Supporting mental wellbeing of UK health and care workers using a mobile application: a mixed-methods feasibility study

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Abstract

Background

Poor mental wellbeing is highly prevalent among health and care workers, causing decreased individual health and patients' safety as well as leading to organisational problems. Prioritising mental wellbeing support for this population is crucial for promoting a healthy work environment. Mobile application-based self-care interventions have emerged as promising tools in recent decades due to their ease of implementation, cost-effectiveness, and user-friendliness. While numerous studies have demonstrated their effectiveness in promoting mental wellbeing, the scoping review revealed limited research focused specifically on health and care workers. Furthermore, existing interventions often target specific aspects of mental wellbeing, such as stress, burnout, anxiety, and depression, neglecting the broader mental wellbeing concept. Additionally, the literature identified a lack of qualitative studies exploring the experiences of health and care workers using these interventions. To address these gaps, this study employed a mobile application-based self-monitoring tool encompassing various aspects of mental wellbeing, from physical components to mental health conditions. The study also incorporated qualitative individual interviews to gain deeper insights into the participants' experiences with mental wellbeing monitoring via a mobile application.

Aims

The main aim of this mixed-method study was to assess the feasibility of a self-monitoring-based mobile application designed to improve mental well-being among health and care workers/students in the UK. The qualitative part also aimed to explore the mobile application's acceptability and usability through users' daily experiences, identifying barriers and facilitators to engagement with the monitoring.

Methods

This feasibility study employed a concurrent mixed method design, incorporating a feasibility randomised control trial (RCT) and subsequent qualitative study. The feasibility criteria included recruitment and enrolment, retention and adherence to the intervention, data collection methods, and daily user engagement rate for mobile applications. The feasibility RCT comprised two arms: the intervention and control group. In the intervention group, participants used the mobile application to monitor mood, behaviours, and mental health-related symptoms based on their preferences. After six weeks, they were invited to conduct a semi-structured individual interview to share their experiences with mental wellbeing monitoring. Participants in the control group were signposted to an NHS website that provided information about how to promote mental wellbeing. Baseline data was collected through a survey using instruments including demographics, the Warwick-Edinburg Mental Wellbeing Scale (WEMWBS), and the Depression Anxiety and Stress Scale (DASS-21). After six weeks, the mHealth Application Usability Questionnaire

(MAUQ) was additionally applied in the intervention group. Descriptive statistical analysis was used for quantitative data.

The qualitative study incorporated semi-structured individual interviews to explore user engagement with the mobile application. Qualitative findings were analysed using Braun and Clark's thematic analysis approach.

Findings

In total, 49 participants (32 health and care workers and 17 health and care students aged between 18 and 60+) were included. Ten dropouts were recorded, accounting for a 20.5% dropout rate. The daily application usage rate was 64.5%. According to the WEMWBS, the control group showed a higher improvement in well-being than the intervention group; however, this improvement did not exceed the cutoff point of 3. Mobile application-based mental wellbeing monitoring showed minimal impact on help-seeking behaviours for seeking mental wellbeing help. The most chosen items to monitor were daily mood, food, sleep, and exercise. Working hours, caffeine intake, work challenges, and low energy were also frequently chosen.

Four main themes were identified from the interviews: *"Usefulness", "Enablers of engagement", "Barriers to engagement", and "Suggested improvements"*. Mental wellbeing monitoring was found acceptable, but there were various views on its usefulness. The factors facilitating engagement included ease of use and accessibility, increased awareness, reminder e-mails, and unique individual strategies. The barriers to the engagement included personal challenges, technical difficulties, and motivational issues. Participants suggested including more work-related questions, push notifications, advice on improving mental well-being, goal settings and interface improvements to increase user engagement.

Conclusion

The research indicates that an RCT testing a mobile application for monitoring mental wellbeing, including physical and mental health aspects, is feasible regarding recruitment, dropout rate, and intervention engagement. The findings from the Mobile App Usability Questionnaire (MAUQ), qualitative interviews, and user engagement show that health and care workers/students find using mobile applications acceptable for promoting their mental wellbeing. Additionally, the study suggests that mobile application-based monitoring has the potential to positively impact daily habit changes, which may contribute to long-term improvements in mental well-being. However, the study's generalisability was limited to young adults aged 20-41 due to recruitment through social media. There are various views on the impact of the intervention on perceived mental well-being improvement. The qualitative data suggest that the application content, interface, and design should be improved by adding work-oriented questions, which finally will help increase user engagement.

Note: *As a part of this PhD, the Patient and Public Involvement Work (PPI) was published in the ICERI2023 conference. Thus, this part included similarities with the published work.*

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- Hassard, J., **Yildirim, M**., Thomson, L., & Blake, H. (2024). Disclosing non-visible disabilities in educational workplaces: a scoping review. British Medical Bulletin.
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- Al-Oraibi, A., Fothergill, L., **Yildirim, M.**, Knight, H., Carlisle, S., O'Connor, M., ... & Blake, H. (2022). Exploring the psychological impacts of COVID-19 social restrictions on international university students: a qualitative study. International journal of environmental research and public health, 19(13), 7631.
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pandemic and Self-Isolation on students and staff in higher education: A qualitative study. International journal of environmental research and public health, 18(20), 10675.

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Abbreviations

Apps Applications

CONSORT Consolidated Standards of Reporting Trials

COREQ-32 The Consolidated Criteria for Reporting Qualitative Research

DASS-21 The Depression Anxiety and Stress Scale (21 Items).

MAUQ The Mobile Health Usability Questionnaire.

mHealth Mobile Health

MRC Medical Research Council

NHS The National Health Service

NIOSH National Institute for Occupational Safety & Health

PPI Public Patient Involvement

RCT Randomised Control Trial

SDT Self Determination Theory

TAM Technology Acceptance Model

TIDieR Template for Intervention Description and Replication

UK The United Kingdom

WEMWBS The Warwick-Edinburg Mental Wellbeing Scale.

WHO The World Health Organisation

Chapter 1: Introduction

Introduction

The introduction chapter starts with a brief explanation of how the understanding of mental health progressed over time. Following its brief history, the current definitions of mental health and wellbeing are given. This chapter emphasises the complexity of mental wellbeing with a holistic approach. Then, the burden and prevalence of mental-ill health from a global and the United Kingdom (UK) perspective is presented. After the general view of mental-ill health, why and how health and care workers/students are vulnerable to poor mental wellbeing are explained. Finally, it presents how self-care management through new digital approaches could be helpful to support their mental wellbeing.

1.1 Mental health

Mental health has been a complex concept in human medical history. It has taken centuries to have the current comprehensive understanding of mental health and treatments for mental diseases. The understanding and development progress in mental health has shown differences depending on countries and societies. In Western societies before the 18th century, mental health was explained through beliefs and supernatural views (Cohen et al., 2013). The approach was that divine punishment, supernatural forces, or evil spirits caused mental diseases. Based on these beliefs, the treatments included rituals, exorcism, and religious practices (Cohen et al., 2013). In England, the only large public hospital was Bethlem in London, built in 1774 for the care of people classified as insane (the term used at the time for those experiencing mental illness) (K. Jones, 2023).

During the Enlightenment period (18th-19th Century), moral and humoral theories emerged, suggesting that mental disorders were caused by imbalances in bodily fluids or moral failings (Foerschner, 2010). Treatments often involve moral instruction and moralising approaches. In the same period, asylums were established as institutions for the care of people with mental illness (Bilir & Artvinli, 2021). This was an important initiative to take care of people with mental illness; however, the quality of care was poor, and the patients were often neglected (Bilir & Artvinli, 2021). In the 19th Century, early biological approaches were claimed, suggesting that mental illness was underpinned by brain pathology and physiological factors (Sadowsky, 2017). However, treatment methods remained limited and often included restraints and crude surgical procedures. During the early 20th century, psychoanalysis and psychological approaches began to rise, pioneered by Sigmund Freud, who brought attention to the role of the unconscious mind in mental health (Zweig, 2019). This new unconscious mind-based approach resulted in new treatment methods, such as talk therapy, and helped explore the psychological origins of mental illnesses (Zweig, 2019). In the 1950s, Skinner's behavioural theories gained momentum, and psychologists focused on understanding human behaviours and applying behavioural therapies (Keller & Schoenfeld, 2014). Behavioural approaches were followed by cognitive approaches, which proposed the information processing model to explain mental health and behaviour (Skinner, 2019). Alongside these new approaches, community mental health was becoming popular rather than large asylums (K. Jones, 2023). The development of psychotropic medications, such as antipsychotics and antidepressants, also revolutionised treatment options (K. Jones, 2023).

In the late 20th Century, biological research, including advancements in brain imaging and genetics, contributed to a better understanding of the physiological underpinnings of mental illnesses. The Diagnostic and Statistical Manual of Mental Disorders (DSM) (1952) was published, providing a standardised system for diagnosing mental disorders. In the late 20th century, there was a shift towards holistic approaches to mental health, expressing overall mental wellbeing and the interrelation of psychological, social, and physical factors. Positive psychology, presented by Seligman, increased the understanding of mental wellbeing, focusing on strengths, resilience, and personal growth (Seligman, 2001). In recent years, efforts to reduce the stigma surrounding mental illness have gained momentum. Advocacy for mental health awareness and improved access to care has become a global movement (Saha, 2021).

Due to the complexity of mental health, its definition and understanding have evolved from supernatural explanations to encompass a more comprehensive understanding of psychological wellbeing, emotional resilience, and social connectedness. The focus has shifted from moral judgment to medical and psychological explanations and institutionalisation to community-based care. Additionally, the integration of various therapeutic approaches, advancements in neuroscience, and a recognition of the interconnectedness between mental and physical health have contributed to the contemporary view of mental health as a vital aspect of overall mental wellbeing.

In the current world, mental health is defined as "... is a state of mental wellbeing that enables people to cope with the stresses of life, realise their abilities, learn well and work well, and contribute to their community" (*Mental health*, 2022). Mental health is a fundamental human right and an integral component of our overall health and wellbeing. Mental health involves balancing various factors, including emotional wellbeing, psychological resilience, social connections, cognitive functioning, self-esteem, coping skills, and work-life balance. Mental health exists on a continuum, ranging from optimal mental health to various levels of distress and mental illness (Franken et al., 2018).

1.2 Mental wellbeing

The terms "mental health" and "mental wellbeing" are used interchangeably; however, these terms are not the same, although having similarities. Health is a continuum concept, ranging from illness (being well means somebody is not sick) to wellness, meaning optimal health, balance, and stability (Ruggeri et al., 2020). Thus, mental wellbeing refers to achieving the best state of mental health, including the physical, social, and emotional capacity to cope with life's challenges (de Cates et al., 2015).

Mental wellbeing has three aspects: emotional, psychological, and social wellbeing. All these aspects are key to quality of life, enabling people to experience life as meaningful, handle daily stress, work productively, and have stable and fulfilling relationships. Emotional wellbeing includes recognising and managing our emotions effectively, having a positive outlook, and experiencing a sense of contentment and happiness (Coyle et al., 2014). Psychological wellbeing is described as *"…is simultaneously the absence of the crippling elements of the human experience – depression, anxiety, anger, fear – and the presence of enabling ones – positive emotions, meaning, healthy relationships, environmental mastery, engagement, self-actualisation. Psychological wellbeing is above and beyond the absence of psychological ill-being, and it is considered a broader spectrum of constructs than what is traditionally conceived of as happiness."* (Adler & Seligman, 2016).

Social wellbeing means the quality of our relationships and social connections, including having a support network, feeling connected to others, and experiencing a sense of belonging and inclusion (Corey Lee M. Keyes, 1998). These three aspects are interrelated, and the core aim is to achieve "the combination of feeling good and functioning well" (Ruggeri et al., 2020). Thus, mental wellbeing is not only the absence of a disease. Beyond the individual level, mental wellbeing has been linked to success at professional and interpersonal levels. Those with high mental wellbeing show greater productivity in the workplace, more prosocial behaviours, and positive relationships (Diener, 2012; Huppert & So, 2013).

Even though it is difficult to measure mental wellbeing objectively, there are questionnaires that measure mental wellbeing through subjective questions. According to the Warwick-Edinburg Mental Wellbeing Scale (WEMWBS), mental wellbeing refers to a state of positive mental health where individuals experience a range of positive feelings and functional capacities (Taggart et al., 2016). Consequently, all 14 statements in the scale are positively worded. WEMWBS specifically measures hedonic (happiness and life satisfaction) and eudaimonic (psychological functioning, good relationship with others, and self realisation) perspectives of mental wellbeing (Taggart et al., 2016). This comprehensive approach, including both hedonic and eudaimonic aspects, aligns with the most recent definition of mental wellbeing (The Scottish Government, 2023). It is a validated tool for the UK general adult population, which could be used in health and care workers/students' population.

The state of mental wellbeing is also closely linked to daily habits, including sleep, diet, caffeine intake, exercise, and alcohol use. Mental health disorders, such as stress, anxiety, and depression, can significantly impact various aspects of these daily habits. For example, sleep, a vital component of both mental and physical health, can be significantly impacted by mental health disorders, thereby affecting overall quality of life and mental wellbeing (K. N. Anderson & Bradley, 2013). High levels of stress and anxiety can lead to insomnia or disrupted sleep patterns (Manzar et al., 2021), which cause poor mental wellbeing (Espie et al., 2019). Conversely, individuals with depression may experience excessive sleepiness, oversleeping, or irregular sleep patterns (Hein et al., 2019). Concerning diet, stress and anxiety may affect eating habits differently in individuals. Some may experience a decrease in appetite, leading to weight loss (Cheng & Mohd Kamil, 2020), while others may engage in stress eating and consume more, leading to weight gain (Cifuentes et al., 2022). Emotional eating can also result in unhealthy food choices (Hill et al., 2022). Physical activity levels can also be altered, with stress and anxiety potentially causing restlessness or fatigue that hinders exercise (Techera et al., 2016), while depression may contribute to a lack of motivation for physical activity (Busch et al., 2016). These examples show how mental disorders cause impairments in daily habits.

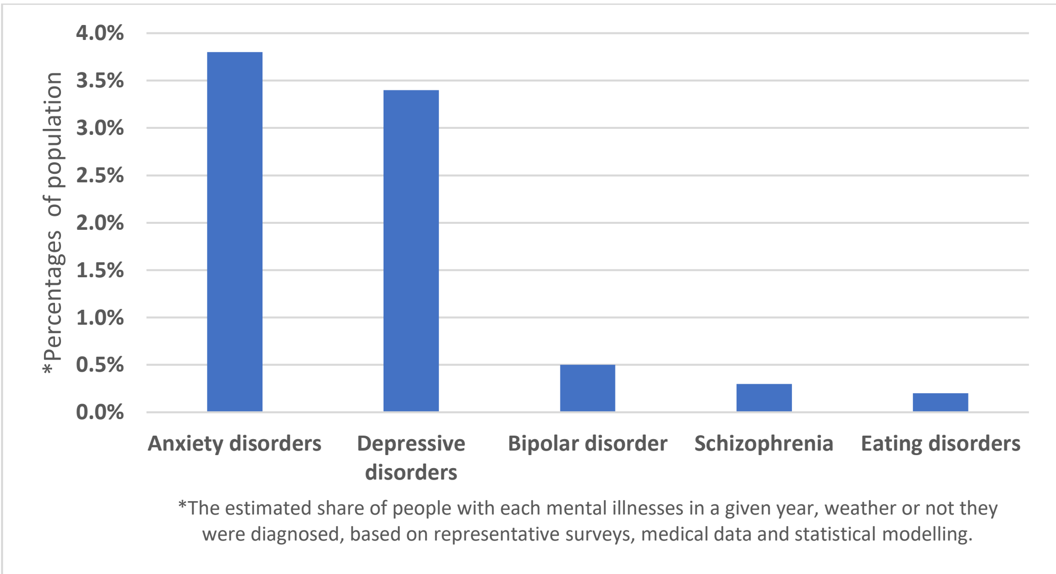
Mental wellbeing includes various factors associated with mental health and daily habits. Any impairment in these aspects of health can harm mental wellbeing, leading to a decrease in the overall quality of daily life, social interactions, and work performance. Poor mental health and wellbeing not only impact individual health but also place a burden on healthcare systems, economies, and social structures. This burden is significant, given the high prevalence of mental ill health worldwide, which will be presented in the following sections. There is an urgent need to address and prioritise mental wellbeing to mitigate these burdens and create a healthier and more resilient society.

1.3 Prevalence of mental-ill health

Mental health problems have become a significant global concern, with their prevalence and burden impacting individuals, communities, healthcare systems, and economies. In 2022, the World Health Organisation (WHO) published its largest-ever review, announcing mental health as "a growing crisis" (World Health Organization, 2022). This report emphasised that around one billion people, which is equivalent to 12.5% of the global population, are living with a mental disorder. It also noted that suicide contributes to over 1% of deaths, and mental health conditions result in 1 in 6 years lived with disability. Notably, the report called for an urgent transformation to manage mental health issues since maintaining the current situation was found ineffective (World Health Organization, 2022).

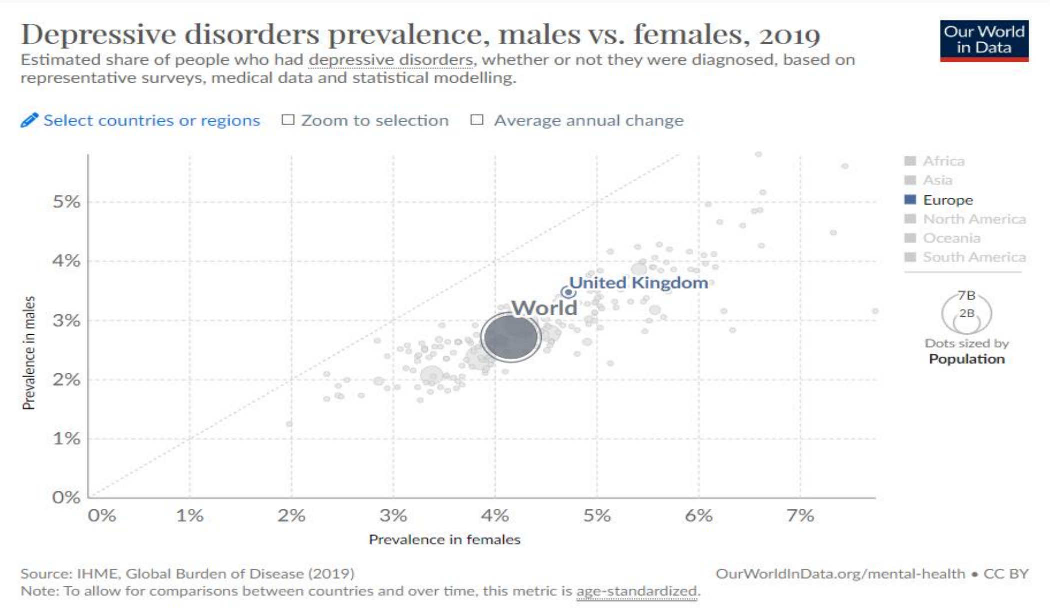
Common mental health problems, such as depression and chronic anxiety, affect a substantial portion of the global population, with over 264 million people living with depression and 284 million with anxiety disorders (Depression, 2017). Severe mental health problems, including bipolar disorder and schizophrenia, although less prevalent, still have a significant impact. Approximately 40 million adults worldwide are affected by bipolar disorder, while roughly 24 million people are estimated to have schizophrenia (*Mental disorders*, 2022). Figure 1 shows the global prevalence of mental illnesses in 2019.

Figure 1: Population percentages of mental illness prevalence in the world, 2019. Source: IHME, Global Burden of Disease (2019)



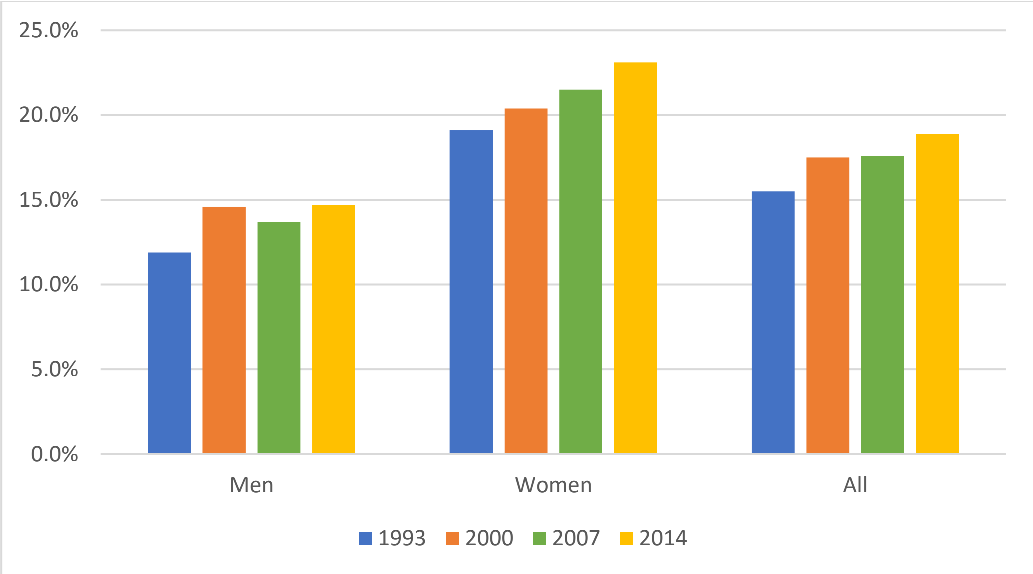
In the UK, mental illnesses are also highly prevalent, which poses a substantial public health challenge. The prevalence of mental ill-health is higher in the UK compared to the World average (*Mental illnesses prevalence*, 2019). In the UK, research suggests that around 1 in 6 adults experience a common mental health problem in any given week (McManus et al., 2016; *Mental health-ONS*, 2022). In terms of specific conditions, depression affects approximately 1 in 10 adults, while anxiety disorders impact around 1 in 8 individuals (McManus et al., 2016). Figure 2 demonstrates the prevalence of depressive disorders, comparing data between males and females as well as between global and UK populations. The figure reveals that the UK population exhibits a higher prevalence of depressive disorders than the global population. This observation highlights the substantial demand for mental health support within the UK. Furthermore, the figure depicts a significant gender disparity, with women being more vulnerable to depressive disorders than men. This data means that the health and care workers/students' population, mostly women (Number of health and care workers in England and Wales for 2019 and 2020, 2021), is at higher risk than the general population.

Figure 2: The comparison of depressive disorder prevalence between males and females, and the world and UK



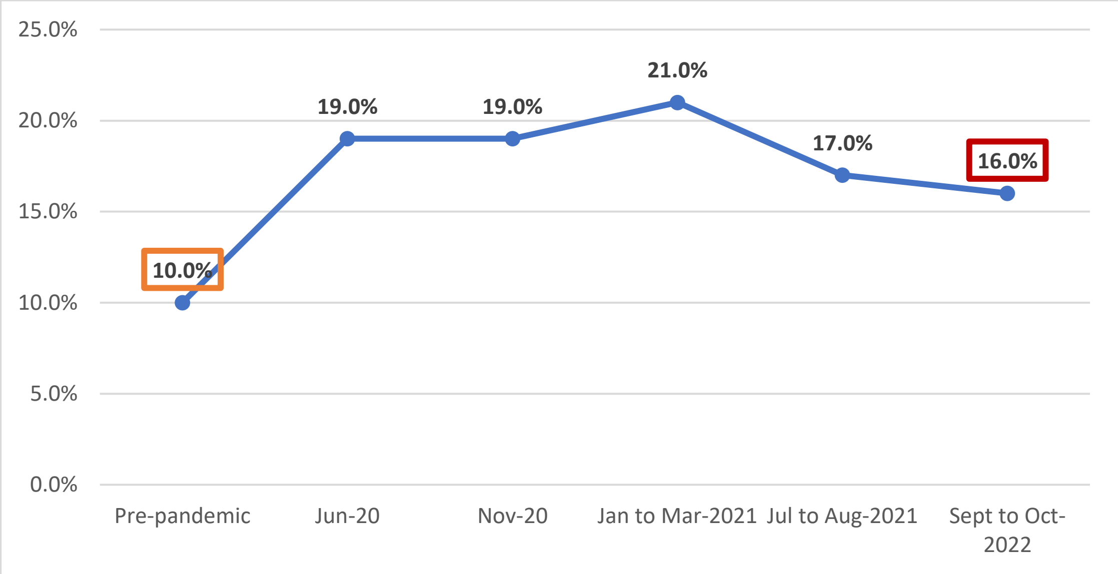
Moreover, the prevalence of common mental disorders in England has shown a concerning upward trend from 1993 to 2014, with both men and women experiencing an increase (McManus et al., 2016). According to the Adult Psychiatric Morbidity Survey in 2014, the prevalence among men reached 14.7%, while for women, it was notably higher at 23.1% (McManus et al., 2016). This persistent gender disparity aligns with global patterns. When considering the entire population, the prevalence rose from 15.5% in 1993 to 18.9% in 2014, indicating a growing burden of common mental disorders across England. More recent data from the UK Household Longitudinal Study showed a similar increasing trend in the prevalence of mental health problems, with a rate of 24.3% between 2017 and 2019 before the COVID-19 pandemic (Daly et al., 2022). These findings highlight the urgency of addressing mental health needs in the country, with the allocation of resources to mitigate the rising prevalence and its associated impacts.

Figure 3: The prevalence of common mental disorders in England from 1993 to 2014



Furthermore, the COVID-19 pandemic has exacerbated the mental health challenges. Figure 3 illustrates the significant rise in moderate to severe depressive symptoms following the pandemic outbreak (Williams et al., 2021). Beginning at a baseline of 10.0% pre-pandemic, the data reveals a substantial increase to 19.0% during the initial pandemic months, emphasising the immediate impact of the crisis on mental health. This prevalence remained consistent through early 2021, reflecting the persistence of mental health challenges. By September to October 2022, while there was a slight decrease to 17.0%, it remained notably elevated compared to the pre-pandemic baseline. In addition to these figures, some other studies also showed a substantial increase in the number of individuals living with anxiety and depressive disorders during the pandemic (e.g. (Vahratian, 2021). Initial estimates indicate a 26% and 28% increase in anxiety and depressive disorders, respectively, in only one year (World Health Organization, 2022). Despite the availability of effective prevention and treatment options, the majority of individuals with mental disorders lack access to effective care (World Health Organization, 2022). Additionally, many people experience stigma, discrimination, and human rights violations in accessing mental health treatment (World Health Organization, 2022). This collective evidence stresses that the COVID-19 pandemic has escalated the prevalence of mental health issues, which were already a global concern, emphasising the continued need for mental health support and interventions to address the wellbeing of affected individuals and communities.

Figure 4: The COVID-19 impact on moderate to severe depressive symptoms in adults in Great Britain, July 2019 to October 2022



The burden of mental health problems extends beyond individuals and communities, placing strain on economies, too. Globally, poor mental health at work impacts economies due to the consequences of lost working days, increasing absenteeism, unemployment, and disability claims (Hassard et al., 2021). In the UK, according to the National Institute for Health and Care Excellence (NICE), one in four people suffer from a common mental health disorder (*NICE impact mental health*, 2019), which means that the National Health System (NHS) faces challenges related to meeting the demand for mental health support, with lengthy waiting times and limited access to specialised care (C. Baker, 2021; Ham, 2017). Mental illnesses impose a significant financial burden on the NHS economy, encompassing both direct and indirect costs. The economic cost of mental health problems in the UK was at least £117.9 billion per year, equivalent to 5% of the country's Gross Domestic Product (GDP) in 2019 (*National Mental Health Programme*, 2022). Direct costs include expenses related to diagnosis, treatment, and ongoing care, such as medications, therapy sessions, and hospital stays. Specialised services provided by mental health professionals and emergency care also contribute to these direct costs. Indirect costs arise from productivity loss due to reduced work capacity, leading to sickness absenteeism and decreased economic output.

According to research conducted by Oxford Economics, it has been found that around 181,600 individuals are unable to participate in the labour force due to their mental health issues (*Added Value: Mental health as a workplace asset*, 2016). Both common mental health problems and more severe mental health conditions ranked as the third most significant factor contributing to sick leave (*Added Value: Mental health as a workplace asset*, 2016). Additionally, mental illnesses often coexist with physical health conditions, resulting in increased healthcare utilisation and associated expenses (Gentil et al., 2021). These financial burdens highlight the substantial impact of mental illnesses on the NHS and the UK economy. This challenge emphasises the importance of implementing cost-effective mental health support as a pivotal strategy to mitigate the economic impact of mental illness.

1.4 Mental ill health among healthcare workers and students in the UK

Mental health issues have been a key problem for health and care workers and students in the UK. Recent studies have stressed the high prevalence of mental ill health among health and care workers and students and also highlighted the increase in mental health issues (Bhugra et al., 2019; Costa et al., 2014;

Rotenstein et al., 2016; Søvold et al., 2021). Importantly, research suggests that health and care workers are at higher risk of mental problems than the general population (Saragih et al., 2021; Sauerteig et al., 2019). This vulnerability is likely attributed to the unique stressors inherent in healthcare practice. The intensive demands of medical training and the emotionally charged nature of patient care create an environment where depression, anxiety, and burnout can thrive (Gong et al., 2014; Letvak et al., 2012). Moreover, studies have found a significant link between high levels of work-related stress and the risk of developing mental health problems (Harvey et al., 2017; Maharaj et al., 2018). The consequences of these challenges expand beyond personal wellbeing, affecting the quality of care provided to patients and the overall healthcare system (Hall et al., 2016).

Healthcare workers and students (tomorrow's workforce) face many work-related challenges leading to poor mental health state. Research indicates that healthcare workers often experience high levels of emotional exhaustion and burnout due to constant exposure to suffering and death (Dyrbye et al., 2017; Shanafelt et al., 2020). The emotional exposure of witnessing patients' pain and distress can lead to symptoms of anxiety and depression among healthcare workers and students (Bhugra et al., 2019; Maben & Bridges, 2020). In addition to the emotional challenges, healthcare workers face unique pressures from their relationships with patients, family members, and employers. Balancing the expectations and demands of multiple stakeholders can lead to increased stress levels and psychological challenges. For example, conflicts with patients and their families, ethical dilemmas, and difficult communication can contribute to frustration and distress (Shanafelt et al., 2020).

Health and care workers often work in conditions with ongoing risks of hazardous exposures. The COVID-19 pandemic has highlighted the increased risk of contagious infectious diseases for healthcare workers (Vizheh et al., 2020). The fear of contracting an infection and transmitting it to loved ones can lead to significant psychological distress (Biber et al., 2022). Additionally, almost one in three registered nurses and midwives reported post-traumatic stress symptoms three months after the first COVID-19 pandemic peak in the UK (Couper et al., 2022).

Health and care workers also face the challenge of handling hazardous medications and the potential for occupational injuries, which further contribute to their mental health challenges (Joseph & Joseph, 2016). The demanding physical nature of healthcare work, including tasks such as patient handling, puts healthcare workers at risk of physical injuries. These injuries not only impact their physical wellbeing but also have implications for their mental wellbeing. Studies have shown that healthcare workers who experience work-related injuries may be at increased risk of developing mental health problems, such as depression and anxiety (Shanafelt et al., 2020). Long and often unpredictably scheduled work hours are another contributing factor to the mental health challenges faced by healthcare workers (Schneider & Harknett, 2019; Stimpfel et al., 2012). Many healthcare professions require as-needed scheduling, unexpected double shifts, and unpredictable intensity of on-call work (Fond et al., 2022). These irregular work schedules can disrupt their work-life balance, lead to sleep disturbances, and contribute to chronic stress.

Furthermore, high administrative burdens and limited control over schedules are additional stressors faced by healthcare workers. Excessive paperwork, documentation requirements, and bureaucratic processes can lead to feeling overwhelmed and lacking control over their work environment (Rao et al., 2017). These factors can contribute to increased stress levels and decreased job satisfaction.

In conclusion, the mental health challenges faced by health and care workers and students are multi-faceted and complex. The literature suggests that the combination of intensely stressful and emotional work environments, unique pressures from various relationships, hazardous exposures, demanding physical work, long and unpredictable work hours, unstable work lives, and high administrative burdens contribute to their increased vulnerability to mental health problems. Recognising and addressing these factors is crucial to supporting healthcare workers' mental wellbeing and ensuring high-quality care (*NHS strengthens mental health support for staff*, 2021; Søvold et al., 2021).

1.5 Digital health interventions to support mental wellbeing

Digital health interventions (DHIs) include applications, programmes, and software used in the health and care system (*National institute for health and care excellence evidence standards framework for digital health technologies*, 2019). These interventions include a broad range of health services that utilise technology to enhance the facilitation, capture, or sharing of health-related knowledge (Soobiah et al., 2020). DHIs have been enhanced progressively over time, closely aligned with technological advancements that substantially impact the accessibility and utilisation of health and care. The rapid advancements of hardware and software-based digital technologies present a fundamentally new approach to improving health, particularly in prevention and health promotion.

DHIs were primarily grounded in telehealth in its earliest stages when communication technology and healthcare services were integrated. The introduction of telehealth initiatives allowed individuals to receive medical guidance, support, and consultations through telephones (Board on Health Care Services & Institute of Medicine, 2012; El-Miedany, 2017; Koivunen & Saranto, 2018; Tuckson et al., 2017). This new approach transformed how individuals accessed medical expertise, including remote consultations, offering a platform that eliminated geographical limitations. With the development of mobile phones, Short Message Service (SMS) interventions started to be used in the healthcare system (Kenny et al., 2016). Taking advantage of mobile devices, these interventions utilised text messages to convey information, provide updates, and even deliver psychological interventions (Berrouiguet et al., 2016). Notably, the healthcare landscape witnessed a transformative shift as individuals began to receive health-related information, appointment reminders, and preventive guidance via SMS (D'Arcey et al., 2020). This was a milestone where healthcare interventions could reach patients directly through their handheld devices, providing a new level of engagement and interaction in managing their health.

The advent of the internet and websites revolutionised the way healthcare systems and organisations engaged with the public. Websites became interactive platforms where individuals could access comprehensive health-related information and educational resources and even participate in self-guided interventions. Health systems transitioned into the digital realm, utilising websites to disseminate information about various health conditions, treatments, and self-care practices (Borg, 2010). These platforms empowered individuals with knowledge and facilitated a new era of self-care management, where individuals could take charge of their health and wellbeing through accessible online resources. The COVID-19 pandemic has expedited this transformation as many people have access to smartphones, tablets, or computers that enable people and healthcare professionals to make voice or video calls through an internet connection (Campbell et al., 2023).

As the digital landscape continues to improve, the present era is implementing mobile applications and wearable devices (Druss & Goldman, 2018). Mobile applications have emerged as a new cornerstone of DHIs, offering tailored solutions to address various health needs (Fiordelli et al., 2013; Steinhubl et al., 2015). For example, mobile application-based interventions may enhance physical activity levels, dietary intake, posture, and mental wellbeing (Schoeppe et al., 2016). Regarding mental wellbeing, these applications are used for different purposes, encompassing mood tracking (Caldeira et al., 2017), mindfulness practices (Plaza et al., 2013), cognitive behavioural exercises (Huguet et al., 2016), and guided meditation sessions (Mani et al., 2015), all accessible through smartphones. Growing literature indicates that these mobile application-delivered interventions help support people with mental health problems and poor wellbeing (Flett et al., 2019; Gál et al., 2021; McCloud et al., 2020).

The trajectory of DHIs undeniably has the potential to influence the future of health and care delivery. In this current world, as many individuals have access to a smartphone and internet connection, self-care health management interventions delivered by mobile phones have become a growing interest in monitoring a wide range of health-related data, including mental wellbeing.

1.6 Self-care management through mobile applications

Selfcare-management, also called self-care, refers to the practice of individuals taking an active role in managing their health and wellbeing (*Self-care interventions for health*, 2022). This includes making informed decisions about their lifestyle, monitoring their symptoms, and implementing strategies to promote physical and mental wellbeing (*Self-care interventions for health*, 2022). Supported self-management is a key aspect of the NHS Long Term Plan's vision to establish more personalised care (*The NHS Long Term Plan*, 2019).

Self-management can be an important concept in achieving effective mental health management (Lloyd & Campion, 2017), with the idea of ‘my health is the responsibility of my physician’ shifting towards the view that ‘my health is my responsibility and I have the tools to manage it’ (Swan, 2012). Some organisations have started to provide people with approved, reliable mobile applications for self-care management. For example, the NHS began to offer approved smartphone applications (often shortened to ‘apps’) for general public use in 2018 (*NHS Apps Library*, 2021). The NHS App Library includes several mental health-related mobile applications such as Be Mindful, Catch It, and Calm Harm. Further, the NHS is providing staff toolkits named *“Caring for* *yourself while you care for others",* which includes many mobile applications for self-care support with a wide range of health aspects from physical activity to mental health and wellbeing (*Caring for yourself while you care for others: the Midlands Edition*, 2020). These initiatives show the importance of self-care management through mobile applications, one potential approach for improving mental wellbeing and personalised healthcare.

Both positive and negative user experiences reported in the literature for self care management through mobile applications. For example, prior experience with mobile application use could be helpful for the engagement. But this also causes high expectations while using a health-related mobile application (Carter et al., 2018). Personal motivations and reasons for application use also influenced engagement. A study showed that participants preferred to use an application with coaching features for physical activity, including a training schedule with tasks to complete (Gowin et al., 2015). Achieving a specific goal, monitoring personal data, and sharing the data with healthcare professionals were reported for long-term adherence to use a mobile application for health promotion such as physical activity (Carter et al., 2018).

According to a study assessing insights from user views on mental health applications, users prioritise ease of use, a well-designed user interface, and the adaptability of application features to their individual needs (Alqahtani & Orji, 2020). Applications that offer a variety of options, functionalities, and content, such as diverse meditation practices, tracking capabilities, and the ability to personalise, tend to receive positive responses and higher user ratings. Regular updates and the inclusion of security measures like data backup and privacy assurance were also valued, enhancing user trust in the application. Conversely, the most prevalent reasons for application abandonment include poor usability, limited content variety, insufficient personalisation, inadequate customer service, and concerns over data security and privacy (Alqahtani & Orji, 2020).

There are various reasons why mobile applications have gained momentum in self-care management. These applications are designed to be installed on smartphones or other mobile devices like tablets. They provide users convenient access to various features and resources supporting their self-care efforts (K. Anderson et al., 2016). Self-care applications often offer functionalities such as symptom tracking, medication reminders, goal setting, mindfulness exercises, and educational resources (K. Anderson et al., 2016).

Furthermore, various behavioural and motivational theories have been used to enhance the use of mobile applications in health promotion activities. A review of mobile applications revealed that several behavioural theories and strategies, including self-monitoring, Social Cognitive Theory (SCT), and Self Determination Theory (SDT), were commonly used to underpin the development and use of these applications (Payne et al., 2015). Additionally, a study focussed on promoting physical activity through mobile applications highlighted the use of behaviour change theories such as the Transtheoretical Model of Behaviour Change (TTM) and Fogg's Behaviour Model (FBM) (Hamper et al., 2016). Moreover, a systematic review encompassing 50 mobile applications aimed at health promotion, including areas such as physical activity, diet, drug and alcohol use, and mental health, found that 49 of these applications employed behaviour change strategies or theories (e.g. self-monitoring, action planning, problem-solving, social support, and habit formation) (Milne-Ives et al., 2020). These theories and strategies not only help to enhance user engagement and the effectiveness of mobile applications in self-care health promotion but also ground these applications in scientific evidence.

Another reason for the increasing use of mobile applications in healthcare is its accessibility. Worldwide, mobile health applications for self-tracking or self-management are increasingly available in consumer electronic markets. According to Zenith's mobile advertising research, in 2017, 63% of people in 52 key countries (making up 65% of the total global population) were smartphone users, which is rising rapidly. Indeed, the number of health and mental health applications is growing dramatically, with 165,000 health applications (Terry, 2015) and 30,000 mental health applications (Westervelt, 2015) available for free or purchase through the iTunes or Google Play stores. The leading two categories comprise wellness management and disease management applications, with additional categories encompassing self-diagnostic tools, medication reminders, and electronic patient portal applications (Kao & Liebovitz, 2017).

There were 60.81 million smartphone users in the UK in 2023, which is estimated to reach 66.62 million in 2028 (Laricchia, 2023). It has been found that 75% of people in the UK go online for health information and advice (Seo, 2019) and that mental health was one of the most attractive sectors for mobile application companies in 2017 (Stewart, 2019). This shows excellent accessibility and a potentially effective way to reach people and support those with mental health issues (Nicholas et al., 2016). However, studies reviewing commercial application stores and literature found a dramatic lack of evidence-based mobile applications that promise mental health and wellbeing support (Lau et al., 2020; Lui et al., 2017).

Another advantage of using a mobile application could be decreasing stigma (Kim et al., 2022), which is an important issue contributing to individuals hiding mental health problems in work environments (Hogg et al., 2023). Generally, workers tend to hide their mental health problems due to fear of losing their jobs, isolation and feeling at a disadvantage (Thornicroft et al., 2022). It has been indicated that mobile applications for mental health promotion may decrease stigma and increase help-seeking behaviours for overcoming mental health problems (Schomerus et al., 2019).

The other advantages of mobile applications in self-care management are personalisation, tracking and monitoring, and education and resources (Grundy, 2022). Many mobile applications offer personalised features based on individual preferences, goals, and health conditions. Users can customise their self-care journey, making it more relevant and engaging for their specific needs. Mobile applications also enable users to track and monitor various aspects of their health, such as symptoms, mood, physical activity, and sleep patterns. This data can help individuals identify patterns, set goals, and make informed decisions about their self-care routines. Furthermore, mobile applications often provide educational resources, articles, videos, and tools that empower users with knowledge about their health conditions and self-care strategies. These resources can enhance individuals' understanding and enable them to make informed decisions (Huckvale et al., 2019).

1.7 Summary of the introduction

- The World Health Organization conducted its largest-ever review on mental health in 2022, which describes mental health is “a growing crisis”.
- The prevalence of mental-ill health and poor mental wellbeing is higher in health and care workers compared to general population.
- Self-management and digital interventions in supporting mental wellbeing has a growing momentum due to its low cost and accessibility through smart phones and internet.

Chapter 2: Scoping Review

Introduction

This chapter includes a scoping review to explore the evidence investigating the use of mobile application-based interventions for healthcare workers' mental wellbeing. It maps the knowledge of the types of studies and interventions and uses mobile applications to promote the mental wellbeing of healthcare workers. This review follows the JBI methodology for scoping reviews (Peters et al., 2021). It includes seventeen studies reporting on six mobile application-delivered interventions targeting mental wellbeing: mindfulness, relaxation, yoga, provider resilience, meditation, positive thinking, and cognitive behavioural therapy. This review identifies that mindfulness-based mobile application use commonly supports healthcare workers' mental wellbeing. While mobile applications may improve healthcare workers' wellbeing, there is insufficient evidence to determine their effectiveness.

2.1 Introduction

Mental wellbeing is a positive internal perspective, indicating effective psychological coping with the daily stresses of life, enabling productive and fruitful work, happiness, and autonomous living (*Mental health*, 2022). It is a dynamic concept which shows changes time to time. Mental wellbeing promotion is a preventive approach against mental diseases such as stress, depression, and anxiety (Singh et al., 2022). The COVID-19 global pandemic has dramatically escalated these mental health problems among healthcare workers (Saragih et al., 2021).

Poor mental wellbeing is a primary concern for healthcare workers for several reasons. It affects not only personal health but also work performance and quality of care (Nahm et al., 2014). The National Institute for Occupational Safety and Health (NIOSH) listed the reasons why healthcare workers are at risk for mental health problems, including emotionally stressful working environment, exposure to human suffering and death, unique pressures from patients, families, and employers, hazardous working conditions, long and unstable scheduled working hours, and high workloads (*Healthcare workers: Work stress & mental health*, 2023). All these reasons highlight the importance of providing adequate mental health support for healthcare workers.

The literature has also claimed that mental health problems are more prevalent among healthcare workers compared to the general population. National statistics in the UK support this claim. For instance, NHS Digital reports a substantially higher sickness absence rate among NHS workers in England. Based on the report in August 2023, the overall sickness absence rate was 4.9% August 2023, 2024), significantly higher than the national average of 2.6% (*Sickness absence in the UK labour market - Office for National Statistics*, 2023). Moreover, the most frequently reported reasons for sickness were anxiety, stress, depression, and other psychiatric illnesses, accounting for over 581,100 full-time equivalent days lost and 27.7% of all sickness absences in August 2023.

Additionally, the COVID-19 pandemic has created a more stressful working environment for healthcare workers, leading to more mental health issues or exacerbating existing mental health ailments (Blake, Bermingham, et al., 2020). There is a global urgent call for mental health support since the pandemic has elevated the risk factors for stress, burnout, and other mental health challenges experienced among healthcare workers who have been on the frontline (Søvold et al., 2021). Furthermore, the ICON study, a large-scale longitudinal survey study, reported that the UK nursing and midwifery workforce showed a high prevalence of negative psychological effects during the pandemic, such as severe stress, severe anxiety, and high impact of events scale-revised scores (Couper et al., 2022). The study searching for the psychological impact of the pandemic on wellbeing and working life among healthcare workers during 2019 and 2023 has emphasised the decreased wellbeing and quality of life (Neill et al., 2023). These psychological effects may create long-term risks in the healthcare system since the number of staff with poor mental wellbeing is likely to increase over time (Gilleen et al., 2021).

Mobile applications may be a useful delivery tool to support healthcare workers in improving their wellbeing since mobile applications are easily accessible, cost-efficient, and user-friendly tools (Marzano et al., 2015). Furthermore, mobile phones are ubiquitous (*Percentage of households with durable goods: Table A45*, 2019), and the number of mental wellbeing-related applications on the market is rapidly expanding. However, many mobile applications do not have evidence to support their effectiveness in supporting mental wellbeing (Lui et al., 2017). In recent years, several reviews have explored the effectiveness of mobile applications for managing stress, anxiety, and depression (Khademian et al., 2020; Lau et al., 2020). Despite growing recognition of the importance of mental wellbeing support in healthcare workers, few studies have examined the specific context of healthcare workers and their unique mental wellbeing needs. For example, a systematic review identified web-based and mobile applications for healthcare workers to provide recommended applications to support their mental problems; however, the included studies were conducted on general populations rather than including healthcare workers (Pospos et al., 2018). Additionally, a preliminary search of PROSPERO, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis was conducted, and no current or in-progress scoping reviews or systematic reviews on the topic were identified. This scoping review addresses this gap by examining the research landscape about mobile application-based interventions to promote wellbeing particularly within the healthcare worker population. This review aims to explore the current knowledge and understanding of mobile applications in promoting mental wellbeing among healthcare workers, potentially including interventions targeting specific mental health conditions like stress, anxiety, and depression, as these significantly impact wellbeing and are prevalent in this population. To meet this aim, the research question was framed as follows: 'What is known regarding mobile application-based interventions for improving the healthcare workers' wellbeing?'. Further objectives were to map the knowledge on the type of studies, interventions and used mobile applications.

2.2 Methods

2.2.1 Scoping literature review

This scoping review was conducted in accordance with the JBI methodology for scoping reviews (Peters et al., 2021). According to the JBI framework, there are six steps for conducting scoping reviews: identifying the research question, identifying relevant studies, selecting studies, charting the data, collating, summarising/reporting the results, and consulting with stakeholders, which is an optional last step. The review protocol was pre-registered in the Open Science Framework (OFS). The registration DOI is https://doi.org/10.17605/OSF.IO/75THU.

2.2.2 Review questions

According to step 1, the following review questions were applied to guide this scoping review.

1. What is known regarding mobile application-based interventions for improving the mental wellbeing of healthcare workers?
2. What psychological approaches underpin the identified mobile applications?
3. How mobile applications were used in the literature to promote the mental wellbeing of healthcare workers?

2.2.3 Identifying relevant studies

The search strategy aimed to locate both published and unpublished primary studies, reviews, and text and opinion papers. The Cochrane Library and MEDLINE (PubMed) were searched in a preliminary limited search to identify relevant studies. The text words contained in the titles and abstracts of relevant articles and the index terms used to describe the articles were used to develop a full search strategy. The search strategy, including all identified keywords and index terms, was adapted for each included information source and a second search was undertaken in June 2022. The full search strategies are provided in Appendix 1. The reference lists of articles included in the review were screened for additional papers.

Studies published in English and Turkish were included since the lead author is fluent in both languages. Articles published in other languages were not included due to a shortage of translation sources. The date range limit was not applied since mobile application-based interventions are an emerging field in the mental wellbeing support of healthcare workers.

The databases that were searched included The Cochrane Library, MEDLINE (OVID), CINAHL (EBSCO), PsycINFO (EBSCO) and Embase (OVID). Google Scholar was also searched for additional articles that may not have been listed in the selected databases.

The PICo format was applied to the research questions to identify the limits of the scoping review. This format includes Population/Problem, Phenomenon of interest, and Context. Table 1 shows how PICo guided the search strategy.

Table 1: PICo format applied to review questions

Population/Problem	Phenomenon of interest	Context
Healthcare workers/students	Mobile application-based interventions to support mental wellbeing	Healthcare settings in the UK

2.2.4 Eligibility criteria for study selection

Eligibility criteria (refer to Table 2) were established to select the appropriate studies. Relevant articles were focused on mobile application-based interventions to support the mental wellbeing of healthcare workers/students. Healthcare workers included clinical staff and students registered in higher education programs targeting healthcare. Qualitative and quantitative studies were included. The included studies were related to interventions for wellbeing or common mental health problems (stress, depression, or anxiety); interventions for severe mental health disorders were excluded. English or Turkish articles were selected as the researcher was fluent in both languages.

Table 2: Inclusion and exclusion criteria

Inclusion	Exclusion
• Studies evaluating smart-phone application-delivered interventions targeting wellbeing related outcomes including but not limited to burnout, quality of work life, stress, anxiety, or depression. • A population consisting of healthcare workers/students, including clinical staff (e.g. physicians, nursing, support workers, midwives, and pharmacists)	• Empirical and primary studies about severe mental health problems • Studies including web and telephone-based (not smartphones) interventions

• Studies including the general healthcare population without a clinical diagnosis of mental health disorder • English and Turkish articles	

2.2.5 Charting and summarising data

Following the search, all identified records were collated and uploaded into Rayyan, a tool for article screening (Ouzzani et al., 2016), and duplicates were removed. Titles and abstracts were screened by two independent reviewers (MY and GN) for assessment against the inclusion criteria for the review. Potentially relevant papers were retrieved in full. Full-text studies that did not meet the inclusion criteria were excluded, and reasons for their exclusion are provided in Appendix 2. Any reviewer disagreements were resolved through discussion or with a third reviewer (HB).

Data were extracted from papers included in the scoping review by two independent reviewers using the JBI data extraction tool (Peters et al., 2021). The reviewers established the data charting tool, and my supervisors (HB and TC) reviewed it before the data extraction. The data extracted included specific details: the author, publication year, title, country, study population, design, type of interventions, mobile applications, study aim, and outcomes of interest relevant to the review questions. Any reviewer disagreements were resolved through discussion or with a third reviewer. Authors of papers were contacted to request missing or additional data, where required.

JBI suggest that scoping reviews establish a thematic construction from the extant literature in a narrative or descriptive manner (Page et al., 2021). Therefore, a narrative review was conducted for knowledge synthesis. This approach enabled the opportunity to explore relationships in the data and compare findings using different methodologies. Considering the scoping review questions, the included papers were analysed in three groups: targets and type of interventions, underpinning psychological approaches, and types of mobile applications. The data were presented in a tabular format.

2.2.6 Consultation with stakeholders

Consulting with stakeholders is an optional step in the scoping reviews (Arksey & O'Malley, 2005). As a part of the protocol development, we consulted with six healthcare workers (four nurses and two midwives) and one mobile application developer.

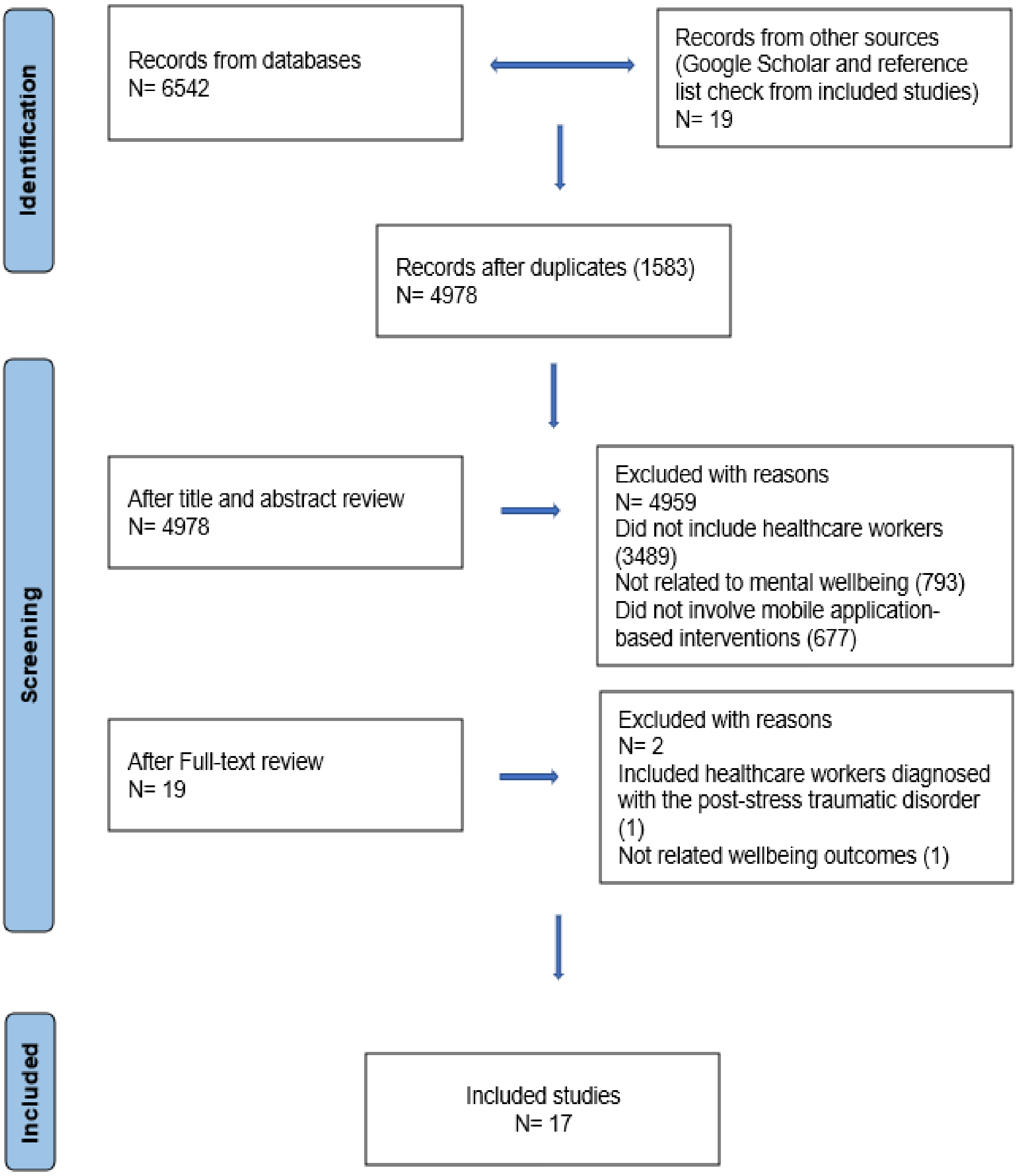
2.3 Results

2.3.1 Study inclusion

The search gathered 6,561 citations from the databases and the reference lists of the included studies. One thousand five hundred eighty-three studies were excluded after removing duplicates (n= 4,978). Following the title and abstract screening, 4959 studies were excluded due to non-relevant content (n=19). The reasons for exclusions were that the studies did not include healthcare workers (3,489), were not related to mental wellbeing (793), did not involve mobile application-based interventions (677), and were not written in English or

Turkish (2). Additionally, two studies did not meet the inclusion criteria due to the study population and outcomes (2). Finally, the review included 17 studies based on the inclusion criteria. The PRISMA flow chart illustrates the process of the study selection (Figure 5).

Figure 5: Search results and study selection and inclusion process



2.3.2 Characteristics of included studies

The included studies were conducted in six different countries, 12 in the USA (Best et al., 2020; Heeter et al., 2017; Jakel et al., 2016; Knill et al., 2021; Lambert et al., 2020; Mistretta et al., 2018; Morrison Wylde et al., 2017; Roy et al., 2020; J. L. Smith et al., 2021; Wen et al., 2017; Wood et al., 2017; Zollars et al., 2019), and the remaining five studies were conducted in Taiwan (Chang et al., 2019), Iran (Motamed-Jahromi et al., 2017), Spain (Orosa-Duarte et al., 2021), Vietnam (Imamura et al., 2021), and Canada (E. Yang et al., 2018). The studies were published between 2016 and 2021. Table 1 provides the characteristics of the studies.

The included studies consisted of 16 quantitative studies and one mixed-method study. Eight studies had quasi-experimental pre- and post-test designs. Six studies had a randomized controlled trial design, while two studies applied a non-randomized control trial design. Finally, one study used a mixed method with a quasi-experimental design and semi-structured interviews.

The sample size varied between six and 951, and the total number of participants was 1921. Participants were from diverse occupational groups. In seven of the studies, the sample included nurses: nurse practitioners, oncology nurses, emergency nurses, and paediatric nurses (Best et al., 2020; Chang et al., 2019; Imamura et al., 2021; Jakel et al., 2016; Knill et al., 2021; Lambert et al., 2020; Morrison Wylde et al., 2017). Four studies specified their study population as healthcare workers, including nurses, physicians, and support workers (Heeter et al., 2017; Mistretta et al., 2018; Motamed-Jahromi et al., 2017; Wen et al., 2017; Wood et al., 2017), and four studies included students from different departments, healthcare students (Orosa-Duarte et al., 2021), physician assistant students(J. L. Smith et al., 2021), medical students (E. Yang et al., 2018) and pharmacy students (Zollars et al., 2019). Two studies involved physicians (Lambert et al., 2020; Roy et al., 2020). Table 3 presents the summary of findings.

Table 3: Characteristics of included studies

Author & Date	Title	Country	Sample size	Design	Duration of the intervention
Best et al. **2020**	Combating Compassion Fatigue with Mindfulness Practice in Military Nurse Practitioners	USA	6	Quasi-experimental	4-week
Chang et al. **2019**	A Stress Relief App Intervention for Newly Employed Nursing Staff: Quasi- Experimental Design	Taiwan	28	Quasi-experimental and semi-structured interview	3-month
Heeter et al. **2017**	Effects of a Technology-Assisted Meditation Program on Healthcare Providers' Interoceptive Awareness, Compassion Fatigue, and Burnout	USA	44	Quasi-experimental	6-week
Imamura et al. **2021**	Effect of smartphone-based stress management programs on depression and anxiety of hospital nurses in Vietnam: a three-arm randomized controlled trial	Vietnam	951	RCT	10-week
Jakel et al. **2016**	Effects of the Use of the Provider Resilience Mobile Application in Reducing Compassion Fatigue in Oncology Nursing	USA	25	Quasi-experimental	6-week
Knill et al. **2021**	Burnout and WellBeing: Evaluating perceptions in bone marrow transplantation nurses using a mindfulness application	USA	86	Quasi-experimental	3-months

Lambert et al. 2020	Does a phone-based meditation application improve mental wellness in emergency medicine personnel?	USA	39	RCT	3-month
Mistretta et al. 2018	Resilience training for work-related stress among healthcare workers: Results of a randomized clinical trial comparing in-person and smartphone-delivered interventions	USA	60	RCT	6-week
Motamed et al. 2017	Effectiveness of Positive Thinking Training Program on Nurses' Quality of Work Life through Smartphone Applications	Iran	100	Quasi-experimental	3-month
Orosa-Duarte et al. 2021	Mindfulness-based mobile app reduces anxiety and increases self-compassion in healthcare students: A randomized controlled trial	Spain	154	RCT	8-week
Roy et al. 2020	Physician Anxiety and Burnout: Symptom Correlates and a Prospective Pilot Study of App-Delivered Mindfulness Training	USA	57	Pilot Non RCT	1-month
Smith et al. 2021	Impact of App-Delivered Mindfulness Meditation on Functional Connectivity, Mental Health, and Sleep Disturbances Among Physician Assistant Students: Randomized, Wait-list Controlled Pilot Study	USA	14	Pilot RCT	8-week
Wen et al.	Encouraging Mindfulness in Medical House Staff via Smartphone App: A Pilot Study	USA	50	Quasi-experimental	4-week

2017					
Wood et al. **2017**	Reduction of Burnout in Mental Health Care Providers Using the Provider Resilience Mobile Application	USA	32	Quasi-experimental	1 month
Wylde et al. **2017**	Mindfulness for Novice Paediatric Nurses: Smartphone Application Versus Traditional Intervention	USA	95	Non-RCT	4-week
Yang et al. **2018**	Happier Healers: Randomized Controlled Trial of Mobile Mindfulness for Stress Management	Canada	88	RCT	1-month
Zollars et al. **2019**	Effects of mindfulness meditation on mindfulness, mental wellbeing, and perceived stress	USA	92	Quasi-experimental	4-week

2.3.4 Type of interventions delivered through mobile applications

Seven interventions with different psychological approaches were utilised in the studies related to mental health promotion. Ten studies used mindfulness techniques (Best et al., 2020; Knill et al., 2021; Mistretta et al., 2018; Morrison Wylde et al., 2017; Orosa-Duarte et al., 2021; Roy et al., 2020; J. L. Smith et al., 2021; Wen et al., 2017; E. Yang et al., 2018; Zollars et al., 2019). Provider resilience was used in two studies (Jakel et al., 2016; Wood et al., 2017). The other five studies included yoga (Heeter et al., 2017), relaxation (Chang et al., 2019), positive thinking (Motamed-Jahromi et al., 2017), CBT (Imamura et al., 2021), and meditation (Lambert et al., 2020). The duration of the interventions varied from four weeks to three months (Table 4).

Mindfulness was the most used intervention, targeting stress, compassion fatigue (CF), burnout, and anxiety. Best et al. (2020) used mindfulness techniques to combat the compassion fatigue of six military nurse practitioners through the 8-week Mindfulness-Based Stress Program (MBSR). Another study by Mistretta et al. (2018) used a mindfulness intervention for 6-weeks to compare a face-to-face mindfulness-based resiliency training program (MBRT) and smartphone-delivered resiliency intervention to target stress, wellbeing, and burnout among 60 healthcare workers. Knill et al. (2021) employed a mindfulness-based mobile application used by marrow transplantation nurses and nurse practitioners for three months. Orosa-Duarte et al. conducted a randomised control trial to compare 8-week in-person mindfulness-based and mobile application-delivered mindfulness programs. Participants were 154 healthcare students in the medical, psychology, nursing, and nutrition disciplines. A non-randomized pilot study used a mobile application that delivered mindfulness training for a month to reduce anxiety and burnout in 57 physicians (Roy et al., 2020). Smith et al. (2021) tested the feasibility of a mindfulness-based mobile application, and 14 physician assistant students used it for eight weeks. Another pilot study used a mindfulness-based smartphone application with 50 medical house staff for stress and burnout reduction (Wen et al., 2017). Wylde et al. (2017) conducted a non-randomized control trial with 95 paediatric nurses. This study used a 4-week mindfulness-based mobile application to reduce stress and CF. Another randomised control trial was implemented with 88 medical students monthly to reduce stress (E. Yang et al., 2018). Lastly, Zollars et al. (2019) used a 4-week mindfulness technique for mental wellbeing and perceived stress improvement in 92 pharmacy students.

Provider resilience (a program against CF and burnout) was used for two studies to underpin the mobile application-delivered intervention. First, Jakel et al. (2016) studied 25 oncology nurses to improve their quality of work life. This 6-week quasi-experimental study focused on stress, compassion fatigue and burnout. Likewise, Wood et al. (2017) used a one-month-provider resilience program to reduce burnout and compassion fatigue of 32 mental health care providers.

The remaining five studies delivered psychological therapies through mobile applications. Heeter et al. (2017) implemented 6-week yoga for compassion fatigue and burnout. This pilot study involved 44 hospice and palliative care providers. A mixed-method study by Chang et al. (2019) used relaxation techniques delivered by a mobile application. In this study, 28 nursing staff were recruited and used the application for three months. Motamed et al. (2017) applied a positive thinking method for three months: sending video, audio, and pictures to a hundred nurses to improve their wellbeing at work life. Lastly, a 3-month mobile application delivered meditation therapy was used in a prospective randomised study by Lambert et al. (2020). Thirty-nine emergency nurses and physicians used it to improve their stress, anxiety, depression, and burnout.

Imamura et al. (2021) conducted the only fully scaled three-arm randomised control trial to test the effectiveness of a CBT-based mobile application built into a stress management program in improving depressive and anxiety symptoms among hospital nurses in Vietnam. Nine hundred fifty-one nurses participated in this study and used the application for ten weeks.

Table 4: The characteristics of mobile applications

Names	Platform	Main approach to improving wellbeing	Content of the application	Key goals	Existing or not
Headspace	IOS and Android	Mindfulness	Mindfulness and meditation-related choices, including guided meditations, breathing exercises, and various other exercises using audio and visual media, under the general headings of meditate, sleep, move, and focus	Increase wellbeing decrease stress and burnout symptoms	Existing
Insight Timer	IOS and Android	Mindfulness	Including timers, sleep stories&music, and more than 30.000 guided meditations	Mitigating burnout and improving compassion fatigue	Existing
SR_APP	N/A	Relaxation	Relaxation techniques	Reducing occupational stress	Developed for the study
Program A/B	IOS, Android and Website	CBT	Six-module stress management programs Program A modules: behavioural activation, cognitive restructuring, problem-solving, assertiveness, self-compassion, and job crafting Program B modules: e CBT-based stress management skills, a self-case formulation based on cognitive behavioural model, behavioural activation, cognitive	Program A/B	IOS, Android and Website

			restructuring, cognitive restructuring, and relaxation, and problem-solving		
PRMA	N/A	Provider Resilience	Psychoeducation, assessment of burn-out, CF, compassion satisfaction and secondary traumatic stress through surveys, reminder tools to engage self-care and brief interventions to increase resilience and burn-out	Reducing compassion fatigue and burnout	Developed for the study
Stress Free Now	IOS	Meditation	12 guided meditations between 3.5 to 21 minutes	Stress relief	Existing
Telegram	IOS and Android	Positive Thinking	Different types of positive thinking-based media, including video, audio, and pictures Positive thinking quotes and picture messages	Telegram	IOS and Android
REM Volver a casa	IOS and Android	Mindfulness	A guided training program providing short videos with explanations about the fundamentals of mindfulness, self-compassion, and physiological stress reactions Audio-guided mindfulness practices (Developed by accredited MBSR teachers)	REM Volver a casa	IOS and Android
Unwinding Anxiety	IOS, Android, and Website	Mindfulness	More than 30 modules of brief didactic and experience-based mindfulness training (videos and animations, approximately 10 min/day) 5-15 minutes guided mindfulness	Reducing anxiety and burnout	Existing

Happier	IOS and Android	Mindfulness	Including two programs. The Basics (16 modules) Emotional Agility (15 modules) Both programs provide mindfulness practices	Reducing burnout, depression, anxiety, and sleep impairment	Existing
PR	IOS and Android	Provider Resilience	Monitoring professional quality of life and burnout ratings	Reducing provider compassion fatigue and burnout	Developed for the study
No name	N/A	Yoga	10 to 12 min meditations with twice weekly automated and personalised reminder e-mail messages Five different types of meditations, Calming Place in nature, Nourishing, Releasing, Spaciousness	Improving burnout and compassion fatigue	Developed for the study
No name	N/A	Mindfulness	Sleep and emotion tracking	Improving wellbeing and burnout	Developed for the study

2.3.5 Type of mobile applications

The 17 studies included 10 mobile applications to deliver the intervention for mental wellbeing promotion. Eleven studies used an existing mobile application which is already been developed and launched for the general population (Best et al., 2020; Knill et al., 2021; Lambert et al., 2020; Morrison Wylde et al., 2017; Motamed-Jahromi et al., 2017; Orosa-Duarte et al., 2021; Roy et al., 2020; J. L. Smith et al., 2021; Wen et al., 2017; E. Yang et al., 2018; Zollars et al., 2019), while four mobile applications were developed by the research teams for their studies (Chang et al., 2019; Imamura et al., 2021; Jakel et al., 2016; Wood et al., 2017). This information was not identifiable in two studies (Heeter et al., 2017; Mistretta et al., 2018). Five studies used the same mobile application, Headspace, based on mindfulness for stress reduction and better sleep (Knill et al., 2021; Morrison Wylde et al., 2017; Wen et al., 2017; E. Yang et al., 2018; Zollars et al., 2019). The majority of the mobile applications were launched on IOS and Android platforms. The type of mobile application is shown in Table 4.

Insight Timer (1) is a mobile application, an 8-week mindfulness-based stress reduction program developed by Dr Jon Kobat-Zin and colleagues (Best et al., 2020). The application includes tracking practices, timers, sleep stories, music, and more than 30,000 guided meditations. Chang et al. (2019) built their relaxation-based application in education on stress alleviation methods and self-monitoring the stress level. It also included warning notifications when the stress level exceeded the threshold value. Heeter et al. used a 6-week-mobile application-assisted yoga therapy to deliver five 10-to-12-minute meditations with twice-weekly automated and personalised e-mail messages. Inamura et al. evaluated two different CBT-based programs delivered by mobile applications, Program A and Program B. These programs included similar six-module stress management sections. Program A consisted of free choice modules, meaning participants could select any module in any sequence. In contrast, Program B involved fixed order, indicating that the participants had to follow the sequence. The modules included behavioural activation, cognitive restructuring, problem-solving, assertiveness, self-compassion, job crafting, a transactional model of stress and coping, and self-care formulation based on the cognitive behavioural model.

Jakel et al. (2016) and Wood et al. (2017) used the same mobile application - Provider Resilience Mobile Application (PRMA) which imparted education on the risks of burnout, compassion fatigue (CF), and secondary traumatic stress (STS) and self-monitoring for the level of burnout, compassion fatigue, and secondary traumatic stress as well as compassion satisfaction. Lambert et al. had a phone-based meditation application called Stress Free Now. This application included 12 guided meditations, ranging in length from roughly 3.5 to 21 min, and instructed to use the application every week for 90 days. Misretta et al. (2018) used the application to include self-monitoring for sleep, happiness and positivity, energy and focus, and productivity. Additionally, this application was the only mobile device providing goal settings: falling asleep faster or feeling refreshed, being happier, boosting energy and focus, or getting things done.

REM Volver a casa is a mindfulness-based mobile application for anxiety reduction and self-compassion improvement (Orosa-Duarte et al., 2021). This application involved a guided training program through eight stages with three sections: listening, practising, and Integration. Another mindfulness-based mobile application was Unwinding Anxiety (Roy et al., 2020). It was built into more than 30 daily modules of brief didactic and experience-based Mindfulness Training (M.T.) (videos and animations, approximately 10 min/day), app-triggered check-ins, user-initiated guided meditations (5-15 minutes), and brief (30 seconds) on-demand mindfulness exercises to help disrupt anxiety cycles in vivo.

Motamed et al. used a text message mobile application, Telegram, which was the only application not including educational or self-monitoring features (Motamed-Jahromi et al., 2017). This application only delivered video, audio, and pictures based on the positive thinking method.

Mindfulness-based Headspace mobile application was used in five studies (Knill et al., 2021; Morrison Wylde et al., 2017; Wen et al., 2017; E. Yang et al., 2018; Zollars et al., 2019). The Headspace app (www.headspace.com) offers more than 265 mindfulness and meditation-related choices involving guided meditations, breathing exercises, and various other exercises using audio and visual media under the general headings of meditating, sleep, moving, and focus, allowing the user to engage in mindfulness any time of the day. Knill et al. (2021) asked participants to use any program within the app for 10 minutes a day, seven days a week, for three months. The rest of the studies implemented a 4-week mindfulness intervention through Headspace. Wen et al. (2017) and Wylde et al. (2017) used the application for stress and burnout improvement, and Yang et al. (2018) and Zollars et al. (2019) focused on perceived stress and wellbeing improvement.

Smith et al. (2021) also implemented a mindfulness-based mobile application with a different mobile application called Happier. Participants were asked to use two modules within the application: Basic and Emotional Agility. The Basics program included 16 modules with didactic instructions and mindfulness practice times between 4:20 and 13:22 minutes. Emotional Agility involved 15 modules with didactic instructions and mindfulness toward mental content (focusing on emotions) between 11:00 and 13:00 minutes.

2.3.6 Summary of outcomes relating to wellbeing

A summary of outcomes is presented in Table 5. The studies focused on divergent aspects of wellbeing, including general stress, burnout, compassion fatigue and quality of work life. Five pilot and one fully scaled randomised control trial implemented six mobile applications that provided positive results for mobile application-based interventions (Imamura et al., 2021; Lambert et al., 2020; Mistretta et al., 2018; Orosa-Duarte et al., 2021; J. L. Smith et al., 2021; E. Yang et al., 2018). Four were based on mindfulness (Mistretta et al., 2018; Orosa-Duarte et al., 2021; J. L. Smith et al., 2021; E. Yang et al., 2018), whereas the others were a CBT-based intervention (Imamura et al., 2021) and meditation-based intervention (Lambert et al., 2020).

In the fully scaled RCT, it was found that Program B, a CBT program (named iCBT) with a fixed-sequential order of modules, provided a significant intervention effect on improving depressive symptoms at 3-month follow-up among hospital nurses in Vietnam, with a small effect size (Imamura et al., 2021). On the other hand, Program A, an iCBT program with a free-choice order of modules, did not show a significant intervention effect on any primary outcomes. Moreover, no significant difference was found between the two intervention programs concerning usefulness or satisfaction at the 3-month follow-up. Therefore, it was concluded that the newly developed smartphone-based iCBT stress management program with fixed sequential order modules might be useful for improving depressive symptoms among nurses in Vietnam.

Mindfulness-based pilot RCT studies found similar positive findings in the improvement of wellbeing (Mistretta et al., 2018), anxiety and self-compassion (Orosa-Duarte et al., 2021), sleep and mental health (J. L. Smith et al., 2021), and stress and wellbeing (E. Yang et al., 2018). For example, Mistretta et al. (2018) found that both the in-person Mindfulness-Based Resilience Training (MBRT) and the smartphone intervention groups (healthcare workers) experienced significant increases in wellbeing immediately following the intervention and at 3-month follow-up with moderate to large effect sizes. Similarly, Orasa-Duarte et al. (2021) provided that the mobile application group and the in-person group showed a large effect size for reductions in trait anxiety and a significant increase in self-compassion and mindfulness for healthcare students in comparison with controls. However, there was no significant effect between the mobile application and in-person groups, even though the intervention group showed higher anxiety reduction. Yang et al. (2018) also found similar positive findings: a significant decrease in perceived stress and a significant increase in general wellbeing for the intervention group of medical students. On the other hand, the study focused on sleep and mental health showed no significant difference between the groups in terms of depression, anxiety, and stress scores; however, a significant reduction in sleep impairment was identified compared with students randomised to the waitlist (J. L. Smith et al., 2021).

The meditation-based study showed that the intervention group experienced significant improvements in stress, depression, anxiety, and feelings of personal accomplishment (MBI-PA) after three months (Lambert et al., 2020). However, no statistically significant or clinically meaningful changes occurred in the control group's mental wellness measures.

The other feasibility and quasi-experimental studies found similar positive results for mobile application-delivered interventions in mental wellbeing improvement. However, the quasi-experimental study with 25 oncology nurses showed no statistically significant relationships between the intervention and control groups for compassion satisfaction and burnout among oncology nurses (Jakel et al., 2016). Additionally, no significant difference was seen between the groups on the scores gathered through the quality-of-life scale.

The only study using the text messaging application for only positive thinking method delivery reported a significant positive impact on the quality of work life and home life compared to the control group who received a paper-based positive thinking intervention (Motamed-Jahromi et al., 2017). The mixed-method study found statistically significant improvements in work stress in both groups; mainly, a higher difference was observed in the experimental group (Chang et al., 2019). They concluded that proper technology use might help new nursing staff with work stress. The application can also be used as an additional tool with the consulting mechanism for stress management. In the same study, users reported that the application could be satisfactorily used to manage work-related stress.

Table 5: Summary of the included studies

Author & Date	Aim	Population	Sample size and intervention	Wellbeing related findings	The rates of application usage
Best et al. 2020	To determine whether the use of an abbreviated mindfulness-based stress reduction (MBSR) program involving a mobile application and integrated web- based tools was feasible and would help decrease symptoms of compassion fatigue and its components among a convenience sample of military providers who identified as active-duty women's health nurse practitioners (WHNPs).	Nurse practitioners	Six active-duty women's health nurse practitioners A mindfulness-based stress reduction (MBSR) 8-week program via a mobile application.	Seventy-five per cent of the participants (3 nurses) showed improvement in burnout and stress levels and 100% improvement in mindfulness attention. Mindfulness training may be one way to mitigate symptoms of compassion fatigue for nurse practitioners in the military.	10.8 min to 122 min per day
Chang et al. 2019	To assess the effectiveness of a stress relief app (SR_APP) to monitor the stress levels of newly employed nurses.	Nurse	28 newly employed nursing staff Stress relief (Relaxation) mobile application for three	The experimental group shows higher stress level improvement but no significant difference between the groups. The device currently used to measure HRV was costly and inefficient.	N/A

			months		
Heeter et al. 2017	To examine the acceptability and preliminary efficacy of a novel 6-week technology-assisted Yoga Therapy meditation program that required minimal health care professionals' time.	Healthcare workers	93 hospice and palliative healthcare professionals The 6-week technology-assisted yoga therapy program	The YT technology-assisted meditation program's combination of smartphone apps and messaging significantly improves CF/burnout. In addition, the program was successful in motivating ongoing meditation practice throughout the 6-week study period.	Frequency of use ranged from once per week to 6 times per week
Imamura et al. 2021	To examine the efficacy of two types of newly developed smartphone-based stress management programs in improving depressive and anxiety symptoms among hospital nurses in Vietnam.	Hospital nurses	951 nurses Mobile application-delivered Program A or B based on CBT.	The present RCT found that Program B, an iCBT program with a fixed-sequential order of modules, showed a significant intervention effect on improving depressive symptoms at a 3-month follow-up among hospital nurses in Vietnam, with a small effect size. Program A, an iCBT program with a free-choice order of modules, did not show a significant intervention effect on any primary outcomes.	84.5%

Jakel et al. 2016	To examine if the use of the Provider Resilience mobile application (PRMA) will improve oncology nurses' professional quality of life.	Oncology nurses	25 registered oncology nurses 6-week Provider Resilience Mobile Application use	The current study's findings demonstrated no statistically significant relationships between the intervention and control groups on compassion satisfaction and burnout among oncology nurses. The study investigators hypothesized an inverse relationship in the intervention group between the pre- and post-test scores for Secondary Traumatic Stress (STS). Such a relationship would indicate the effectiveness of PRMA in reducing nurses' stress.	N/A
Knill et al. 2021	To evaluate whether the use of a mindfulness mobile application (app), Headspace® increases perceptions of well-being and decreases perceptions of burnout among inpatient bone marrow transplantation (BMT) staff nurses and nurse practitioners (NPs).	Marrow transplantation (BMT) staff nurses and nurse practitioners (NPs).	55 nurse practitioners and 12 Marrow transplantation staff nurses Headspace for three months.	For staff nurses, mean scores for wellbeing showed an improvement at 30, 60, and 90 days, whereas NP mean scores for wellbeing improved from baseline to 30 days; however, at 60 days, mean wellbeing scores remained the same and decreased at 90 days.	53.75%

Lambert et al. 2020	To evaluate the effectiveness of a phone-based meditation application in reducing stress, depression, anxiety and burnout among emergency medical nurses and physicians after three months of weekly use.	Emergency medical physicians and nurses	39 emergency medical physicians and nurses Weekly used a meditation-based mobile application for three months.	The intervention group experienced significant improvements in stress (PSS), depression (BDI), anxiety (BAI) and feelings of personal accomplishment (MBI-PA). There were not statistically significant or clinically meaningful changes in the control group's mental wellness measures.	N/A
Mistretta et al. 2018	To compare the effectiveness of an in-person mindfulness-based resilience training program to a smartphone-delivered resilience-based intervention for improving stress and wellbeing and decreasing burnout in employees at a major tertiary healthcare institution.	60 employees at Mayo Clinic	60 employees at Mayo Clinic Mindfulness-based mobile application resilience training for six weeks A 3-month follow-up	Both the in-person MBRT and the smartphone intervention groups experienced significant increases in wellbeing immediately following the intervention and at a 3-month follow-up with moderate to large effect sizes.	N/A
Motamed et al. 2017	To determine the effect of positive thinking via social media applications on the nurses' quality of work life.	Nurse	100 nurses Positive thinking based on 12 picture messages, three	There was a significant difference in the intervention group's total mean scores of pre-tests and post-tests in terms of work-life, work design, work context, and work	N/A

			audios, and one video through Telegram	world. In addition, the difference between the total mean scores of pre-tests and post-tests in the intervention group is more than in the control group.	
Orosa-Duarte et al. 2021	To compare the effect of a mindfulness-based mobile application versus an in- person mindfulness-based training program on reducing anxiety and increasing empathy, self-compassion, and mindfulness in a population of healthcare students.	Healthcare students	154 healthcare students Mindfulness-based mobile application use for eight weeks	The main finding was that participants allocated to both programs (app and IMBP) improved their anxiety, self-compassion, and mindfulness levels more than those in the control group. Further, anxiety levels decreased more in the app arm than in the IMBP or the control groups. Empathy remained equally unchanged in the three arms after the eight weeks.	40.3%
Roy et al. 2020	To assess whether app-based mindfulness training can reduce anxiety in physicians and to explore if anxiety and burnout are correlated, thus leading to a	Physicians	57 physicians Daily use of mindfulness-based mobile applications for a month	We found preliminary evidence that app-based MT reduced anxiety and burnout, demonstrating that this modality and type of training may be an accessible and possibly effective tool for helping busy	36.7%

	reduction in both anxiety and burnout.			physicians manage these conditions. In addition, it is found significant correlations between anxiety and burnout at all time points, confirming the hypothesised link between the two.	
Smith et al. 2021	To examine the impact of app-delivered mindfulness meditation on self-reported mental health symptoms among physician assistant students	Physician assistant students	14 physician assistant students Mindfulness-based mobile application for eight weeks.	PA students randomised to mindfulness reported a significant reduction in sleep impairment compared with students randomised to the waitlist.	N/A
Wen et al. 2017	To assess how a mindfulness and meditation practice among residents, supported via a self-guided, smartphone-based mindfulness app, affects wellness as measured by pre-validated surveys.	Healthcare workers	43 house staff at Stanford University Hospital and Clinics Mindfulness-based mobile application Headspace, for four weeks	We found that the administration of the Headspace app for 30 days improved both positive affect and mindfulness scores. We also found that increased app usage was significantly associated with an increased frequency of self-reported mindfulness episodes outside the app.	17.1%

Wood et al. 2017	To examine the usability, acceptability, and effectiveness of a free Provider Resilience (PR) mobile application (app) designed by the National Centre for Telehealth and Technology to reduce provider burnout	Mental health providers	32 mental health providers Provider resilience mobile application for one month	Provider Resilience app shows promise in reducing burnout and compassion fatigue in mental health care providers.	54.6%
Wylde et al. 2017	To compare the effects of a traditionally delivered mindfulness (TDM) intervention to a smartphone-delivered mindfulness (SDM) intervention, Headspace, an audio-guided mindfulness meditation program, in a group of novice nurses	Newly employed paediatric nurses	95 novice paediatric nurses Headspace mobile application usage once a week for four weeks.	The mobile app-delivered program provided more benefits for the nurses. Nurses in the SDM intervention show marginally increased compassion satisfaction and decreased burnout. In addition, the app may provide more accessibility than TDM. However, there is no significant relationship between the groups, including nurses with post-traumatic stress symptoms and compassion fatigue.	N/A
Yang et al. 2018	To assess whether 10–20 min of daily mindfulness meditation for 30 days, using a mobile phone application, could decrease	Medical students	88 medical students Headspace application for a month.	The current findings support that such an intervention can significantly decrease stress and improve the wellbeing of medical students.	39.9%

	perceived stress and improve the wellbeing of medical students				
Zollars et al. 2019	To evaluate the effects of mindfulness meditation using the Headspace app in pharmacy students at Southern Illinois University Edwardsville School of Pharmacy on mindfulness, mental wellbeing, and perceived stress	Pharmacy students	92 pharmacy students Daily use of the mindfulness-based mobile application Headspace for four weeks.	The data revealed that the intervention enhanced mindfulness and mental wellbeing for all scales and decreased perceived stress.	N/A

2.4 Discussion

This scoping review aimed to map the literature on mobile application-delivered interventions to promote healthcare workers/students' wellbeing. This review discovered that numerous psychological approaches had been delivered using a range of mobile applications. It reveals four major findings from the literature: the majority of studies were conducted in the United States, mindfulness was the most commonly used intervention delivered through mobile applications, and the shortage of fully scaled RCTs.

Almost all studies were conducted in high-income countries, namely the United States (12), Spain (1), Canada (1), and Taiwan (1). This disparity of the studies showed a notable difference between higher-income and lower-income countries, indicating the necessity of paying attention to research and interventions while considering the unique challenges faced by healthcare workers/students in low-income countries. The literature in a general context confirmed this disparity, showing the treatment gap for mental ill-health in low and middle-income countries (Wainberg et al., 2017). Technological issues, infrastructure requirements, socioeconomic status, health, and technology literacy may also cause this disparity (Yadav & Poellabauer, 2013).

The review included 17 studies with seven psychological therapies delivered by mobile applications: mindfulness, meditation, yoga, provider resilience, CBT, positive thinking, and relaxation. This variety suggests that mobile applications are compatible with various psychological therapies that rely on evidence-based practices. This evidence-based approach increases mobile applications' reliability, validity, and usability (Breton et al., 2011). Despite including seven distinct psychological therapies in the reviewed studies, mindfulness was the most common intervention delivered through mobile applications. In ten studies -more than half used mindfulness-based mobile applications. This might be because mindfulness-based mobile applications have growing attention in psychology and medicine (Daudén Roquet & Sas, 2018). Also, mindfulness is easy to learn and self-implement through mobile applications without requiring clinical supervision (Diano et al., 2019). Another reason for mindfulness's popularity might be that five studies employed the same existing mobile application called Headspace, including mindfulness-based activities for stress reduction. This popularity of mindfulness might help provide a better understanding of how mobile application-delivered mindfulness is beneficial for the wellbeing improvement of healthcare workers. However, there is a need to expand the knowledge and evidence about using other psychological therapies, such as cognitive behavioural therapy, behavioural activation, positive thinking, and relaxation techniques, on the wellbeing of healthcare workers through quantitative and qualitative research.

The RCTs in this review provided potential positive outcomes for mobile application-based-psychological interventions -especially mindfulness- to improve healthcare workers' wellbeing, stress, anxiety, and burnout. This supports the argument that mobile application-based psychological therapies may be as effective as those delivered in person (Serrano-Ripoll et al., 2022; Webb et al., 2010). Similarly, the included pilot studies comparing in-person and mobile application-delivered interventions also suggested that mobile applications are potentially as effective as in-person interventions. However, because of the small sample sizes, evaluating mobile applications' effectiveness in promoting healthcare workers' mental wellbeing is impossible. This review included only one fully scaled RCT with a large sample size (951), which claims that the mobile application delivered CBT Program B significantly improves depressive symptoms at 3-month follow-up among hospital nurses in Vietnam. Therefore, this review recommends that more fully powered RCTs are needed to determine the effectiveness of mobile application-based psychological interventions on the mental wellbeing of healthcare workers.

This review included studies on mobile application-delivered interventions for several mental wellbeing concerns among healthcare workers/students (i.e., burnout, compassion fatigue, stress, anxiety, depression). Other technology-based interventions (e.g., web-based interventions, wearable devices, and traditional phones) and interventions focused on clinical disorders (e.g., schizophrenia, major depressive disorder) are beyond the scope of this review. Due to the pre-defined inclusion criteria, this scoping review could not capture qualitative studies that explored user experiences with mobile applications for mental wellbeing. In addition, studies not available in English or Turkish were excluded, which may have omitted some relevant studies. Moreover, we cannot determine the effectiveness of interventions from this scoping review; however, a systematic review of RCTs may not be feasible for now since this scoping review clearly showed a shortage of fully scaled RCTs in the published evidence.

2.5 Conclusion

To the best of our knowledge, this is the first scoping review exploring literature on mobile application-delivered interventions to enhance the wellbeing of healthcare workers. Despite limited research to date, the findings suggest that evidence supports using mobile applications as effective delivery tools for diverse, evidence-based psychological interventions, showcasing a high level of adaptability. However, the determination of effectiveness requires RCTs.

2.6 Summary of the Scoping Review

- The purpose of this review was to explore the evidence investigating the use of mobile application-based interventions for healthcare workers' mental wellbeing.
- Mindfulness-based mobile applications were predominantly chosen to promote healthcare workers' mental wellbeing.
- Mobile application-based interventions may improve healthcare workers' mental wellbeing, but there is insufficient evidence to determine their effectiveness due to the lack of full-scale RCTs.

Chapter 3: The mobile application

Introduction

The scoping review (Chapter 2) revealed a need for a comprehensive mobile application to track mental wellbeing, as detailed leading to the research question of this thesis described in Chapter 5. This chapter introduces the mobile application MYARKEO, which is designed for daily mental wellbeing monitoring, and was chosen to be used to test its feasibility to improve mental wellbeing of health and care workers/students.

The chapter begins by outlining the development process of the mobile application, including the generation of daily scores based on users' inputs. The reasons for using this mobile application are explained. The calculation of these scores is also explained, as shared by the company. Lastly, the chapter explains theories (Self Determination Theory and Reinforcement Theory) underlying how using this mobile application can enhance mental wellbeing.

3.1 The mobile application "MYARKEO"

This application was developed by Jana Downing, the founder of the 888 Collective, a social enterprise focused on helping people with mental health issues return to the workforce (organisation website: https://www.the888collective.com/, accessed in April 2022). Based on her own personal recovery experience, she developed a course, ‘Personal Development and Mental Fitness Management’, to help people who are out of work due to mental health issues. As part of the course, she taught attendees to use a tracking system she developed. As part of the tracking system, attendees recorded their daily lifestyle, moods, and mental health symptoms. Following course completion, they were provided with paid work through various channels to support their transition back into a working environment. After two years of experience teaching this system using a paper-based form, Downing collaborated with a UK design agency to develop the application MYARKEO. Beta testing was conducted with 150 participants to optimise the content and involve users in the development process. The participants provided positive feedback on what had already been developed and valuable advice for enhancing the user experience; for example, an option to enter data for ‘yesterday’. In addition to the beta-testing process, Prof Holly Blake conducted patient and public involvement (PPI) work (see Appendix 3). The PPI works highlighted student demand for mental wellbeing support, willingness to use technology, potential advantages of mobile application use for mental wellbeing development and addressing a few barriers to use it.

Please see Appendix 4 for screenshots of MYARKEO. For further information, please see the application's website: https://www.myarkeo.com/ (accessed in June 2021).

This mobile application was chosen based on three main reasons: flexibility, allowing users to personalise daily tracking items, comprehensive content (including physical and mental aspects of wellbeing), and a daily scoring system. The scoping review, conducted in 2020 (Chapter 2) guided this decision by showing that the current mobile applications for mental wellbeing improvement in healthcare workers were focused on more specific mental health issues such as stress, anxiety, and depression with mostly mindfulness practices. However, for mental wellbeing improvement, there is a need for a comprehensive approach which includes physical and mental health aspects. After this review in 2021, MY found two mobile applications and met with their developers. Finally, MY decided to use MYARKEO as this mobile application promised comprehensive daily tracking with daily data sharing. The other alternative was Hollo. However, MYARKEO was easier to use, more flexible, and offered both physical and mental input tracking with daily scores.

The mobile application serves primarily as a comprehensive monitoring tool, enabling users to track various aspects of their mental wellbeing through a set of 28 questions. These questions encompass a wide range of factors, including daily mood, stress levels, anxiety, work-related stress, general worry, dietary choices, sleep patterns, exercise routines, caffeine and alcohol consumption, smoking habits, medication usage, menstrual cycles, and menopause. Detailed information about questions and answers can be found in Appendix 5. The questions should be answered daily, with the flexibility to choose which aspects they wish to monitor. Based on their responses, the mobile application generates a daily mental wellbeing score and individual item scores, such as the daily mood. Users can compare these scores daily, weekly, or monthly, exploring potential correlations between different factors, such as sleep patterns and daily mood. It's important to note that this mobile application does not function as a treatment or diagnostic tool.

3.2 Score calculation

The mobile application offers users a mental wellbeing score based on their responses to various questions covering mental and physical health aspects. While the specific details of the scoring system have not been disclosed due to company confidentiality concerns, some general information has been provided. It is important to note that only the given answers contribute to the final daily scores, and unanswered questions do not impact the overall result. Each answer is assigned a weight between 0 and 10, then divided by 10 to standardise the weights. The sum of all weighted answers is also divided by 10. In the data store sheet, the scores range from 0 to 1. However, for user convenience, the scores are presented on the mobile application screen in a range from 0 to 100. If a user selects all answers weighing 10, they will achieve the maximum score of 100, indicating better mental wellbeing. It is important to clarify that the score provided by the application does not constitute a diagnosis of mental health diseases. Instead, it is a rewarding indicator of overall mental wellbeing, linked to the Reinforcement Theory, explained in the next section.

3.3 Underpinning theories for the application

In the context of self-care management through mobile applications, the Self-Determination Theory (SDT) (Ryan & Deci, 2018) and Reinforcement Theory (Skinner, 2019) can be applied. The intervention in the current study (see Methodology Chapter for details) is the daily use of a mobile application for six weeks to improve mental wellbeing. This mobile application is a self-monitoring tool that aligns with the SDT and Reinforcement Theory.

Self-Determination Theory (SDT) is a psychological framework that focuses on human motivation and the factors contributing to personal growth and wellbeing (Ryan & Deci, 2018). It emphasises the importance of three basic psychological needs: autonomy, competence, and relatedness. In the current study context, the self-monitoring intervention aligns with SDT principles. The mobile application promotes autonomy since users can choose which daily questions they want to monitor. There are 28 different questions, including various aspects of their mental wellbeing. This flexibility empowers individuals to make decisions based on their preferences and needs. The intervention encourages autonomy and self-regulation by giving users control over their monitoring process. Users can also monitor their progress through daily scores. This form of mental wellbeing score allows users to observe their improvements, and this can enhance users' sense of competence. SDT also emphasises the importance of social connections and support for wellbeing. Although the mobile application intervention is primarily a self-monitoring tool, it can promote relatedness in several ways. Users can share their progress and experiences with others, such as friends, family, or support groups, creating a sense of community and social connection. Additionally, the mobile application includes several links that provide general information about improving mental wellbeing and promoting relatedness by offering support.

Operant conditioning is a learning theory claiming that someone's behaviour is impacted by its consequences (Gordan & Krishanan, 2014). There are various ways to motivate people to change their behaviours, including reinforcement.

Reinforcement theory proposes that individuals are more likely to continue a behaviour if it is followed by positive reinforcement (Gordan & Krishanan, 2014). Positive reinforcement refers to providing a rewarding stimulus or consequence that strengthens the likelihood of a behaviour being repeated. It can take various forms, such as praise, rewards, or positive feedback (Nickerson, 2022). By experiencing positive reinforcement, individuals associate the behaviour with positive outcomes, increasing the motivation to continue engaging in that behaviour.

Mobile applications can utilise positive reinforcement strategies such as rewards, badges, or positive feedback to motivate individuals to engage in self-care activities. The mobile application's scoring system for this study aligns with reinforcement theory by providing users with daily mental wellbeing scores and sub-total scores for each question. These scores serve as a form of positive reinforcement, providing users with feedback and information about their progress. The daily mental wellbeing score acts as a reward by quantifying and summarising the user's overall mental wellbeing for the day. When users receive a high score, it reinforces the behaviours and choices contributing to their wellbeing, encouraging them to continue engaging in those activities. Conversely, if users receive a low score, it serves as feedback that may motivate them to make changes and improve their wellbeing. The sub-total scores for each question in the mobile application's scoring system also align with reinforcement theory. These scores provide feedback on specific areas of mental wellbeing, such as mood, stress levels, dietary choices, and exercise routines. By receiving sub-total scores, users gain insights into their performance in different aspects of their mental wellbeing. Positive sub-total scores can reinforce specific behaviours or choices, while lower scores may encourage users to modify their behaviours to improve their wellbeing in those areas.

Table 6: The underpinning of the mental wellbeing monitoring intervention

Theory	Health concept	Function	Intervention	Targeted outcome
Self-determination theory Reinforcement theory	Self-management	Self-monitoring tool	Daily monitoring of mental wellbeing items	Improvement in mental wellbeing based on the wellbeing questionnaire

3.4 Summary of the mobile application

- MYARKEO is a self-monitoring tool designed to track mood, habits, and mental health symptoms on a daily basis.
- It includes a set of 28 questions about daily mood, stress levels, anxiety, work-related stress, general worry, dietary choices, sleep patterns, exercise routines, caffeine and alcohol consumption, smoking habits, medication usage, menstrual cycles, and menopause.
- Digital self monitoring aligns with the principles of Self Determination Theory (SDT). The daily application scores for increasing engagement with the mobile application align with Reinforcement Theory.

Chapter 4: Patient and Public Involvement work (PPI)

Introduction

This chapter explores nurses' understanding of a commercially available mobile application called MYARKEO to inform its use in the main study. It includes a Patient and Public and Involvement (PPI) initiative, where nurses were introduced to the MYARKEO application and their feedback on its convenience and any barriers or facilitators was collected.

4.1 Background

Nurses' wellbeing is a growing global concern. There were roughly 661,000 employed nurses in the UK in 2019 (J. Yang, 2023), almost half of whom (290,000) were employed by the National Health Service (NHS) (K. Baker, 2023). A labour force survey across Great Britain examined figures over three years (2009–2012) and found that work-related stress was the highest among nurses (Jones-Berry, 2013). More recent studies show similar findings; for example, Fond et al. (2022) estimated that the prevalence rate of depression was 30% in a nationwide survey of more than 10,000 healthcare workers (Fond et al., 2022). The COVID-19 pandemic exacerbated these findings with increasing burnout risk among nurses (Galanis et al., 2021). Furthermore, the sickness absence rate among NHS nurses and health visitors was 4.61% in 2019, which is one of the highest rates in any sector (*Provisional Statistics," NHS*

Digital, 2020). Interestingly, the most common reasons stated for these employees' absences were anxiety, stress, depression and other psychiatric illnesses, which accounted for 24.3% of all nurses' absences in January 2020 alone and for 116,501 lost full-time working days throughout 2019 (*Provisional Statistics," NHS Digital*, 2020). These research studies strongly indicate that nurses are at higher risk than the general population for mental health problems.

Mobile application-based interventions to provide mental wellbeing support to nurses could be highly accessible and cost-effective tools to support people in managing poor mental wellbeing and reducing their prevalence. Mobile applications are software applications designed to run on smart mobile phones with various aims, such as delivering mental health therapies, education, monitoring, and communication. In the United Kingdom (UK), there were 57.79 million smartphone users in 2019, which is estimated to reach 61.06 million in 2024 (Laricchia, 2023). It has been found that 75% of people in the UK go online for health information and advice (Seo, 2019) and that mental health is one of the most attractive sectors for mobile application companies (Lui et al., 2017). This shows excellent accessibility and a potentially effective way to reach out to people and support those with mental health issues.

Additionally, there is a growing literature indicating that mobile application-delivered interventions help support people with mental health problems and wellbeing (Flett et al., 2019; Gál et al., 2021; McCloud et al., 2020). Given the high prevalence of mental ill health in the nursing professions, mobile applications may also have value for use with these populations. However, it is important to conduct public patient involvement work before a main trial to gather professional feedback and perspectives (Arumugam et al., 2023) on the use of mobile applications to enhance mental well-being. This work was conducted to explore the convenience of the self-monitoring mobile application (MyArkeo) and identify its understanding by nurses to improve mental wellbeing.

4.2 Methodology

This work was undertaken following the Medical Research Council Framework (MRC), which navigates steps for developing and evaluating complex interventions (Skivington et al., 2021). It aims to explore nurses' (end-users) understanding of a commercially developed mobile application (MyArkeo) to determine whether it is suitable for use in a future trial. A workforce public consultation activity was conducted, including individual trainer-led education, followed by discussions with all participants. Because of the COVID-19 pandemic, the trainer-led education was conducted remotely through online one-to-one meetings conducted on Microsoft Teams. The session included a PowerPoint presentation (see Appendix 6) delivered by MY, outlining the mobile application, its aim, use, functionality, and target audience. Following these virtual meetings, the participants were invited to complete semi-structured interview surveys to provide their feedback and insights (see Appendix 7).

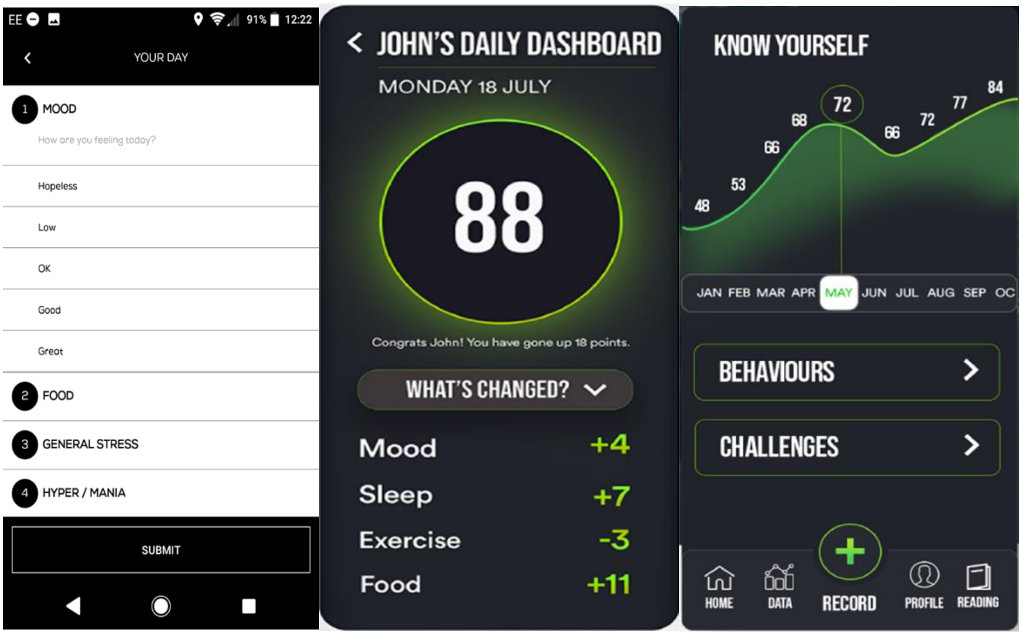
To recruit participants for the study, nurses working in the UK were targeted through social media posts and professional networks. Nurses who expressed an initial interest in taking part were then contacted to schedule a mutually convenient time for an individual consultation. This activity was focused on determining the potential value and relevance of the application and the best routes to implementing it into daily life. The application was designed to improve mental wellbeing by monitoring various aspects of physical and mental health. Ethical approval was not required for this study as it did not meet the Frascati definition of research (i.e., it focused solely on public consultation and did not implement any intervention). The data collected from the discussions were analysed thematically by following a Step-by-Step Guide for Learning and Teaching Scholars (Maguire & Delahunt, 2017).

The mobile application functions as a monitoring tool that allows users to track their mental wellbeing on a daily basis. It includes questions about mood (hopeless, low, ok, good, great), mental health symptoms (e.g., anxiety/worry, low energy/fatigue, family stress, financial stress, negative thoughts), and daily lifestyle, including work hours, exercise, diet, sleep, alcohol consumption, caffeine intake, nicotine intake, and medication usage (if applicable). The users can select the specific questions they wish to monitor. The mobile application assigns a score to each response for each selected question. Based on these scores, the application generates individual sub-scores and an overall score ranging from 0 to 100, where a higher score indicates better mental wellbeing.

The development of this mobile application was inspired by a paper-based mental wellbeing monitoring approach, which proved to be a supporting tool for treating depression and facilitating individuals' return to work (Balaskas et al., 2021). The application is designed to be accessible and beneficial for everyone who wishes to monitor and improve their mental wellbeing. Screenshots of the application are provided in Figure 1. Note that this relates to Beta Version 1.0 of the application, which has since been revised and updated.

The original version used in this work was used in a subsequent feasibility study undertaken by the author team (the findings of which will be published in due course); access to this original version of the application was courtesy of Jana Dowling, founder of www.myarkeo.com)

Figure 6. Application Screenshots, Beta Version 1.0



4.3 Results

A total of six nurses, all woman and aged between 28-60 years, were recruited for this study. These nurses represented various nursing specialities, including adult (2), neonatal (1), child (1), and community (2).

Among the participants, it was found that the average time spent using any mobile application was approximately 2 hours per day. Five out of the six participants reported using health-related mobile applications, while two of them also used mental health-related apps.

Interviews generated three themes including *"Perceived benefits of the application", "Concerns and barriers to use the application", and "Recommendations for future improvement".*

4.3.1 Perceived benefits of the application

This theme presents several positive aspects of the application for monitoring mental wellbeing and promoting positive behaviours. The majority of the participants expressed their willingness to use the application in the future. Nurses liked the user-friendly interface, ease of use, and the ability to track and monitor various health-related behaviours, *"It appeared easy to use, and results are easy to read" Interview 3, Adult Nurse*. They appreciated the idea that mental and physical health are closely linked and that the application emphasised the importance of addressing both aspects together. The application was seen as a mechanism for promoting positive behaviour changes and improving overall wellbeing, *"I like the fact that it includes other lifestyle aspects and not just mental health." Interview 1, Adult Nurse*. They found the advice section valuable, as it provided helpful information and guidance for improving mental wellbeing. Additionally, the application was seen as a useful tool for raising awareness about mental (and physical) health and facilitating self-reflection, allowing individuals to recognise areas for improvement and set targets for change, *"It could make nurses more aware of their own wellbeing." Interview 1, Adult Nurse.*

4.3.2 Concerns and barriers to using the application

While the nurses generally had positive views, they also raised concerns and barriers to using the mobile application for mental wellbeing monitoring. One concern was about the potential detrimental effects of self-monitoring without supervision for individuals with pre-existing poor mental health. They questioned how the application would monitor and ensure the exclusion of those with serious underlying mental health conditions for whom their ill health might be exacerbated by monitoring. A nurse expressed this concern, stating, *"Could it be detrimental to someone who decides to use it with poor mental health?" Interview 3, Adult Nurse*. Additionally, another concern was about users' access to medical support in instances where their scores consistently declined (e.g., not all members of the public can access health and medical services or are proactive in accessing them). Of course, for use with nurses, this is less likely to be an issue given their high level of health literacy and knowledge about health promotion.

Privacy and data security were also highlighted as significant concerns. The nurses emphasised the need for clear information on data handling and the fate of personal information. A nurse stated, *"Concerns over privacy and who could access personal information." Interview 4, Community Nurse*. This quote reflects the emphasis on transparency and the need for users to receive reassurance regarding data privacy.

The nurses identified age and technology familiarity as potential barriers to application usage, particularly among older nurses who may be less familiar with mobile applications, *"Not everyone is into technology or applications like older nurses." Interview 2, Neonatal Nurse*.

4.3.3 Recommendation for future improvement

This theme includes recommendations from nurses on how the mobile application could be more beneficial for mental wellbeing improvement. Participants emphasised the need for clear guidance and reminders for users to seek help if their mental health worsens. A nurse reported, *"Does it have a trigger on it as to when medical help should be sought?" Interview 1, Adult Nurse*. This highlights the importance of proactive support, and the application may provide some links to access any help, such as the NHS staff helpline. The nurses also highlighted the importance of providing information on potential small and personal changes, as well as the recognition that mental health can fluctuate.

Another suggestion was adding more sections about individuals' experiences and what improves their daily mood. This improvement may allow them to identify and reflect on activities or factors that positively impact their mood and wellbeing, *"You can add something like what makes you feel better when feeling low in mood." Interview 2, Neonatal Nurse*.

4.4 Conclusions

This PPI work included the delivery of trainer-led education and data collection using semi-structured interview questions to explore nurses' understanding of a commercially developed mobile application, MyArkeo, and inform its potential use in a future trial. The findings provide valuable insights into the use of a mobile application for monitoring mental wellbeing among nurses. This work confirms that nurses are familiar with mental health-related mobile applications and, therefore, likely to use a mobile application-based tool for monitoring wellbeing. This familiarity suggests a high accessibility and acceptance of mobile apps for health promotion among nurses.

The work highlights the importance of self-awareness and self-reflection in motivating individuals to use mobile applications to engage with mental health interventions. Nurses suggested that mobile application monitoring can be helpful for mental wellbeing promotion by increasing self-awareness (Bakker & Rickard, 2018) and stimulating self-reflection (Chandrashekar, 2018). The ability to choose from different facets of health, encompassing both physical and mental health monitoring, was also highlighted as a significant contributor to user engagement. This adaptability enhances a sense of autonomy, which serves as an internal motivational factor in establishing daily usage habits of the mobile application (Lally & Gardner, 2013). This wide range of holistic mental wellbeing concepts may also increase users' engagement and motivation (Thieme et al., 2015).

However, there were some drawbacks and concerns about using the mobile application for health monitoring. In the digital concept, privacy is a main concern (Bari & O’Neill, 2019), and nurses in this study stated that the data holders should provide clear information about how the data will be handled. Another concern expressed by participants was the potential barrier posed by individuals who may not be technologically savvy, particularly among older generations. This issue aligns with existing literature, highlighting the challenge of engaging older adults in digital interventions (Pywell et al., 2020). Additionally, there was a concern regarding the potential for misperception of the mobile application as a diagnostic or treatment tool. To mitigate this issue, it is crucial to provide clear and accurate information about the capabilities and limitations of the application. Proper education and communication are essential in ensuring that users understand the intended purpose of the mobile application (Vo et al., 2019).

A vital necessity was the development of a clear and comprehensive information sheet for users. This sheet would contain essential information regarding data privacy and the functionalities of the mobile application. Additionally, it was proposed that helplines and links to up-to-date information and support be made available for those using the application to ensure signposting was available for users whose mental wellbeing scores consistently decreased. Introducing mental health helplines into the application (or provided through additional materials accessible to users) could potentially encourage individuals to actively seek assistance, addressing a common barrier to accessing mental health support (Clement et al., 2015).

In conclusion, the findings suggest that this mobile application has the potential to serve as a usable and relevant tool for enhancing mental wellbeing through the self-monitoring of various aspects of health and wellbeing. However, the feasibility of delivering this mobile application to nurses and the effectiveness of the application in changing health and wellbeing outcomes is yet to be determined. This early investigation demonstrated that it is crucial to ensure that users are provided with clear and easily understandable information regarding the capabilities and limitations of the mobile application.

Additionally, addressing concerns related to data privacy is important to establish user confidence and trust. This is important to ensure uptake and engagement with this mobile application. Future studies should consider the age-related differences in technology familiarity, as younger adults may exhibit higher levels of comfort and proficiency in using such applications. To further enhance user engagement and facilitate help-seeking behaviours, the inclusion of information about helplines or similar support mechanisms is recommended.

4.5 Summary of proof-of-concept study

- This PPI work explored nurses' (end-users') understanding of MYARKEO, a commercially developed mobile application designed to improve mental wellbeing, to inform its use in a future trial.
- Nurses found the concept of monitoring both physical and mental health aspects through MYARKEO valuable, relevant, and comprehensive.
- Concerns were raised regarding lack of technological familiarity, which may hinder engagement with the application. Also, participants recommended the use of reminder push notifications to maximise application engagement.

Chapter 5: Methodology and methods

Introduction

This chapter provides an overview of the research methodology and methods employed to address the research aims and objectives outlined at the beginning of this chapter. The chapter begins by explaining the research design and methodology, highlighting the rationale for choosing a mixed methods approach due to the complexity of the intervention. The philosophical underpinnings supporting this methodology are also discussed. Next, this chapter outlines participant recruitment and progress, presenting the participant pathway along with details of the recruitment process, including the utilisation of social media. The data collection tools are then introduced, along with an explanation of how raw data are organised and analysed. Lastly, the chapter explores the ethical considerations surrounding the study, providing the ethical approval obtained to ensure that this study is safe for both the researchers and participants.

It is important to note that this methodology chapter adheres to the Consolidated Standards of Reporting Trials Checklist (CONSORT Checklist) for randomised controlled trials (Cuschieri, 2019), ensuring that all relevant information is presented in a structured and systematic manner. The TIDieR checklist adheres to describe the intervention (Hoffmann et al., 2014). Reporting the qualitative component of the study adheres to the Consolidated Criteria for Reporting

Qualitative Research (COREQ-32) (Tong et al., 2007). The checklists can be found in Appendix 8, 9, and 10, respectively.

5.1 Aims and objectives

Aim 1: to assess the feasibility of an RCT, including a mobile application designed for mental wellbeing improvement

Objectives

- Determine the feasibility of methods of recruitment and enrolment
- Assess retention rate and adherence to the intervention
- Evaluate the methods of data collection and analysis for a full-scale RCT
- Provide estimates of the variability of key outcomes to enable calculation of the sample size and resources required for a future full-scale RCT

Aim 2: to explore user experiences of the mobile application's acceptability and usability

Objectives

- To understand how participants engage with the mobile application
- To discover facilitators and barriers to the engagement
- To determine whether and how the mobile application could be refined for future delivery.

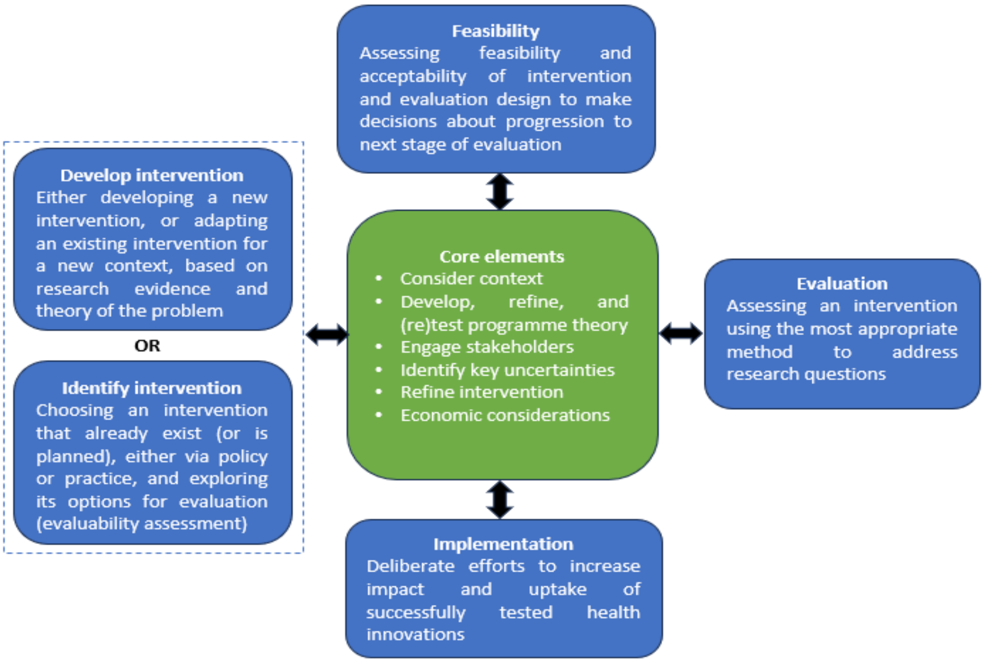
5.2 Study Design

As given above, this study included two different aims, which require different research methods to achieve relevant data. In such cases, mixed-method designs are recommended (John W. Creswell & Plano Clark, 2011). A concurrent mixed method design was applied to this study, collecting quantitative data to assess the feasibility of RCT, followed by qualitative data to explore users' experiences on the usability and acceptability of the mobile application. The reason for merging both quantitative and qualitative data is to better understand the study questions by integrating numeric trends and personal views on mobile application use. While the quantitative design was a feasibility RCT study, the qualitative design was individual interviews with those who used the mobile application. Table 7 summarises the study design.

The quantitative design, a feasibility RCT with a pragmatic approach, was applied to test the number recruited, dropout rates, randomisation, standard deviations of the proposed primary outcome, and the engagement rates of the mobile application. Conducting a feasibility trial based on the Medical Research Council (MRC) framework (Skivington et al., 2021) is crucial as it allows researchers to assess the practicality of the study, refine the intervention, evaluate recruitment and retention strategies, and inform sample size calculations for a future large-scale trial (Skivington et al., 2021).

The MRC Framework outlines five stages for implementing evidence-based interventions into practice, as depicted in the diagram below. Considering these stages, a feasibility trial was conducted because the mobile application MYARKEO had already been developed, and health monitoring interventions had been utilised in practice. Nevertheless, there had been no previous feasibility trial utilising a mobile application specifically designed to monitor both physical and mental health components together to enhance mental wellbeing among health and care workers/students.

Figure 7: MRC Framework modified from Skivington et al., 2021



The qualitative design, semi-structured individual interviews, was employed to explore the acceptability and usability of the mobile application health monitoring by gathering users' experiences during the study period. In trials involving user experiences, relying solely on a quantitative design that focuses on "how many" or "how much" questions is insufficient, as there is a need to address "how" and "why" questions (Tenny et al., 2022). Qualitative designs such as interviews are necessary to gather in-depth knowledge about real-life experiences, views of users and facilitators and barriers to the intervention (J. W. Creswell & Plano Clark, 2023).

Moreover, according to the MRC Framework, qualitative designs are needed and significant in evaluating of complex interventions since they provide valuable insights into intervention development, acceptability, delivery, contextual factors, evaluation methods, and theory development. This current qualitative design provided insights into the underlying mechanisms of the intervention. It helped the research team understand how and why the intervention worked or did not work in this population.

Table 7: Concurrent study design

Quantitative Design **Two armed RCT with a 1:1 randomisation ratio**	**Qualitative Design** **Semi-structured individual interviews (intervention group only)**
Aim: to determine the feasibility of a randomised control trial	**Aim:** to explore user experiences on the mobile application's acceptability and usability
Objectives	**Objectives**

• Identifying;
    • Recruitment rate and progress
    • Attrition rate
    • Dropout rate and reasons
    • Standard deviations on primary outcomes
• Assessing the frequency of the application use
• Testing the user engagement with the application
	• Understanding how participants engage with the mobile application
	• Discovering facilitators and barriers to the engagement
	• Determining whether and how the mobile application could be refined for future delivery

5.3 Philosophical framework

This current research philosophy aligns with the pragmatism approach. Research philosophy refers to the set of beliefs, principles, and assumptions guiding the researcher's research approach (Saunders et al., 2015). It serves as a foundation for the researcher's worldview and influences their choice of research methods, data collection techniques, data analysis, and interpretation of findings (Hughes & Sharrock, 2016). Table 8 below illustrates the flow of how researchers acquire scientific knowledge.

Table 8**:** The flow of the current study philosophy

Research philosophy	Key questions	Application to the current study
Ontology	What's out there to know?	• Feasibility of an RCT • Usability and acceptability of the mobile application • Mental wellbeing state
Epistemology	What and how can we know about it?	• Through experiments • User experiences • Questionnaires or surveys
Methodology	How can we go about acquiring that knowledge?	• Utilising both quantitative experiments (mobile application use) and qualitative approaches (user experiences) • Synthesising findings from both methodologies

Methods	What precise procedures can we use to acquire it?	• Feasibility design • WEMWBS and DASS-21 • MAUQ • Individual interviews

Research philosophy's foundation begins with identifying scientific knowledge and how it can be acquired. There are basically two ontological approaches to scientific knowledge: whether it already exists (positivism) or is produced (interpretivism). Positivism claims that scientific knowledge already exists, which is testable by experience, observable, and generalisable (Benton & Craib, 2023a). It also emphasises objectivity, quantifiable data, and cause-and-effect relationships (Park et al., 2020). Positivists seek to discover universal laws.

On the other hand, interpretivism emphasises the subjective and socially constructed nature of reality (Alharahsheh & Pius, 2020). It recognises that individuals and groups interpret and give meaning to their experiences based on their social and cultural contexts (Alharahsheh & Pius, 2020). Interpretivists aim to understand the unique perspectives and meanings attributed to phenomena by exploring the rich and context-bound nature of human experiences, which are the resource of scientific knowledge (Benton & Craib, 2023). Qualitative methods such as interviews, observations, and textual analysis are commonly used in interpretive research.

Positivism and interpretivism are contrasting paradigms within research philosophy (Hughes & Sharrock, 2016). However, alternative approaches, such as pragmatism, claim that both positivism and interpretivism paradigms can be combined to achieve scientific knowledge (Benton & Craib, 2023). Pragmatism emphasises that no single approach can comprehensively understand complex phenomena, such as the current feasibility study, which includes numeric data and user experiences on a mobile application to promote mental wellbeing. Pragmatic researchers focus on the practicality and usefulness of research methods and outcomes to answer research questions (Benton & Craib, 2023; Morgan, 2014). It promotes a flexible and adaptive approach to research, allowing researchers to modify their philosophical assumptions and conduct a combination of positivist and interpretive approaches as needed. Pragmatism claims that research should be context-specific and aims to bridge the gap between theory and practice (Morgan, 2014). It values the application of research findings to solve real-world problems and improve decision-making. By focusing on practical outcomes and actionable insights, pragmatism contributes to developing knowledge that can be effectively applied in various domains and disciplines (Benton & Craib, 2023).

5.4 Complex interventions

Complex interventions involve a comprehensive approach integrating multiple components within complex contexts. These interventions typically involve various factors, such as individuals, groups, organisations, or communities, and aim to change behaviour, healthcare delivery, or social systems (O'Cathain et al., 2019). The present study focuses on delivering a mobile application-based intervention encompassing mental wellbeing improvement, a personal and sensitive topic (Thornicroft et al., 2022). The application use includes multiple interactions such as everyday use of the application, in which users need an account, password, and profiles and monitor physical and mental components of health based on their personal preferences. Furthermore, the study examines a vulnerable population consisting of health and care workers and students who face a higher risk of experiencing common mental health problems compared to the general population (*National institute for Occupational Safety & health*, 2023). The COVID-19 pandemic has also escalated mental health problems, where health and care workers and students have been at the forefront of preventing and mitigating the impact of the pandemic (Gilleen et al., 2021; Uphoff et al., 2021). Therefore, this study can be classified as a complex intervention and requires adhering to the MRC Framework—a widely accepted and utilised guideline for designing and implementing such interventions. By following this framework, the study ensures a comprehensive and systematic approach that aligns with best practices in the field.

5.5 Mixed-method studies

Mixed-method studies typically combine qualitative and quantitative research methods to collect and analyse data within the same study (Shorten & Smith, 2017). As the value of qualitative research has been recognised, there has been a growing interest in combining qualitative and quantitative methods. A review of health services research within England has demonstrated an increase in the proportion of mixed-method studies from 17% in the mid-1990s to 30% in the early 2000s (O'Cathain et al., 2019). This increasing trend has also remained in recent years (Doyle et al., 2016).

Complex research questions need complex and plexiform research methods to answer them by gathering knowledge from different fields of resources. The importance of mixed-method studies lies in their ability to provide a more comprehensive understanding of complex phenomena by combining the strengths of both qualitative and quantitative research methods (Plano Clark, 2017). Qualitative research methods are useful for exploring and understanding individuals' subjective experiences and perspectives, while quantitative research methods are useful for measuring and analysing objective data (Nassaji, 2015). By combining these methods, researchers can better understand the research question or problem being studied (Tariq & Woodman, 2013).

Several mixed methods designs are available, each offering unique approaches to research. These designs include explanatory sequential, exploratory sequential, parallel, and nested designs. Researchers must carefully consider their research questions and objectives to determine the most suitable design for addressing them. The explanatory sequential design starts with a quantitative process and is followed by applying qualitative methods (Halcomb et al., 2023). Conversely, the exploratory sequential design takes the opposite approach, starting with qualitative processes and then incorporating quantitative methods (Halcomb et al., 2023). The parallel design involves the simultaneous collection and analysis of qualitative and quantitative data (Halcomb et al., 2023). In all these designs, both types of data hold equal significance. However, in the nested design, either the quantitative or qualitative design takes centre stage, while the other provides complementary support to the research question (Halcomb et al., 2023).

The current study employs a *"concurrent mixed method"* design to investigate the feasibility of research and mental wellbeing monitoring through the mobile application. Both research feasibility outcomes and user experiences on the mobile application play equally significant roles in explaining the viability of the research and the usability and acceptability of the mobile application. Initially, quantitative data collection started to evaluate various aspects, including recruitment, randomisation, dropout rates, and adherence to the intervention. Surveys covering demographic information, wellbeing, depression, stress, and anxiety were applied to gather relevant quantitative data. Individual interviews were conducted within the intervention group to explore user experiences regarding the usability and acceptability of the mobile application. These qualitative data helped particularly in understanding factors contributing to dropouts, retention rates, and adherence to the mobile application. Data analysis was undertaken separately for quantitative and qualitative data, with an integrated approach during interpretation to derive comprehensive insights.

5.6 Participants

The participants in this research study were healthcare workers employed in the UK. The recruitment opened to healthcare students due to the challenges posed by the COVID-19 pandemic in recruiting the target number of participants. The term "healthcare workers" refers to clinical staff, while "healthcare students" includes individuals registered in higher education institutions studying health sciences or medicine in the UK.

The "potential participant" who expressed interest in the study were evaluated for eligibility. To be considered eligible, individuals were required to have a smartphone and were able to use mobile applications. As the mobile application utilised in this research was developed for the general population, individuals who had been diagnosed with mental health conditions and were currently undergoing mental health therapy or treatment were excluded from participation. This decision was made to prevent any potential bias in the results that their ongoing therapy or treatment could impact. The information regarding their mental health status was obtained through self-reporting by the participants.

5.7 Recruitment and sampling

Participants were recruited through social media posts and e-mails among professional networks, including Twitter, Facebook, and two digital newsletters, the Foundation of Nursing Studies (FoNS) and the Florence Nightingale Foundation. Additionally, a study invitation email was circulated within the School of Health Sciences, Medicine, and Pharmacy at the University of Nottingham to access eligible health and care workers and students. Examples of study invitation social media posts and e-mails are shown in Appendix 11.

Two sampling techniques were employed in this study: convenience and snowball sampling. Convenience and snowball sampling were initially employed during the commencement of study recruitment, while only convenience sampling was used for conducting the interviews.

In research, sampling techniques play a crucial role in gathering data and drawing meaningful conclusions. The ideal option is to include the entire population eligible for a study. However, in most cases, it is not possible to recruit every participant due to the impractical size of the population.

Therefore, appropriate sampling techniques have been used to represent the targeted population (Stratton, 2021).

One such technique is convenience sampling, which involves selecting participants based on their easy accessibility and willingness to participate (Etikan et al., 2016). This type of non-probability or non-random sampling offers several advantages, including cost-effectiveness, efficiency, and simplicity of implementation (Jager et al., 2017). Convenience sampling allows researchers to quickly gather data without the extensive efforts required for other sampling techniques, such as random or stratified sampling. This sampling method is also useful for preliminary or exploratory research, providing a swift overview of a specific population or phenomenon (Lohr, 2021). It helps researchers gain insights, generate hypotheses, and identify potential areas for further investigation.

Snowball sampling, also known as chain referral sampling, is a non-probability sampling method widely used in social sciences and qualitative research (Parker et al., 2019). It involves using existing participants as informants to recruit additional participants, forming a network of interconnected individuals. This method is particularly useful when studying hard-to-reach populations or sensitive topics where traditional sampling approaches may not be feasible. During the pandemic, it was hard to reach health and care workers. It was not possible to use traditional in-person methods for this recruitment. Therefore, snowball sampling was an appropriate technique to support convenience sampling for recruiting health and care workers and students.

Both convenience and snowball sampling were highly useful for the current study, as the pandemic has brought many challenges in the recruitment process. Recruiting healthcare workers from the NHS for student-led studies was significantly challenging during the pandemic. Thus, we needed to recruit participants through social media without in-person interactions. That means people who are accessible through social media were recruited into the study. In these difficult times, convenience sampling was more appropriate for the study due to the pandemic, limited time, and accessibility of eligible participants. Snowball sampling was used as an additional method to increase recruitment among professional networks.

5.8 Social media recruitment

Any study requires the recruitment of a sufficient number of participants who represent the intended population. Failure to achieve this objective can jeopardise the validity of the results, increase costs, and delay or even terminate the study prematurely (Topolovec-Vranic & Natarajan, 2016). Less than one-third of trials reached their original target within a specified time frame, and approximately one-third required extension (Darmawan et al., 2020). One of the main reasons for this delay is difficulties in participant recruitment (Chaudhari et al., 2020).

In this digital age, technological advancements have provided researchers opportunities to implement new strategies to recruit research participants. Social media use such as Twitter, Facebook, Instagram, and LinkedIn are some of the new strategies to access people, groups, companies, organisations, or even governments (Quickfall, 2022). A recent scoping review showed that various studies have applied social media recruitment strategies alone or in conjunction with traditional recruitment ways (Darko et al., 2022).

Social media refers to internet-based platforms and applications that enable users to create, share, and exchange content in virtual communities and networks (A. Jones et al., 2021). It allows individuals to interact, communicate, and engage with others, often in real-time, through various forms of media, such as text, images, videos, and audio. As it is internet-based, people can be in contact with others, disregarding geographical limitations. Therefore, social media recruitment has been a growing method for researchers to recruit related participants all around the world. Additionally, it is more cost-effective and easier to implement compared to traditional methods such as flyers, posters, or other advertisements (Gelinas et al., 2017). Social media also allows researchers to recruit people 24 hours a day (Gelinas et al., 2017).

The current study employed social media recruitment due to the COVID-19 pandemic. To address the increasing incidence of COVID-19 cases and fatalities, the UK government took essential measures to prevent the transmission of the virus. These measures encompassed stay-at-home mandates, self-isolation protocols, the implementation of social distancing guidelines, and the enforcement of varying degrees of lockdowns and border restrictions (L. E. Smith et al., 2022).

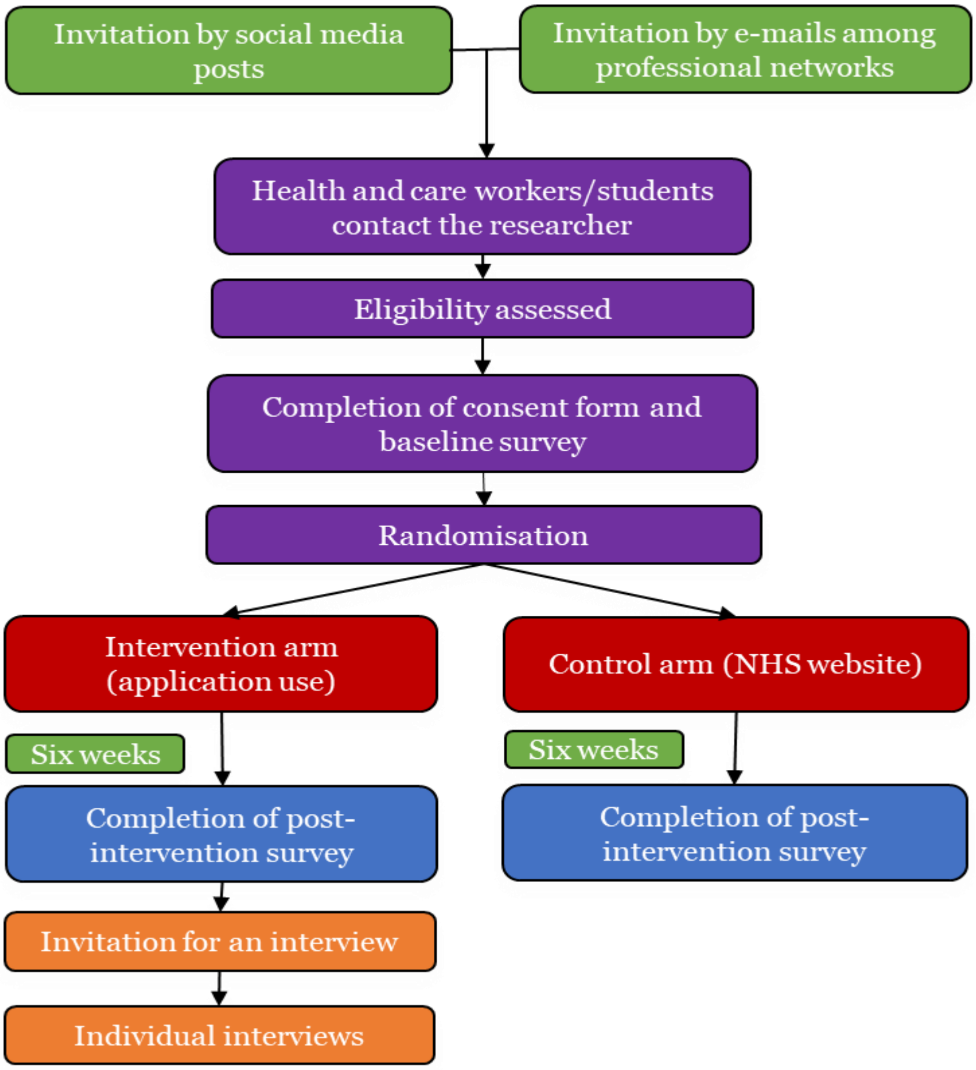
The original recruitment plan was to recruit registered nurses from Nottingham University Hospitals NHS Trust. However, due to the impact of the COVID-19 pandemic, the NHS Trust paused the process of granting ethical approval for student-led studies with participants from the NHS. Therefore, as a contingency plan, registered nurses around the UK were recruited through social media advertisements, professional networks, and groups, as we did in our PPI work. However, the recruitment speed was insufficient to reach the targeted number of participants. To maximise recruitment during the pandemic, the eligibility criteria for study entry were broadened to include any health and care workers (e.g. clinical staff such as nurses, midwives, and other clinically active clinicians) alongside students studying a healthcare programme. This plan was reported in the ethical approval application.

5.9 Participant pathway

Participants were invited through social media posts and professional networks. Those who wanted to participate in the study contacted the research team. The researcher (MY) informed participants and assessed their eligibility based on the study's inclusion and exclusion criteria. Eligible participants were asked to sign the consent form. After that, the baseline survey link was shared with the participants. Following the completion of the baseline survey, the participants were randomly assigned to either an intervention or control group (four and six-block randomisation technique). In the intervention group, the participant was informed by an e-mail that they could download the mobile application MYARKEO from the Apple Store or Play Store. The participant received weekly e-mails as a reminder of mobile application use. After six weeks, each participant was asked to complete the post-intervention survey. They were also invited to conduct a one-to-one, semi-structured and online interview. Those who consented to take part in an interview received a Microsoft Teams Meeting Link from the researcher. After the meeting, the participants were thanked and informed about the next stages of the study, including data analysis and dissemination.

In the control group, the participants were sent an e-mail signposting them to an NHS website about mental wellbeing improvement. This website contains generic information that is widely accessible to the public and provides steps around how to improve mental wellbeing with ‘do’ and ‘do not’ instructions (https://www.nhs.uk/mental-health/self-help/guides-tools-and-activities/five-steps-to-mental-wellbeing/). After the study period (six weeks), the post-intervention survey was shared with the participants to gather postintervention data. Then, we thanked the participants and informed them of the next stages of the study. The participant pathway diagram summarised these processes (Figure 8).

Figure 8: Participant pathway



5.10 Randomisation and allocation concealment

Internal validity and bias are the main concerns in RCTs. Internal validity refers to how much a study can accurately measure any causal relationship between the predefined variables (Spieth et al., 2016). In other words, it assesses if observed effects truly rely on an intervention being tested and not due to other factors. Randomisation and allocation concealment are vital elements of a trial to ensure internal validity and minimise bias (Armijo-Olivo et al., 2015). By randomly assigning participants to different groups or interventions, researchers can mitigate the influence of confounding variables and increase the likelihood of obtaining unbiased and reliable results. Randomisation helps create groups that are comparable in terms of known and unknown factors, reducing the risk of systematic differences between groups and increasing the study's internal validity (Armijo-Olivo et al., 2015).

Researchers should employ robust randomisation techniques to ensure random allocation and minimise selection bias. There are two main steps to implement randomisation. The first one is to generate a random sequence of participants. It should be truly based on chance, and the sequence should not be predictable (Dettori, 2010). The second step is to conceal this sequence of participants, which means that recruiters should not be aware of the next allocation until it is assigned (Dettori, 2010). Several methods can be utilised to achieve these steps, but one common approach involves the computerised generation of a random sequence, which was adopted in the present study. An independent researcher conducted this computerised random sequence generation to ensure concealment and communicated the sequence to the primary researcher as new participants were recruited.

In this study, block randomisation was implemented as the randomisation technique. This approach is an appropriate technique to minimise selection bias and offers several advantages (Suresh, 2011). This randomisation could be used not only to ensure a balance in sample size across groups over time but also to divide participants' characteristics equally among the groups (Suresh, 2011). For this study, block randomisation was implemented to achieve balanced group sizes and reduce the predictability of the allocation sequence.

Consequently, varying block sizes (4 and 6) were utilised to enhance the unpredictability of group allocation, making it more challenging to recognise the underlying randomisation pattern.

5.11 Intervention

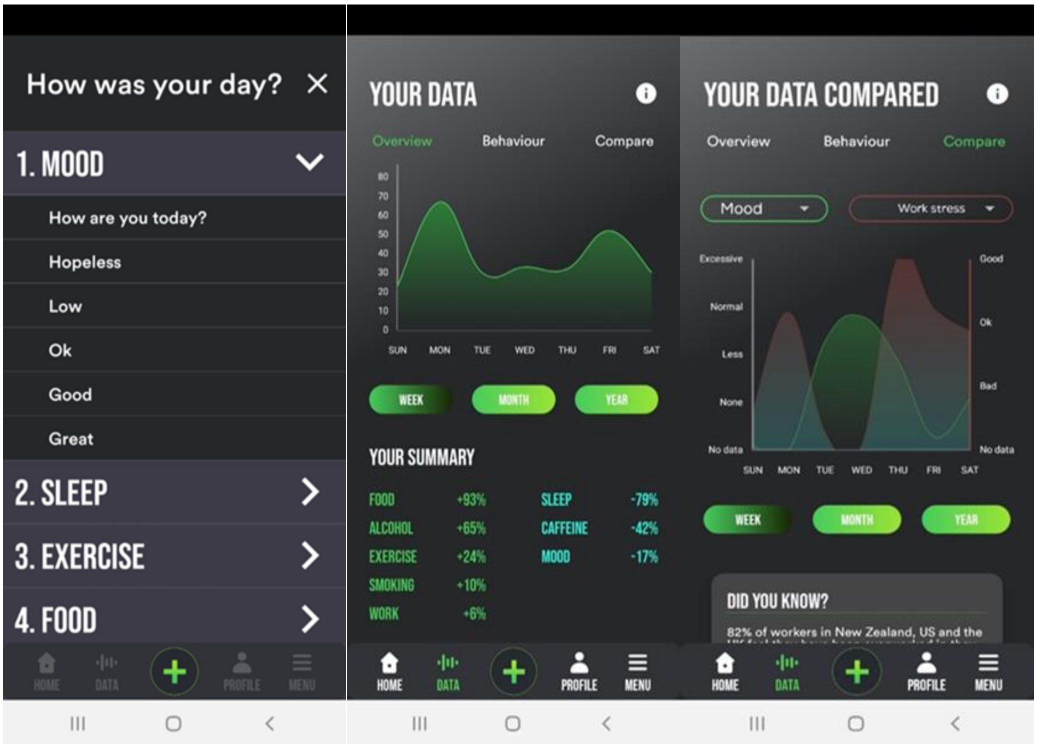
The core of MFapp intervention involved using a mobile application called MYARKEO for daily monitoring of mental wellbeing over 6 weeks. The goal of the intervention is to promote participants' mental wellbeing by stimulating their self-awareness and self-care in their lifestyle. The development of this mobile application was inspired by a paper-based mental wellbeing monitoring approach, which proved to be a supporting tool for treating depression and facilitating individuals' return to work (Balaskas et al., 2021). The lead author will provide the mobile application to participants.

This mobile application functions as a self-tracking tool. It was accessible through mobile application markets, Apple Store, and Google Play. The users need an email and password to log in. Then, they can start to use the mobile application immediately by creating their profile and selecting items they wish to monitor. The application collected health-related data through daily questions about participants' daily moods and behaviours. It includes twenty-eight questions to track a range of physical lifestyle factors and mental wellbeing items, including daily mood, stress levels, anxiety, work-related stress, low energy, general worry, negative thoughts, dietary choices, sleep patterns, exercise routines, caffeine and alcohol consumption, smoking habits, medication usage, menstrual cycles, and menopause. The participants picked what data they wanted to monitor based on their personal preferences.

According to their answers about their mood, behaviours, or symptoms, they received a daily score to reflect the level of their mental wellbeing (score range: 0 to 100). The score does not represent a diagnosis of depression, anxiety, or stress. The score was produced as a positive reinforcement to increase engagement and motivation for daily use of the application. The higher the score, the better the user's level of mental wellbeing.

The mobile application not only facilitated the tracking of mental wellbeing items but also allowed participants to compare their wellbeing status over different days and weeks. Additionally, it provided insights into the correlations between various factors, such as the relationship between sleep and daily mood. These choices could be adjusted based on their personal preferences throughout the duration of the intervention. For more information about the mobile application, please see Chapter 3. All questions related to mental wellbeing can be found in Appendix 5. A selection of screenshots is displayed in Figure 9.

Figure 9: Screenshots from the application



The company agreed to transfer the health-related raw data to the researcher. The transfer method involved a link allowing the researcher to download the data directly using a CSV extension (an Excel file). For data protection legislation, MYARKEO is the data controller of user's personal data. MYARKEO is registered with the Information Commissioners Office in the UK with reference number A8485743. For further information, please follow the link: https://www.myarkeo.com/privacy/, accessed in June 2021.

5.12 Outcome measures

5.12.1 Feasibility criteria

Prior to the study, feasibility criteria were identified according to the relevant literature. Four feasibility criteria were identified as follows: (i) total number of participants, (ii) dropout rate, (iii) retention rate, and (iv) mobile application usage rate. Table 9 presents the target criteria. The first criterion, the number of participants, was set to between 30 and 50, as recommended by studies on feasibility outcomes (Lancaster et al., 2004; Sim & Lewis, 2012). A recent systematic review searching for sample sizes for UK pilot and feasibility studies from 2013 to 2020 found that the median target sample size was 30 with IQR 20-50 (Totton et al., 2023).

The expected ideal dropout rate in clinical trials is less than 5%, with up to less than 20% being acceptable to avoid attrition bias (Dettori, 2011). However, dropout rates could vary based on the nature of the studies. For instance, studies on mobile application-based interventions, such as mindfulness interventions, have reported high dropout rates (Linardon, 2023). Similarly, a review of application-based interventions for chronic disease found a 40% dropout rate in randomised control trials (Meyerowitz-Katz et al., 2020). Another review focusing on trials with mobile application-based support for depression reported a 26.2% dropout rate (Torous et al., 2020). Furthermore, the scoping review conducted in this thesis (Chapter 2) indicated an average 27% dropout rate. Considering the high attrition nature of mobile application-based interventions and the scoping review findings, this study's dropout rate was set to less than 27%.

The last criterion, the mobile application usage rate, was set to over 40% based on the scoping review conducted before this feasibility study, which discovered that the application usage rate was 40.9% (Chapter 2).

Table 9: Feasibility criteria

Feasibility criteria	Target
Number of participants	30-50
Dropout rate	Under 27%
Application usage	Over 40%
Retention rate	Over 73%

5.12.2 Warwick-Edinburg Mental Wellbeing Scale (WEMWBS)

The WEMWBS was the questionnaire for mental wellbeing assessment (see Appendix 12). It was developed by a team led by Stewart-Brown and Platt between 2005 and 2010 and commissioned by the Scottish Government (Warwick Analytical Science Centre, 2020). This scale enables the monitoring of mental wellbeing in the general population and the evaluation of projects, programmes and policies which aim to improve mental wellbeing (Warwick Analytical Science Centre, 2020). This scale aims to capture a wide conception of wellbeing, including affective-emotional aspects, cognitive-evaluative dimensions, and psychological functioning, in a form which is short enough to be used in population-level surveys (Tennant et al., 2007). The scale has been validated for use in various geographical locations, languages, and cultural contexts, as well as many divergent settings, including workplaces, schools, health services and community wellbeing projects.

This scale included 14 positively worded statements to describe people's experiences on satisfaction (3), affection (4), competence (2), relatedness (3), and autonomy (2) over the last two weeks. Answers included a Likert scale with five options, "None of the time", "Rarely", "Some of the time", "Often", and "All the time". Each option has a score from 1 to 5, respectively. The total score is obtained by summing the score for each of the 14 items. The lowest score would be 14, and the highest would be 70. The total score categorises a person as having low wellbeing where the total score is less than 43, moderate for 43-60 and high for greater than 60 (*Collect, score, analyse and interpret WEMWBS*, 2023).

The Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) is valid, reliable, and acceptable in adult populations across Europe, in adolescents (13–15 years), and in minority ethnic groups (Stewart-Brown et al., 2011).

5.12.3 Depression, Anxiety, and Stress Scale (DASS-21)

The Depression, Anxiety, and Stress Scale-21 (DASS-21) is a widely used self-report questionnaire designed to measure the severity of symptoms related to depression, anxiety, and stress (Gomez, 2016). The severity was grouped into normal, mild, moderate, severe, and extremely severe (see Appendix 13). It is a shorter version of the original DASS, which consisted of 42 items. The DASS-21 was developed by researchers Lovibond and Lovibond in 1995 (Lovibond & Lovibond, 1995). The scale includes three subscales, each measuring a distinct psychological construct:

- Depression: assesses symptoms such as low mood, lack of interest, and feelings of worthlessness or hopelessness.
- Anxiety: measures symptoms related to physiological arousal, fear, and excessive worrying.
- Stress: evaluates symptoms associated with irritability, tension, and difficulty relaxing.

Each subscale contains seven items, resulting in a total of 21 items for the entire questionnaire. Respondents rate the presence and severity of each symptom over the past week on a 4-point Likert scale, ranging from "Did not apply to me at all" to "Applied to me very much, or most of the time."

The DASS-21 is a screening and assessment tool used to measure the severity of depression, anxiety, and stress symptoms in clinical and research settings. It quantitatively measures these constructs, allowing clinicians and researchers to evaluate symptom severity and track changes over time. The scale is not intended to provide a formal diagnosis of mental disorders but rather serves as an indicator of symptom severity.

In terms of reliability, the DASS-21 has demonstrated good psychometric properties. It has shown high internal consistency, indicating that the items within each subscale measure the same underlying construct (Le et al., 2017). The scale has also exhibited good test-retest reliability with consistent results when administered to the same individual at different time points (Le et al., 2017). Additionally, the DASS-21 has demonstrated good construct validity, as it correlates well with other established measures of depression, anxiety, and stress (Marijanović et al., 2021).

5.12.4 mHealth App Usability Questionnaire

The mHealth App Usability Questionnaire (MAUQ) (see Appendix 14) is designed to evaluate the ease of use, interface, satisfaction, and usefulness of mHealth applications for end users (Zhou et al., 2019). *"mHealth"* refers to health-related mobile applications.

It was developed because commonly used questionnaires such as the System Usability Scale (SUS) and Post-Study System Usability Questionnaire (PSSUQ) were not designed to evaluate the usability of mHealth applications (Zhao et al., 2022). The MAUQ has three subscales, and their internal consistency reliability is high, ease of use= .84, interface and satisfaction= .90, and usefulness= .71 (Zhou et al., 2019). The relevant subscales correlated well with the subscales of the PSSUQ. The overall scale also strongly correlated with the PSSUQ and SUS1 (Zhou et al., 2019). A few other studies also reported high validity and reliability scores in Malay (Mustafa et al., 2021) and Chinese (Zhao et al., 2022) versions of the questionnaire.

This questionnaire included 18 questions, which were divided into three groups: ease of use (the first five questions), interface and satisfaction (the following seven questions), and usefulness (the last six questions). This Likert scale included the answers and scores as follows:

1- Strongly disagree
2- Disagree
3- Somewhat disagree
4- Neither agree nor disagree
5- Somewhat agree
6- Agree
7- Strongly agree

Each answer creates a score between 1 and 7. The mean value of the score was calculated to degree each area of a mobile application, ease of use, interface and satisfaction, and usefulness. The lowest score would be 18, and the highest score would be 126. Basically, a higher mean score represents better usability and acceptability. A mean score of 5 to 6 is defined as "Good." If the mean is higher than 6, this means "Excellent" usability and acceptability.

5.13 Quantitative data analysis

The quantitative analysis was predominantly descriptive, with a primary focus on determining feasibility by estimating recruitment, attrition, and non-compliance rates.

Additionally, the means and standard deviations of mental health and wellbeing outcomes by the group at baseline and end trial were reported to indicate the likelihood of change in outcome measures (to inform a future trial). We determined a 95% Confidence Interval for differences in means of outcomes between groups and assessment of change following the intervention at the end of the trial. Sample size calculations for the future RCT were estimated using the intervention effect size and variance estimates from the immediate post-intervention change data for the selected outcome measure. G-power software (Version 3.1.9.7) (Faul et al., 2009) was used for the sample size calculation.

Demographic and intervention data were reported as means and SDs for continuous parametric data, medians and ranges for continuous non-parametric data, and frequencies and percentages for categorical data. IBM SPSS Statistics (Version 26) (*IBM SPSS Statistics for Windows*, 2020) was used for this data analysis.

At the end of the 6-week study period, the raw usage data from the mobile application was downloaded as Excel spreadsheets for each day. Subsequently, all these spreadsheets were combined into a single spreadsheet for each participant. Finally, all participants' spreadsheets were merged into one spreadsheet for data analysis to determine what items were chosen to monitor and the frequency of daily usage.

5.14 Qualitative design and process

As previously outlined, the qualitative component of the feasibility study involved semi-structured interviews. An interview guide was developed by MY, aligning with the objectives of the qualitative study. The initial guide was revised following discussions with the research team HB and TC.

This interview guide aimed to assess the acceptability and usability of a mobile application designed to improve mental wellbeing. The Technology Acceptance Model (TAM) informed the development of this interview guide. TAM posits that perceived ease of use and perceived usefulness are key determinants of user acceptance and engagement with technology (Davis, 1989). Therefore, the interview included questions about initial impressions of the mobile application's use, its impact on the user's well-being, and assessments, along with suggestions for future development for healthcare workers. For full details, please see Appendix 15.

Using convenience sampling, participants were recruited from the intervention group only, based on their availability. The reason for recruiting only intervention participants was to maintain focus on the direct impact of the intervention. This approach is consistent with the rationale provided by Patton (2002), who argues that selecting participants directly affected by the intervention can yield more relevant and specific insights into the outcomes and effectiveness of the intervention (Patton, 2014).

The target was to include all nineteen participants in the intervention group. However, thirteen of them responded to e-mails and participated in the interviews. According to the relevant literature (e.g. (Francis et al., 2010; Guest et al., 2006), saturation—the point at which no new information or themes are emerging from additional interviews—can often be reached with a sample size between 12 and 15 participants, particularly in qualitative research focusing on a specific phenomenon or intervention.

All interviews were conducted online via Microsoft Teams due to the COVID-19 restrictions. Before starting the interview, the participants were informed about the interview content and asked for their verbal consent to be recorded. They were also reminded that the transcripts would be anonymised and treated confidentially. MY informed them that they are free to withdraw at any point during the interview without giving a reason if they wish to do so. All interviews were organised and conducted by the researcher, MY. Interview data was collected between June 2021 and February 2022. The qualitative study report adhered to the 32-item checklist of the Consolidated Criteria for Reporting Qualitative Studies (COREQ) (Tong et al., 2007).

5.14.1 Qualitative data analysis

Thematic analysis is a widely used method for analysing qualitative data. It has been used in various fields, including health research, education, and management. Researchers have found the thematic analysis to be accessible and flexible, allowing them to identify and analyse patterns in the data that they may not have anticipated. It has also been used to analyse the perspectives of different research participants, identify similarities and differences, and generate insights.

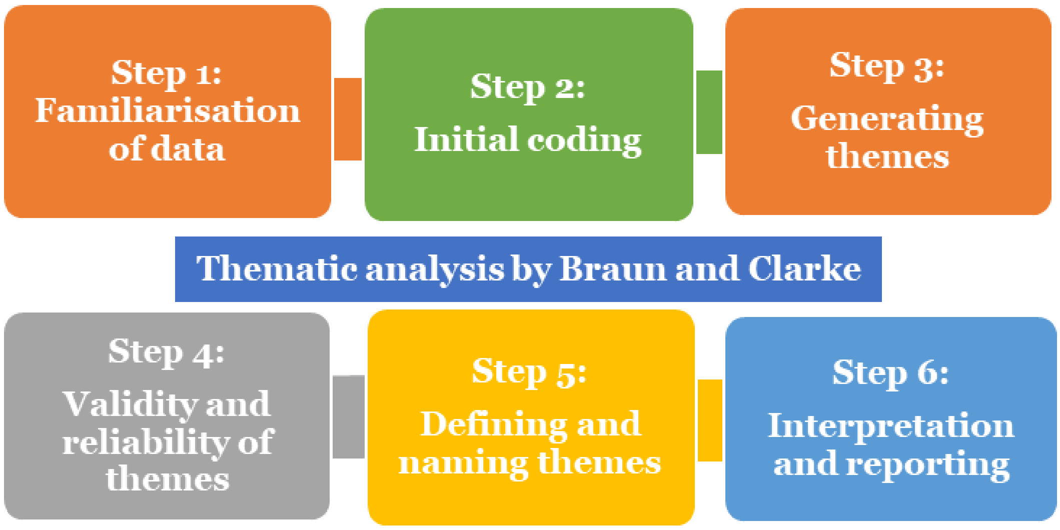
Braun and Clark's approach to the thematic analysis was applied to this study (Braun & Clarke, 2006). It is a flexible approach that can be used with different epistemological and theoretical frameworks. This approach involves six phases: familiarising oneself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report (see Figure 10). The approach is iterative, meaning that the researcher goes back and forth between the different phases until they are satisfied with the analysis (Braun & Clarke, 2006).

The lead researcher (MY), trained in qualitative research methods, conducted and transcribed all the interviews, which helped familiarise the data.

Subsequently, MY double-read each transcription for further familiarisation and identifying initial impressions and recurring patterns (Braun & Clarke, 2006). The transcriptions were then uploaded to NVivo v12 (Bazeley & Jackson, 2019) for the initial coding phase. MY systematically coded the data by labelling relevant information about mobile application user experiences. After that, MY examined the codes and data to inductively group them into potential themes (Braun & Clarke, 2006). This involved identifying patterns and relationships between codes to form overarching themes that capture the essence of the data (Naeem et al., 2023). To ensure robust analysis, the initial codes and themes were revisited and shared with the research team for their opinions and recommendations to ensure that the themes were coherent and well-supported by the data (Nowell et al., 2017). After a series of discussions, the main and sub-themes were named and defined. MY reported the findings illustrating how each theme was developed and supported by the data. This included providing examples and quotes from the data to substantiate the themes (Clarke & Braun, 2017).

Finally, the findings were triangulated and reported in conjunction with the quantitative results in the discussion chapter. Triangulation was done by integrating qualitative data from semi-structured user interviews with quantitative data collected from the mobile application use findings and survey responses. Data about reasons for dropouts, consistency of the use, acceptability and usability of the application were triangulated.

Figure 10**:** Six steps for the thematic analysis by Braun and Clarke (2006)



5.14.2 Reflexivity

Reflexivity in qualitative research is a critical and nuanced concept. It highlights the importance of researchers acknowledging and transparently addressing their positionality, biases, and interactions within the research process (Palaganas et al., 2017). The practice of reflexivity contributes to the contextual understanding of the study and enhances the credibility of findings (Dodgson, 2019). Thus, explaining the researcher's positionality in qualitative studies is considered a gold standard (Gabriel, 2018).

In the current study, interviewees had no prior relationship with the interviewer. The lead researcher is a man and a Ph.D. student studying mental wellbeing improvement through mobile applications. He is a nurse with experience in clinical work settings. This background has contributed to his understanding of the working environment and the challenges encountered by health and care workers and students.

He is a trained qualitative researcher and has been involved in several other published studies as a research associate. Before the main study commenced, he conducted a PPI work, including semi-structured interview with nurses (Yildirim et al., 2023). Additionally, before the qualitative data collection, he took training in qualitative research methods by completing a module titled "Foundations in Qualitative Methods" at the University of Nottingham. Further, he was involved in a research project including focus group and individual interviews (Al-Oraibi et al., 2022), where his role included organising, conducting, and analysing the interviews. He also completed a course in Advanced Qualitative Methods at the University of King's College. All these activities and courses improved his academic skills and attitudes in conducting qualitative research.

The study included a mobile application called *"MYARKEO"* for mental wellbeing monitoring. It is important to note that this application was already developed, and the lead researcher and team were not involved in its development phases. Before the study, the team had several meetings with the developer to understand the function of the mobile application and its use. Moreover, the lead researcher used the mobile application for a week to become familiar with its use, content, and interface. This experience potentially enhanced the researcher's ability to connect with participants during interviews and ask informed questions about their application usage, such as the colour of the application interface, navigation of items, and terms used within the mobile application. However, familiarity with the mobile application could limit the interviewer's ability to gather a wider range of perspectives on the user experience. The lead researcher might have preconceptions about the application's functionality and its use, which may cause unintentionally leading the follow up questions with his own experiences (Maxwell, 2012). Additionally, the interviewer was an international student whose native language was not English. This could limit to expand follow up questions with-in depth details, potentially resulting in interviews shorter than 30-60 minutes.

5.15 Ethical considerations

The participant information sheet (PIS) was developed using the University of Nottingham PIS template (Appendix 16). This PIS statement provided a detailed description of the study, including its aim, participant rights, and information regarding the handling and management of data. Additionally, a consent form was created through a participant consent template provided by the University of Nottingham (Appendix 17). Both the PIS and consent form clearly stated the voluntary nature of study participation and the participants' right to withdraw from the study at any point. Informed consent is a principle in research ethics that ensures that participants are free to participate voluntarily (U. C. Gupta, 2013).

The participants received information about the potential benefits and risks associated with their involvement in the study. Then, they were asked for their consent before participating. The participant pathway can be found in Figure 8. There was no time pressure to sign the consent form after receiving PIS; therefore, each participant had their own time to think and decide to sign the form. The consent form included the terms of the study in separate clauses, and any person had to declare having agreed to each clause before participating.

The participants were informed that the MYARKEO application is a tracking tool and not a treatment or diagnostic tool for their potential mental health problems. This information was a recommendation from professionals who participated in the PPI work, a consultancy activity to obtain professionals' views on the application use. They stated that participants might be confused about or misperceive the application's aim. Thus, the PIS expressed that the application is a tracking tool. Another concern about the application was the meaning of the daily scores. The participants were also informed that the higher the score, the higher their wellbeing. However, another question from the professionals was that someone's score may decrease constantly, and this person may have difficulty understanding this decreasing pattern. To prevent this risk, all participants were informed that they were free to withdraw their participation from the study at any time without giving any reason. The participants were also informed that they may contact their local GP for further help in case they have any concerns about their mental wellbeing.

In response to the COVID-19 pandemic, this study adhered to the UK Government's COVID-19 Regulations (https://www.gov.uk/coronavirus). Participant recruitment, intervention, and individual interviews were modified based on the restrictions related to COVID-19. To prioritise the health and safety of both researchers and participants, alternative methods were employed to ensure minimal in-person interactions. Recruitment was done through social media platforms and professional networks, eliminating the need for in-person contact. Participants received their mobile application account credentials via email and could download the application from trusted digital stores such as the Apple Store or Google Store. Throughout the study, communication with participants was maintained through email correspondence. Furthermore, individual interviews were conducted using remote online meetings facilitated by Microsoft Teams. This approach allowed for effective interactions with participants while adhering to social distancing measures and minimising any potential risks associated with in-person meetings.

5.16 Data management

Data protection and confidentiality were applied during the data management process by following the University of Nottingham's data protection and retention policies (*Data protection policy*, 2018) and the NHS data protection policy (*Data Protection Policy*, 2019). All research data created by the project were deposited in the University of Nottingham research data archive, https://rdmc.nottingham.ac.uk/. The data were only shared amongst the study group for analysis. All findings were anonymously disseminated in published papers and conferences.

Data in this study were collected through JISC Online Surveys, the mobile application, and online interviews through Microsoft Teams. All these three platforms adhered to the General Data Protection Regulation (GDPR) which is the most recent data privacy and security law created by the European Union (EU) and applied since 25th May 2018 (Murphy, 2018). SPSS v26 and NVivo v12 were used for data analysis and both software are also compliant with GDPR.

The survey data were initially stored on the JISC Online Survey during the data collection phase (https://www.jisc.ac.uk/online-surveys). A participant identification number was automatically provided to ensure that the data were anonymised. After the completion of survey data collection, all anonymised data were transferred to Excel spreadsheets, which were stored on the OneDrive account provided by the University of Nottingham. For data analysis purposes, these Excel spreadsheets were imported to SPSS v26. After data analysis, the findings were presented anonymously for study dissemination purposes.

The developer securely provided the mental wellbeing data generated by the mobile application through encrypted Google Drive. Qualitative interview data were recorded on Microsoft Teams with the encrypted university account. All interviews were transcribed by the researcher (MY). The transcribed Microsoft Word documents were uploaded to NVivo for coding and establishing sub-themes and main themes (Bazeley & Jackson, 2019).

5.17 Ethical approval

Before starting any study, it is vital to follow ethical guidelines to ensure that no one is harmed, and participants fully understand the study requirements. In accordance with the guidelines of the UK Health Department's Research Ethics Service (Health Research Authority, 2013), this study and all related study materials were reviewed by a Research Ethics Committee (REC). Recruitment only started after the REC's approval of the final protocol and related material. The study received ethical approval from the Faculty of Medicine and Health Sciences REC, University of Nottingham, on 11/03/2021. REC reference was FMHS 172-0221.

5.18 Funding

This study was funded by the General Directorate for Higher and Foreign Education of the Ministry of National Education, Republic of Türkiye.

5.19 Summary of the methodology

- Concurrent mixed-method design was implemented for this study.
- Quantitative design was a feasibility of a RCT, and qualitative design was individual interviews with those using the mobile application.
- This study includes a complex intervention, adhering to the definition of complex interventions outlined by MRC Framework.
- Due to the COVID-19 pandemic, a pragmatic approach was taken to recruitment which occurred remotely via social media.
- This study was conducted by following the COVID-19 Regulations announced by the UK Government.

Chapter 6: Quantitative Results

Introduction

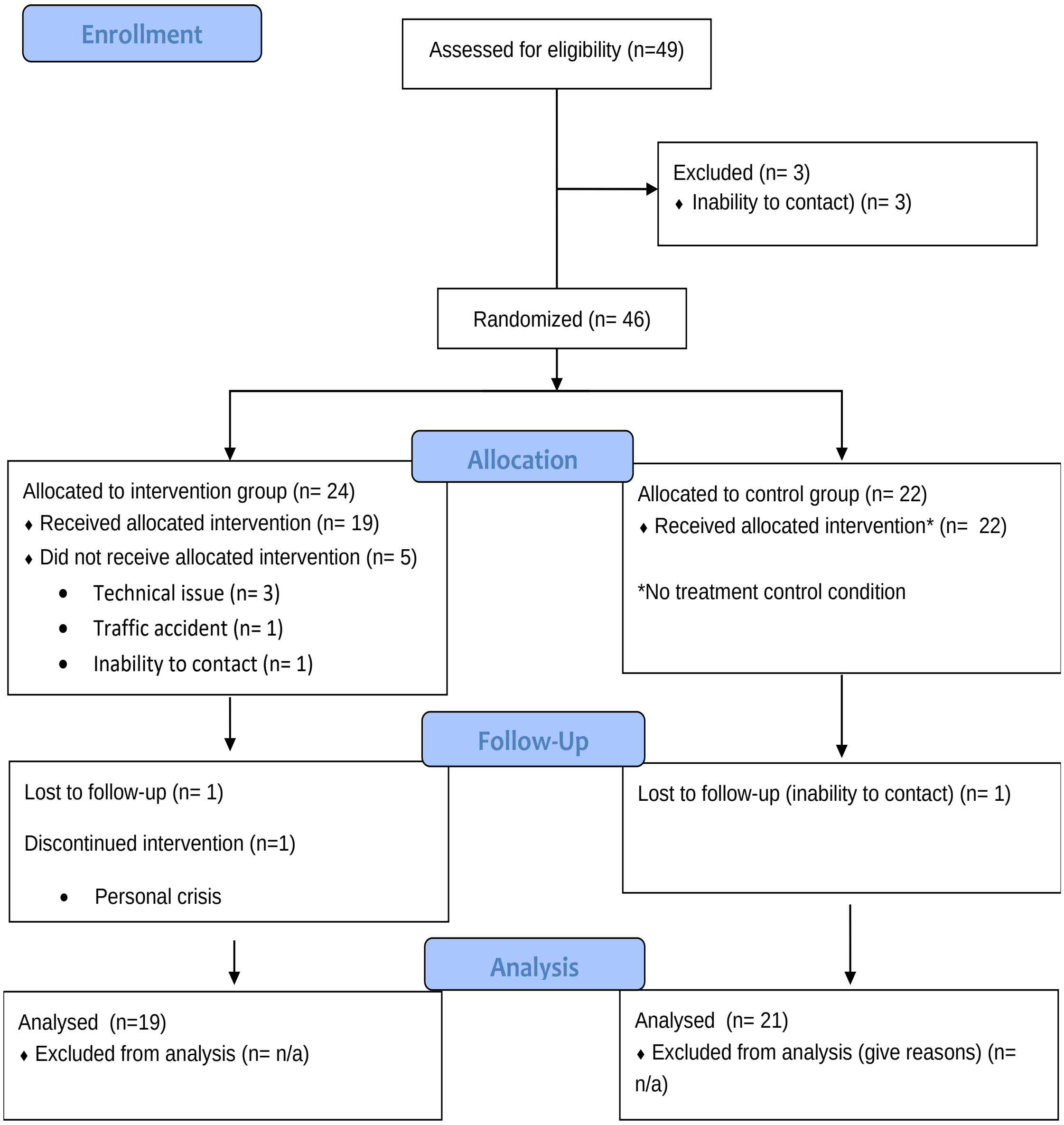
The first part of the results section presented quantitative data, including main outcomes on recruitment findings, pre-defined feasibility criteria, and dropouts with rationales. A sample size calculation was also provided to inform future RCTs. Demographic information was followed by findings on micro-level engagement, such as acceptability, usability, and frequency of daily engagement with the intervention. Additionally, usability results from the MAUQ were presented. Macro-level engagement, focusing on the intervention's efficiency, was assessed using WEMWBS and DASS-21 scores compared across the intervention and control groups.

6.1 Recruitment

The recruitment period was between 1st April 2021 and 15th November 2021. Convenience and snowball sampling were employed. The targeted participants were health and care workers and students from all around the UK, as outlined in the methodology chapter (Chapter 5). Social media (Twitter and Facebook) and professional networks were used for recruitment. The recruitment poster was also advertised in two online newsletters, the Foundation of Nursing Studies and the Florence Nightingale Foundation. The study invitation letter, the samples of the social posts, and the poster are given in Appendix 11.

During recruitment, 49 health and care workers/students were recruited (17 nurses, 17 students, three physiotherapists, two support workers, two primary care counsellors, and one midwife, medicine, psychotherapist, psychologist, and dentist). The detailed demographic information is presented in Table 13. Roughly eight participants were recruited per month. Details of participant eligibility and randomisation procedures are presented in Figure 11, following the CONSORT 2010 flow diagram (Moher et al., 2010).

Figure 11: CONSORT 2010 flow diagram



6.2 Demographic characteristics

Demographic descriptive results were gathered from 46 participants since three people dropped the study after signing the consent form. The survey completion rate was 100% among respondents who began the assessment process. The demographic characteristics of participants included age, gender, ethnicity, and occupational groups. Table 10 shows all participants' characteristics. The majority of participants were women (39, 84.8%), aged between 21-40 (36, 78.2%), and white ethnicity group (31, 67.3 %). Concerning the occupational group, the vast majority were nurses (17, 36.9%) and students (17, 36.9%). The healthcare students included Nursing (9), Psychology (4), Physiotherapy (2) and Medicine (2). The rest was physiotherapists (3), support workers (2), primary care counsellors (2), midwives (1), medicine (1), psychotherapists (1), psychologists (1), and dentists (1).

Table 10: Baseline participants' characteristics

Age	**n (%)**
18-20	1 (2.2)
21-30	22 (47.8)
31-40	14 (30.4)
41-50	5 (10.9)
51-60	1 (2.2)
60+	3 (6.5)
Gender	
Man	5 (10.9)
Woman	39 (84.8)
Non-Binary	2 (4.3)
Not disclose	-
Ethnicity	
White	31 (67.4)

Mixed	2 (4.3)
Black/Black British	1 (2.2)
Asian/Asian British	10 (21.7)
Chinese and others	2 (4.3)
Occupational group	
Nurse	17 (37)
Student*	17 (37)
Physiotherapist	3 (6.5)
Support worker	2 (4.3)
Primary care counsellor	2 (4.3)
Midwife	1 (2.2)
Medic	1 (2.2)
Psychotherapist	1 (2.2)
Psychologist	1 (2.2)
Dentist	1 (2.2)
*Students include nursing (9), psychology (4), physiotherapy (2), and medicine (2).	

Demographic information for the control and intervention group is presented in Table 11. The intervention group included 24 participants, and the control group was 22. Participants aged between 21-40 composed the vast majority of both groups (intervention = 16 and control = 20). The oldest participants were in the intervention group (60+), while the youngest were in the control group (16-20). The number of woman participants was 21 and 18 in the intervention and control groups, respectively. Both groups included men (one intervention and four control groups), but non-binary participants were in the intervention group (2). In relation to ethnicity, the white ethnic background was the highest in both groups, 16/24 and 15/22. The second highest ethnicity group was Asian/Asian British, 4/24 and 6/22. Nurses and healthcare students dominated the occupational group, with nine nurses and six students in the intervention group and eight nurses and 11 students in the control group. Five different minority occupational groups were in the intervention arm and three in the control group (see Table 11).

Table 11: Participants's characteristics within the groups

Characteristics n=46	Intervention (n, within group %)	Control (n, within group %)
Age		
18-20	-	1 (4.5)
21-30	9 (37.5)	13 (59.1)
31-40	7 (29.2)	7 (31.8)
41-50	4 (16.7)	1 (4.5)
51-60	1 (4.2)	-
60+	3 (12.5)	-
Gender		
Man	1 (4.2)	4 (18.2)
Woman	21 (87.5)	18 (81.8)
Non-Binary	2 (8.3)	-
Ethnicity		
White	16 (66.7)	15 (68.2)
Mixed	1 (4.2)	1 (4.5)
Black/Black British	1 (4.2)	-
Asian/Asian British	4 (16.7)	6 (27.3)
Chinese and others	2 (8.3)	-
Occupational group		
Nurse	9 (37.5)	8 (36.4)
Student	6 (25)	11 (50)
Physiotherapist	3 (12.5)	-
Support worker	2 (8.3)	-
Primary care counsellor	2 (8.3)	-
Medicine	1 (4.2)	-
Practitioner (Psychologist)	1 (2.2)	-
Midwife	-	1 (4.5)
Psychotherapist	-	1 (4.5)
Dentist	-	1 (4.5)

6.3 Study feasibility criteria

Four feasibility criteria were established prior to the study. These were: (1) total number of participants, (2) dropout rate, (3) retention rate, and (4) mobile application usage rate. Table 11 lists these target criteria and presents the achievement status according to this study's figures. The first criterion, the number of participants, was met with 49 participants. The second criterion, the dropout rate, was met at 20.5%. The current study dropout rate is 20.5%, which is less than 27% and lower than the results of systematic reviews mentioned in Methodology, Chapter 5.

The final criterion, the mobile application usage rate, reached 64.5%. All feasibility criteria were met following the study, suggesting that a fully scaled randomised control trial might be feasible in this field in the future. Additionally, the main study results demonstrated a lower dropout rate, higher retention rate, and higher average application usage days compared to the findings reported in the scoping review (Chapter 2).

Table 12: Feasibility criteria and status

Feasibility criteria	Target	Study figures	Achieved or not achieved
Number of participants	30-50	49	Achieved
Dropout rate	<27%	20.5%	Achieved
Application usage	>40%	64.5%	Achieved
Retention rate	>70%	79.5%	Achieved

Table 12: A feasibility outcomes comparison with findings derived from the scoping review (Chapter 2)

Feasibility items	N	%	Findings from the Scoping Review*
Dropout	10	20.50%	27%*
Retention	39	79.5%	73%*
Application usage (Number of days)	27.09/42	64.50%	40.90%*
*These numbers represent the average dropout rates, retention rate, and application usage days from the key articles in the scoping review (Chapter 2).			

6.4 Sample size calculation

Several factors need to be considered to calculate the sample size for an RCT with two independent groups, as conducted in this current study. These include an acceptable level of significance between the groups, the power of the study, the expected effect size, and the standard deviations in the primary outcome (Bhalerao & Kadam, 2010). The p-value, the probability of observing a given result by chance, is also important in determining the sample size and is typically set to 0.05.

In this feasibility study, the primary outcome measurement is the Warwick-Edinburg Mental Wellbeing Scale (WEMWBS). For this scale, the cutoff point for a meaningful change is 3.

G*Power, version 3.1.9.7, was used to calculate the sample size to inform future trials. The program followed the following steps.

- Test family = t-tests
- Means: Difference between two independent means (two groups)
- Type of power analysis = A priori: Compute required sample size – given alpha (p-value= .05), power (80%), and effect size (.3004134)
- Two tails and allocation ratio 1:1

According to the results, 348 participants are needed in total (174 for each group). Based on the expected dropout rate of 20.5%, this total number of participants reached 439.

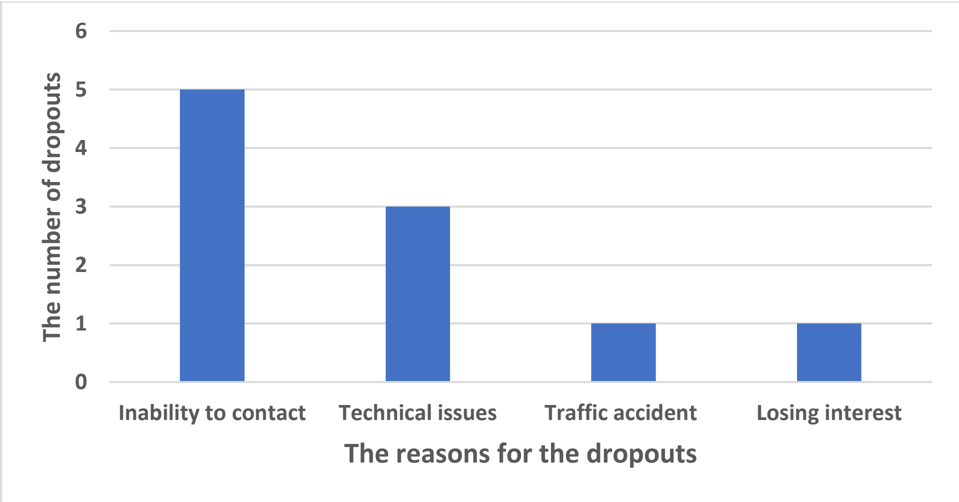
6.5 Dropouts

10 of 49 participants dropped out of the study for several reasons, including a technical problem, inability to contact, losing interest, and a traffic accident. The dropout rate was 20.5%, and the retention rate was 79.5%. Three participants dropped out of the study after filling out the consent form. Therefore, the baseline characteristics included 46 participants (see Table 13).

In the intervention group, 19 participants started using the mobile application, but six did not complete the post-survey, resulting in a 25% dropout rate (6/24). Reasons for dropping out included a technical issue (3), a traffic accident (1), inability to contact (1), and losing interest (1) (See Figure 12). Specifically, the major technical difficulty experienced by Android users involved an error message stating 'invalid email or password.' This issue could not be resolved. Due to this, three participants were unable to use the mobile application after consenting and completing the baseline survey. (Note: This major technical issue is different from the fixed bugs and glitches mentioned in the interviews.)

One dropout was in the control group (4%; 1/22). The reason was that the participant did not respond to the e-mails, which was classified as an inability to contact the participant.

Figure 12: The number of dropouts with rationales



6.6 Intervention Engagement

6.6.1 Micro-level engagement

Micro-level engagement refers to the usability and acceptability of the mobile application (Short et al., 2018). This section includes the daily usage of the mobile application, how often it was used, and what sub-items were preferred to track. It will also include the analysis of scores from the mHealth Application Usability Questionnaire (MAUQ).

Participants were asked to use the mobile application for 42 days (six weeks). 19 of 24 (79.1%) participants started to use the application. Table 13 presents how frequently 19 participants used the mobile application. The overall daily usage rate is 64.41% (514/789 days), and the total missing rate is 35.59% (284/789 days). Daily usage ranged between four and 42 days. Two of the 19 participants completed all 42 days. Over half of the participants (10) used the mobile application for at least 32 days, accounting for over 70% daily usage rate.

Table 13: The frequency of the application use

ID	Completed days (%)	Missing days (%)	Total Day
1	42 (100)	-	42
2	4 (10)	38 (90)	42
3	42 (100)	-	42
4	14 (34)	28 (66)	42
5	11 (27)	31 (73)	42
6	22 (53)	20 (47)	42
7	8 (20)	34 (80)	42
8	33 (79)	9 (21)	42
9	36 (86)	6 (14)	42
10	26 (62)	16 (38)	42
11	37 (89)	5 (11)	42
12	32 (77)	10 (23)	42
13	38 (91)	4 (9)	42
14	27 (65)	15 (35)	42
15	33 (79)	9 (21)	42
16	41 (98)	1 (2)	42
17	34 (81)	8 (19)	42
18	25 (60)	17 (40)	42
19	9 (22)	33 (78)	42
Total	**514 (64.41)**	**284 (35.59)**	**798 (100)**

Figure 13 below provides more specific information regarding the daily usage by participants. It gives which days were missed by how many participants. All 19 participants completed Days 1 and 2, implying that missing days occurred between Days 3 and 42. Day 37 is the most frequently missed day. This day has not been entered by 13 participants (13/19, 68.4%). The number of participants who missed the days ranged from three to thirteen. The trend line in the figure indicates that participants utilised the mobile application less frequently as the days progressed. According to the weekly basis (Figure 14), the lowest number of missing days was observed in the first week, with 23 days, while the highest was 63 days in the last week. Weeks 2, 3 and 4 showed a similar pattern with 45, 43 and 49 days, respectively; however, the missing days considerably increased in Weeks 5 and 6, with 61 and 63 days, respectively.

Figure 13: The pattern of missing days

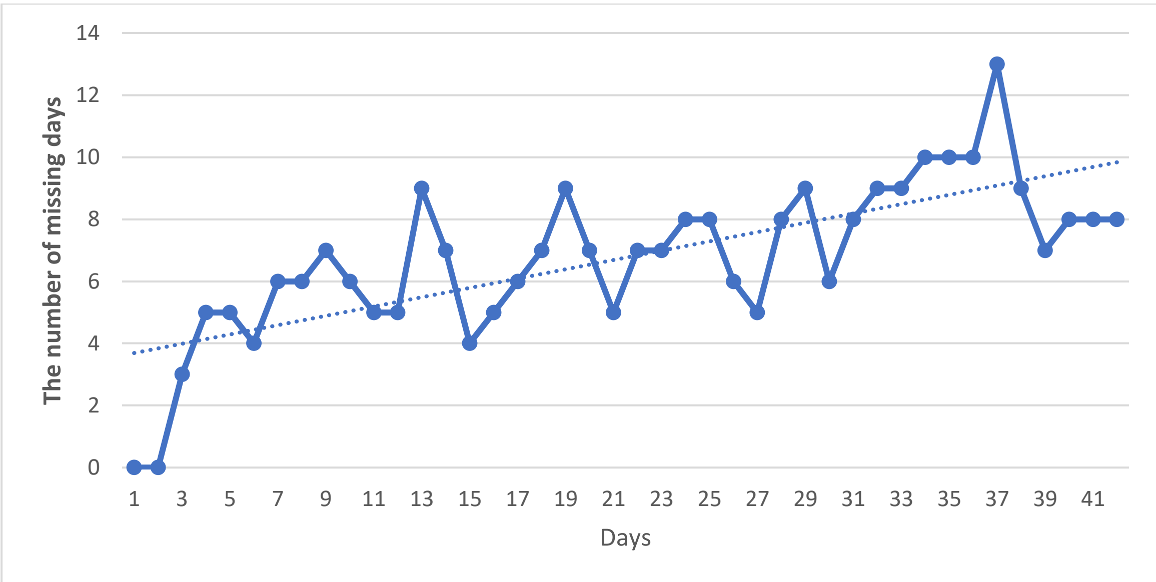
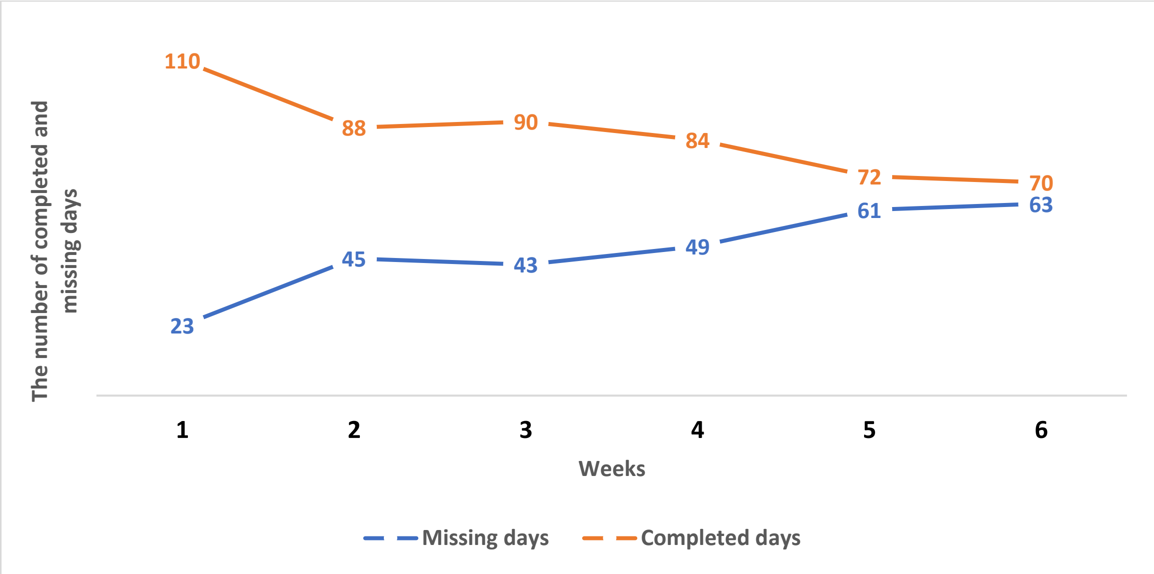


Figure 14: The pattern of missing and completed days on a weekly basis



6.6.1.1 Missing days by demographic characteristics

Figures 15, 16, 17, and 18 present the percentages of missed days by age, gender, ethnicity, and occupational background, respectively. The highest rates of missing days were observed among 31-40 ages (46.8%), non-binary (40.4), Asian/Asian British ethnic groups (61.1%), and physiotherapists (84.5%). The lowest rates were seen in 41-50 (10.7%), men (23.8%), mixed ethnicity (23.8%), and primary care counsellors (10.7). Two participants who completed all days were from the 41-50 and 60+ age groups: woman, non-binary, white, nurse, and primary care counsellor.

Figure 15: Percentages of missing days by age

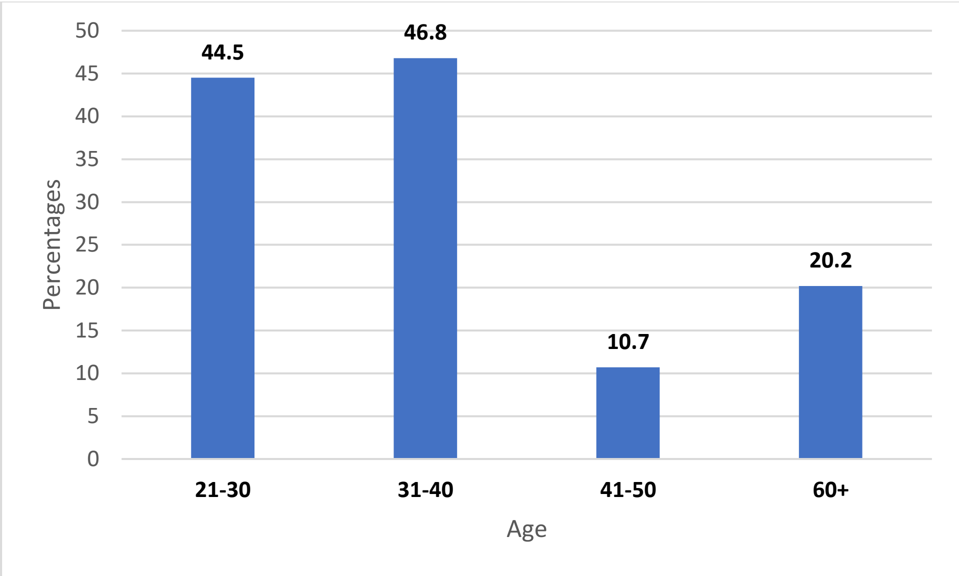


Figure 16: Percentages of the missing days by gender

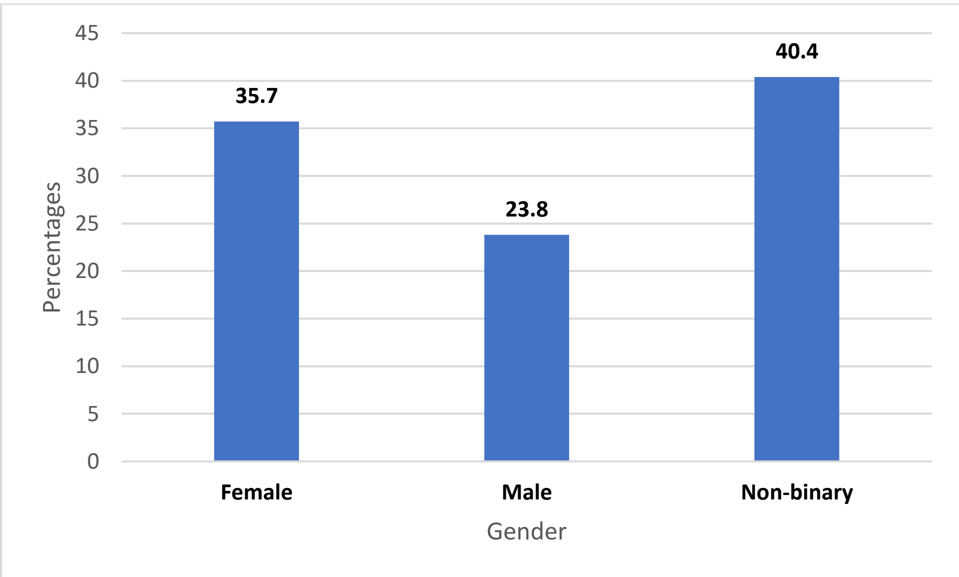


Figure 17: Percentages of missing days by ethnicity

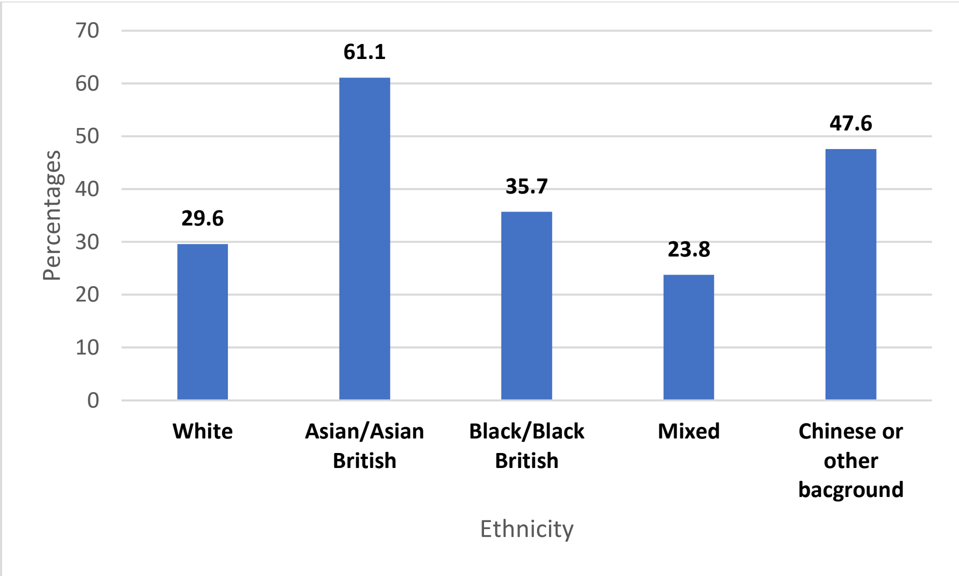
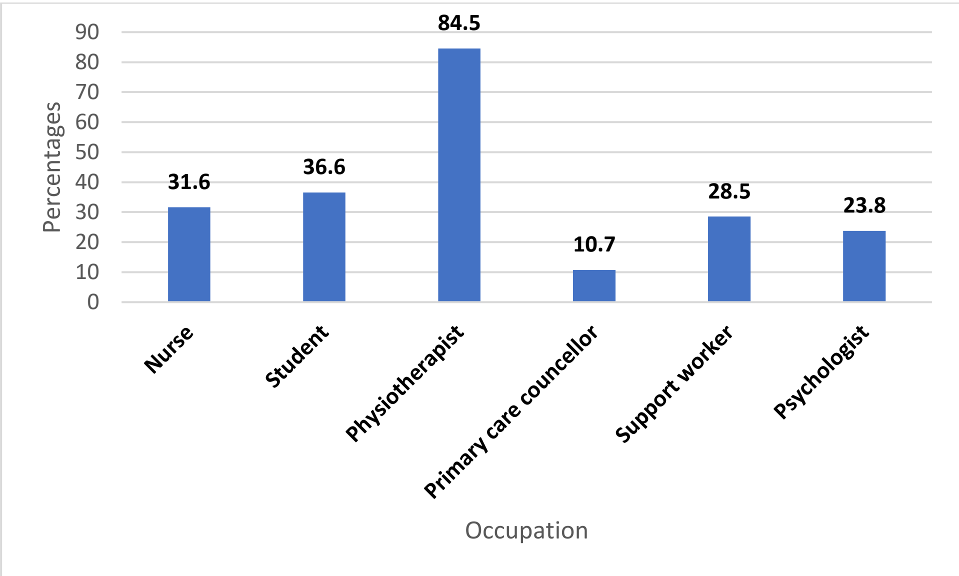


Figure 18: Percentages of missing days by occupation



6.6.1.2 Mental wellbeing tracking by questions

Table 14 provides which questions the participants preferred to track. Daily habit-related questions were selected more frequently than symptom-related questions. All 19 participants chose the four questions; “How are you today?”, "How many meals did you eat today?", "How many hours did you sleep last night?" and "Did you exercise today?". The other most common chosen questions were "Did you work today?" (15, 78.9%), "How many caffeinated drinks today" (11, 57.9%), "Have you felt work challenges today?" (10, 52.6%), "Have you felt low energy today?" (10, 52.6%), "Have you felt general worry today?" (8, 41.1%), "Have you felt anxiety today?" (8, 41.1%), and "Have you felt unable to focus today?" (8, 41.1%). There were seven questions selected by only one person (5.3%); "Have you felt irritable today?", "Have you felt anger today?", "Have you felt agitation today?" "Have you felt tearful?" "Have you felt withdrawn today?" "Did you struggle with your disability?" and "Have you felt hyper?".

Table 14: The chosen questions to monitor

Questions	N (%)
How are you today?	19 (100)
How many meals did you eat today?	19 (100)
How many hours did you sleep last night?	19 (100)
Did you exercise today?	19 (100)
Did you work today?	15 (78.9)
How many caffeinated drinks today?	11 (57.9)
Have you felt work challenges today?	10 (52.6)
Have you felt low energy today?	10 (52.6)
Have you felt general worry today?	8 (42.1)
Have you felt anxiety today?	8 (42.1)
Have you felt unable to focus today?	8 (42.1)
How many alcoholic drinks today?	5 (26.3)
Have you felt relationship challenges today?	5 (26.3)
Did you have your period today?	4 (21.1)

Did you experience menopause symptoms today?	4 (21.1)
Have you felt family challenges today?	4 (21.1)
Have you felt physical pain today?	3 (15.8)
Have you taken your medicine today?	3 (15.8)
How much did you smoke/vape today?	3 (15.8)
Have you felt lonely?	2 (10.6)
Have you felt financial challenges today?	2 (10.6)
Have you felt irritable today?	1 (5.3)
Have you felt anger today?	1 (5.3)
Have you felt agitation today?	1 (5.3)
Have you felt tearful?	1 (5.3)
Have you felt withdrawn today?	1 (5.3)
Did you struggle with your disability?	1 (5.3)
Have you felt hyper?	1 (5.3)

Table 15 shows the details of how frequently these questions were tracked by grouping the questions into Mood, Food, Sleep, Exercise, Caffeine intake, Alcohol, Nicotine, Period, and Menopause. Mood, Food, Sleep, and Exercise were chosen by all the participants (19). Fewer people preferred the other sub-items. Caffeine, Alcohol, Nicotine, Period, and Menopause were selected by 11, five, three, four and four people, respectively. The daily usage rates were similar among most four selected sub-items: Mood (64%), Food (62.8%), Sleep (64.5%), and Exercise (64.3%). The highest completion rate was reported in Nicotine (76.7%), while the lowest was in Menopause with 32.1%. Furthermore, the completion rates of Period and Menopause showed considerably lower proportions compared to the rest of the sub-items rates, 34.5% and 32.1%, respectively. In Figure 19, the missing days are summarised in descending order.

Table 15: The frequency of daily tracked items

Selected Items	Selected by how many participants	Total days (%)	Adherence percentages (%)	Missing percentages (%)
Mood	19	798	511 (64)	36
Food	19	798	501 (62.8)	37.2
Sleep	19	798	515 (64.5)	35.5
Exercise	19	798	513 (64.3)	35.7
Caffeine	11	462	243 (52.6)	47.4
Alcohol	5	210	115 (54.8)	45.2
Nicotine	3	126	84 (76.7)	33.3
Period	4	168	58 (34.5)	65.5
Menopause	4	168	54 (32.1)	67.9

Figure 19: Percentages of missing days by the items

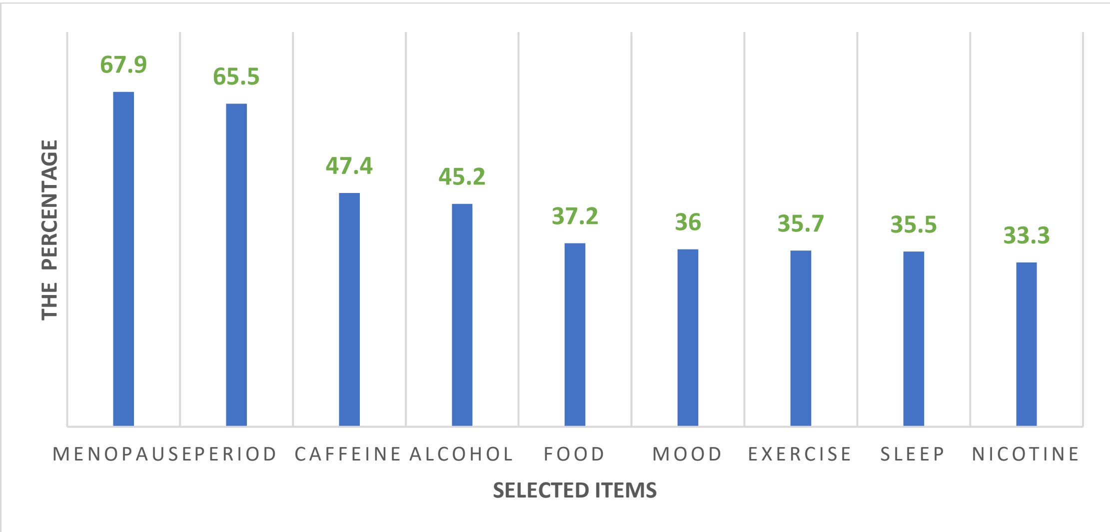


Table 16 shows the distribution of Caffeine, Alcohol, Nicotine, Period and Menopause monitoring based on demographic information. The age range of 21-40 exhibits the highest frequency of individuals reporting caffeine use. Mood, Food, Sleep, and Exercise were excluded, as all 19 participants selected them.

Table 16: The selected items by participants' characteristics

Demographics	Caffeine (n= 11)	Alcohol (n= 5)	Nicotine (n= 3)	Period (n= 4)	Menopause (n= 4)
Age					
16-20	-	-	-	-	-
21-30	4	2	1	2	-
31-40	4	-	-	1	1
41-50	2	2	2	1	1
51-60	-	-	-	-	-
60+	1	1	-	-	2
Gender					
Woman	8	5	2	4	4
Man	1	-	-	-	-
Non-Binary	2	-	1	-	-
Ethnicity					
White	8	5	3	3	3
Other	3	-	-	1	1
Occupational group					
Nurse	3	2	1	1	3
Student	4	2	-	2	1
Physiotherapist	1	1	1	1	-
Support worker	1	-	-	-	-
Primary care counsellor	1	-	1	-	-
Medicine	-	-	-	-	-
Practitioner (Psychologist)	-	-	-	-	-
Midwife	-	-	-	-	-
Psychotherapist	1	-	-	-	-
Dentist	-	-	-	-	-

6.6.1.3 Usability and Acceptability

In total, 18 participants completed the questionnaire, and 17 were included in the analysis. To ensure a reliable result, it is necessary to answer at least 15 questions. Consequently, one participant was excluded from the analysis due to having answered 14 questions.

Table 17 provides the means of the Likert scale, the means of scores, and the ranges for total and sub-scores of ease of use, interface and satisfaction, and usefulness. What is interesting in this data is that the total mean score was 5.2, implying that the overall usability and acceptability were "Good". Regarding the sub-items, participants found the application was easy to use at an excellent level. However, they were not highly satisfied with the application and reported that it was not useful for improving mental wellbeing.

Table 17: The findings from the mHealth App Usability Questionnaire

Items	The Likert scale Means	Mean scores (SD)	Range
The total score	5.2 - Good	84.17 (25.5)	35-123
Ease of use	6.2 - Excellent	28 (7.7)	9-35
Interface and satisfaction	4.8	33.83 (11.6)	15-49
Usefulness	4.1	22.33 (9.5)	9-41

6.6.2 Macro-level engagement

Macro-level engagement refers to the usefulness of mobile applications in promoting mental wellbeing (Short et al., 2018). Thus, this section provides outcomes from the Warwick Edinburg Mental Wellbeing Scales (WEMWBS), Depression Anxiety and Stress Scale (DASS-21), and help-seeking behaviour.

6.6.2.1 Baseline wellbeing, depression, anxiety, and stress scores by demographic characteristics

Table 18 provides the results of the Warwick Edinburg Mental Wellbeing Scale (WEMWBS) and Depression, Anxiety and Stress Scale (DASS-21) by demographic characteristics of 46 health and care workers/students. WEMWBS includes 14 questions about wellbeing. Each question has answers ranging from 1 (none of the time) to 5 (all of the time). The scale assigns wellbeing scores between 14-70. The total score was classified as low wellbeing for less than 43, moderate wellbeing for 43-60, and high wellbeing for greater than 60 (*Collect, score, analyse and interpret WEMWBS*, 2023). In this study, the mean score of the WEMWBS showed moderate wellbeing (mean= 48.57, SD= 7.5).

The DASS-21 comprises 21 questions, with seven questions for depression, anxiety, and stress. Answers assigned scores between 0 (never) and 3 (almost always). The scoring of the DASS-21 ranks each participant's depression, anxiety, and stress levels, classifying each area as either "normal," "mild," "moderate," "severe," or "extremely severe." (see Appendix 13). These terms are used to describe the full range of scores in a population. They do not mean the level of the disorder. According to this labelling, the DASS-21 scores of participants indicated a normal level of depression, anxiety, and stress. However, one participant in the Black/Black ethnic group showed extremely severe symptoms of depression, anxiety, and stress. Additionally, the two age groups (16-20 and 60+) and one occupational group (Dentist) reported a moderate level of Anxiety.

Table 18: Baseline findings from WEMWBS and DASS-21 by characteristics

Characteristics (n =46)	n	WEMWBS+ (SD)	Depression (SD)	Anxiety (SD)	Stress (SD)
Age					
16-20	1	43	12	10	12
21-30	2	48.18 (6.5)	8.27 (6.3)	7.27 (7.3)	13 (6.8)
31-40	4	49.36 (9.8)	9.14 (8.4)	8.14 (6.2)	15.57 (10.3)
41-50	5	46.40 (6.5)	7.20 (2.2)	3.20 (2.2)	12 (4.2)
51-60	1	43	12	2	18
60+	3	55 (3.6)	5.33 (3)	10 (8.7)	16 (6.9)
Gender					
Woman	9	47.85 (7.8)	8.97 (6.8)	7.85 (7)	14.97 (7.8)
Man	5	50.4 (2.8)	5.2 (1.7)	3.6 (1.6)	7.6 (2.9)
Non-Binary	2	58 (2.8)	5 (1.4)	4 (0)	10 (2.8)
Ethnicity					
White	1	49.94 (7.1)	7.74 (4.4)	6.19 (4.8)	13.74 (6.5)
Asian/Asian British	0	47 (6.8)	8.6 (8.2)	9.6 (8.9)	13.8 (8.5)
Mixed	2	48.5 (3.5)	5 (1.4)	3 (1.4)	6 (2.8)
Black/Black British	1	26	34	26	38
Chinese and others	2	46.5 (2.1)	8 (2.8)	6 (8.4)	14 (0)
Occupational group					
Nurse	7	46.35 (9.9)	10.35 (9.1)	9.53 (8.5)	15.88 (10.7)
Student	7	49.76 (5.3)	8.12 (4.1)	6.47 (5.5)	12.35 (4.7)
Physiotherapist	3	47 (6.9)	7.33 (5)	7.33 (6.1)	18 (8)
Support worker	2	54.5 (7.7)	5 (7)	2 (0)	12 (2.8)
Primary care counsellor	2	51.5 (6.3)	5 (1.4)	3 (1.4)	10 (2.8
Midwife	1	53	6	8	14
Medicine	1	49	2	2	8
Psychotherapist	1	42	8	4	18
Practitioner (Psychologist)	1	46	6	4	8

Dentist	1	57	8	10	16
Total	46	48.57 (7.5)	8.39 (6.4)	7.22 (6.6)	13.9 (7.6)

+Mental wellbeing range: low wellbeing= less than 43, moderate wellbeing= 43 – 60, and high wellbeing= greater than 60.

	Depression	Anxiety	Stress
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-18
Moderate	14-20	10-14	19-25
Severe	21-27	15-19	26-33
Extremely Severe	28+	20+	34+

In addition to the results above, the baseline level of wellbeing by demographic characteristics is presented in Table 19. According to the WEMWBS's labelling, most participants (82.6%) showed moderate wellbeing (38 of 46 participants), and no participants reported high levels of wellbeing. Eight participants (17.4%) showed low mental wellbeing aged between 21-50; women; White (6), Asian/Asian British (1), and Black/Black British (1); nurse (5), students (2), and physiotherapist (1).

Table 19: Baseline mental wellbeing

Characteristics	Low (%)	Moderate (%)	High (%)
Age			
18-20	-	1 (2.2)	-
21-30	4 (8.7)	18 (39.1)	-
31-40	2 (4.3)	12 (26.1)	-
41-50	2 (4.3)	3 (6.5)	-
51-60	-	1 (2.2)	-
60+	-	3 (6.5)	-
Gender			
Woman	8 (17.4)	31 (67.4)	-

Man	-	5 (10.9)	-
Non-Binary	-	2 (4.3)	-
Ethnicity			
White	6 (13)	25 (54.3)	-
Asian/Asian British	1 (2.2)	9 (19.6)	-
Mixed	-	2 (4.3)	-
Black/Black British	1 (2.2)	-	-
Chinese and others	-	2 (4.3)	-
Occupational group			
Nurse	5 (10.9)	12 (26.1)	-
Student	2 (4.3)	15 (32.6)	-
Physiotherapist	-	3 (6.5)	-
Support worker	-	2 (4.3)	-
Primary care counsellor	-	2(4.3)	-
Midwife	-	1 (2.2)	-
Medicine	-	1 (2.2)	-
Psychotherapist	1 (2.2)	-	-
Practitioner (Psychologist)	-	1 (2.2)	-
Dentist	-	1 (2.2)	-
Total 46 (100)	**8 (17.4)**	**38 (82.6)**	**-**

6.6.2.2 The summary of mental wellbeing, depression, anxiety, and stress scores before and after the intervention

Table 20 displays the WEMWBS and DASS-21 mean scores before and after the intervention. The number of respondents was 46 before the intervention and 39 after the intervention. The total means of WEMWBS showed a slight increase after the intervention. (Before mean= 48.57 SD= 7.58, and after mean= 49.49 SD= 9.87). Based on the WEMWBS score classification, these numbers indicated that the participants' level of wellbeing was moderate before and after the intervention. Additionally, there was no statistically significant difference between the means (p-value= .37).

DASS-21 scores also showed a similar trend to the WEMWBS scores. Before and after the intervention, Depression, Anxiety, and Stress scores were in normal ranges based on the DASS-21 severity labelling (See Appendix 13). According to the Paired sample t-test, no significant difference before and after the intervention was seen in three aspects: Depression (p-value= .71), Anxiety (p-value= .71), and Stress (p-value= .73).

Table 20: Comparison between baseline and post-intervention figures from WEMWBS and DASS-21

Questionnaires	N	Before (Means and SD)	N	After (Means and SD)	p-value*
WEMBWS (Total)	46	48.57+ (7.58)	39	49.49+ (9.87)	.37
Depression	46	8.39 (6.48)	39	9.03 (7.03)	.71
Anxiety	46	7.22 (6.63)	39	7.49 (7.36)	.71
Stress	46	13.96 (7.67)	39	13.74 (7.72)	.73

*Paired sample t-test. Significant at p< .05.
+Moderate level of mental wellbeing: 43 to 60.

Table 21 compares the mean scores of wellbeing, depression, anxiety, and stress within the groups, control, and intervention. In the control and intervention groups, there was no change in relation to the level of wellbeing before and after the intervention; a moderate level of wellbeing was reported before and after the intervention. In terms of the mean of wellbeing scores, there was a slight increase after the intervention in the control group (before mean= 47.64 SD= 7.4, and after mean= 50.05 SD= 9.1); in contrast, a slight decrease was seen in the intervention group (before mean= 49.42 SD= 7.7, and after mean= 48.83 SD= 10.8). However, these differences were not statistically significant (control group p-value= .22, intervention group p-value= .97).

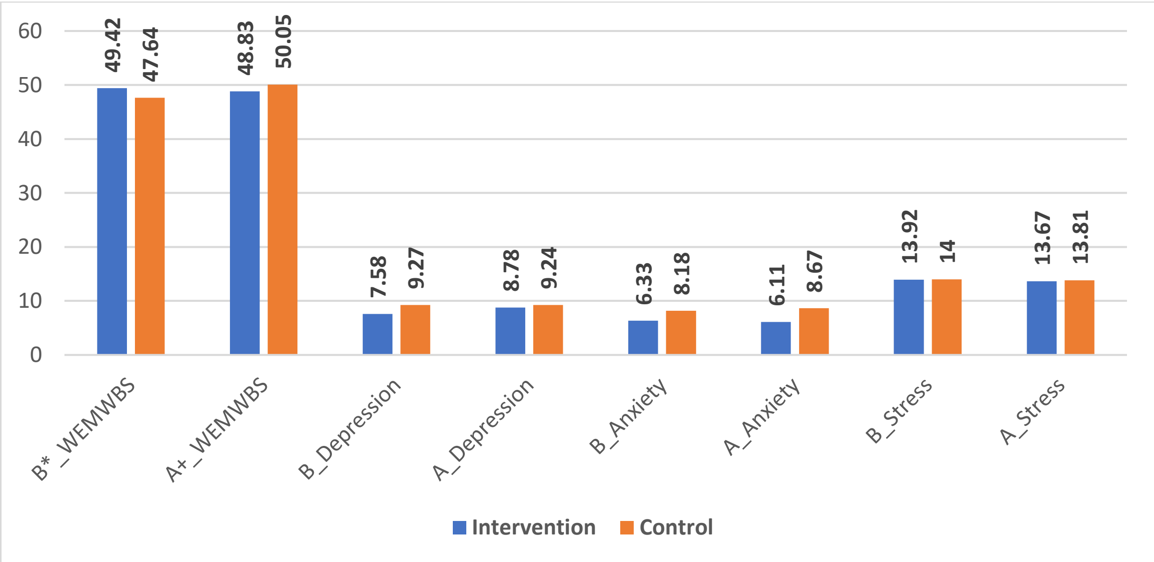
Table 21: The mean scores of wellbeing, depression, anxiety, and stress within the groups

	Before intervention	After intervention	p-value*
Control group			
WEMWBS	47.64 (7.4)	50.05 (9.1)	.22
Depression	9.27 (6.3)	9.24 (5.2)	.94
Anxiety	8.18 (6.8)	8.67 (6.9)	.77
Stress	14 (8.3)	13.81 (6.8)	.96
Intervention			
WEMWBS	49.42 (7.7)	48.83 (10.8)	.97
Depression	7.58 (6.6)	8.78 (8.8)	.61
Anxiety	6.33 (6.4)	6.11 (7.7)	.54
Stress	13.92 (7.2)	13.67 (8.7)	.64
*Significant at p<.05			

Figure 20 provides the comparison of wellbeing, depression, anxiety, and stress mean scores between the intervention and control groups. In the figure, B refers to "before the intervention", and A refers to "After the intervention". While the wellbeing score was higher in the intervention group at the beginning of the intervention (mean= 49.42 SD= 7.7), after the intervention, the wellbeing score was higher in the control group (mean= 50.05 SD= 9.1). This means that the wellbeing improvement was higher in the control group compared to the intervention group. However, there was no change in the level of wellbeing based on the WEMWBS classification. Additionally, no statistically significant change was observed.

In the DASS-21 scores, it is seen that depression, anxiety and stress scores of the control group were slightly higher than the intervention group after the intervention. These differences showed no change in depression, anxiety and stress levels based on the DASS-21 severity labelling. Also, there was no statistically significant change between the groups before and after the intervention.

Figure 20: The comparison of wellbeing, depression, anxiety, and stress scores within the groups



*B: Before the intervention and +A: After the intervention

6.6.2.3 WEMWBS results in the control group

Table 22 compares the WEMWS scores before and after the intervention in the control group. The number of respondents before the intervention was 22, and after the intervention, it was 21, indicating a retention rate of 95.4%. Before the intervention, 27.3% of respondents showed a low level of wellbeing, while 72.7% showed a moderate level of wellbeing. There were no reports of high levels of wellbeing. However, after the intervention, 14.3% reported a high level of wellbeing, while the rate of low wellbeing was 71.4% and moderate wellbeing was 14.3%.

The total wellbeing score slightly increased after the six weeks (Before the intervention mean= 47.64 SD= 7.4 and after the intervention mean= 50.05 SD= 9.1, positive change = +2.41). Both mean scores represent a moderate level of mental wellbeing, and there was no statistically significant difference between before and after the intervention (p-value= .22 >.05). Ten participants (47.6%) showed a positive meaningful change. In contrast, five (28.5%) experienced a negative meaningful change. Regarding the mean wellbeing scores based on characteristics, the highest positive change was observed in nurses, with +5.5. The only negative change was seen in the dentist group with -7.

Table 22: The comparison of wellbeing scores before and after the intervention in the control group

	Before intervention	After intervention	Change	Positive change?	Statistically significant change?
The number of respondents	22	21			
% Low wellbeing	27.3%	14.3%			
% Moderate wellbeing	72.7%	71.4%			
% High wellbeing	-	14.3%			
Mean score	47.64	50.05	+2.41	Yes	No
Standard deviation	7.4	9.1	+1.7	Yes	
By age					
18-20	43	44	+1	Yes	
21-30	46.69	48.85	+2.16	Yes	
31-40	50.86	53.14			
41-50	42	-			
51-60	-	-			
60+	-	-			
By gender					
Woman	46.78	48.88	+2.1	Yes	
Man	51.50	55	+3.5	Yes	
Non-Binary	-	-			
By ethnicity					
White	47.73	48.93	+1.2	Yes	
Asian/Asian British	46.83	50.17	+3.34	Yes	
Mixed	51	65	+14	Yes	
Black/Black British	-	-			
Chinese and others	-	-			
By occupational group					
Nurse	44.75	50.25	+5.5	Yes	
Student	48.91	49.55	+.64	Yes	

Midwife	53	54	+1	Yes
Psychotherapist	42	-	-	
Dentist	57	50	-7	No
Number of people with a meaningful positive change 7 (33.3%)				
Number of people with a meaningful negative change 4 (19%)				
*Significant at p<.05				

Figure 21:Illustration of the percentages of wellbeing levels before and after the intervention

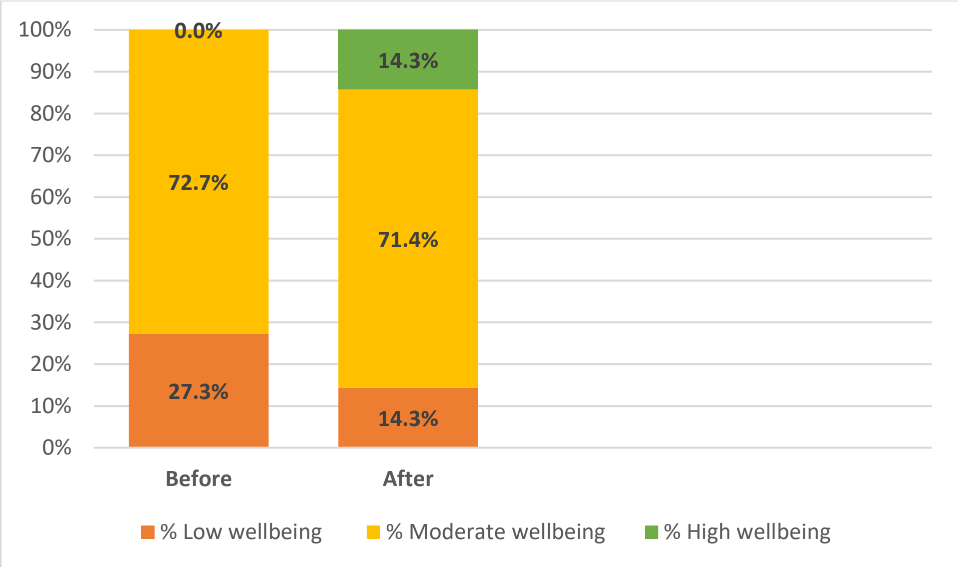


Table 23 gives the change between the before-and-after intervention scores of each WEMWBS question. There were 12 positive changes and two negative changes. The meaningful change was observed only in the 14th question, "I have been feeling cheerful," p-value= .01.

Table 23: Positive and negative changes in wellbeing statements (WEMWBS)

	Before Mean (SD)	After Mean (SD)	Change	p-value*
I've been feeling optimistic about the future	3.50 (.67)	3.86 (.79)	+.36	.11
I've been feeling useful	3.45 (.91)	3.62 (.92)	+.16	.62

I've been feeling relaxed	2.77 (.92)	3.00 (.77)	+.23	.17
I've been feeling interested in other people	3.32 (.89)	3.24 (94)	-.08	.69
I've had energy to spare	3.09 (.86)	3.24 (1.04)	+.15	.81
I've been dealing with problems well	3.36 (.90)	3.71 (.90)	+.35	.20
I've been thinking clearly	3.50 (.85)	3.71 (1.05)	+.21	.40
I've been feeling good about myself	3.45 (.96)	3.67 (.91)	+.21	.38
I've been feeling close to other people	3.45 (.67)	3.48 (.87)	+.02	1.0
I've been feeling confident	3.50 (.91)	3.81 (.75)	+.31	.08
I've been able to make up my mind about things	3.68 (.83)	3.71 (.90)	+.03	1.0
I've been feeling loved	3.91 (.86)	3.76 (1.09)	-.15	.70
I've been interested in new things	3.55 (.80)	3.62 (.86)	+.07	.83
I've been feeling cheerful	3.09 (.86)	3.62 (.97)	+.53	**.01**
*Significant at p<.05				

6.6.2.4 WEMWBS results in the intervention group

In the intervention group, the changes in the scores of WEMWBS are presented in Table 24. Before the intervention, 24 participants completed the survey. However, this number decreased to 18 after the intervention. Most participants reported a moderate level of wellbeing before the intervention, 91.7%, while 8.3% showed a low level of mental wellbeing. There was no substantial change in the percentages of low and moderate levels of mental wellbeing after the intervention, 22.2% and 77.8%, respectively. Interestingly, there was no person with a high level of mental wellbeing before and after the intervention in this group.

In a comparison of the mean scores of WEMWBS before and after the intervention, there was a slight decrease after the intervention. However, the difference was not statistically significant. (Before mean= 49.42 SD= 7.7, After mean= 48.83 SD= 10.8, the negative change= -.53, p-value= .79). However, slightly more than half (52.9) reported a positive meaningful change in their wellbeing scores. In contrast, six participants (35.2%) showed a negative change. Based on the characteristics of the participants, the highest positive change was seen in the Mixed Ethnicity, Man and Practitioner occupational group with +8. The highest negative change was observed in Asian/Asian British ethnicity, with -6.92.

Table 24: The comparison of wellbeing scores before and after the intervention in the intervention group

	Before intervention	After intervention	Change	Positive change?	Statistically significant change?
The number of respondents	24	18			
% Low wellbeing	8.3%	22.2%			
% Moderate wellbeing	91.7%	77.8%			
% High wellbeing	-	-			
Mean score	49.42	48.83	-.53	No	No
Standard deviation	7.7	10.8	-3.1	No	
By age					
18-20	-	-	-		
21-30	50.33	48.67	-1.66	No	
31-40	47.86	45.83	-2.03	No	
41-50	47.5	49.75	2.25	Yes	
51-60	43	-	-		
60+	55	56.5	1.5	Yes	

By gender				
Woman	48.76	47.53	-1.23	No
Man	46	54	8	Yes
Non-Binary	58	56	-2	No
By ethnicity				
White	52	52.08	.08	Yes
Asian/Asian British	47.25	40.33	-6.92	No
Mixed	46	54	8	Yes
Black/Black British	26	26	-	
Chinese and others	46.5	53	6.5	Yes
By occupational group				
Nurse	47.78	46	-1.78	No
Student	51.33	54.4	3.07	Yes
Physiotherapist	47	21	-26	No
Support worker	54.5	49	-4.5	No
Primary care counsellor	51.5	56	4.5	Yes
Medicine	49	-		
Practitioner (Psychologist)	46	54	8	Yes
Number of people with a meaningful positive change 7 (38.8%)				
Number of people with a meaningful negative change 5 (27.7%)				
*Significant at p<.05				

Figure 22: Illustration of the percentages of wellbeing levels before and after the intervention

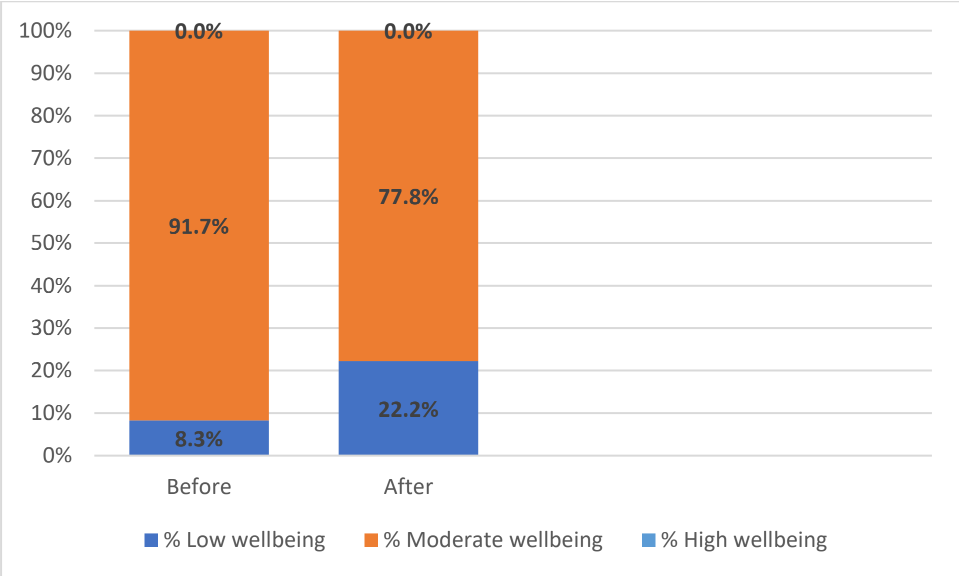


Table 25 provides the positive and negative changes for each WEMWBS question before and after the intervention. Five positive and nine negative changes were reported; however, these changes were not statistically significant.

Table 25: Positive and negative changes in wellbeing statements (WEMWBS)

	Before Mean (SD)	After Mean (SD)	Change	p-value*
I've been feeling optimistic about the future	3.63 (.71)	3.56 (1.09)	-.07	.81
I've been feeling useful	4.04 (.75)	3.78 (.73)	-.26	.29
I've been feeling relaxed	2.88 (.74)	3.06 (.93)	+.18	.16
I've been feeling interested in other people	3.63 (.87)	3.72 (1.01)	+.09	.21
I've had energy to spare	2.92 (.88)	3.11 (.83)	+.19	.16
I've been dealing with problems well	3.50 (.78)	3.67 (.68)	+.16	.23
I've been thinking clearly	3.67 (.86)	3.61 (.97)	-.06	.33

I've been feeling good about myself	3.42 (.71)	3.50 (1.04)	+.08	.80
I've been feeling close to other people	3.63 (.77)	3.22 (1.26)	-.41	.09
I've been feeling confident	3.54 (.65)	3.22 (.94)	-.32	.23
I've been able to make up my mind about things	3.75 (.73)	3.67 (.97)	-.08	1.0
I've been feeling loved	3.96 (.99)	3.89 (1.13)	-.07	.81
I've been interested in new things	3.46 (.83)	3.39 (.97)	-.07	.57
I've been feeling cheerful	3.46 (.72)	3.44 (.92)	-.02	.82
*Significant at p<.05				

6.6.2.5 DASS-21 results in the control group

The comparison of DASS-21 scores before and after the intervention is presented with demographic characteristics in Table 26. There was no substantial change in Depression, Anxiety, and Stress scores in the baseline and after the six weeks. Overall, all scores were in the normal range according to the DASS-21 labelling symptom severity. From the data in the total scores, there was a slight decrease in Depression and Stress after the intervention (before and after depression means= 9.27 and 9.24 SD= 6.3 and 5.2 – before and after stress means= 14 and 13.81 SD= 8.3 and 6.8). On the other hand, anxiety scores slightly increased from 8.18 (SD= 6.8) to 8.67 (SD= 6.9).

Table 26: Comparison of depression, anxiety, and stress scores

Characteristics	n	Depression Before Mean and (SD)	Depression After Mean and (SD)	Anxiety Before Mean and (SD)	Anxiety After Mean and (SD)	Stress Before Mean and (SD)	Stress After Mean and (SD)
Age							
18-20	1	12	10	10	6	12	12
21-30	13	10.62 (7)	10 (5)	9.23 (8.5)	9.85 (8.1)	14 (7.6)	14.62 (7.1)
31-40	7	6.57 (4.9)	7.71 (5.9)	6.57 (2.5)	6.86 (4.7)	13.71 (11.1)	12.57 (7.2)
41-50	1	8	-	4	-	18	-
51-60	-	-	-	-	-	-	-
60+	-	-	-	-	-	-	-
Gender							
Woman	18	10.22 (6.5)	9.88 (5.3)	9.22 (7.1)	8.59 (7.6)	15.44 (8.4)	14.71 (7.2)
Man	4	5 (2)	6.5 (4.1)	3.5 (1.9)	9 (3.4)	7.5 (3.4)	10 (3.6)
Non-Binary	-	-	-	-	-	-	-
Ethnicity							
White	15	9.07 (4.6)	10.43 (5.4)	6.8 (4.7)	7.71 (6.6)	15.07 (7.8)	15.29 (7.5)
Asian/Asian British	6	10.67 (9.9)	7.67 (3.8)	12.67 (9.7)	11.33 (8.2)	13 (9.6)	11.67 (4.4)
Mixed	1	4	2	2	6	4	6
Black/Black British	-	-	-	-	-	-	-

Chinese and others	-	-	-	-	-	-	-
Occupational group							
Nurse	8	10.25 (9.2)	8.25 (5.4)	8 (9.5)	6.75 (7.9)	13.5 (12.9)	11.5 (7.9)
Student	11	9.09 (4.6)	10.18 (5.3)	8.55 (5.6)	10.18 (6.8)	13.82 (5.1)	15.45 (6.5)
Physiotherapist	-	-	-	-	-	-	-
Support worker	-	-	-	-	-	-	-
Primary care counsellor	-						
Midwife	1	6	4	8	10	14	12
Medicine		-	-	-	-	-	-
Psychotherapist	1	8	-	4	-	18	-
Practitioner (Psychologist)	-	-	-	-	-	-	-
Dentist	1	8	12	10	6	16	16
Total	22	9.27 (6.3)	9.24 (5.2)	8.18 (6.8)	8.67 (6.9)	14 (8.3)	13.81 (6.8)

6.6.2.6 DASS-21 results in the intervention group

The comparison of DASS-21 scores before and after the intervention is provided in Table 27. Overall, the means of depression, anxiety, and stress before and after the intervention were in normal ranges based on the DASS-21 labelling. A slight increase was observed in depression scores after the intervention (before mean= 7.58 SD= 6.6 and after mean= 8.78 SD= 8.8). However, anxiety and stress scores were slightly decreased after the intervention. (Anxiety before and after means= 6.33 and 6.11 SD= 6.4 and 7.7 – Stress before and after means= 13.92 and 13.67 SD= 7.2 and 8.7).

Participants in the 31-40 age group showed mild stress levels before and after the intervention. Similarly, Asian/Asian British participants reported mild levels of stress, and their depression and anxiety increased to a moderate level after the intervention. Nurses reported mild levels of depression, anxiety, and stress, but their anxiety decreased to the normal level after the intervention.

Table 27: Comparison of depression, anxiety, and stress scores

Characteristics	n	Depression Before Mean and (SD)	Depression After Mean and (SD)	Anxiety Before Mean and (SD)	Anxiety After Mean and (SD)	Stress Before Mean and (SD)	Stress After Mean and (SD)
Age							
18-20	-	-	-	-	-	-	-
21-30	9	4.89 (3.1)	7.67 (11.2)	4.44 (4)	8.67 (10.7)	11.56 (5.7)	12.67 (11)
31-40	7	11.71 (10.06)	9.67 (8.8)	9.71 (8.5)	6.33 (7.6)	17.43 (9.9)	17.33 (8.8)
41-50	4	7 (2.5)	10.5 (9.2)	3 (2.5)	2.5 (3.7)	10.5 (3)	12 (7.4)
51-60	1	12	-	2	-	18	-
60+	3	5.33 (3)	6 (2.8)	10 (8.7)	5 (4.2)	16 (6.9)	9 (1.4
Gender							
Woman	21	7.9 (7)	9.73 (9.4)	6.67 (6.8)	6.93 (8.2)	14.57 (7.4)	13.87 (9.6)
Man	1	6	6	4	2	8	12
Non-Binary	2	5 (1.4)	3 (1.4)	4 (0)	2 (0)	10 (2.8)	13 (1.4)
Ethnicity							
White	16	6.5 (3.8)	6.83 (6.9)	5.63 (5)	5.17 (5.5)	12.5 (4.9)	11 (6.1)
Asian/Asian British	4	5.5 (4.1)	14.67 (13.6)	5 (6)	12.67 (15.5)	15 (7.7	18 (14.4)
Mixed	1	6	6	4	2	8	12
Black/Black British	1	34	24	26	8	38	32
Chinese and others	2	8 (2.8)	2 (0)	6 (8.4)	0	14 (0)	16 (0)

Occupational group							
Nurse	9	10.44 (9.6)	11.43 (9.1)	10.89 (7.9)	6.57 (6.9)	18 (8.7)	16.57 (9.3)
Student	6	6.33 (2.3)	4 (5.6)	2.67 (2.4)	3.2 (3)	9.67 (2.3)	8.4 (4.3)
Physiotherapist	3	7.33 (3)	30	7.33 (6.1)	30	18 (3)	34
Support worker	2	5 (7)	8 (2.8)	2 (0)	7 (1.4)	12 (2.8)	13 (1.4)
Primary care counsellor	2	5 (1.4)	3 (1.4)	3 (1.4)	1 (1.4)	10 (2.8)	8 (5.6)
Midwife	-	-	-	-	-	-	-
Medicine	1	2	-	2	-	8	-
Psychotherapist	-	-	-	-	-	-	-
Practitioner (Psychologist)	1	6	6	4	2	8	12
Dentist	-	-	-	-	-	-	-
Total	24	7.58 (6.6)	8.78 (8.8)	6.33 (6.4)	6.11 (7.7)	13.92 (7.2)	13.67 (8.7)

6.6.2.7 Help-seeking behaviour and contamination

The participants were asked if they sought any help for mental health support during the intervention. This question was asked to discover whether the mobile application could encourage or increase more help-seeking behaviours among participants compared to the control group. In the intervention group, 22.2% of the participants reported seeking help, including a GP appointment, speaking with the coach, husband, or friends. Similarly, in the control group, 23.8% reported seeking help behaviours, including speaking with a friend, supervisor, or colleague.

Regarding contamination, it was inquired if the participants used any other mental health-related mobile application during the study period. The aim was to identify if there was an external impact on the mental wellbeing status by using any other mental health-related mobile application. It is important to note that at the beginning of the study, the participants were not told that they should/should not use any other mental health-related mobile application.

There was no substantial difference in the use of other mobile applications between the groups. The majority of participants in the control (90.5%) and intervention (94.4%) groups did not use other mental health-related mobile applications during the intervention. One participant (5.6%) reported using another mobile application in the intervention group, and two participants (9.5%) used another mobile application in the control group.

Table 28: Help-seeking behaviour and contamination numbers in the groups

The intervention group	**n (%)**
Help-seeking behaviour	
Yes	4 (22.2)
No	14 (77.8)
Other application use	
Yes	1 (5.6)
No	17 (94.4)
Total	18 (100)
The control group	**n (%)**
Help-seeking behaviour	
Yes	5 (23.8)
No	16 (76.2)
Other application use	
Yes	2 (9.5)
No	19 (90.5)
Total	21 (100)

6.7 Summary of the quantitative results

- Pre-defined feasibility criteria were met, including recruitment numbers, retention/dropout rates, and application usage.
- Daily application use exceeded the average rate reported in prior studies (the Scoping Review, Chapter 2).
- Food, mood, exercise, sleep, caffeine intake, and alcohol consumption were the most frequently monitored items.
- No substantial changes were identified in wellbeing, depression, anxiety, and stress scores.
- Application use prompted help-seeking behaviour in a small number of participants.

Chapter 7: Qualitative Findings

Introduction

This chapter presented the findings of individual interviews with thirteen participants. It began by describing their characteristics. The process of generating themes was then briefly explained, followed by a summary of the findings using key themes and representative quotes. Finally, a more detailed report on both main and subthemes was provided.

7.1 Descriptions of the participants

All interviews were conducted between 24/06/2021 and 22/02/2022. Interviews lasted between 11 minutes and 37 minutes (Mean:19 minutes). The interview guide was generated by the PhD student Mehmet Yildirim (Mental Health Nurse) under the supervision of Prof. Holly Blake (Behavioural Psychologist) and Dr. Tim Carter (Assistant Professor in Mental Health). The guide is given in Appendix 15. All interviews were facilitated by MY, who is trained in qualitative research and interview skills.

The total number of participants is 13. The total sample comprised ten women, two non-binary, and one man. Their ages range from 21 to 60+ years. A range of ethnicities were included. Participants' occupations were nurse (5), health and care student (5), Physiotherapist (1), Primary care counsellor (1), and Psychologist (1). Table 29 presents the distribution of all participants' characteristics by age, gender, ethnicity, and occupational groups.

Table 29: Characteristics of Interviewees

Age	N	%
21-30	5	38.5
31-40	3	23.1
41-50	3	23.1
60+	2	15.3
Gender		
Man	1	7.7
Woman	10	76.9
Non-Binary/not disclose	2	15.4
Ethnicity		
White	11	84.6
Others	2	15.4
Occupational group		
Nurse	5	38.5
Student	5	38.5
Physiotherapist	1	7.7
Primary care counsellor	1	7.7
Practitioner Psychologist	1	7.7

Table 30 shows the description of the analytic steps undertaken while doing an analysis of the thirteen interviews.

Table 30: Description of analytic steps

Analytic steps suggested by Braun and Clarke (2006, 2013)	Analytic steps of this study
Familiarisation with the data	Verbatim transcription with a focus on the systematic and equal transcription of all the interviews. The interviewer read all the interviews several times and recorded the initial pre-codes and thoughts.
Generating initial codes	Patterns concerning themes were identified as initial thoughts and reflections. The data-driven focus was on the actual verbal statements and not the studies' goals.

Searching for themes	Codes were divided into themes and sub-themes. The differences between the interviews were critically reviewed. Themes and sub-themes were discussed regarding their relevance to the studies' goals.
Reviewing themes	The themes were critically reviewed once more to determine the core meaning of the themes, and initial themes that had a certain pattern of similarities were joined together as one theme. The interviews were listened to once more to try to ensure that all relevant themes had been captured during the analytic process.
Defining and naming themes	Discussion between the interviewer and supervisory team about the definition and precision of the relevant themes to the research questions. Applying relevant names to describe the core of the theme.
Producing the report	Mutual discussion between the supervisory team about the themes and how to describe them in an article.

7.2 Findings

Four themes were generated, with a total of 11 sub-themes. The four main themes were *"Usefulness"*, *"Enablers of engagement"*, *"Barriers to engagement"*, and *"Suggested improvements"*. The main themes and sub-themes with representative quotes are presented in Table 31.

Table 31: Key themes and sub-themes with representative quotes

Themes	Sample quotes
Usefulness	
• **Impact on behaviours**	"Another thing maybe I can say my caffein intake. I am drinking lots of coffee, but I try to decrease my caffein intake. I try to drink one,

	two, or three coffees." Participant 16, Healthcare student, Woman. "I think it was useful in terms of like sleep, like monitoring your sleep and stuff because that's one thing that I've been trying to get more of, so that was useful." Participant 5, Healthcare student, Woman.
• **Impact on mental wellbeing**	"I didn't realise until I started the app (MYARKEO). That I was in pain every day, which was really interesting. Then I reflected on that. I started to get up and move more in [...03:08] and also, I think it helped me kind of understand that really I enjoy working in an office more because I found when I was working in the office more my mental health was slightly better." Participant 3, Primary care counsellor, Non-binary
Enablers of engagement	
• **Increased awareness**	"I think the aspect I liked most was solved holding myself accountable. I felt like I'd be at the end of the day, with how many caffeinated drinks I'd had or how many hours of work I had. So, I guess that made me mindful of what I was doing throughout the day. So, I felt like I was holding myself accountable, and I think that was probably the most enjoyable aspect." Participant 12, Practitioner psychologist, Man
• **Personal strategies**	"It was on my home page so I tended to see it there, but I think the future I would set, and I would get the notifications to remind me more." Participant 9, Nurse, Woman
• **External motivators**	"It was quick and easy to input. And also, a couple of times you sent reminders at the weekend and I didn't forget most of the time." Participant 1, Nurse, Woman
Barriers to engagement	

• **Personal challenges**	"There were a few days where I just completely forgot it was just so hectic that. I didn't get to log, but I did try my upmost best to do every day." Participant 11, Healthcare student, Woman
• **Motivational challenges**	"There is a simple formula or algorithm to show my situation, or my problem based on my answers. I think that your application provides to observe myself, my problem, or my emotional point of view. But I don't think it is offering any solution or answer to solve them." Participant 8 Nursing student, Woman
• **Technical challenges**	"A couple of times it didn't work. So, there's a couple of times, I think, when it was on about where you at work. If not, you weren't at work. Sometimes, it asks you for a reason, and sometimes, it doesn't. And then I think there was one day when it just wouldn't load at all. So, I just didn't enter anything." Participant 13, Nurse, Woman
Suggested improvements	
• **Work-oriented recommendations**	"Maybe have some things that are in there that may be tailored towards people in healthcare. And make it a little bit more personal. NHS and people working in private hospitals as well. Don't leave them out. But then yeah, just generally, I suppose, maybe recognised their stress levels, and are they drinking and how are they hydrated? That's one of the issues as well. That's often causes people to be rundown and ill. And you know, are they getting that time off appropriately to recover. Yeah, maybe make it more personal to them." Participant 11, Healthcare student, Woman
• **Content improvements**	"I think having goals or targets that you can set. So, for example, because the effects of stopping caffeine won't be immediate. You could maybe do a target for yourself somehow incorporated

	with the app. So, two weeks no caffeine. From harden your caffeine use. So, for example, once the app has some data on your caffeine news that can tell you what your average number of cups are, and then how you can cut that by half over two weeks and then see its effect on anxiety with graphs and stuff. I guess setting targets and then doing that target for a couple of weeks, and then the app could show you how your low mood in the previous two weeks was compared to the current two weeks." Participant 2, Physiotherapist, Woman
• **Design improvements**	"If it was maybe a bit brighter as well. You know, so it stands out a bit more because, you know, if you've got an iPhone, then you have lots of applications. And even though it literally was sitting on its own. Just had to keep remembering what it was. So maybe it was a bit brighter or had a health, something healthy in it, or I don't know. Something that might trigger it a little bit more." Participant 13, Nurse, Woman

7.2.1 Theme 1: Usefulness

Usefulness refers to in what ways the mobile application helped participants to improve their mental wellbeing. The mobile application allowed participants to track a variety of behaviours, daily moods, and symptoms. The participants were able to decide which items they would like to monitor. Therefore, each participant had a different usefulness experience based on their selections. Two sub-themes emerged from reporting these experiences: the impact of health monitoring on behaviours and mental wellbeing.

7.2.1.1 Impacts on behaviours

The mobile application appeared to help people make positive changes to their behaviours. Participants initially found that the mobile application was easy to use, accessible, and user-friendly.

"I thought it was really easy to use, definitely. It doesn't take long, so it's not like a burden on your day." Participant 5, Healthcare student, Woman

Many participants reported that the mobile application provided a valuable tracking system that helped them be aware of unhealthy behaviours and make changes to them. The mobile application's capacity to compare the flow of behaviours throughout days, weeks, and months was cited as the feature that participants found most useful.

Interviews revealed insights into changing daily behaviours with the monitoring intervention. Participants described three stages for this change. First, they chose behaviours to monitor, gaining awareness of their current habits. This led to the realisation that the behaviour needed improvement, which resulted in taking an action to improve that behaviour. For example, a participant shared reducing smoking experience with the help from the monitoring intervention.

"*I've been thinking about giving up smoking. I noticed I pretty much smoked than my usual amount... Then, I have stopped smoking as much as I can.*" Participant 3, Primary care counsellor, Non-binary

Food intake, sleep, and exercise were the most tracked behaviours through the mobile application. Participants selected these items based on their needs. For example, while some focussed on improving sleep patterns, others mentioned improvements in exercise routine and frequency. This difference in tracked behaviours highlighted how the application empowered participants to address their concerns in personalised ways.

"I think it was useful in terms of like sleep, like monitoring your sleep and stuff because that's one thing that I've been trying to get more of, so that was useful." Participant 5, Healthcare student, Woman

"Actually, that (the mobile application use) increased my activity levels because I focused on that more. So, I definitely had that increase in my fitness levels." Participant 1, Nurse, Woman

Less frequently selected wellbeing aspects included caffeine intake, alcohol consumption, nicotine use, menstrual cycles, menopausal experiences, and medication tracking. This may be because participants were intent not to pick an aspect that they considered acceptable and unproblematic.

"*The alcohol I didn't use (to monitor), but I don't drink a lot anyway*" Participant 18, Nurse, Woman

Menopause and medication intake were the least selected aspects by participants. With this small group of participants, the mobile application was found helpful in these aspects by reminding them of their medication intake. As people age, it could be difficult for them to track their medication, and they may need a reminder tool. Additionally, menopause tracking was described as highly valuable because participants think that menopause is sometimes underestimated by health-related mobile application developers.

“*It did help med as well and remind me to take my medication as well.*” Participant 9, Nurse, Woman

“*What was good, actually was there having the bit about menopause in there. Because, I don't think that's something that a lot of applications consider… I've got my hair up at the moment, so I got quite long hair and if I hair down the back of my neck. I just get really hot and I'm sure that's probably part of the post-menopausal*” Participant 18, Nurse, Woman

Even though the majority of the participants reported improvements in various behaviours, a few participants stated that tracking their behaviours was not helpful for them to make any positive changes. The reasons why they did not make changes differed across participants. Some participants reported that the mobile application did not advise them on how to improve the selected items, such as sleeping. Some of them said no change was made due to private life issues and stopped using the application after a while.

“It hasn’t really changed my behaviour in any way” Participant 2, Physiotherapist, Woman

Overall, all participants found that the mobile application was easy to use and accessible for tracking behaviours. Monitoring behaviours enabled them to make positive changes in their habits, such as sleep pattern, exercise, alcohol, caffeine, nicotine, and food intake. The most reported habits with improvements were sleep pattern and exercise. However, some participants reported that they did not make any positive changes in their tracked behaviours.

7.2.1.2 Impacts on mental wellbeing

This sub-theme explored participants' experiences of the impact of daily health monitoring on their mental wellbeing. Similarly, to the behaviour aspect, the usefulness of the mobile application for improving mental wellbeing may vary from person to person. Some participants found the mobile application useful for improving their wellbeing; however, many reported no change in their perceived mental wellbeing.

Health monitoring was found useful as a reflection tool in terms of its positive impacts on mental well-being. Participants felt that the mobile application helped them reflect on their feelings and emotions. Thanks to this reflection, participants understood their mental wellbeing better by checking triggers in their emotions.

Participants reported a variety of reflections. For example, one of the reflections was to investigate the correlation between how they felt while they were working long shifts. Based on this reflection, some actions, such as rewarding themself, were also taken to improve their daily mood. Another reflection was to try to understand the link between caffeine intake and anxiety. Lessening the caffeine intake was reported by a participant to decrease their anxiety. Another interesting reflection was changing the working routine by monitoring working hours and daily mood. One participant stated that working at the office was better than working at home. As seen from these examples, health monitoring enables participants not only to increase their self-awareness of mental wellbeing but also to take an action for to change their behaviours or routines to improve their mental wellbeing.

"*I think it helped me kind of understand that really I enjoy working in an office more because I found when I was working in the office more, my mental health was slightly better*." Participant 3, Primary care counsellor, Non-binary.

"I think it helped me to become more aware of some mental health issues, and look at the correlation between perhaps working long shifts how about links in with mental health? Is struggling with and I definitely recognise that (long shifts negatively affect wellbeing) … When perhaps I am not having a great day, then what I have started to do is to give myself little rewards throughout the day. And it helps me." Participant 11, Healthcare student, Woman

On the other hand, many participants claimed that they did not feel improvement in their mental wellbeing because of mental wellbeing monitoring through the mobile application. All participants found that the mobile application increased their self-awareness of their mental wellbeing (the state of their mental wellbeing and the elements affecting it). However, they reported no perceived positive change in their mental wellbeing.

Several reasons were reported to express why there was no perceived mental wellbeing improvement. The first one was that the mobile application did not provide solutions or advice on how to improve wellbeing. The participants believed that only monitoring was not beneficial enough to improve their mental wellbeing. Any advice based on the tracking items would be more helpful by facilitating and motivating them to improve their mental wellbeing. The second reason was the expectation of an immediate effect on wellbeing, such as a behaviour change. For example, if some have a sleep problem because of their caffeine intake, they may immediately sleep better on the same day after they stop drinking coffee. However, it may take time to perceive mental wellbeing improvement compared to a behaviour, such as the relation between anxiety and caffeine intake. The third reason was that participants already felt better mentally. Participants reported that the health monitoring would be more effective when they feel stressed or depressed.

"*I think not. Probably not a direct impact as such, but it's made me realise different things that may affect your mental health.*" Participant 6, Nurse, Woman

"I think the only issue would be that you would expect to see immediate effect or the app. So, you'd say for example, today I haven't had any caffeine. How does that affect my anxiety and the reality is, it probably won't because it takes time." Participant 12, Practitioner psychologist, Man

"To be honest, no (change in mental wellbeing) ... I guess because from what I could see, you were just recording how you were feeling, so I'm not sure how it would, how it was meant to kind of affect my mental health. I guess I know if I'm feeling a bit down the, you know, you got the percentage change, but I'm not quite sure what I was meant to kind of do with that in a way." Participant 13, Nurse, Woman

7.2.2 Theme 2: Enablers of engagement

This theme refers to the various factors that supported and encouraged the participants' use of the mobile application over the intervention period. This theme comprised three sub-themes: increased awareness, which refers to how the application helped participants to become more aware of their behaviours and mental wellbeing; personal strategies, which refers to the strategies that participants developed to help them maintain their use of the application; and external motivators, which refers to the external factors that motivated participants to continue using the application. Examining these sub-themes provides a better understanding of the factors that facilitated the participants' use of the mobile application and how they may have contributed to their overall experience with the application.

7.2.2.1 Increased awareness of mental wellbeing

Many participants stated that monitoring their mental wellbeing through the mobile application helps them gain more insight into their thoughts, emotions, and behaviours. The application's ability to track and provide data about the participant's mental wellbeing state allowed them to identify patterns and areas they wanted to improve. As a result, participants felt that they better understood their mental wellbeing and felt empowered to take control of it. This feeling leads to motivating them to use the mobile application consistently.

"I think it's really helped me to be more self-aware of my emotions and my feelings." Participant 5, Healthcare student, Woman

The participants emphasised that their self-awareness increased in various ways, including self-reflection, regular tracking, visual representation, and awareness of patterns. Participants reflected on the data collected by the mobile application, which led to being more mindful of their mental wellbeing. Regular tracking showed them the flow of the selected items such as diet, anxiety or working hours. The mobile application provided colourful graphics showing the scores of the selected items. This visualisation showed not only the current day but also the previous days to compare the patterns. All these factors gave participants a sense of control over their mental wellbeing, as well as responsibility for managing their own health.

"It helped me to be more mindful of my mental wellbeing", Participant 11, Healthcare student, Woman

"I think the aspect I liked most was solved holding myself accountable. I felt like I'd be at the end of the day, with how many caffeinated drinks I'd had or how many hours of work I had. So, I guess that made me mindful of what I was doing throughout the day. So, I felt like I was holding myself accountable, and I think that was probably the most enjoyable aspect." Participant 12 Practitioner Psychologist, Man

7.2.2.2 Practical strategies

Many people engaged in specific practical actions that facilitated regular use of the mobile application. These strategies helped overcome any challenge to using the application and encouraged consistent engagement with it.

Three specific practical strategies were common among the interviewees. The first one was placing the application icon on the home page. This may help participants increase the application's visibility since the home page is the initial screen displayed while launching a mobile application. This visibility can serve as a constant reminder to participants to use the mobile application whenever they check their mobile phones. Also, it will make the mobile application handier and more accessible.

"*It was on my home page so I tended to see it there, but I think the future I would set, and I would get the notifications to remind me more.*" Participant 9, Nurse, Woman

The second individual-led strategy was setting an alarm to use the mobile application. The wellbeing monitoring application did not have a built-in reminder notification. However, some participants used another application on their phone to set an alarm to complete their monitoring questions. This strategy was to overcome the challenge of forgetting to use the mobile application.

"I set an alarm on my phone so that I would remember to do it." Participant 1, Nurse, Woman

The third strategy was using the mobile application at the same time each day. By setting a specific time each day to use the application and committing to this routine, participants may form a habit, which can make it easier and more automatic over time. This habit formation can lead to greater consistency in mobile application use, which in turn can enhance the mental wellbeing outcomes that the application is designed to promote.

"I tried to set the same time every day to complete the app. So, I'd either do it first thing in the morning or last thing at night. And that seemed to help." Participant 11, Healthcare student, Woman

As seen from the interviews, all these strategies aimed to remind participants to use the mobile application to monitor their mental wellbeing. It was found that those who applied these practical strategies used the mobile application most frequently. Therefore, these strategies could be built into the mobile application itself in the future to overcome barriers to use, such as forgetfulness or lack of motivation.

7.2.2.3 External motivators

This theme highlights the importance of external prompts and factors which stimulate participants to use the mobile application during the intervention period. External motivators refer to facilitators that come from outside the individuals to help with consistent use and engagement with the mobile application.

The most frequently mentioned external motivator was the researcher's weekly email reminders. Each week on Sunday, the intervention group participants received an email containing a message informing them that they had registered for the study and were using the mobile application that could help them improve their mental health (for the e-mail, see Appendix 18). Numerous participants reported that this weekly email reminder encouraged them to use the mobile application more frequently.

"The e-mails help me to remember to use the application." Participant 8, Nursing student, Woman

Other external motivators were quick and easy input and personalised time to complete the daily questions asked through the mobile application. Participants were required to answer the daily questions according to their selected items to monitor. They found that answering the questions was easy, clear, and quick. This facilitates their mobile application use since it does not take much time and effort. Additionally, they were able to choose any time of the day that worked best for them to complete the questions. This flexibility provided them with the feeling of taking control, which did not pressure them to use the application at a certain time of the day. They were also able to enter yesterday's data in case they forgot to use it.

"It was quick and easy to input. And also, a couple of times you sent reminders at the weekend, and I didn't forget most of the time." Participant 1, Nurse, Woman

"I thought it was really easy to use, definitely. It doesn't take long, so it's not like a burden on your day." Participant 5, Healthcare student, Woman

Participants mentioned feeling being observed as being a particularly motivating factor. Because of the nature of the study, participants were aware that their data were being recorded and that the researcher would review them. They also thought they should use the mobile application because it is good for people and research. In addition to the commonly mentioned motivators above, these feelings might also encourage them to use the mobile application for mental wellbeing monitoring.

"I think it's where I was conscious that it was just a six-week trial. You know, to make sure that was done for six weeks. I think that probably made me focus on it more." Participant 1, Nurse, Woman

7.2.3 Theme 3: Barriers to engagement

Participants faced several challenges when trying to improve their wellbeing through the mobile application. Three key sub-themes were identified: personal challenges, motivational challenges, and technical challenges. Aside from technical difficulties, these barriers also depended on individual preferences or differences.

7.2.3.1 Personal challenges

Personal challenges refer to individual difficulties that limit the consistent use of the mobile application. Various personal challenges were reported, including forgetfulness, busy working life, private life difficulties, being pedantic, and dissatisfaction with the questions.

The most reported challenges were forgetfulness and being busy during the day due to work. There appeared to be some link between these two challenges because participants expressed that being busy led to forgetting to use the mobile application to monitor their mental wellbeing. It appears that participants did not prioritise the use of the mobile application when they were busy with other activities, especially work-related tasks. Also, those working on a night shift schedule found logging the daily data difficult due to their tiredness.

"I used it when I remembered to use it If I'm honest. And I think I'd probably use it on days when I was probably doing really well. So, days when I noticed I was really busy and not feeling great. And then I did forget to use it. Actually, because it just went out of my mind." Participant 13, Nurse, Woman

"Maybe something around shift patterns. So, in order to input the data, you have to do it so later on in your day, when I was on a late shift that's when I found it difficult. Because I'm not finishing to 9:30 at night and then at the time

you get home, you're tired and just forgot a couple of times." Participant 1, Nurse, Woman

The other personal difficulties included being pedantic with the information they provided and dissatisfaction with the questions or scores. Some participants wanted to input precise data about the items they tracked, such as sleep patterns. It was asking how many hours you slept last night. The answer options ranged from 0-3, 4-6, 7-9, and 10+. A few participants found these ranges confusing since they were unsure about which range to choose if they slept between 3 and 4. Another topic which some participants were dissatisfied with was the mood question. It was reported that mood is a changeable item, meaning that people may experience different moods during the day. In this example, some participants stated that they were confused about describing their mood. This could be a result of the structure of the question, which was "How are you today?". This general question could be, "How do you describe your mood today?". Or it could be asked based on the time when participants entered the data, such as morning, afternoon, evening, or night. For instance, "How do you describe your mood this morning?".

Some participants were strict about entering precise data about their health items. They were also dissatisfied with the structure of some questions and answers because they thought that some questions and answers did not adequately reflect their feelings. As a result, their motivation to use the mobile application weakened after a while, and they stopped using it.

"There's a few bits that I found a bit confusing, and so like the sleep bit, it's not three to four. It was four to six. So, I had a bit of a problem if I slept between

three and four hours is like do I put it in the note to three or do I put it in the four to six?" Participant 18, Nurse, Woman

"I think my main issue was that the main question that was a, how do you, the main question that was about yourself, because it was very confusing. That's a question that has put me off from that app... Say how many hours are okay for the night's sleep. It's the end of the day exercise. It's like I am half day through. I don't know. I haven't been there. So that kind of made it difficult to be better." Participant 7, Healthcare student, Non-binary

Personal life difficulties, such as private life issues, were also stressed as barriers to engaging with the mobile application. It was mentioned that personal life could be chaotic and stressful, which made it difficult for them to prioritise using the mobile application on a daily basis. In one case, a participant stopped using the mobile application because of private life issues and did not have the energy or mental capacity to focus on mental wellbeing at that time. It was especially emphasised that these issues not only had an impact on application use but also work-related tasks.

"It was like just purely because of my private life (unable to continue using the mobile application). Because it was like I was having problems, and that's why I just like couldn't keep going with the application like, you know, like, I just didn't even do my invoices at that time, which I was supposed to do like regularly. So, I mean that was just like purely personal issues." Participant 2, Physiotherapist, Woman

7.2.3.2 Motivational challenges

This sub-theme refers to the factors that can make it difficult for participants to find the motivation to use the mobile application to monitor and improve their mental wellbeing. Motivation is an important factor in maintaining a consistent and healthy routine or habit, which helps improve mental wellbeing.

When participants start using the application, they may be motivated by the belief that it will help them improve their mental wellbeing. However, this initial motivation can decrese over time if people do not see the immediate results they expected. This can lead participants to lose interest in the application and stop using it.

One participant reported that feeling a need to improve wellbeing encouraged her to try finding a way to improve her wellbeing. She believed that the health monitoring through a mobile application could be helpful for her. In the beginning, her motivation and interest to use the application were high. However, after a while, she could not keep up her motivation to use the application and stopped using it.

"I think feeling down helped me (to use the application) because I was looking for something to keep myself up. But afterwards I had tough days. And the application wasn't enough to keep my motivation up. That's why I probably stopped it slowly. I ended up not using afterwards." Participant 2, Physiotherapist, Woman

The other commonly reported demotivating factors were the expectation of immediate improvements, lack of perceived benefits and lack of advice on improving impaired behaviours or symptoms. Participants expected that the mobile application use would improve their mental wellbeing or behaviours immediately. However, they did not feel an improvement, and this feeling discouraged them from using the application. Additionally, it was thought that they were able to determine unhealthy behaviours and whether they had stress or anxiety by monitoring them. However, there was no advice on how to improve the identified problems, such as how to overcome stress.

"For example, today I haven't had any caffeine. How does that affect my anxiety and the reality is, it probably won't because it takes time. So, I wonder if it would still have that element of discouraging people from certain factors." Participant 12, Practitioner psychologist, Man

"There is a simple formula or algorithm to show my situation, or my problem based on my answers. I think that your application provides to observe myself, my problem, or my emotional point of view. But I don't think it is offering any solution or answer to solve them." Participant 8, Nursing student, Woman

7.2.3.3 Technical challenges

The theme of "*technical challenges*" emerged as a significant barrier to the effective and consistent use of the mobile application for mental wellbeing improvement of healthcare workers/students. Technical challenges mean any issue or malfunction that arises with the mobile application. The participants faced various technical problems based on software issues related to programming and system components. While some technical issues might be resolved, some vital issues did not allow participants to use the mobile application. Participants reported a few bugs, which meant an unexpected defect, fault, flaw, or imperfection in the mobile application.

Three bugs were reported in the interviews. The first one was that the mobile application did not give a response for some questions such as working hours or no/delayed response for all questions while saving the daily data. Participants tried to enter their answers but when they clicked the answer the mobile application did not respond it and saved the answer. This issue was resolved after restarting the application again.

"A couple of times it didn't work. So, there's a couple of times I think when it was on about where you at work. If not, you weren't at work. Sometimes it asks you for a reason, and sometimes it wouldn't. And then I think there was one day when it just wouldn't load at all. So, I just didn't enter anything." Participant 13, Nurse, Woman

"Sometimes when I was putting in the details, it took a while for the results to come up. I had to redo it because it didn't just show how, maybe take some time for it. So just kind of slow in saving the results." Participant 7, Healthcare student, Non-binary

The second reported bug was that the mobile application did not present the daily scores based on the participant's answer. This issue also was resolved after restarting the mobile application.

"There was only one occasion where it didn't show my overall score and for some reason it just didn't load it up. But then it was fine. So that was the only a little technical glitch I think." Participant 11, Healthcare student, Woman

The third technical bug was about starting up the mobile application. After a participant was assigned to the intervention group, the researcher provided the participant with a password for the mobile application. The participant should first sign in to the mobile application with that password. In the IOS platform (Apple), some participants were not able to sign in to the application due to an error called *'invalid user'*. The researcher reported this error to the tech team, and it was resolved quickly.

"When I first downloaded it, I couldn't log in, but I believe you sorted it out. So, it wasn't an issue after that." Participant 3, Primary care counsellor, Non-binary

7.2.4 Theme 4: Suggested improvements

The participants made several suggestions as to what aspect of the mobile application could be improved to increase its benefits in the future. three subthemes were generated: work-oriented recommendations, content related suggestions and design related suggestions.

7.2.4.1 Work-oriented recommendations

This sub-theme presented suggested improvements in relation to how the mobile application could be improved to better meet the needs of healthcare workers and support their mental wellbeing. These suggestions consisted of working patterns, working environments, and specific challenges healthcare workers faced.

From the interviews, the common emphasis was that healthcare workers work in a stressful and busy environment, which negatively affects their mental wellbeing. It was seen in the previous themes that some participants reported that they experienced very hectic and tiring days, causing decreased quality of life. Working in shift patterns was reported as another challenge to creating balance between work and daily life. In a tiring and stressful environment, healthcare workers might ignore or neglect their self-care since stressful work becomes a norm for them.

"When you're working 12-hour shifts and you know it can be quite tiring. We couldn't help ourselves as well" Participant 9, Nurse, Woman

In light of these challenges and comments, the first and most commonly reported suggestion was to have a more personalised mental wellbeing tracking tool, including work-related questions. It is recommended to add new questions or features in relation to monitoring communication with colleagues, shift working, hydration, and setting targets. These new work-related features might respond to their needs and challenges resulting from their work.

"That would be quite crucial because having this possibly it would add just like you select targets, then it would be a thing to be helpful for them (healthcare workers) to create put those targets in relation with their shifts. And select things, for example, I don't know how they felt their relationship with their colleagues went or do I feel that I communicate effectively. I don't know if it's something that, it's sort of they work longer hours. Do they miss the meal or something? So, it may make them a little bit more relevant to that shift patterns." Participant 7, Healthcare student, Non-binary

Additionally, some participants reported that they wanted to monitor their breaks at work. Breaks are important for recovering physically and mentally during work. The mobile application might remind them whether they are using their breaks appropriately.

"I suppose maybe recognised their stress levels and are they drinking and how far they hydrated? Are they getting time off appropriately to recover. I think maybe make it more personal to them." Participant 11, Healthcare student, Woman

Some participants also suggested adding more options for working absence questions. In the mobile application, it was asked whether participants were working today or not. If not, they could pick sickness or a day off. An annual leave option would be helpful for them to monitor their mental wellbeing during their leaves.

"You're working and if you weren't working then the work absent was sick day off and then other. I just wondered for me it would have felt more useful to have kind of annual leave in there or something." Participant 18, Nurse, Woman

7.2.4.2 Content improvements

The content improvements' sub-theme concerns the information and features included within the mobile application. These can include text, images, videos, audio files, and other types of media, as well as interactive elements such as buttons and forms.

Participants mainly reported that they want to see information regarding advice on how to improve their wellbeing and behaviours if needed based on tracked items. Basically, the mobile application was helpful in detecting any problem with daily behaviours or mental wellbeing. However, participants wanted to have the next step, which was about what they needed to do to improve the impaired items. Advice could include any form of information such as website, article or video links, and brief information in the application itself.

"The other things that there is an answer if you have a stress, yes. But you can't go in. Yes, but I can cope with that one. If I just click for yes, but I don't cope with that one, but I need to cope with that. Just let's calculate number. You didn't give any tips or any solution. Maybe you can also add some article links, maybe some tips according to my answer, or the overall score." Participant 8, Nursing Student, Woman

Some participants also mentioned that they would like more information —more educational information—about how behaviours are connected with mental well-being. This would improve their knowledge of the connections between mental wellbeing and behaviours. It might also help them understand why the mobile application included physical items like exercise and mental items like stress together.

"Maybe giving some tips. For example, good sleeping habits, such as how they affect people's mental health or daily life motivation, and their mood during the day." Participant 2, Physiotherapist, Woman

In addition to these features, the most mentioned advice was building up the mobile application with push notifications, which are alerts generated by the application, notifying users of a new message, reminder, or update even while the application is not open. Almost all participants complained about forgetting to use the mobile application during the day. Some participants set their reminders through other applications or using diaries, but these were not convenient and practical. Participants believed that having push and reminder notifications in the mobile application could be more practical and functional to increase consistency and prevent forgetfulness.

"I forgot. It wasn't a reminder on there. Maybe an option for a bit of a reminder, but you could do that as opposed to yourself with your diary, but maybe just something. I mean, maybe you could have had notifications on it" Participant 9, Nurse, Woman

Some participants expressed that peer support would be a beneficial factor in improving their mental wellbeing and might increase their engagement with the mobile application. A peer support platform could be created in the mobile application. Those monitoring their wellbeing would contact each other through that platform. People might find their buddy and check on each other to see whether they are doing well. They could motivate themselves by sharing their experiences or achievements.

"It allows you to come share your information with their buddy. So, if you're having dropped scores, then your buddy would kind of get notification and then could come in and say do you need any help?" Participant 18, Nurse, Woman

The other content-related suggestion was adding a feature that enables users to create their goals. They thought that this might be useful for seeing the differences in the progression of one week, two weeks, or one month.

"I guess setting targets and then doing that target for a couple of weeks and then the app could show you how was your low mood in the previous two weeks

compared to the current two weeks." Participant 12, Practitioner psychologist, Man

7.2.4.3 Design improvements

There were several suggestions around a mobile application's visual and interactive elements, including its layout, user interface, and user experience.

The mobile application interface uses mainly green and black colours. It was reported that more personalised designs would be more attractive. Interestingly, some perceived the current green and black design as masculine. Additionally, some other participants found the current colour theme dark and described the interface as unfriendly. They proposed brighter colours, which might be more appealing to a wider range of users. Another suggestion was to be able to customise the colours. With this personalised design, anyone can create a colour theme that best suits their preferences. This design would be more inclusive while also empowering their sense of autonomy.

"I guess it wasn't very sort of user-friendly interface, so I guess I would do something a bit more open, open colours, brighter colours." Participant 12, Practitioner psychologist, Man

"I might like a different colour, and somebody might like a different colour. Maybe people can choose their own colour." Participant 2, Physiotherapist, Woman

In addition to the personalised colour design, adding images, emojis, animations, voice messages, and motivational quotes was suggested. Participants believed that these interactive elements would make the mobile application fancier and more attractive.

"I thought about maybe having some little emojis in there and things and then making a thumbs up, smiley face. Hey, well done! You know that kind of things like WhatsApp" Participant 11, Healthcare student, Woman

Moreover, a participant mentioned that a mobile application built with a gamification design could be more fun and increase consistency.

"For me, making it seem like fun and bit of play. Just would feel possibly like something I would do more. I do like to play rather than feel that I'm having to do something that feels a bit boring." Participant 18, Nurse, Woman

7.3 Summary of qualitative findings

- Participants found the mobile app acceptable, user-friendly, accessible, and easy to use.
- Monitoring mental wellbeing through the application was mostly seen as useful for tracking health behaviours like sleep, exercise, diet, smoking, and alcohol intake.
- However, views on the application's impact on perceived mental wellbeing improvement varied.
- Facilitators for engagement included increased awareness of mental wellbeing, access to practical individual strategies, and weekly reminder emails.
- Barriers to consistent use included forgetfulness, busy lifestyles, lack of perceived personal benefit, and technical challenges.

Chapter 8: Discussion

Introduction

To the best of our knowledge, this is the first mixed-method feasibility RCT study with a qualitative component to explore if mental wellbeing monitoring through a mobile application could be useful for promoting the mental wellbeing of health and care workers and students in the UK. In addition, it aimed to explore users' experiences and views on its usability and acceptability, which may help to understand how such mobile applications could improve mental wellbeing for this population. The study also makes novel contributions to research through individual interviews. Lastly, this study provides valuable information about social media recruitment during the COVID-19 pandemic, as well as its advantages and disadvantages.

8.1 Discussion of feasibility outcomes

It is generally claimed that the function of feasibility studies is to assess predefined progression criteria to a full RCT regarding the evaluation design (e.g., reducing uncertainty around recruitment, data collection, retention, outcomes, and analysis) and the intervention itself (e.g., around optimal content and delivery, acceptability, adherence, likelihood of cost-effectiveness, or capacity of providers to deliver the intervention) (Skivington et al., 2021). The recruitment of an appropriate sample size is, therefore, a critical component of feasibility studies. The literature provides various views on the sample sizes of such studies. A recent National Institute for Health Research (NIHR) report suggested that there should be between 24 and 50 participants for feasibility studies (Hooper, 2019). A recent review of sample sizes for UK pilot and feasibility studies between 2013-2020 identified that the median target sample size was 30 (IQR 20-50) (Totton et al., 2023). Based on this NIHR report and the recent review, the recruitment rate of this study could be considered satisfactory, with 49 participants recruited over six months.

However, recruitment was a challenging part of this study due to the COVID-19 pandemic. Recruitment took place between April 2021 and November 2021, when the COVID-19 social distancing restrictions were still enforced (Gutiérrez et al., 2021). Participant recruitment is known to be a challenge in intervention studies (Treweek et al., 2018); additionally, during the pandemic, the recruitment of participants to non-COVID-19-related clinical studies was further negatively impacted by prioritisation of COVID-19 research (Mitchell et al., 2020), redeployment of health and care workers (Panda et al., 2021), extraordinarily busy working environments (Armitage & Nellums, 2020), and the need for social distancing (Mitchell et al., 2020).

At the beginning of the study, it was planned to recruit nurses from the Nottingham University Hospitals NHS Trust. However, this plan changed due to the impacts of the pandemic on in-person interactions. The pandemic-related challenges in accessing nurses resulted in expanding the recruitment population to include health and care workers and students around the UK. In addition, traditional recruitment methods were replaced by new recruitment methods, such as using social media and digital newsletters to access eligible participants without in-person interactions. This re-planned social media recruitment strategy helped find a sufficient number of participants over six months. The existing literature also supports the efficacy of social media in participant recruitment due to its accessibility, ease of use, time efficiency, and cost-effectiveness (Darko et al., 2022). However, literature reviews suggest that the best practice is a combined recruitment strategy including both traditional and social media methods (Darko et al., 2022; Topolovec-Vranic & Natarajan, 2016) as the strengths of each method can compensate for the weaknesses of the other.

The main reason for utilising social media in this study recruitment was the ability to access people during the pandemic restrictions impeding in-person contact. The other advantages were cost-effectiveness, time-saving, highly effective snowball sampling and national accessibility (Lafferty & Manca, 2018). Snowball sampling was applied because the health and care population was hard to reach during the COVID-19 pandemic. The use of social media in recruitment had the potential to increase the effect of snowball sampling as participants could easily share the study with colleagues or friends without geographical limitations (Wasilewski et al., 2019).

On the other hand, social media recruitment has several disadvantages. One significant disadvantage is that it is limited to those who have an account, leading to limited representativeness (Arigo et al., 2018), as people without a social media account cannot view the recruitment advertising. In addition to that, social media use is less common in the older population compared to the younger population (Zimmermann et al., 2022). This difference in social media use could result in decreased demographic variability in recruitment and thus reduce the potential representativeness of the sample to the wider population under a study. Another drawback of using social media in recruitment was the inability to determine recruitment speed or percentage of recruited participants. The researcher was unable to control who saw the recruitment advertising, as everybody could see and click it. This has resulted in continued uncertainty about the appeal of the intervention as it is unknown how many eligible people viewed the advertisement before the 49 were recruited. Considering these drawbacks of social media recruitment, future studies continue to apply traditional recruitment strategies to improve study representation and generalisability.

The dropout rate is another significant consideration in feasibility studies, which contributes to understanding whether a study or intervention is feasible. It is important to mention that dropouts in this current study could be classified into study and intervention dropouts. Study dropouts refer to dropouts before starting the intervention or dropouts in control groups. Intervention dropouts refer to participants who dropped out of the study after beginning the wellbeing promotion intervention, which was mobile application use for six weeks. While the study dropouts provided direct information about the study's feasibility, intervention dropouts helped identify the level of intervention engagement.

The literature provides different opinions on appropriate dropout rates for feasibility studies. Recently, evidence has suggested that between 5%-20% dropout rates are generally acceptable, but lower rates are preferable for maintaining statistical power and the integrity of a study (Nunan et al., 2018). However, higher dropout rates can be acceptable in some studies, depending on the nature of the study, the reasons for dropout, the study population size and its characteristics (Nice, 2013). The current study's overall dropout rate was 20.5%, which is on the threshold recommended by the literature regarding general clinical trials (Nunan et al., 2018). However, this dropout rate is lower when compared with other trials that implemented a digital intervention. For example, a systematic review and meta-analysis that assessed attrition and dropout rates in application-based interventions for chronic diseases found a 43% pooled dropout rate (Meyerowitz-Katz et al., 2020). Torous and colleagues presented a 26.2% pooled dropout rate (47.8% when adjusting for publication bias) in clinical trials of mobile applications for depressive symptoms (Torous et al., 2020). Based on these findings, the overall dropout rate of the current study (20.5%) can be considered acceptable. In addition, future studies implementing mobile application-based interventions for mental health should expect higher dropout rates compared to other trials.

On the other hand, the intervention group dropout rate (6, 25%) was dramatically higher than the control group (1, 4%). The main reason for dropouts in the intervention group was a technical issue: Android phone users could not log into the mobile application due to an error "*invalid e-mail or password*". This technical issue could not be resolved by contacting the developer because of the lack of funding due to the pandemic. This issue resulted in three dropouts and finally caused us to stop recruiting since it would also cause a selective bias against Android users. In addition, there were a few other minor technical issues, such as shutting down while adjusting profile preferences, logging into the account, and bugs in saving the data. The minor issues were resolved by contacting the tech team and did not cause participants to drop out.

Excluding the major technical issue, the intervention group dropout rate would be 12.5%, significantly lower than the literature's recommended threshold. However, technical challenges have been a prevalent issue in mobile application-delivered interventions. A systematic review of smartphone-delivered mental health-related mobile applications revealed dropout rates ranging from 12.5% to

34.3%, with technical issues identified as significant reasons for dropouts (Donker et al., 2013). A recent scoping review on internet-delivered interventions for personality disorders also highlighted technical difficulties, such as bugs and programming errors, negatively impacting engagement in the intervention (van der Boom et al., 2022). While some minor technical issues may be manageable, such as the few bugs mentioned above, major issues, such as log-in problems, might not be resolved due to business reasons, including a lack of funding. This study confirmed that technical issues with the mobile application could present a critical challenge, leading to interruptions or termination of the intervention. However, during the study implementation, an extraordinary incident occurred, which was the COVID-19 pandemic. This global pandemic has significantly impacted studies worldwide, resulting in reduced funding, lockdowns, limited in-person interactions, social anxiety, and an extremely high workload in healthcare settings. The current study has been affected by the pandemic, particularly challenges around lack of funding and extremely high workload in the healthcare settings. Future studies with mobile application-based interventions should have a well-defined budget plan and a qualified technical team to address any potential technical issues.

This study presented valuable and comprehensive insights into the usage patterns of tracked items and the potential reasons behind these patterns. Based on our current knowledge, no prior study has investigated the detailed daily usage of a wellbeing monitoring mobile application for mental wellbeing promotion among healthcare workers. Understanding this usage frequency is a key factor in assessing the acceptability and feasibility of the wellbeing monitoring mobile application among the targeted population. In the related literature, varying usage rates for mobile applications have been reported. For example, a study assessing a mindfulness-based mobile application showed a 45.5% mobile application usage rate based on self-reporting of participants (van Emmerik et al., 2018). Another study with undergraduate students reported a 61.9% mobile application usage rate based on the participant's responses to notifications (Daugherty et al., 2018). Furthermore, the current scoping review (Chapter 2) indicated an average application usage rate of 40.9% in studies focusing on improving mental wellbeing through mobile applications. Thus, this study targeted a feasible application usage criterion at over 40.9%. This criterion was achieved by 64.4%, which was dramatically higher than the average based on the scoping review. This suggests that the mobile application may exhibit greater acceptability and feasibility compared to the average in the literature.

However, this rate also showed 33.6% missing days, accounting for approximately one in three days. Based on the analysis of missing patterns, it was seen that the participants were highly engaged in the use in the first week. However, the usage rate decreased as the days progressed. Other studies have reported similar findings implementing digital interventions (Wright et al., 2023). The main reason for this declining pattern was "lack of perceived benefits", according to the individual interviews. The participants reported that they did not feel improvement, particularly in their mental wellbeing, which decreased their adherence and even stopped some from using the mobile application. According to the Health Belief Model for behaviour change (using the wellbeing monitoring mobile application), it was reported that "perceived benefits" are one of the factors that stimulate people to engage in changing behaviours or habits (Prochaska, 2020). Consequently, when individuals perceive the application as ineffective in enhancing mental wellbeing, they tend to discontinue its usage.

The other reasons for missing days and data included personal challenges, technical issues, the application's content, and design preferences. The participants commonly forgot to use the mobile application mostly because of their busy work life. Forgetfulness is commonly reported as the most significant barrier to self-monitoring (Van Til et al., 2020). The lack of reminder notifications in the application contributed to this forgetfulness. Indeed, notifications are a way of building communication with users. They help stimulate user engagement in different ways, such as by reminding a user of an action that a user should take or providing personal and motivational information about self-monitoring (Bidargaddi et al., 2018). Due to technical and funding issues, the mobile application did not include daily notifications, which may have contributed to the disengagement as notifications are reported to increase engagement and interactions with a mobile application (Alqahtani et al., 2021; Sahami Shirazi et al., 2014). Additionally, the interview findings confirmed that the weekly reminder e-mails helped the participants use the application more consistently, as e-mails prevented forgetfulness. Thus, implementing a mobile application with daily notifications as reminders or feedback providers would likely improve the current usage rate of 64.4%.

In summary, this feasibility study assessed the progression criteria for a full RCT, including recruitment, data collection process, retention and dropouts, and outcomes. Despite the challenges of the COVID-19 pandemic, this feasibility study met the targeted progression criteria, including the number of participants, retention and dropout rates, data collection rate, and mobile application usage rate (see Results Chapter 6). Due to the challenges of the COVID-19 pandemic, the first recruitment plan (targeting only nurses) was changed to include health and care workers and students from around the UK. Online recruitment strategies were applied, including social media posts, advertisement in digital newsletters and e-mail circulation among professional networks. This change impacted the generalisability of the study; however, it also allowed the research team to recruit a sufficient number of participants. The retention and dropout rates were found feasible as both were acceptable ranges compared to the relevant literature and guidelines. This study confirmed that technical challenges are one of the major issues in implementing such digital interventions for health promotion. Although the dropout rate was higher in the intervention group than in the control group, the primary reason was a technical issue. This factor suggests that addressing major technical issues may improve dropout rates in future studies. Future recommendations included mixed recruitment strategies (e.g., incorporating traditional and online approaches), a well-defined funding plan, and the integration of daily notifications in mobile applications.

8.2 Discussion of demographic information

In this study, the majority of participants were young adults and white women aged between 21 and 40 (see Results Chapter 6 for percentages). This demographic profile aligns with observations in review studies focussing on mental health promotion interventions (Borghouts et al., 2021; Eisenstadt et al., 2021). The distribution could be due to a higher prevalence of mental health problems among women, which may indicate a higher demand for such interventions (McManus et al., 2016). The NHS population also included mostly health and care workers, predominantly women and white workers (England, 2021; *NHS workforce*, 2023). Therefore, a higher representation of white women in the study was anticipated, reflecting the demographics of the NHS population. Consequently, due to the lower participation of other genders, age groups, and ethnicities, this study might be limited to exploring their user experiences with mental wellbeing monitoring through the mobile application.

Most participants were young adults between the ages of 21 and 40. This high representation of young adults might result from the social media recruitment strategy implemented due to the pandemic. The recruitment was done through Twitter, Facebook, and digital newsletters. Indeed, the need for social distancing and COVID-19 national restrictions led to using social media to access participants, as it enables people to communicate remotely. However, social media recruitment might impede the recruitment of older participants as social media use is more prevalent among young people (*Internet access - households and individuals*, 2020). Opening the recruitment to health and care students, who generally represent a younger population, may also have contributed to this study's high proportion of young adults. This recruitment strategy may not be feasible for recruiting health and care workers of various age groups (in particular, those over 40). Therefore, a wider, more inclusive recruitment plan that includes more traditional methods such as in-person contact, brochures, or flyers is recommended.

In terms of user engagement based on the demographic information, it was found that participants aged above 40 used the application more frequently than younger participants. As the sample size was too small to detect a statistically significant difference in this case, this finding might not be sufficient evidence to identify the age impact on user engagement. However, in the literature, short-term studies (up to 12 weeks) on digital mental health interventions with large sample sizes indicated that age has an impact on user engagement by showing that older people engaged in the digital interventions more consistently compared to younger people (Abel et al., 2018; Kannisto et al., 2017). A similar trend was also seen in other studies with smaller sample sizes (Gunn et al., 2018; Pavliscsak et al., 2016). These findings may conclude that young adult participation might be high in such digital mental health promotion interventions; however, older people might more adhere to engaging in the intervention. Researchers might consider methods such as gamification (Kazemi et al., 2019) to increase the younger population's engagement and motivation. In terms of occupation, there was no difference in the number of usage days between nurses and students. It was not possible to compare the engagement differences in relation to other characteristics such as gender, ethnicity, and occupation as the numbers of their distributions were not equal or close (e.g., 16 women, one man, and two non-binary).

8.3 Discussion of questionnaire outcomes

The baseline and post-survey completion rates were both 100% among respondents who initiated filling out the surveys. This high completion rate suggests that the surveys showed a high level of acceptability among the respondents. It also indicates that the surveys were an appropriate length, not overly complex, well-designed, and relevant to the research area.

8.3.1 Wellbeing, depression, anxiety, and stress

It is worth noting that the study's main aim was to test research feasibility and explore to what extent the participants would complete the outcome measures. In addition to that, pre- and post-outcome measures in the groups were analysed to provide descriptive information on the likelihood of seeing a change in these measures in a future trial.

At baseline, moderate levels of wellbeing were found in both the intervention and control groups, according to the WEMWBS. After the intervention period, moderate levels were still seen, indicating no substantial change in the wellbeing scores. There may be several reasons for this lack of change. First, due to the small sample size of this feasibility study, it may not have been possible to detect a statistically significant change in wellbeing scores before and after the intervention period, which could have resulted in a Type II error due to the small sample size (Faber & Fonseca, 2014). Another reason could be "the ceiling effect," where the participants showed moderate wellbeing levels, which is similar to the general UK population. In 2007, a study with 1,749 participants reported that the median of the UK population's wellbeing mean score was 51, classified as a moderate level of wellbeing (Tennant et al., 2007). Another population study with 7,020 respondents showed a 52 mean score for mental wellbeing in England (*Health Survey for England - 2011, Health, social care and lifestyles*, 2012). These mean scores can be considered an upper limit that may lead to "the ceiling effect," which means reaching the limit or potential maximum level (*APA Dictionary of Psychology*, 2023).

However, the control group showed a greater increase in wellbeing scores after six weeks compared to the intervention group. Several factors can contribute to this outcome. Firstly, the small sample size in the intervention group could have led to significant influence from outliers on the mean scores, a phenomenon noted in quantitative research where small samples can exaggerate the impact of extreme values (Field, 2024). Additionally, the higher dropout rate in the intervention group may have impacted the mean scores. Higher attrition can introduce bias and affect the representativeness of the results, as individuals who drop out may differ systematically from those who remain (S. K. Gupta, 2011). However, as this is a feasibility study with a small sample size, it is unable to determine the effectiveness of the intervention.

Similarly, there was no substantial difference in DASS-21 scores before and after the intervention for all depression, stress, and anxiety scores in both groups. The average DASS-21 scores indicated no clinical level of depression, stress, or anxiety. However, the study results indicate that health and care workers and students show higher depression, anxiety, and stress scores in the current study when compared to a previous study conducted in the UK among the general adult population (Crawford & Henry, 2003). This previous research conducted with 1771 participants in 2003 reported smaller medians, with three for depression, two for anxiety, and eight for stress (Crawford & Henry, 2003). This comparison may suggest that those experiencing higher levels of stress, depression and anxiety were more willing to take part in the study and use the mobile application (Kinderman et al., 2016). On the other hand, the COVID-19 pandemic may escalate their levels of stress, depression and anxiety, as found in several studies (Blake et al., 2021; Blake, Yildirim, et al., 2020; De Kock et al., 2021; Knight et al., 2021; Søvold et al., 2021; Zhang et al., 2020).

8.3.2 Acceptability and usability of the mobile application

Usability and acceptability are vital factors for the feasibility of implementing any mobile application-delivered intervention promoting mental wellbeing. Research by O'Brien (2008) and Sun (2013) suggests that users are more motivated to engage with applications that offer simple navigation and user-friendly interfaces (O'Brien & Toms, 2008; Sun et al., 2013). To evaluate the usability and acceptability of the mobile application, MYARKEO, the mHealth App Usability Questionnaire (MAUQ) was employed, yielding an overall score alongside sub-scores for *"ease of use," "interface and satisfaction,"* and *"usefulness"*. The questionnaire indicated a good overall usability and acceptability level and an excellent level of *"ease of use"*. However, it revealed that the sub-scores for *"interface and satisfaction"* and *"usefulness"* were low level compared to the overall score and *"ease of use"*.

Insights from the interviews shed light on the reasons behind the lower level of *"usefulness"* and *"interface and satisfaction"* when compared to *"ease of use"* and overall score. Participants reported a lack of advice or useful links on how to improve their mental wellbeing when their wellbeing scores showed a decline. The lack of daily reminders and push notifications also reduced engagement with the mobile application, making the intervention less useful. A literature review exploring participant engagement with mobile health applications revealed that feedback, appropriate reminder notifications, and in-application support are the factors that promote user engagement (Amagai et al., 2022). Additionally, some participants found the application interface to be masculine, which might lower their satisfaction with the application. Evidence suggests that mobile application design should consider user diversity to appeal to people with different preferences (Bardzell & Bardzell, 2011). In sum, the more individualised features and designs -unless too complicated- the more user engagement there is (Madeira et al., 2018; Wei et al., 2020).

The mobile application was not found to be very useful in relation to perceived mental wellbeing improvement, as reported in the interviews. This lack of perceived benefits was identified as a major factor contributing to the decreased usefulness of the application as a barrier to engaging with it (Fletcher, 2015). Consequently, participants may have felt that the application did not effectively support their wellbeing. In addition, the absence of personalised advice and goal setting led to lesser interest and motivation for consistent use of the application. This decreasing interest potentially impacts its long-term effects on promoting mental wellbeing. Therefore, the lack of perceived benefits, personalised advice, and goal setting were identified as factors leading to low usefulness scores in the questionnaire.

8.3.3 Help seeking behaviour and risk of other application use

Help-seeking behaviour in mental health problems refers to "an adaptive coping process that attempts to obtain external assistance to deal with mental health problems, including not only formal (e.g. psychiatrists) but also informal sources of help (e.g. friends)" (Doll et al., 2021). The literature indicates that help-seeking behaviour is important in mental health outcomes (Yonemoto & Kawashima, 2023). Health monitoring interventions through mobile applications may encourage people to seek further help to improve their health. In the concept of mental health, help-seeking behaviour is an important and developing area. Due to the stigma, individuals who experience mental health problems are often less likely to seek professional or pastoral help (peer support) (Wilson, 2010; World Health Organization, 2022). A recent systematic review of technology-based interventions to improve help-seeking for mental health concerns indicated a 33% average rate of help-seeking behaviour. (Johnson et al., 2022). In the current study, participants were asked if they sought further help during the intervention. One in five participants in both groups reported seeking help, such as a GP appointment or talking to family members, colleagues, or friends. This rate could be considered a low level of help-seeking behaviour. This low rate may result from stigma; however, this study included health and care workers whose wellbeing score was moderate, consistent with the general UK population (*Health Survey for England - 2011, Health, social care and lifestyles*, 2012; Tennant et al., 2007). Before and after the intervention, there was no significant difference in wellbeing scores. Thus, the help-seeking behaviour rate might be low due to the lack of change in the level of wellbeing. This effect in the literature is called the "ceiling effect", which means that an independent variable (wellbeing monitoring through the mobile application) has no further effect on a dependent variable (level of wellbeing) (Salkind, 2010).

In the current study, participants were also asked if they used any other mental health related mobile applications during the intervention. To the best of our knowledge, no study has provided such information about whether a participant used any other mental health-related mobile application over an intervention period. This would be an important risk in this field since the other application's use might have impacted research findings, which may cause false results. There is no widely accepted way to prevent this risk; however, it is possible to explore the risk rate by self-reporting. Based on the participants ' self-report, the risk rates for another mental health-related application use were low: 5.6% in the intervention group and 9.5% in the control group. These figures might mean that there was a very low risk in this current study, which may increase the reliability and validity of the findings. In future studies, it is strongly recommended that participants be informed about avoiding using other similar mobile applications on the market during the study period. Additionally, it is important to ask participants whether they use any other similar applications to assess the presence and prevalence of this potential confounding factor.

8.4 Qualitative findings discussion

8.4.1 Perceived usefulness

The purpose of the interviews was to explore participants' experiences of using a mobile application to improve their mental wellbeing by monitoring their behaviours, daily mood, and symptoms. User experiences in the mobile application concept are a significant area for understanding the weak and strong points of the mobile application and how people use it.

It is claimed that mobile application-delivered interventions are becoming popular for improving mental health and wellbeing. This trend is because mobile applications are widely used across ages, incomes, and cultures; they are also highly accessible, portable, person-centred, and often connected to the Internet (Peng et al., 2020; Proudfoot, 2013). In the interviews, the main point was that the mobile application was easy to use, handy, and quick to enter real-time data. Participants reported that these factors helped them maintain consistency. Another advantage is that mobile applications are acceptable to individuals as they provide a sense of autonomy and self-control, which are essential elements for self-awareness of healthy behaviours (Stawarz et al., 2015). The findings of interviews supported this claim, as participants expressed that mental wellbeing monitoring through the mobile application improved their sense of autonomy, motivating them to continue to use the application. This aligns with SDT, which emphasises the importance of autonomy, competence, and relatedness in fostering intrinsic motivation and well-being (Ryan & Deci, 2018). By offering users control over their mental wellbeing management and enabling self-regulation, mobile applications can effectively support these psychological needs. Consequently, the sense of autonomy and self-control reported by participants likely contributed to their sustained engagement with the application.

Participants reported varying perceptions of the mobile application's effectiveness in influencing their behaviours and symptoms. The application was found to be helpful for both behaviour formation (diet, exercise, sleep, alcohol, smoking, and caffeine) and symptom improvement (stress, anxiety, depression, daily mood, focus, energy, and worry). However, participants generally perceived it as more beneficial for behaviour formation than mental health-related symptom improvement. Interviews suggest this may be because behavioural changes are often more noticeable compared to the longer-term improvements in mental wellbeing. The literature endorses this finding and explains that mental wellbeing includes changes in attitudes, beliefs, emotions, and cognitive processes, which are more complex and challenging to measure than observable behaviours (Voukelatou et al., 2021). However, there is no doubt that healthy behaviour formation through the mobile application (sleep, exercises, smoking cessation, reducing excessive caffeine and alcohol intake) will also help promote long-term mental wellbeing improvements (Dale et al., 2014; Rebar & Taylor, 2017). The study's focus on recruiting health and care workers/students without diagnosed mental health conditions might also contribute to the perceived greater effectiveness in behaviour formation. This could be because participants were more likely to prioritise and focus on changing their behaviours compared to addressing mental health-related symptoms.

8.4.2 Enablers

This study showed a 64.4% engagement rate with the mobile application, which is higher than similar studies derived from the scoping review (see Chapter 2). Based on the interviews, the contributing factors for this rate could be increased self-awareness, individual-led practical strategies, easy use and access, a holistic wellbeing approach (including both physical and mental items), personalised tracking, and a rewarding scoring system.

Daily use of a mobile application can form a new habit (AlSlaity et al., 2022). There are five stages of behaviour change according to the transtheoretical model of health behaviour change (Prochaska, 2020). One of these phases is "contemplation," in which individuals become aware of the need for change and begin to consider the advantages of making a change. People move from the contemplation stage to the action stage when they take concrete measures to improve their behaviour and mental health (Prochaska, 2020). Participants reported that monitoring mental health-related items helped them gain greater insight into their thoughts, emotions, and actions. The mobile application visualised their mental health and behavioural patterns, allowing them to identify areas where they wished to improve. This intervention increased their sense of self-awareness, self-evaluation, and self-autonomy. According to the interviews, self-reflection, regular monitoring, and the visual representation of the patterns of their mental wellbeing status and behaviours (as measured by the mobile application scores) play a critical role in improving this self-awareness. RT suggests that desired behaviours are strengthened when consistently followed by positive reinforcement (Gordan & Krishanan, 2014; Nickerson, 2022). The mobile application's daily scores function as a reinforcement system. Seeing their progress through positive changes in scores reinforces users' healthy behaviours, promoting long-term mental wellbeing improvement.

Personalisation, allowing participants to select a wide range of physical and mental wellbeing related items, emerged as enablers for the mental wellbeing monitoring intervention. This is because participants were motivated to monitor specific items they perceived as needing improvement. Daily tracking of these items through scores further increased their engagement with the mobile application. Thus, future studies should focus on improving visualisation, feedback, and the interface showing the flow of monitored items.

There were also reported individual-led strategies aimed at remembering to use the application and increasing engagement with it. The strategies are placing the application icon on the phone homepage, setting a reminder alarm, and entering the data at the same time of day. These strategies can be considered unique because the participants individually decided to apply them, showing high engagement attitudes towards the application. Quick and easy data input was also reported as an enabler factor, which is a critical aspect in mobile application fields because mobile application use should be as practical as possible (Wang & Qi, 2021).

Qualitative findings showed that *"feeling observed"* reported by some participants was another enabler to the use of the application, which may indicate that the Hawthorne effect may impact this study's results. This effect refers to unexpected outcomes that might depend on the fact that participants in a study have been aware of being part of an experiment and receiving extra attention as a result (Merrett, 2006; Roethlisberger & Dickson, 2003). The current study reported that the feeling being observed helped the participants consistently use the mobile application.

8.4.3 Suggested improvements

The present study's findings revealed several suggestions for improving the mobile application. There are a few unique suggestions for this population, such as monitoring shift work, hydration, breaks, communication, and adjustable, colourful designs.

One of the main suggestions made by participants was the inclusion of work-related questions in the mobile application. Work-related stress among healthcare workers, including those in the UK, is a significant concern. In the UK, the Health, and Safety Executive (HSE) conducts surveys and research to assess work-related stress across various sectors, including healthcare. Their reports indicate that healthcare professionals, including nurses, doctors, and support staff, are among the most stressed workers (*Work-related stress, depression or anxiety statistics in Great Britain, 2023*, 2023). Research has highlighted the detrimental impact of work-related stress on the mental health of health and care workers (McFadden et al., 2021; Shemtob et al., 2022). Users could reflect on their work-related stressors by including work-related stress questions in the mobile application and seek help managing them. For example, shift work was a concern for participants as it changed their daily routine, such as the sleep-wake cycle (Torquati et al., 2019), which may cause them to forget to use the mobile application. Previous research has also highlighted the negative impact of shift work on mental health and wellbeing (Brown et al., 2020; Rosa et al., 2019). By guiding users on how to manage the challenges of shift work, the mobile application could help users maintain their mental health and wellbeing. Participants also emphasised the importance of hydration and breaks. They suggested that reminders or tracking items for water intake and breaks could be useful. Due to the high workload and busy environment, health and care workers may not drink sufficient amounts or take breaks to recover and refresh (El-Sharkawy et al., 2016). Both hydration and breaks impact cognitive performance and mood (Blake & Stacey, 2022). Thus, monitoring hydration and breaks may remind them to have enough drinks and breaks at work, which in turn could positively impact their mental health and wellbeing. Another work-related suggestion was adding communication questions to track their relationships with colleagues, which might facilitate peer support and reduce feelings of isolation.

Another area for improvement that participants identified was the suggestion of giving advice and tips based on the user's scores. One of the main reasons for inconsistent application use was a lack of advice or tips on how to improve the identified impaired health item. Feedback or coaching features, which have many advantages for motivating people to use the mobile application consistently, would offer advice and tips (Szinay et al., 2021). A systematic review of mobile application-based health promotion programmes for the general population indicated that feedback and practical tips were useful to increase the application's engagement and effectiveness (Lee et al., 2018). The ability to set goals in the application was also suggested, which might facilitate participants taking action to reach their goals. Goal-setting theory supports this idea, as researchers have found that it increases individuals' enthusiasm and intrinsic motivations and, thus, leads them to expend more energy towards achieving goal-directed tasks (Abhari & Vaghefi, 2022). Another notable suggestion was that the mobile application would provide information on how behaviours relate to mental wellbeing. This suggestion might be important because this information would increase the "perceived benefits" of mobile application use for mental wellbeing improvement. It was found that behaviour formation was more frequently reported than mental wellbeing improvement.

Higher awareness of the connection between physical and mental health would lead to higher motivation to use the application. By providing information on how behaviours such as physical activity, nutrition, and sleep relate to mental wellbeing, the mobile application could help users make informed choices about their lifestyle behaviours.

The other suggestions focused on personalised design, which was useful for increasing engagement and a sense of self-autonomy. The current mobile application has personalised features, such as customised items, comparison among those chosen items, flexibility for data entry time, and an option for yesterday's data entry. This approach was reported as a strong point of the application, which led to increased user engagement as it created a more relevant and meaningful experience. On the other hand, in addition to these features, participants expected a more personalised design, including adjustable colour themes, setting notifications for data entry time, and visualisations such as emojis and pictures. Previous research has indicated that this individually tailored design would also improve user experience and satisfaction (Alqahtani et al., 2021; Harrison et al., 2011), which were not at an excellent level based on the MAUQ and interviews in the present study. Additionally, by incorporating visually appealing design features, the mobile application could improve motivation and adherence to mental wellbeing monitoring.

8.5 Study strength and limitations

This is the first mixed-method feasibility study, which includes a mobile application-based monitoring intervention to promote the mental wellbeing of health and care workers/students. This monitoring included items related to both physical and mental health, aligning with a holistic approach to mental wellbeing. The qualitative part of this study provided novel insights into the experiences of health and care workers/students regarding mobile application-based mental wellbeing monitoring. Individual interviews were also valuable in exploring the reasons behind the feasibility of study outcomes and user engagement with the intervention.

In this study, user engagement with mental wellbeing monitoring was higher than the relevant literature average based on the scoping review (Chapter 2). Relying on Reinforcement Theory, the mobile application's scoring system would have contributed to this higher engagement with the intervention, as no such feature existed in the reviewed applications. Additionally, answering the daily questions in the mobile application only took about a minute, and it is possible that the wide range of mental wellbeing items from both physical and mental aspects, with a free-to-choose option, may have also contributed to this higher intervention engagement.

This study was conducted during the COVID-19 pandemic. Thus, it provides strategies for dealing with challenges in unexpected, extraordinary circumstances concerning financial issues, ethical problems, and recruitment challenges. Non-COVID-19 UK trials have encountered lower-than-expected participant recruitment due to pandemic-related factors (Lorenc et al., 2023). Therefore, this study replaced its original recruitment plan with social media recruitment, including health and care workers/students across the UK. All interactions were conducted online for participant and researcher safety (e.g., video calls, e-mails, and social media posts). It also added to the literature about social media recruitment, highlighting both its strengths and weaknesses as it is a relatively new participant recruitment strategy in clinical trials. For example, although the participants could be contacted through social media platforms like Twitter and Facebook, other users were inadvertently excluded. Also, those who do not use social media were excluded, which decreased the generalisability of the study.

To our knowledge, this study is the first to ask about participants' use of other mental health and wellbeing-related mobile applications during the study period. This is crucial, as using other applications could influence the study results. This confounding factor could potentially bias the findings. There is no standardised approach to eliminate this factor entirely. However, asking participants about their use of other relevant applications is highly recommended to enhance the reliability and transparency of future studies.

Moreover, to our knowledge, this is the first study adhering to the recent guidelines for presenting the WEMWBS questionnaire. The University of Warwick offers a guideline for the presentation of WEMWBS findings (*Collect, score, analyse and interpret WEMWBS*, 2023). This representation introduced a few new approaches for the descriptive findings. Firstly, it presents percentages indicating low, moderate, and high wellbeing scores. Secondly, it involves the number of participants showing a meaningful positive or negative change.

Despite those strong points, this study also includes limitations. Social media recruitment led to a decrease in study representation and generalisability. For example, people with no social media accounts or inactive users were excluded.

From this point of view, this study may represent social media users. The participants' age distribution was homogeneous and mostly included young adults (21-40). Recruitment through social media (X (formerly Twitter), Facebook, and digital newsletters) might cause this young adult age profile, which does not represent older people’s perspectives on mental wellbeing monitoring. Further, the number of women participants greatly exceeded the number of other genders. Even though this gender distribution aligns with the NHS population (England, 2021), low participation of other genders may lead to underrepresentation. Future studies may establish more inclusive recruitment strategies, including both traditional (e.g. flyers, posters, or in-person contact) and digital methods.

This feasibility study could not produce a recruitment rate, which is an important factor in future trials concerning recruitment progress. Recruitment rate in clinical trials refers to dividing the number of accepted offers (accepting joining the study) by the number of offers made. However, this calculation was not feasible in this current study since the study invitation was posted on social and digital media, which are accessible to the public for everyone. Consequently, it was not possible to determine how many health and care workers/students had seen the post and how many of them had decided to take part in the study. However, asking participants on which platform they heard about the study could be helpful in the baseline survey. This may help to identify which social media platforms could be more useful for recruitment. Additionally, different study invitation posts were published on X. However, only a single invitation post could be shared, allowing its tracking via X's post activity feature. This feature displays the number of times users have viewed the post and how frequently it has been clicked. This information might provide insights about X’s impact on recruitment. As a result, the current study can not provide information on what digital platform was more useful for recruitment than the other platforms employed in this study.

This study employed snowball sampling, which introduces a potential risk of contamination between the intervention and control groups. Snowball sampling relies on participants recruiting others they know, and some participants might be assigned to different groups (intervention vs. control) (Nikolopoulou, 2022). If participants discuss the study or the mobile application's effects with each other, it could influence their experiences and bias the results.

Another limitation was about the mHealth App Usability Questionnaire (MAUQ), a validated questionnaire particularly developed for assessing health and wellbeing related to mobile applications’ acceptability and usability (Zhou et al., 2019). This allows researchers to gather specific acceptability and usability information about the mobile application, which will help to increase the understanding of mobile application use in mental wellbeing promotion. However, as it is a new questionnaire, there were no previous studies using the MAUQ questionnaire for their mobile applications for mental wellbeing promotion, which causes a lack of comparisons between the mobile applications used for similar purposes (Hajesmaeel-Gohari et al., 2022).

Lastly, the mobile application shows limitations in its design and content, notably the absence of reminder and push notification features. Instead, weekly emails were utilised as one-time reminders for participants regarding mobile application usage. However, the lack of notifications, which are crucial for maintaining daily user engagement, may have affected the monitoring of mental wellbeing through the mobile application. This absence resulted from financial challenges faced by the developer during the COVID-19 pandemic, which prevented the integration of notifications into the mobile application.

8.6 Future research directions

We believe that this study will stimulate research areas on mental wellbeing promotion among healthcare workers/students in the UK using mobile applications. It is important to consider holistic approaches to support mental wellbeing, including both physical and mental aspects. This study shows that mobile application-based mental wellbeing monitoring promises improvements; however, there is a need for future studies, specifically full randomised controlled trials, to determine the effectiveness of mobile application-delivered monitoring interventions. After identifying this mobile application's effectiveness, it could be considered for inclusion in the NHS-recommended mobile application list. For example, it would be listed in health promotion support toolkit provided by the NHS for healthcare workers (e.g., (*Caring for yourself while you care for others: the Midlands Edition*, 2020)).

Moreover, mobile application monitoring involves human interactions; thus, all research related to mobile application use must assess human experiences, particularly with qualitative methods. Additionally, the literature primarily focuses on mindfulness-based mobile applications; however, there is a need for assessing other psychological interventions or therapies (e.g. Cognitive Behavioural Therapy (CBT)) to enhance the understanding of mobile application-based interventions. This will contribute to the literature by comparing the effectiveness of different approaches to support the mental wellbeing of healthcare workers and students in the UK.

8.7 Summary of the discussion

- This is the first mixed-method feasibility RCT study with qualitative components to explore if mental wellbeing monitoring through a mobile application could be acceptable and useful for promoting the mental wellbeing of health and care workers and students in the UK.
- This study shows the mobile application and research would be feasible according to the engagement, recruitment, dropouts' rate, and high response rate in questionnaires.
- Future studies should consider that social media recruitment could cause a selection bias, particularly with age.
- Technological issues would be a major challenge during such mobile application-delivered interventions.

Chapter 9: Conclusions

This study suggests that mobile application-based mental wellbeing monitoring (including both physical and mental aspects of health) is feasible research in terms of recruitment, application of the questionnaires, and dropout rate. The findings from the Mobile App Usability Questionnaire (MAUQ), qualitative interviews, and user engagement indicate that health and care workers/students find using mobile applications acceptable for promoting their mental wellbeing. The study also suggests that mobile application-based monitoring potentially impacts particularly daily positive habit change, which may impact long-term mental wellbeing improvement.

Mental ill health is highly prevalent in health and care workers and students. Poor mental wellbeing is a personal challenge and a risk for decreasing quality of care and patient safety. Moreover, there is a growing concern about the mental wellbeing of health and care workers/students, as healthcare workers are the key people in the fight against extraordinary circumstances such as pandemics like COVID-19. There is a need to support the mental wellbeing of health and care workers/students to increase their resilience and improve their mental wellbeing.

In this digitalised world, every sector is searching for digitalised solutions for their challenges. Digitalisation offers many advantages, such as accessibility, cost efficiency, practicality, and swift implementation. There are various new approaches to service use and delivery within the healthcare sector. Mental wellbeing promotion through mobile application-based interventions is one of these rapidly developing approaches which can be applied to support the mental wellbeing of health and care workers/students.

However, several aspects need attention to enhance intervention engagement and participant recruitment. Push notifications, built into the application-goal settings, and health-related advice were the most frequently mentioned future recommendations for improving the design and content of the mobile application. Adding gamification features, personalised interface colours, and enriching the mobile application with emojis and daily quotes were found to be factors that improved participants' engagement with the application. The interview findings suggest that the mobile application's content could be tailored to health and care workers by adding work-oriented items such as hydration, work breaks, and monitoring shift working.

Lastly, this study indicates that relying solely on digital media recruitment can skew participant demographics, potentially excluding older adults or individuals without social media accounts. Future studies should consider including traditional recruitment methods to increase the study's generalisability.

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Appendices

Appendix 1: Searching terms

Medline (OVID)

#	Term	Results retrieved on June 2022
1	exp Mobile Applications/	10561
2	Exp Smartphone/	8242
3	Exp Software/	178512
4	2 and 3	3006
5	(“mobile application*” or “mobile app” or “mobile apps” or apps or “m health” or mhealth or “mobile health” or “digital health” or “ehealth” or ehealth or “smartphone app”* or “smart phone app*).mp.	41967
6	1 or 4 or 5	42211
7	Exp Mental Health	55739
8	Exp Stress, Psychological/	149051
9	Exp Anxiety/	105630
10	Exp Depression/	144043
11	(wellbeing or “well being” or “mental health” or stress or anxiety or anxious or depress*).mp.	1999289
12	7 or 8 or 9 or 10 or 11	2007789
13	Exp Health Personnel/	592331
14	(“healthcare worker*” or “healthcare personnel” or “healthcare professional*” or “healthcare students” or doctor* or gp or gps or “general practitioner*” or nurse* or physician*).mp.	1181182
15	13 or 14	1443010
16	6 and 12 and 15	844

Embase (OVID)

#	Term	Results retrieved on June 2022
1	Exp Smartphone/	22053
2	Exp Software/	291453
3	1 and 2	6764
4	("mobile application*" or "mobile app" or "mobile apps" or apps or "m health" or mhealth or "mobile health" or "digital health" or "ehealth" or ehealth or "smartphone app"* or "smart phone app*).mp.	48374
5	Exp Mental Health	207476
6	Exp Stress, Psychological/	184580
7	Exp Anxiety/	261196
8	Exp Depression/	564880
9	(wellbeing or "well being" or "mental health" or stress or anxiety or anxious or depress*).mp.	2792700
10	5 or 6 or 7 or 8 or 9	2839031
11	("healthcare worker*" or "healthcare personnel" or "healthcare professional*" or "healthcare students" or doctor* or gp or gps or "general practitioner*" or nurse* or physician*).mp.	1590364
12	Exp mobile application/	21564
13	("portable electronic app*" or "portable software app*").mp.	12
14	Exp mobile phone/ or exp smartphone/	41860
15	2 and 14	9142
16	4 or 12 or 13 or 15	49787
17	Exp wellbeing/	109145
18	10 or 17	2839031
19	Exp health care personnel/	1837120
20	"healthcare practitioner*".mp.	3164
21	11 or 19 or 20	2607155
22	16 and 18 and 21	2096

CINAHL and PsycINFO (EBSCO)

#	Term	Results retrieved on June 2022
S1	Mobile Applications	29826
S2	Smartphone	33178
S3	Software	816329
S4	2 and 3	3572
S5	mobile application* or mobile app or mobile apps or apps or m health or mhealth or mobile health or digital health or ehealth or ehealth or smartphone app*	170658
S6	1 or 4 or 5	171967
S7	Mental Health	596323
S8	Psychological stress	210397
S9	Anxiety	436591
S10	Depression	710215
S11	wellbeing or well being or mental health or stress or anxiety or anxious or depress*	2946653
S12	7 or 8 or 9 or 10 or 11	2946653
S13	Health Personnel	333623
S14	healthcare worker* or healthcare personnel or healthcare professional* or "healthcare students" or doctor or gp or gps or general practitioner* or nurse* or physician*	2546950
S15	13 or 14	2691379
S16	6 and 12 and 15	3173

The Cochrane Library

#	Term	Results retrieved on June 2022
1	Mobile Application*	6743
2	Smartphone*	6005
3	1 and 2	1629

4	mobile application* or mobile app* or apps or mhealth or mobile health or digital health or e health or smartphone app*	55340
5	3 and 4	9019
6	Mental Health	37369
7	stress or anxiety or depression	182743
8	wellbeing or well being	37976
9	6 and 7 and 8	3515
10	"healthcare worker*" or "healthcare personnel" or "healthcare professional*" or "healthcare students" or doctor* or gp or gps or "general practitioner*" or nurse* or physician*	3076
11	3 and 5 and 9 and 10	429

Appendix 2: Studies ineligible following full text review

1. van der Meer, C. A., Bakker, A., van Zuiden, M., Lok, A., & Olff, M. Help in hand after traumatic events: a randomized controlled trial in health care professionals on the efficacy, usability, and user satisfaction of a self-help app to reduce trauma-related symptoms. European journal of psychotraumatology 2020; 11(1), 1717155.

Reason for exclusion: Participants diagnosed with post-traumatic stress disorder

2. Smith, J. L., Allen, J. W., Haack, C., Wehrmeyer, K., Alden, K., Lund, M. B., & Mascaro, J. S. The impact of app-delivered mindfulness meditation on functional connectivity and self-reported mindfulness among health profession trainees. Mindfulness 2021; 12(1), 92-106.

Reason for exclusion: Not related wellbeing outcomes

Appendix 3: PPI Works

PPI Section done by Holly Blake

1- We held a consultation group with ~100 students in April 2019 (Midlands4Cities, Nottingham, UK) in which university students from diverse disciplines engaged in discussions which clearly identified a need for mental wellbeing promotion support, and promotion of healthy active lifestyles for positive mental wellbeing. Students raised the need for increased self-awareness and self-monitoring their own behaviours to prevent mental ill-health.

2- We have previously worked with students to assess their engagement with new technologies used in higher education settings (Blake et al, 2010) – This suggested that students are willing to use new technologies so long as adequate technical support is available – This will be available through the MYARKEO technical team.

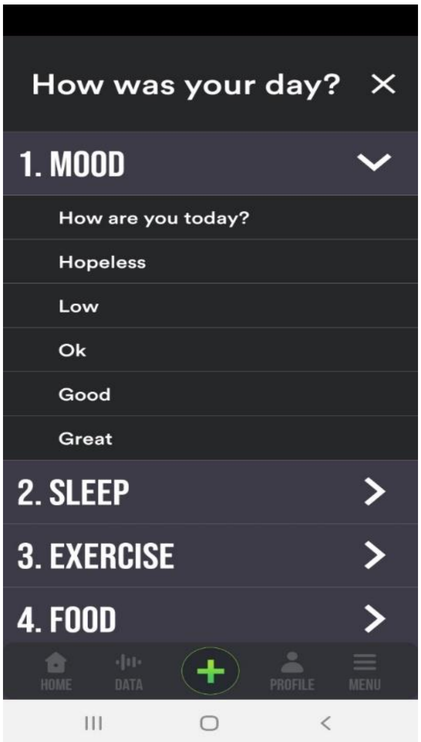
3- We have conducted online consultation in March 2019 about the use of technology in health promotion intervention (https://blogs.ucl.ac.uk/cbc-digi-hub-blog/2019/03/12/mapping-out-technological-designs-employed-in-digital-interventions-to-reduce-sedentary-behaviours/). This clearly demonstrated the potential of using novel digital technologies for delivering behaviour change intervention. Specifically, responses indicated that apps are regularly used by the healthy general public.

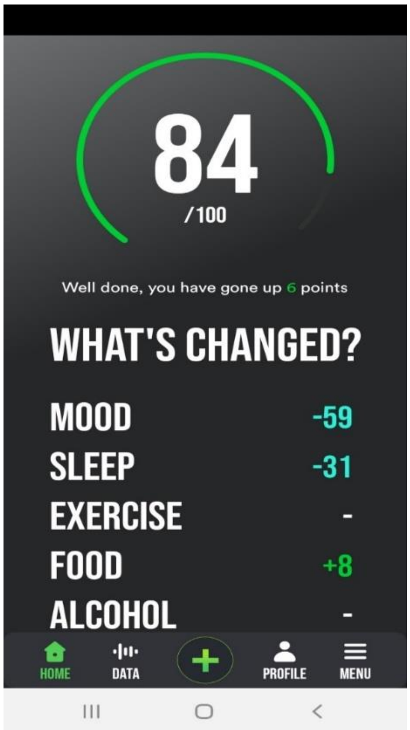
4- We consulted with students about their mobile phone use (n=250, Jan 2020). This demonstrated that mobile phones are ubiquitous among students - 100% owned a mobile phone and all reported prior experience of using apps.

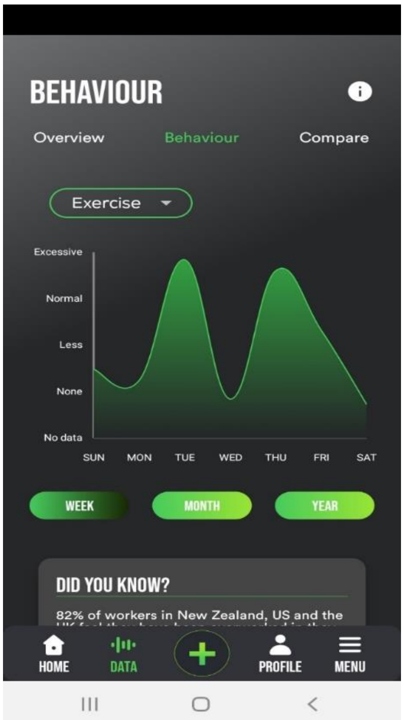
5- We held a student consultation group (n=32, Jan 2020). This involved group activities about their perceptions towards using digital technologies for health. Students were positive about digital health and suggested the use of an app to promote mental wellbeing, physical activity, diet and sleep. These areas are all tracked through the MYARKEO app. Students suggested that any requirement for health tracking should be flexible to allow completion at any time of day and any location. This flexibility is provided by MYARKEO.

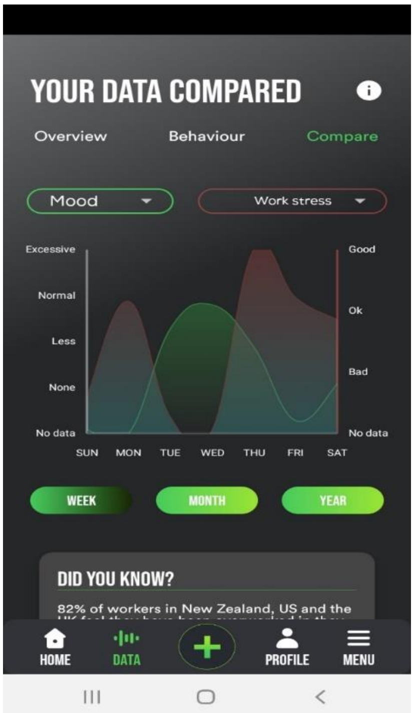
6- We have engaged in a discussion group with students (n=25, Feb 2020), which involved presentation of the MYARKEO purpose and functionality. All participants identified potential benefits of the app with regards raising awareness of health behaviours, promoting wellbeing and advocating technology for health. The concept of mental fitness was viewed positively as reducing stigma around mental health. The focus on tracking lifestyle behaviours was viewed more positively than educational intervention or a sole focus on mental health. Barriers to use included the potential burden of tracking behaviours without receipt of any feedback – this will be completed addressed by the launch of the updated version of MYARKEO in March 2020 that includes self-monitoring, goal setting and feedback.

Appendix 4: Screenshots of the MYARKEO application









Appendix 5: All questions in the application

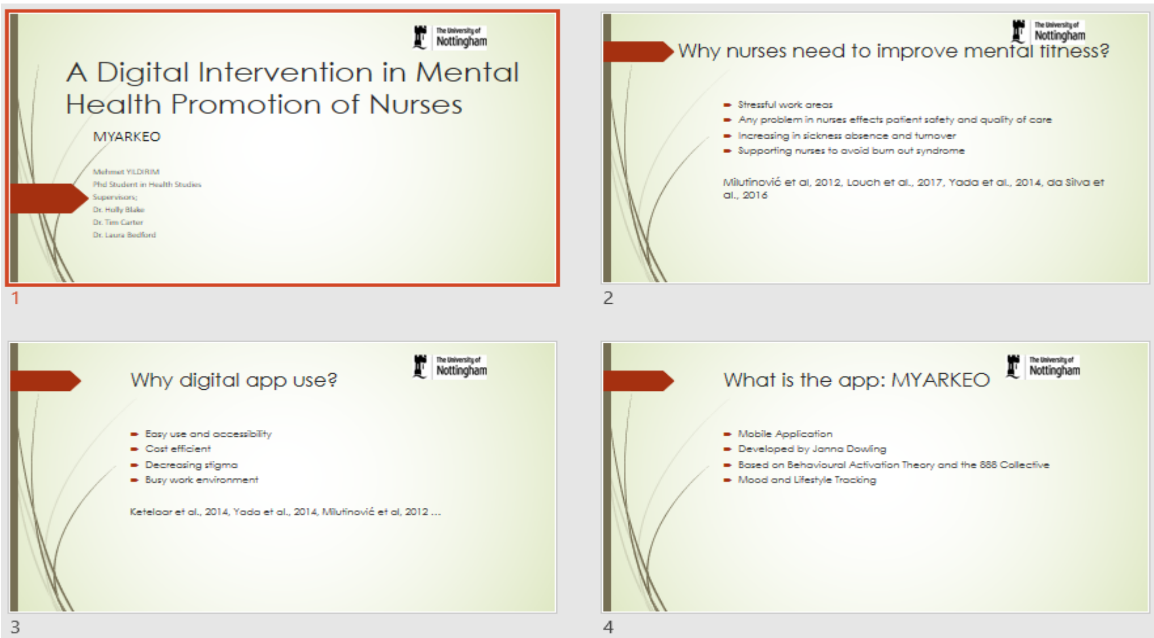
Num ber	Questions	Answer options	Follow up question	Answer options
1	How are you today?	Hopeless		
		Low		
		Okay		
		Good		
		Great		
2	How many meals did you eat today?	0		
		1		
		2		
		3		
		4+		
3	How many hours did you sleep last night?	0-3		
		4--6		
		7--9		
		10+		
4	Did you exercise today?	Not at all		
		Somewhat active		
		Fairly active		
		Very active		
		Excessively active		
5	Did you work today?	Yes	How many hours?	1-4 hours
		No		5-9 hours
6	How many caffeinated drinks today?	0		10+
		1--3		
		4--6		
		7--9		
		10+		
7	Have you felt work challenges today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
8	Have you felt low energy today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		

9	Have you felt general worry today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
10	Have you felt anxiety today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
11	Have you felt unable to focus today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
12	How many alcoholic drinks today?	0		
		1--3		
		4--6		
		6+		
13	Have you felt relationship challenges today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
14	Did you have your period today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
15	Did you experience menopause symptoms today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
16	Have you felt family challenges today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
17	Have you felt physical pain today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		

18	Have you taken your medicine today?	No		
		Yes		
19	How much did you smoke/vape today?	0		
		1--3		
		4--6		
		6+		
20	Have you felt lonely?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
21	Have you felt financial challenges today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
22	Have you felt irritable today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
23	Have you felt anger today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
24	Have you felt agitation today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
25	Have you felt tearful?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
26	Have you felt withdrawn today?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		
27	Did you struggle with your disability?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		

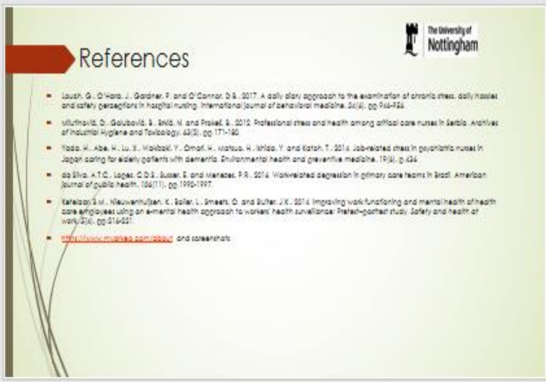
28	Have you felt hyper?	No		
		Yes, I can deal with it.		
		Yes, I can't deal with it.		

Appendix 6: PowerPoint presentation for the PPI work




The University of
Nottingham
Any Questions?

9


The University of
Nottingham
References

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Appendix 7: Feedback survey after the presentation

Participant ID:

ARKEO

FEEDBACK SURVEY

Thank you for taking the time to complete this survey. All feedback – both positive and negative – is really helpful for us. If you have any questions, please feel free to contact the research team.

ABOUT YOU

1. **Gender:** ………………………………………………….

2. **Age:** ………………………………………………….

3. **Are you a student nurse or registered nurse? Please provide your branch**

……

YOUR USE OF HEALTH APPS

4. **How many mobile phone apps do you currently have?**

………………………………………………………………………………………

5. **In general, how frequently would you say you use these apps?** [hours (or minutes) per day]

………………………………………………………………………………………

6. **Have you used any apps related to health?** (e.g., lifestyle/symptom monitoring and tracking, remote coaching, health information)

Page **1** of **4**

Participant ID:

☐ **Yes**
- In general, please specify how long you have had them: _______________

☐ **No**
- Would consider using such apps in the future? Yes / No (please delete as appropriate)

☐ **Prefer not to say**

7. Have you used any apps specifically related to mental health?

☐ **Yes**
- In general, please specify how long you have had them: _______________

☐ **No**
- Would you consider using such apps in the future? Yes / No (please delete as appropriate)

☐ **Prefer not to say**

YOUR VIEWS ON ARKEO

8. What are your general views of the app?

Participant ID:

9. What did you like about the app?

10. Is there anything about the app that you feel could be improved?

11. Do you think that using ARKEO could influence the health of nurses? In what ways?

Participant ID:

12. Would you use the app to track your mental fitness?

13. What barriers would you face about using the app?

Page **4** of **4**

Appendix 8: Reporting checklist for randomised trial (CONSORT)

Based on the CONSORT guideline

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a", and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the CONSORT reporting guidelines, and cite them as:

Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials.

		Reporting Item	Page Number
Title and Abstract			
Title	#1a	Identification as a randomized trial in the title.	n/a
Abstract	#1b	Structured summary of trial design, methods, results, and conclusions	n/a
Introduction			
Background and objectives	#2a	Scientific background and explanation of rationale	Chapter 1 and 2
Background and objectives	#2b	Specific objectives or hypothesis	82
Methods			
Trial design	#3a	Description of trial design (such as parallel, factorial) including allocation ratio.	82-89
Trial design	#3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	n/a
Participants	#4a	Eligibility criteria for participants	91

Participants	#4b	Settings and locations where the data were collected	91-96
Interventions	#5	The experimental and control interventions for each group with sufficient details to allow replication, including how and when they were actually administered	100-102
Outcomes	#6a	Completely defined prespecified primary and secondary outcome measures, including how and when they were assessed	102-108
Outcomes	#6b	Any changes to trial outcomes after the trial commenced, with reasons	n/a
Sample size	#7a	How sample size was determined.	102-104
Sample size	#7b	When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomization - Sequence generation 98-100	#8a	Method used to generate the random allocation sequence.	
Randomization – Sequence generation	#8b	Type of randomization; details of any restriction (such as blocking and block size)	
102-104 Randomization - Allocation concealment mechanism	#9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	98-100
Randomization - Implementation	#10	Who generated the allocation sequence, who enrolled participants, and who assigned participants to interventions	98-100
Blinding	#11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how.	98-100
Blinding	#11b	If relevant, description of the similarity of interventions	n/a
Statistical methods	#12a	Statistical methods used to compare groups for primary and secondary outcomes	108-111
Statistical methods	#12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	108-111

Results

Participant flow diagram (strongly recommended)	#13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	98
Participant flow	#13b	For each group, losses, and exclusions after randomization, together with reason	119
Recruitment	#14a	Dates defining the periods of recruitment and follow-up	118
Recruitment	#14b	Why the trial ended or was stopped	n/a
Baseline data	#15	A table showing baseline demographic and clinical characteristics for each group	120-122
Numbers analysed	#16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	148, 152
Outcomes and estimation	#17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	n/a
Outcomes and estimation	#17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	n/a
Ancillary analyses	#18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	n/a
Harms	#19	All important harms or unintended effects in each group (For specific guidance see CONSORT for harms)	n/a
Discussion			
Limitations	#20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	214
Generalisability	#21	Generalisability (external validity, applicability) of the trial findings	201-203
Interpretation	#22	Interpretation consistent with results, balancing benefits, and harms, and considering other relevant evidence	193-203

Registration	#23	Registration number and name of trial registry	n/a
Other information			
Interpretation	#22	Interpretation consistent with results, balancing benefits, and harms, and considering other relevant evidence	204
Registration	#23	Registration number and name of trial registry	
Protocol	#24	Where the full trial protocol can be accessed, if available	n/a
Funding	#25	Sources of funding and other support (such as supply of drugs), role of funders	117

Appendix 9: The Template for Intervention Description and Replication Checklist (TIDieR)

Item number	Item	Where located
1	**BRIEF NAME** Provide the name or a phrase that describes the intervention.	104
2	**WHY** Describe any rationale, theory, or goal of the elements essential to the intervention.	104
3	**WHAT** Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g., online appendix, URL).	104
4	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	

5	**WHO PROVIDED** For each category of intervention provider (e.g., psychologist, nursing assistant), describe their expertise, background and any specific training given.	104
6	**HOW** Describe the modes of delivery (e.g., face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	104-105
7	**WHERE** Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	104
8	**WHEN and HOW MUCH** Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.	104
9	**TAILORING** If the intervention was planned to be personalised, titrated, or adapted, then describe what, why, when, and how.	n/a
10	**MODIFICATIONS** If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	n/a
11	**HOW WELL** Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.	112
12	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned.	112

Appendix 10: Checklist for reporting qualitative studies, COREQ-32

No	Item	Guide questions/description
Domain 1: Research team and reflexivity		
Personal Characteristics		
1.	Interviewer/facilitator	Which author/s conducted the interview or focus group?
2.	Credentials	What were the researcher's credentials? *E.g. PhD, MD*
3.	Occupation	What was their occupation at the time of the study?
4.	Gender	Was the researcher male or female?
5.	Experience and training	What experience or training did the researcher have?
Relationship with participants		
6.	Relationship established	Was a relationship established prior to study commencement?
7.	Participant knowledge of the interviewer	What did the participants know about the researcher? e.*g. personal goals, reasons for doing the research*
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. *Bias, assumptions, reasons, and interests in the research topic*
Domain 2: study design		
Theoretical framework		

No	Item	Guide questions/description
9.	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? *e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis*
Participant selection		
10.	Sampling	How were participants selected? *e.g. purposive, convenience, consecutive, snowball*
11.	Method of approach	How were participants approached? e.*g. face-to-face, telephone, mail, email*
12.	Sample size	How many participants were in the study?
13.	Non-participation	How many people refused to participate or dropped out? Reasons?
Setting		
14.	Setting of data collection	Where was the data collected? e.*g. home, clinic, workplace*
15.	Presence of non-participants	Was anyone else present besides the participants and researchers?
16.	Description of sample	What are the important characteristics of the sample? *e.g. demographic data, date*
Data collection		
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?

No	Item	Guide questions/description
20.	Field notes	Were field notes made during and/or after the interview or focus group?
21.	Duration	What was the duration of the interviews or focus group?
22.	Data saturation	Was data saturation discussed?
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?
Domain 3: analysis and findingsz		
Data analysis		
24.	Number of data coders	How many data coders coded the data?
25.	Description of the coding tree	Did authors provide a description of the coding tree?
26.	Derivation of themes	Were themes identified in advance or derived from the data?
27.	Software	What software, if applicable, was used to manage the data?
28.	Participant checking	Did participants provide feedback on the findings?
Reporting		
29.	Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.*g. participant number*
30.	Data and findings consistent	Was there consistency between the data presented and the findings?
31.	Clarity of major themes	Were major themes clearly presented in the findings?

No	Item	Guide questions/description
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?

Appendix 11: Study invitation e-mail and social media posts

E-mail:

Dear XXX,

We would like to invite you to participate in a study that explores whether a mobile application specifically designed to help improve mental wellbeing is useful and acceptable to healthcare workers in the United Kingdom. It is clear that healthcare workers spend much of their time in a stressful environment that has, in many cases, become increasingly stressful since the start of the covid-19 pandemic. This app is free to use and simply encourages you to think about aspects of your health and lifestyle, and to focus on self-care.

If you agree to join the study, you will be invited to take part for 6 weeks. Everyone who joins the study is randomly split into one of two possibilities. You will either be allocated to receive the mobile application which you can then use for 6 weeks, or you will be not receive the mobile application and instead be directed to a website with information and advice around supporting your wellbeing. After 6 weeks, you may be invited to an interview to share your experiences during the study. There are also a small number of questionnaires to complete before and after the 6-week period.

If you would like to take part in the study or are interested to find out more, then please read the information sheet attached in this e-mail and follow the link for a consent form. https://nottingham.onlinesurveys.ac.uk/mental_fitness_study

Note: If you are currently receiving a psychological therapy and absent from your work/studies due to stress and/or mental health issues, it is better not to participate in the study since this is a study for general population.

Many thanks for your time…

Social media posts:

Are you a #HealthcareWorker or #healthcaretrainees? Want to join our research study? We are testing a mobile app to promote mental fitness in the healthcare #workforce, find out more at https://nottingham.onlinesurveys.ac.uk/participant-information-sheet-for-mental-fitness-study-fm and https://nottingham.onlinesurveys.ac.uk/mental_fitness_study. #Covid19

Mental Fitness Study Call for healthcare workers and trainees. We are experiencing tough days which shows the importance of #mentalhealthcare during #covid19. To improve #mentalfitness via a mobile app, we are conducting a study for #healthcare workers. Just follow the link to join! https://nottingham.onlinesurveys.ac.uk/participant-information-sheet-for-mental-fitness-study-fm

Appendix 12: The Warwick-Edinburg Mental Wellbeing Scale (WEMWBS)

Please tick (√) the box that best describes your experience of each over the last 2 weeks

STATEMENTS	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling optimistic about the future	1	2	3	4	5
I've been feeling useful	1	2	3	4	5
I've been feeling relaxed	1	2	3	4	5
I've been feeling interested in other people	1	2	3	4	5
I've had energy to spare	1	2	3	4	5
I've been dealing with problems well	1	2	3	4	5
I've been thinking clearly	1	2	3	4	5
I've been feeling good about myself	1	2	3	4	5
I've been feeling close to other people	1	2	3	4	5
I've been feeling confident	1	2	3	4	5
I've been able to make up my own mind about things	1	2	3	4	5
I've been feeling loved	1	2	3		
I've been interested in new things	1	2	3		
I've been feeling cheerful	1	2	3		

Satisfaction
Affect
Competence
Relatedness
Autonomy

Appendix 13: Depression, Anxiety, and Stress Scale (DASS-21)

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all

1 Applied to me to some degree, or some of the time

2 Applied to me to a considerable degree or a good part of time

3 Applied to me very much or most of the time

1 (s)	I found it hard to wind down	0	1	2	3
2 (a)	I was aware of dryness of my mouth	0	1	2	3
3 (d)	I couldn't seem to experience any positive feeling at all	0	1	2	3
4 (a)	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5 (d)	I found it difficult to work up the initiative to do things	0	1	2	3
6 (s)	I tended to over-react to situations	0	1	2	3
7 (a)	I experienced trembling (e.g. in the hands)	0	1	2	3
8 (s)	I felt that I was using a lot of nervous energy	0	1	2	3
9 (a)	I was worried about situations in which I might panic and make a foolof myself	0	1	2	3
10 (d)	I felt that I had nothing to look forward to	0	1	2	3
11 (s)	I found myself getting agitated	0	1	2	3
12 (s)	I found it difficult to relax	0	1	2	3
13 (d)	I felt down-hearted and blue	0	1	2	3
14 (s)	I was intolerant of anything that kept me from getting on with what Iwas doing	0	1	2	3
15 (a)	I felt I was close to panic	0	1	2	3
16 (d)	I was unable to become enthusiastic about anything	0	1	2	3
17 (d)	I felt I wasn't worth much as a person	0	1	2	3
18 (s)	I felt that I was rather touchy	0	1	2	3
19 (a)	I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	0	1	2	3
20 (a)	I felt scared without any good reason	0	1	2	3
21 (d)	I felt that life was meaningless	0	1	2	3

DASS-21 Scoring Instructions

The DASS-21 should not be used to replace a face to face clinical interview. If you are experiencing significant emotional difficulties you should contact your GP for a referral to a qualified professional.

Depression, Anxiety and Stress Scale - 21 Items (DASS-21)

The Depression, Anxiety and Stress Scale - 21 Items (DASS-21) is a set of three self-report scales designed to measure the emotional states of depression, anxiety and stress.

Each of the three DASS-21 scales contains 7 items, divided into subscales with similar content. The depression scale assesses dysphoria, hopelessness, devaluation of life, self-deprecation, lack of interest / involvement, anhedonia and inertia. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect. The stress scale is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset / agitated, irritable / over-reactive and impatient. Scores for depression, anxiety and stress are calculated by summing the scores for the relevant items.

The DASS-21 is based on a dimensional rather than a categorical conception of psychological disorder. The assumption on which the DASS-21 development was based (and which was confirmed by the research data) is that the differences between the depression, anxiety and the stress experienced by normal subjects and clinical populations are essentially differences of degree. The DASS-21 therefore has no direct implications for the allocation of patients to discrete diagnostic categories postulated in classificatory systems such as the DSM and ICD.

Recommended cut-off scores for conventional severity labels (normal, moderate, severe) are as follows:

NB Scores on the DASS-21 will need to be multiplied by 2 to calculate the final score.

	Depression	**Anxiety**	**Stress**
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-18
Moderate	14-20	10-14	19-25
Severe	21-27	15-19	26-33
Extremely Severe	28+	20+	34+

Lovibond, S.H. & Lovibond, P.F. (1995). Manual for the Depression Anxiety & Stress Scales. (2nd Ed.)Sydney: Psychology Foundation.

Appendix 14: mHealth App Usability Questionnaire (MAUQ)

#	Statements	N/A		1	2	3	4	5	6	7	
1.	The app was easy to use.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
2.	It was easy for me to learn to use the app.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
3.	The navigation was consistent when moving between screens.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
4.	The interface of the app allowed me to use all the functions (such as entering information, responding to reminders, viewing information) offered by the app.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
5.	Whenever I made a mistake using the app, I could recover easily and quickly.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
6.	I like the interface of the app.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
7.	The information in the app was well organised, so I could easily find the information I needed.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
8.	The app adequately acknowledged and provided information to let me know the progress of my action.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
9.	I feel comfortable using this app in social settings.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
10	The amount of time involved in using this app has been fitting for me.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
11	I would use this app again.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
12	Overall, I am satisfied with this app.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
13	The app would be useful for my health and well-being.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
14.	The app improved my access to healthcare services.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
15.	The app helped me manage my health effectively.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
16.	This app has all the functions and capabilities I expected it to have.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
17.	I could use the app even when internet connection was poor or not available.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
18.	This mHealth app provides an acceptable way to receive healthcare services such as accessing educational materials, tracking my own activities and performing self-assessment.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE

In this questionnaire, 1 - strongly disagree, 2 – disagree, 3 – somewhat disagree, 4 – neither agree nor disagree, 5 – somewhat agree, 6 – agree, 7 – strongly agree

To determine the usability of an app, calculate the total and determine the average of the responses to all statements. The higher the overall average, the higher the usability of the app.

Please cite: Zhou L, Bao J, Setiawan A, Saptono A, Parmanto B, (2019), "The mHealth App Usability Questionnaire (MAUQ): Development and Validation Study", *JMIR mHealth and uHealth*, 7(4):e11500. DOI: 10.2196/11500. PMID: 30973342

Appendix 15: Individual interview guide

A Mobile Application-Based Intervention to Promote Mental Wellbeing in health and care workers/students during the Covid-19 Pandemic

INTERVIEW TOPIC GUIDE

Package Title: A Mobile Application-Based Intervention to Improve Mental Fitness in Nurses in the United Kingdom, Version 1.1.

Introduction:

Hi ______________, my name is ________________________Thank you for agreeing to speak with me today about our project, I am the member of the research team conducting the study about mental fitness improvement in healthcare workers through a mobile application, MYARKEO. This is an evaluation of users' experiences of using the mobile application.

As outlined in the accompanying information, we would like to record this interview, with your permission, so that we can use anonymised quotes from this interview when we produce summaries of our findings. This will help us to clarify nurses' views of the mobile application. Your comments are confidential which means that at no point will you be identifiable in our data analysis and report. We will anonymise any content that we use in publications.

Before we start, do you have any questions for me?

Are you happy for this interview to be recorded? Thank you.

Questions

1- Could you start by telling me a bit about your overall experience of using the MYARKEO app?

[prompts: What are your initial thoughts about the application use? How easy was it to use the application? What you like most about the application?]

2- Did the app have any impact on your wellbeing or mental health? If so in what ways? If not Why?

[prompts: What makes you say that? Can you tell me more about that? Was there anything else you noticed? How did the application affect your mental well-being? Did it help you to improve your daily mood?]

3- Did you make any changes to your behaviour while using the app? [If yes] Could you tell me more about these changes? [If no] Are there any reasons why you did not make changes?

[prompts ask for specific behaviour change and impacts on the life, ask for the reason why the application did not lead to behaviour change, e.g., individual reasons or organisational reasons or other]

4- What helped to ensure your consistent use of the app? [What was most useful about the application? What was least useful?].

[prompts ask for specific reasons]

5- Did you experience any issues while using the app or problems using it?

[prompts easy to use, the application content, accessibility, articles on the application about wellbeing, any issues with accessibility, technical issues etc.]

6- Did you stop using the app at any point? If so, could you tell me why?

[prompts ask for any specific reasons. If you stop using the app, what would be helpful for you to continue using the app again?]

7- Do you think that the app might be useful to support mental wellbeing of healthcare workers? In what ways?

[prompts: In what aspects could the app be helpful most? Improving daily mood, behaviour change or improving symptoms such as stress level, anxiety etc.]

8- How could the app be improved for use with healthcare workers?

[prompts ask for app content, articles, interface, language, etc.]

Close: Is there anything else you would like to share with me today?

Thank you for sharing your experiences with me today. It has been interesting to hear your views on this mobile application. [if discussion raised difficult emotions - I am aware that this discussion might have raised some difficult emotions, so I just want to check that you are feeling okay now?]

In terms of what happens next, we are speaking with other nurses about their views of this application. We will write up the analysis of these interviews (anonymised) and we intend to publish our project findings in an academic journal.

Thanks again for taking the time to speak with me today.

Appendix 16: Participant Information Sheet (PIS)

Study Title: A Mobile Application-Based Intervention to Promote Mental Fitness in Healthcare Workers during the Covid-19 Pandemic

PARTICIPANT INFORMATION SHEET

Research Ethics Reference:

Version 1.1   Date: 12/03/2021

We would like to invite you to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. One of our team members will go through the information sheet with you and answer any questions you have. Please take time to read this carefully and discuss it with others if you wish. Ask us anything that is not clear.

What is the purpose of the research?

We are aiming to determine the usefulness of an app called MYARKEO in improving mental fitness in healthcare workers. This app is designed to help people to track their own health and lifestyle behaviours, daily mood, and symptoms such as work stress. To do this, we need to compare wellbeing outcomes in people who have, and have not, used the app.

Why have I been invited to take part?

You are being invited to take part because you are a healthcare worker or healthcare trainee. We are inviting 100 participants like you to take part.

Do I have to take part?

No. It is up to you to decide if you want to take part in this research. We will describe the study and go through this information sheet with you to answer any questions you may have. If you agree to participate in this study, we will ask you to sign a consent form and will give you a copy to keep. However, you would still be free to withdraw from the study at any time, without giving a reason and without any negative consequences, by advising the researchers of this decision. This would not affect your legal rights.

1. What will happen to me if I take part?

If you provide your consent to take part, we will ask you to complete some questionnaire measures about your health and wellbeing. We will then randomly allocate you to receive either the MYARKEO app (intervention group), or alternatively you will be signposted to a website about mental wellbeing (control group). Random allocation means you have an equal chance of getting access to the app or not. If you receive access to the app, we will ask you to use the app for 6 weeks. It simply involves tracking some aspects of your own health and wellbeing, and you can set targets for mental fitness yourself if you wish. We will provide instructions on how to do this. If you are in the group that does not receive the app, we will signpost you to some online information about health and wellbeing and there is nothing you need to do for 6 weeks. At the end of the 6 weeks, we will ask you to complete the same questionnaires again. If you were in the group that received the app, then we will invite you to an interview of 30-60 minutes which will be an audio-recorded discussion via telephone or digital platform such as Microsoft Teams. The purpose of this for you to share your views about the app and what worked well, or less well.

2. Are there any risks in taking part?

Although there are no significant risks of taking part in this study, it is important to note that, should you be allocated to the group receiving the app, you will become aware of changes in your own mental fitness scores, and this may influence how you feel. It is important to note that the app is simply a tool to help you to consider your mental fitness and lifestyle. It is not a diagnostic tool and it does not provide any treatment. If you feel upset by changes in your scores or notice that you are struggling then you can stop using the app whenever you want, and you may wish to contact your GP for advice and support.

3. Are there any benefits in taking part?

We cannot promise the study will help you but the information we get from this study may help to improve wellbeing support for healthcare workers and healthcare trainees more broadly.

4. Are there any costs of taking part?

No. Those allocated to receive the app will be able to use it free of charge. The interview will take place remotely (e.g., by telephone or Microsoft Teams) and so there will be no costs associated with taking part.

5. What happens to the data provided?

We will follow ethical and legal practice and all information about you will be handled in confidence.

If you join the study, the data collected for the study will be looked at by authorised persons from the University of Nottingham who are organising the research. They may also be looked at by authorised people to check that the study is being carried out correctly. All will have a duty of confidentiality to you as a research participant and we will do our best to meet this duty.

All information which is collected about you during the research will be kept strictly confidential, secured within the University of Nottingham. Any information about you which leaves the University will have your name and address removed (anonymised) and a unique code will be used so that you cannot be recognised from it. Anonymised data may also be stored in data archives for future researchers interested in this area.

Your personal data (address, telephone number) will be kept for (3 years) after the end of the study so that we are able to contact you about the findings of the study and possible follow-up studies (unless you advise us that you do not wish to be contacted). All identifiable research data will be kept securely for 7 years. After this time, your data will be disposed of securely. During this time, all precautions will be taken by all those involved to maintain your confidentiality, only members of the research team will have access to your personal data from this research study.

Although what you say in the interview is confidential, should you disclose anything to us which we feel puts you or anyone else at any risk, we may feel it necessary to report this to the appropriate persons.

6. What will happen if I do not want to carry on with the study?

Your participation is voluntary, and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected. If you withdraw then the information collected so far may not be possible to extract and erase after (3 years) and this information may still be used in the project analysis.

7. What will happen to the results of the research?

A summary of the research will be published in clinical or academic journals and presented at academic conferences. We will also share summarised findings with academic institutions to inform provisions for the health and wellbeing of healthcare workers and healthcare trainees. You will not be identified in any reports of the research findings.

8. Who has reviewed this study?

All research involving people is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the Faculty of Medicine and Health Sciences Research Ethics Committee (FMHS REC 172-0221).

9. Who is organising and funding the research?

This study is being organised by the University of Nottingham.

10. What if there is a problem?

If you have a concern about any aspect of this project, please speak to a member of the project team who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how he/she intends to deal with it. If you remain unhappy and wish to complain formally, you can do this by contacting the FMHS Research Ethics Committee Administrator, Faculty Hub, Medicine, and Health Sciences, E41, E Floor, Medical School, Queen's Medical Centre Campus, Nottingham University Hospitals, Nottingham, NG7 2UH or via E-mail: FMHS-ResearchEthics@nottingham.ac.uk.

11. Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact a project researcher in the first instance, or the project lead):

Researcher:

Mr. Mehmet YILDIRIM: ntxmy4@exmail.nottingham.ac.uk

Supervisors:

Dr Holly Blake

School of Health Sciences

Queen's Medical Centre

Nottingham

NG7 2HA

e: holly.blake@nottingham.ac.uk

Dr Timothy Carter

Assistant Professor

Faculty of Medicine & Health Sciences

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Phone: 01157484098

e: tim.carter@nottingham.ac.uk

Dr Laura Bedford

Postdoctoral Fellow

Department of Family Medicine and Primary Care

The University of Hong Kong

e: lbedford@hku.hk

Appendix 17: The consent form

Participants Consent Form

Version 1.2: 29.03.2021

Title of Study: A Mobile Application-Based Intervention to Promote Mental Fitness in Healthcare Workers during Covid-19 Pandemic

REC ref: FMHS REC 172-0221

Name of Researchers: Mehmet Yildirim, PhD for Health Studies.

Name of Participant:

1. I confirm that I have read and understand the information sheet for the above study which is attached and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I understand that should I withdraw, more than 7 days after the interview has taken place then the information collected so far cannot be erased and that this information may still be used in the study analysis.

4. I understand that my contact information and relevant sections of my health-related data stored on the MYARKEO app will be shared with the research team. I give permission for the research team to have access to my data on MYARKEO for the duration of my involvement in the study.

5. I understand that relevant sections of my data collected in the study may be looked at by the research group and by authorised individuals from the University of Nottingham, or other regulatory authorities, for monitoring and audit purposes. I give permission for these individuals to have access to these records and to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential.

6. I agree to be contacted and invited to an interview after 6 weeks to share my experiences during the study. The interview will be video/audio recorded using a digital device and that anonymous direct quotes from the interview may be used in the study reports.

7. I understand that what I say during the interview will be kept confidential unless I reveal something of concern that may put myself or someone else at any risk. It will then be necessary to report this to the appropriate persons.

8. I understand that information about me recorded during the study will be made anonymous before it is stored. It will be uploaded into a secure database on a computer kept in a secure place. Data will be kept for 7 years after the study has ended and then destroyed.

9. I agree that my research data may be stored and used in possible future research during and after 7 years and shared with other researchers including those working outside the University.

10. I agree to take part in the above study.

Name of Participant Date Signature

Name of Person taking consent Date Signature

Appendix 18: Weekly reminder e-mail for the intervention group

Dear X,

Hope this email finds you well,

This is a general weekly reminder e-mail about using the MYARKEO. You can use the MYARKEO to track your behaviours, daily mood, and any challenges like stress. Your scores will help you to see your changes over the days. The application needs everyday data entry which takes just 20secs/per day. This is important to see your progress which will help you to improve your mental fitness.

Thanks for your participation in the study. If you have any questions, please let me know for further support.

Best Wishes,