.2% (47/114) of the participants reported that they liked the module on tackling negative and anxious thoughts the most, followed by the social anxiety module (45/114, 39.5%) and the study issues and

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procrastination module (44/114, 38.6%); a low proportion of students reported liking the module on thoughts of suicide (13/114, 11.4%) and social media and internet use (24/114, 21.1%).

Discussion

Principal Findings

This trial examined the effectiveness of a brief, video-based intervention for improving the symptoms of depression and generalized anxiety disorder among university students with moderate psychological distress. Brief, self-guided interventions delivered at scale have the potential to confer significant public health benefits, particularly in university-based settings where demand for resource-intensive services outstrips supply. However, in this trial, the intervention was not effective relative to the control condition on either of the primary outcomes or any of the secondary outcomes. This is at odds with the findings of systematic reviews and meta-analyses suggesting that internet-based programs can be effective for a range of mental health outcomes in university students [31-33]. Despite a degree of heterogeneity in digital interventions for university students in terms of the level of guidance, program length and mode of delivery, therapeutic approach, and program components, most digital interventions for students comprise text-based modules that are based on CBT. Reviews suggest that the effects generally tend to be higher in programs that are guided, are based on CBT, and target an indicated sample [30,32,33]. The results from the very few studies to date that have examined digital transdiagnostic interventions for university students are mixed. A recent randomized controlled trial of a guided digital transdiagnostic intervention was not found to be effective [7], whereas an older study comparing a transdiagnostic intervention to a waitlist control group found positive outcomes for anxiety and depression [36]. The findings of this trial, together with the limited and mixed evidence to date, suggest that uncertainty remains regarding the utility of digital transdiagnostic interventions for students or what components are needed in an effective intervention. More high-powered trials are needed, particularly those examining brief interventions and the use of video and other alternatives to text-based intervention modules.

There are several possible explanations for the null findings in this trial. First, engagement with the intervention was low. Approximately two-thirds of participants (168/243, 69.1%) accessed at least 1 component of the intervention, which is comparable to the rates of uptake in other studies of digital mental health interventions for university students (79.1%; range 32.2%-100%) [74]. However, among those who accessed the intervention, very few participants either completed these components (11/168, 6.5%) or accessed all the program modules (14/168, 8.3%), which is also consistent with other studies of digital interventions with students [33] and a study of a comparable transdiagnostic video-based intervention trialed in the general community [75]. Possible reasons for the low levels of engagement in this trial include low perceived need, administration issues with the trial, or lack of interest among participants in engaging with the trial materials. The trial was originally designed to recruit students with at least moderate levels of psychological distress at baseline (DQ5 score>8). However, due to concerns expressed by the university ethics review committee about the appropriateness of a low-intensity digital intervention for students with high levels of distress, eligibility criteria for the trial were revised to exclude students who screened positive for high levels of distress (DQ5 score>17). As indicated in the trial flow diagram, a significant number of students expressed interest in the trial but were deemed ineligible on the basis of high psychological distress (n=640). Students who were screened as eligible on the basis of moderate psychological distress (DQ5 score=8-17) scored within the mild ranges of the PHQ-9 and GAD-7 at baseline, possibly indicating a low perceived or actual need for the intervention. Higher symptom severity has been shown to be positively associated with engagement with digital interventions [76], and in this trial, those with higher baseline distress were more likely to engage with the intervention, supporting the theory that low rates of adherence were potentially driven by low perceived need.

Second, due to an administrative error, a proportion of trial participants (n=129, 26.5%) did not receive their condition allocation and materials within a timely window after registering for the trial and completing the baseline assessment. For some participants, there was a delay of almost 1 month. Although these errors were not significantly associated with negative impacts on intervention uptake or survey completion in this study, they nonetheless jeopardized the fidelity of the trial and may have somewhat contributed to the low intervention adherence and missing data. There is a risk that participants may lose interest in research participation if there are long gaps in receiving contact from the research team, which has led researchers to use strategies to maintain ongoing contact with research participants (email or phone reminders, newsletters, and social media groups). Randomization and initial email contact were conducted manually in this trial and were thus vulnerable to administrative error. Automating these procedures can help to minimize delays and errors in administering trial materials. Technical issues have been previously shown to be a major barrier to engagement with digital mental health interventions [76].

Third, the trial materials were delivered twice weekly to participants via email, which might have been missed or ignored by students who receive a large volume of email or check their email infrequently. Despite attempts to make these emails more engaging using eye-catching subject lines and wording, other methods for linking students to intervention materials should be considered, such as SMS text message reminders or prompts. Finally, it is possible that the intervention was not engaging for participants or that participants lacked interest in engaging with the trial materials. Young people may be changing in the ways that they engage with technology over time, such that an internet-based intervention may be less novel and attractive now than it was in the past. Moreover, the version of the intervention that was trialed in this study was neither co-designed with the students nor personalized or customizable. Lack of perceived relevance and personalization have been previously reported as the barriers to engagement with digital mental health interventions [76]. In this study, using co-design

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principles may have better aligned the intervention with the needs and expectations of the target users, leading to improved engagement.

The intervention was acceptable among the sample, as indicated by most participants indicating high satisfaction with the program and a willingness to recommend the program to others. Participants indicated that they liked the CBT-based modules the most (tackling negative and anxious thoughts and social anxiety), possibly because these modules contained tangible written exercises that users could complete or because these topics resonated the most with the participants in the sample. Engagement with the intervention was also higher among the later-year students than with the first-year students. This is noteworthy, given previous research suggesting that students may be at a heightened risk of developing mental health problems during their first year of university [77]. Possible delays in problem recognition or perceived need for treatment among students may account for the higher rates of engagement with the intervention among the later-year students in this trial. Students in their first year of university are often targeted with programs designed to help them adjust to university study and build social connections and study skills. Preventative mental health interventions could also be delivered at this time to assist students to build mental health literacy and skills in managing distress. However, findings from this trial suggest an ongoing need for accessible mental health interventions throughout a student's university candidature.

Strengths and Limitations

The study recruited a relatively larger sample than other trials of digital transdiagnostic interventions in university student populations [7,36]. The study also recruited a national sample from multiple universities, enhancing the generalizability of the findings. The study used a robust attention-control condition rather than a waitlist or no-treatment control. However, there are also several notable limitations, most of which are discussed in the previous section in relation to the study findings. In addition, there was low participation among male and gender-diverse students, limiting the generalizability of the findings to these groups. There was also high attrition in the trial, and although the data analytic methods used robustly accounted for missing data, the trial was likely underpowered due to not reaching the recruitment target and greater than expected dropouts from the assessments.

Future Directions

The findings highlight several implications for both future research on the UVC-Lite intervention and the implementation of this and other digital interventions in higher education settings. UVC-Lite was designed to be a highly accessible and flexible intervention that does not require significant financial or technological resourcing to implement. It was associated with high satisfaction among students and was not associated with symptom deterioration. Given the challenges faced by universities in meeting demand for mental health services, interventions such as UVC-Lite have significant potential to assist students to manage low-level distress and prevent the development of severe symptomatology when delivered universally. However, low uptake and engagement among students with low levels of symptomatology is a significant challenge that requires further attention. Future studies should examine the effectiveness of the intervention in a more appropriately symptomatic sample. Moreover, very few studies have examined the drivers of engagement with digital interventions among university students [78] or robustly tested strategies to facilitate engagement. The order of delivery of the modules appeared to affect the engagement in the current trial, with earlier modules being accessed more frequently than later modules. This may suggest that 12 modules are too many or that tailoring modules to participant symptoms, rather than expecting participants to engage with all 12 modules may improve engagement. Delivery of the intervention was fully automated, with no human support or contact. Further studies are needed to test different implementation pathways for digital interventions in university settings, particularly those involving greater support (eg, through counseling centers or other health services or via the classroom). Longitudinal studies of mental health in university settings may provide useful data about critical time points for targeting digital interventions to different student groups. There is capacity for interventions such as UVC-Lite to be expanded and adapted to address a wider range of topics relevant to students from different ethnic and cultural backgrounds, and this should also be a focus of future research and implementation efforts.

Conclusions

This study was the first to examine the effectiveness of a video-based transdiagnostic internet intervention for improving the mental health of university students. Although the intervention was designed to be highly engaging for a university student population, it was not effective in improving mental health outcomes, and sustained use of the intervention was low, possibly due to the low perceived need for the intervention among the study sample. Nonetheless, satisfaction with the intervention was high, and given the potential utility of brief transdiagnostic digital interventions in higher education settings, further research should examine the effectiveness of the UVC-Lite program among students with higher need for the program, as well as implementation pathways and strategies that optimize effective engagement with the program.

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Conflicts of Interest

LMF, AG, ALC, LL, PH, NK, and PJB are codevelopers of the Uni Virtual Clinic-Lite intervention. LMF, AG, and NK were involved in the development of the original Uni Virtual Clinic intervention.

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Multimedia Appendix 1

Screenshots of the Uni Virtual Clinic-Lite intervention.
[DOCX File , 1502 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Descriptive statistics for uptake and engagement with each intervention module.
[DOCX File , 15 KB-Multimedia Appendix 2]

Multimedia Appendix 3

CONSORT-EHEALTH checklist.
[PDF File (Adobe PDF File), 3384 KB-Multimedia Appendix 3]

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Abbreviations

BAS-2: Body Appreciation Scale-2
CBT: cognitive behavioral therapy
CSEI: College Self-Efficacy Inventory
DQ5: Distress Questionnaire
EUROHIS-8: European Health Interview Survey-8
GAD-7: Generalized Anxiety Disorder Scale-7

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PHQ-9: Patient Health Questionnaire-9
UVC-Lite: Uni Virtual Clinic-Lite

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