Improving the Health Equity of Women Now and in the Post COVID-19 Era: Mobile Technology-Assisted Mental Health Interventions for Pregnant and Postpartum Women

Ammar Saad

Thesis submitted to the University of Ottawa
in partial fulfillment of the requirements for the
MSc degree in Epidemiology

Department of Epidemiology and Public Health
Faculty of Medicine
University of Ottawa

Epigraph

"*If I can stop one heart from breaking, I shall not live in vain;*
If I can ease one life the aching, or cool one pain,
Or help one fainting robin, unto his nest again,
I shall not live in vain"

-Emily Dickinson

Acknowledgements

I would like to extend my appreciation and deepest gratitude to my supervisor, Dr. Kevin Pottie, for his continuous guidance, advice, and mentorship throughout the years.

For their dedication and support, I am grateful to my research team members and project partners, Olivia Magwood, Dr. Tim Aubry, Dr. Qasem Alkhateeb, Syeda Shanza Hashmi, Dr. Julie Hakim, Leanne Ford, Dr. Azaad Kassam, and Dr. Peter Tugwell, as well as the pregnant and postpartum women who have collaborated on this work.

For their unconditional and unmeasurable love and caring, I am eternally beholden to my mother and father.

For their emotional support and consistent encouragement, I thank my sisters, best friends, grandmother, classmates, and pets.

This work could not have been possible without the graduate studentship award of the Bruyère Research Institute.

Preface

Ammar Saad is the primary investigator, author, and guarantor of this work. He has determined the scope of the work and conceptualized the methods and timeline of this project in consultation with his supervisor *Kevin Pottie*. *Ammar* performed all research activities, including reviewing the introductory and interpretative literature on the subject matter. For activities that required duplication of efforts, such as screening and data extraction, Ammar used the help of another team member as described in the preface to Chapter 2.

This work follows a "collaborative Research" approach and includes a knowledge translation and exchange plan (March 2020 - April 2022) that has engaged different knowledge user groups in the formulation of the project scope and questions, selecting outcomes, interpreting findings, and planning for the translation of our knowledge. Key stakeholder groups, including pregnant and postpartum women with lived experience of common mental disorders have provided their feedback on this work and have helped tailor our findings to the needs of the population. Details on this engagement are explained in Chapter 4.

Our team included experts in the fields of psychiatry, psychology, maternal psychotherapy, reproductive health, primary health care, equity methods, health services evaluation, knowledge translation, as well as undergraduate and graduate medical students. Names and affiliations of authors are presented at the beginning of Chapter 2.

Finally, our research included only secondary analysis of data, thus exempting us from seeking ethical approval from the University of Ottawa Research Ethics Board.

Abstract

Pregnant and postpartum women often face high levels of psychological stress that increase the risk of common mental disorders (CMDs), such as depression and anxiety. This stress is often not met with timely mental health care and, therefore, may create health inequities. Mobile technology-assisted interventions represent a new opportunity for pregnant and postpartum women that may address health equity, especially during and after the COVID-19 era. We conducted an equity-focused systematic review and included 18 randomized and non-randomized controlled trials for analysis. Our results suggest that mobile interventions can prevent and manage depression across ethnicities and carry the potential to reduce psychological distress. Evidence on anxiety and utilization of care was limited and more research is needed among pregnant adolescents. Our collaborative research approach highlights the potential of mobile technologies and the need for active involvement of patients and other stakeholders in the co-creation and evaluation of mobile interventions.

Keywords:

Pregnancy, Mobile Interventions, Common Mental Disorders, Health Equity, Prevention, Management, Collaborative Research.

Table of Contents

List of Abbreviations

CMDs: Common Mental Disorders
GRADE: Grading of Recommendations, Assessment, Development and Evaluations
PICO: Population, Intervention, Comparison, and Outcomes
ROB 2.0: The Revised Cochrane Risk of Bias Tool
ROBINS-I: Cochrane's Risk of Bias In Non-randomized Studies of Interventions
M: Mean
SD: Standard Deviation
CI: Confidence Interval
KT: Knowledge Translation
EPDS: Edinburgh Postnatal Depression Scale

List of Tables

List of Figures

List of Appendices

List of Supplementary Materials

CHAPTER 1
Introduction

1.1 Pregnancy, Stress, and Common Mental Disorders

The sacred act of carrying and bringing a new life into the world has been the function of human existence and the prime reason behind our continuity. In many cultures, pregnant and postpartum women are often promoted to a holy status (1), and perceived to embody the "miracle of creation" (2).

This phenomenon has captured the attention of clinicians and scientists who, for decades, have explored the impact of pregnancy on a plethora of physiological functions (3–5), such as cardiovascular circulation (6,7), respiration (8,9), and renal secretion and filtration (10,11). As well, research on the psychological influence of pregnancy is rapidly evolving (12), as scientists continue to recognize the long term consequences of pregnancy and delivery on the mental health of women (13,14). Mental illness is responsible for almost one-third of all health disabilities worldwide (15) and continues to negatively impact populations' quality of life and incur costs to health systems (15). It is of no wonder that promoting mental health has become a global public health priority (16).

The physiological and emotional complexity of pregnancy increases women's vulnerability to experience psychological stress, hereafter termed "pregnancy stress" (17). A meta-synthesis of qualitative evidence by Staneva and colleagues has shed light on the pregnancy experiences of women and the major reasons behind their increased stress (18). Unmet pregnancy expectations, difficulty making health decisions, and emotional vulnerability magnified the feeling of "*things are not right*" (18). Coupled with the perception of "*lack of control*" over one's body and mind and "*feelings of entrapment*", many pregnant women found themselves "*spiralling down*" into a confusing state of distress (18):

"It's hard to explain this anxiety. Because it's like something horrible is wrong, like something horrible happened to you. But nothing horrible happened to me. I don't know how to explain it."

-Bennet 2007 of Staneva 2015 (18,19)

Equity, in a broader sense, is an ethical value of fairness and distributive social justice (20). Health equity is defined as the absence of avoidable health disparities that are judged to be socially unfair and unjust (21). For example, pregnancy stress is variable across multiple personal characteristics and social identities of pregnant and postpartum women, such as ethnicity and culture, socioeconomic status, social capital and support, employment, and education (22). This variability and the health disparities that follow are socially unjust. Why should pregnant women with a lower socioeconomic status have to suffer from increased psychological stress and depression compared to women with more financial stability? (23). As well, these disparities may be avoidable. Could improving the socioeconomic status of pregnant women decrease their stress levels and subsequent depression? (24). This example highlights one of many health disparities among pregnant and postpartum women that raise a concern of compromised health equity if left unaddressed (25).

Common mental disorders (CMDs) represent a category of non-psychotic mental illnesses characterized by having one of two major dimensions of common symptom states: depression and anxiety (26). Even though depression and anxiety differ in their clinical manifestations, the bio-social model proposed by psychiatrist David Goldberg suggests that these conditions often overlap under stress, creating an overlap of symptoms (27). The taxonomy and approach to diagnosis and management are, therefore, often similar (28), making it easier for clinicians and scientists to use this categorization, not only for the selection of appropriate psychotherapies, but also to further build knowledge on the etiology of these common disorders (26).

Research among pregnant and postpartum women highlights the impact of pregnancy stress on the development and worsening of mental health symptoms (29,30), and

confirms that depression and anxiety are the most common mental health disorders during and after pregnancy (31,32). A systematic review by Gavin and colleagues included 28 studies that examined the prevalence of depression among pregnant and postpartum women and found that up to 18.4% of women are diagnosed with a depressive disorder throughout pregnancy, and as high as 19.2% of postpartum women are diagnosed with a depressive disorder in the first three months after delivery (33). This review also estimated the period prevalence of major depression as 12.7% throughout pregnancy and 7.1% in the first three months postpartum (33). Another meta-analysis by Fawcett and colleagues included 26 studies that examined the prevalence of anxiety (34). Even though investigators highlighted the heterogeneity of prevalence across all anxiety spectrum disorders, they estimated that as high as 20.7% of pregnant and postpartum women experience at least one or more anxiety disorders during this period (34). Post-traumatic stress disorder (PTSD) is noteworthy to highlight among anxiety spectrum disorders. In one systematic review and meta-analysis, 59 studies examined the prevalence of PTSD during and after pregnancy (35). Even though the prevalence of PTSD was relatively low and comparable to endemic values (3.3% and 4.0% during pregnancy and postpartum, respectively), investigators highlighted the high prevalence of PTSD among high risk populations who have experienced interpersonal, sexual or physical violence, or pregnancy-related complications, such as diagnosis of fetal anomaly (18.95% and 18.5% during pregnancy and postpartum, respectively) (35).

Early in the year 2020, most countries and states rapidly realized that the consequences of COVID-19 far exceeded the viral nature of the disease, and significantly impacted most aspects of health and life (36). The public health restrictions that called for physical distancing to prevent the spread of the disease did not come without adverse events on the mental health status and access to care for most populations worldwide (37). Pregnant and postpartum women found themselves lacking the essential social support and connectedness (38), which in turn, worsened their mental health and wellbeing (39). An international cross-sectional survey among n=900 pregnant and postpartum women at the footsteps of the COVID-19 pandemic (April- May 2020), found that the prevalence of depression increased from 15% pre-pandemic to 40.7% during (40). As well, the prevalence of moderate to high anxiety arose from 29% before the pandemic to 72%

during (40). Another multi-centre cross-sectional study among n=4124 pregnant and postpartum women in China found an increase in the severity of depression and anxiety symptoms, as well as a 20% increase in the risk of depression (aRR=1.20; 95% CI 1.04 to 1.40; P=.01), and a 185% increase in the risk of self-harm thoughts following the pandemic compared to before (aRR=2.85; 95% CI 1.70 to 8.85; p=0.005) (41). The unnerving reality these numbers portray mandates a timely reaction from researchers, healthcare providers and decision makers to address the mental health state of pregnant and postpartum women during and after the pandemic.

1.2 The Paradox of Heightened Needs and Limited Access to Care

There is a growing body of evidence suggesting that traditional models of mental health care delivery may fall short of adequately addressing the increased needs of populations worldwide (15,42), especially during the COVID-19 pandemic (43). Pregnant and postpartum women have long suffered from limited access and uptake of mental health care (44). One cohort study of n=15,143 new mothers, found that among those with pregnancy stress, only 25% reported consulting a mental health specialist and only 11% used necessary psychotropic drugs (45). Similarly, a cross-sectional study among n=648 nulliparous pregnant women found that only 20.1% consulted their health care provider in regard to their emotional symptoms (46). Another cross-sectional study of n=463 pregnant women found that among those diagnosed with depression, only 12% reported accessing mental health care services in the past year (47). Finally, one cohort study of n=465 pregnant and postpartum women found that only 6% of those referred to mental health care remained in treatment over a period of 6 months (48). This discontinuity of mental health care is only expected to worsen during the COVID-19 pandemic (49), further exacerbating the mental health outcomes of this vulnerable population.

Scientific literature has explored the reasons behind this limited access and uptake of mental health care among pregnant and postpartum women. Lack of acceptability and fear of stigmatization were highlighted as major barriers; one systematic review of qualitative evidence reported reluctance and lack of acceptability among pregnant women to disclose their emotions and seek mental health help from their health care providers

(50). Another exploratory study among pregnant women with depression found that only 46% perceived their mental health treatment to be acceptable during pregnancy, and as high as 94% stopped depression medications by themselves when they learned about their pregnancy without consulting their health care provider (51). Exploring fear of stigmatization yielded similar trends; one cross-sectional study among n=532 pregnant women found a significant correlation between fear of stigmatization and keeping symptoms secret (52). As well, a thematic analysis of perinatal online forums found that women often suffered from internalized stigmatization, as well as fear of externalized stigmatization from health care providers which impeded their help seeking behaviours (53);

"*I have seen the perinatal team and dr previously but kind of played down my feelings as I am scared that if I show I am not coping with my moods then they might look down on me, see me as an unfit mother and pass me over to social services*"

-Moore, Ayers, & Drey 2016 (53)

Such concerns were confirmed by a systematic review of qualitative evidence that highlighted stigmatizing attitudes from some health care providers who showed "*disinterest*" and "*patronizing attitudes*", leaving women "*dissatisfied*" with their care (50).

Time constraint and provider unavailability were other major barriers to accessing mental health care. One cross-sectional study among n=648 nulliparous pregnant women found that "*not having gotten around to it*" and "*being too busy*" accounted for 72.2% of reasons behind not seeking mental health care (46). Another mixed method study among n=41 low-income pregnant and postpartum women highlighted these findings qualitatively during pregnancy and postpartum (54);

"It's just been really hard because there're so many different appointments for me, and there's double the appointments now"

-Sacks and colleagues 2015 (54)

"*I was able to see my therapist once, but then he went on vacation and I haven't seen him since*"

-Sacks and colleagues 2015 (54)

These barriers to mental health care have only intensified in magnitude and influence during the COVID-19 pandemic (55). Public health restrictions limiting pregnant and postpartum women's ability to visit their health care provider (56), as well as the limited human resources and lack of training to address mental health issues in a timely fashion within the context of COVID-19 (55) are some of the additional barriers that further magnify the vulnerability of this population.

1.3 The Health Inequity of Pregnant and Postpartum Women

Although the gap between elevated levels of mental health needs and limited access to adequate services and care exists across different populations of pregnant and postpartum women, scientific literature highlights inter- and intra-population variabilities in the extent to which they experience mental health symptoms and access mental health care when needed (57–59). These variabilities are hypothesized to be avoidable and ethically and morally unjust and unfair, shedding a light on their inequitable nature (20,21,60), and raising a global concern of their associated social injustice (25).

Understanding the health inequities of disadvantaged populations and designing interventions that would remedy the unjust and unfair variabilities in their health outcomes requires using an equity lens to explore the factors and characteristics that amplify or attenuate these variations (61). O'Neill and colleagues have described a framework for that purpose termed "PROGRESS+" which stands for **p**lace of residence; **r**ace, ethnicity, culture, and language; **o**ccupation; **g**ender and sex; **r**eligion; **e**ducation; **s**ocioeconomic status; **s**ocial capital; as well as personal characteristics associated with discrimination such as age and disability; features of relationships; and time-dependent relationships where a person may be temporarily at a disadvantage (62).

We reviewed the literature on the characteristics and social identities of pregnant and postpartum women that may influence their mental health status and outcomes, as well as their utilization of pregnancy-related and mental health care. The methods of this activity have been described elsewhere (63). In summary, we searched five databases for studies that examined an association between pregnant and postpartum women's PROGRESS+ characteristics and their mental health outcomes. We included n=34 studies that highlighted the following five characteristics:

1.3.1 Age: There is an abundance of literature that highlights young age as a characteristic that influences mental health outcomes and access to care; two cross-sectional studies found that young age was associated with an increased risk and severity of common mental disorders throughout pregnancy (64,65), a finding highlighted by two reviews of the literature (66,67). Further, five studies (three cohort and two cross-sectional) found that being of young age at delivery was linked to inadequate access to perinatal care and utilization of mental health services (45,46,68–70), and one additional cross-sectional study found that pregnant adolescents were less likely to engage in favourable health behaviours (71).

1.3.2 Socioeconomic Status: Evidence suggests that lower socioeconomic status is associated with worsened mental health outcomes; Three studies (two cohort and one cross-sectional) found that women with low socioeconomic status were more likely to experience pregnancy stress and common mental disorders compared to higher income pregnant women (45,72,73), a finding highlighted by another review of the literature (66). This characteristic was also found to negatively impact access and uptake of services and care, as additional three studies (two cohort and one nested case control) found an association between low socioeconomic status and a lower likelihood to utilize pregnancy-related and mental health services (68,74,75).

The reasons behind this phenomenon could, very well, be attributed to the unaffordability of mental health care among pregnant and postpartum women with low socioeconomic status. A cross-sectional study among Hawaiian pregnant women highlighted that the unaffordability of postpartum depression services was a major barrier of accessing mental

health care (76). This finding holds true in the United States, where health coverage varies significantly between populations and communities of pregnant and postpartum women. Nonetheless, evidence also suggests that socioeconomic status might influence women's willingness to discuss their mental health needs and seek help. For example, a cross-sectional study found that pregnant women with adequate personal income were more likely to have a conversation with their healthcare provider about mood disorders during and after pregnancy (77). Another qualitative study among refugee and immigrant pregnant women found that lower socioeconomic status negatively influenced their mental health seeking behaviour (78).

1.3.3 Ethnicity and Race: We recognize that categories of ethnicity are socially and politically constructed with little validity. These ethnicities, however, are commonly examined in the scientific literature. Our findings highlighted several inter-ethnicity and inter-race variabilities among pregnant and postpartum women. One mixed-method cohort study found that Black Caribbean women were less likely to access depression treatment when needed compared to their Caucasian counterparts (79). Similarly, a cross-sectional study found that being Hispanic or African American was a risk factor for discontinuing mental health treatment (70). These findings were confirmed by a large scale cohort study of n=1,106,757 pregnancies that found lower psychiatric treatment utilization among women from Black, Hispanic, and other race groups in the United States compared to Caucasian pregnant women (69). In the context of COVID-19, a cross-sectional study among n=4451 pregnant women in the United States between April 25 and May 15 of 2020 found that women of colour were more likely to experience high pandemic-related pregnancy stress compared to Caucasian women (80).

Ethnicity and race also influenced pregnant and postpartum women's willingness to talk about and seek help for mental health symptoms. A cross-sectional study found that pregnant women from Asian or Pacific islander ethnicities were less likely to have a conversation about prenatal and postpartum depression with their healthcare provider compared to Caucasian women (77). Similarly, another cross-sectional study found that Caucasian pregnant women with depression symptoms were more likely to have a

conversation with their healthcare provider about their emotional symptoms compared to other ethnicities (46).

1.3.4 Experience of Intimate Partner Violence (IPV): Four cross-sectional studies among pregnant women found a relationship between past history of intimate partner violence and the likelihood of developing depression during pregnancy and postpartum (81–84). As well, this time-dependent relationship impacted utilization of care; one cohort study found that only 5% of postpartum women who had experienced intimate partner violence were willing to discuss it with their healthcare providers (85). Another cross-sectional study found that experiencing intimate partner violence was associated with inadequate utilization of prenatal health care (86). Conversely, a cohort study among n=465 pregnant women found that those who were exposed to intimate partner violence had higher odds of attending at least one mental health care visit compared to their counterparts (48).

1.3.5 Social Capital: We have adapted Adler and Kwon's definition of social capital which refers to the "goodwill" derived from the characteristics of individuals' social relations (87). "Capital" is, therefore, determined by the sum and quality of social networks and relations (87). The level of social support that pregnant and postpartum women received from their partners, family members, and social network, seem to influence their mental health outcomes; five studies (four cross-sectional and one cohort) found an inverse relationship between family and non-family social support and rates of depression throughout pregnancy and postpartum (81,82,88–90). This relationship was highlighted by two reviews of the literature (66,67). Further, one cohort study found that suffering from social isolation was associated with inadequate health care utilization during pregnancy (68).

Our mapping of the literature highlighted the social disadvantages experienced by many subgroups of pregnant and postpartum women. Interventions targeting these subgroups should not, therefore, be designed or implemented homogeneously and independent of considering their impact on health equity (91). This requires a comprehensive evidence base (92), established by utilizing rigorous equity methods (93,94) to examine the

gradients in effect estimates of novel interventions that are influenced by patient characteristics and social identities (62).

1.4 Mobile Technology: A Novel Approach to Mental Health Care

The paradox described above brings about health inequities to pregnant and postpartum women who are left stranded with their heightened levels of mental health needs against major access barriers to traditional mental health care. Addressing this paradox requires re-envisioning mental health care (15), by utilizing innovative approaches to care delivery that are attuned to the COVID-19 context, such as virtual care (38,95). Mobile health, also known as "mhealth", refers to the use of mobile and wireless communications to improve health outcomes and access to care (96). This emerging approach to health care has evolved over the years (97,98), and has been adapted to different fields of health care, including but not limited to: cardiology (99); nutrition (100); diabetes management (101); promotion of health (102); as well as mental health (103). Most recently, mobile technology has risen as not only a reliable approach in response to the COVID-19 pandemic (104), but also as an alternative method to the traditional, face-to-face, communication with health care providers (105).

In this thesis, we elected to focus on "*mobile technology-assisted interventions*", also referred to as "mobile interventions", that utilize smartphone applications "mhealth" as one mode of healthcare access or delivery, but also extend their design to encompass other features of mobile phones such as text messages or pushed notifications for the same purpose. The specific feature that distinguishes mobile-technology assisted interventions from other virtual and digital health approaches is their ability to serve their purpose without the need for direct and synchronous communication with health care providers (106).

The evolving nature of mobile phones provides an opportunity to integrate their agile technologies into the paradigm of mental health care (107). Their convenience, easy accessibility, and lower cost provide an opportunity to reach a larger cohort of patients in need of otherwise unavailable mental health services (108). "Mobile Technology Assisted

Interventions" use any features of mobile phones to deliver care or support. Even though these interventions are similar in regard to using mobile technologies, their intended features differ greatly (108):

1. **Supported care management interventions** provide patients with the means to connect with peers who have a similar lived experience, for the purpose of improving social support and discussing emotions and symptoms (109).

2. **Symptom monitoring and mood tracking interventions** aim to increase self-awareness of mental health conditions and allow for a timely response to severe symptoms (110).

3. **Psychotherapy interventions** deliver a validated psychotherapy technique such as cognitive behavioural therapy to decrease the severity of patients' symptoms (111).

4. **Mindfulness and meditation interventions** target psychological distress and affective state by increasing patients' awareness of their thoughts and feelings (112).

5. **Behavioural and skill training interventions** provide patients' with health promotion and knowledge about their mental and physical health, available health care services, and other community resources, with the purpose of preventing psychological distress (113).

Knowledge syntheses on the effectiveness of mobile technology-assisted interventions among pregnant and postpartum women exist, but are often targeted towards one condition (e.g., depression), one pregnancy period (e.g., perinatal), or one mobile feature (e.g., smartphone applications). For example, one systematic review examined mhealth based interventions (Smartphone applications) that solely target the management of postpartum depression and included 11 randomized controlled trials. Findings of that review suggest a significant reduction in the severity of depression symptoms compared

to usual care (MD=−1.09, 95% CI −1.39 to −0.79) (114). Another systematic review examined mhealth interventions that targeted pregnant women's psychosocial outcomes only during the perinatal period (115). Investigators included 10 randomized controlled trials and 11 quasi-experiments, and concluded that mhealth interventions targeting postpartum depression significantly decreased its symptom severity (MD= -6.01, 95% confidence interval = -8.34 to -3.67) (115). These reviews provide synthesized evidence that speaks to the potential mobile interventions carry among pregnant and postpartum women. To the best of our knowledge, however, no reviews have examined mobile technology assisted interventions in the broader context and definition described above. As well, no reviews have examined the health equity impact of such interventions among different subgroups of pregnant and postpartum women.

1.5 The Juxtaposition of Mobile Interventions and Health Equity

Characterized by their easy accessibility and lower cost (108), mobile interventions are well suited to improve mental health care delivery among different populations (116), and we postulate that they carry the potential to reach a vast and diverse cohort of pregnant and postpartum women and mitigate the challenges they face when accessing mental health care.

The lack of acceptability and fear of stigmatization associated with traditional mental health care was detrimental to pregnant and postpartum women's access and uptake of these services (50,51,53). Mobile interventions could provide a solution to this barrier; a cross-sectional study found that up to 77.5% of pregnant women would accept a technology-assisted mental health treatment during pregnancy (117). From a healthcare provider perspective, a cross-sectional study among mental health care professionals highlighted their intent to recommend mobile interventions to pregnant and postpartum women (118), suggesting the preliminary acceptability of this approach of mental health care delivery.

Time constraint was highlighted as a major barrier of accessing traditional mental health care (54). The self-paced nature of mobile interventions provide the opportunity to access

mental health care at any time of the day, and any day of the week (119). Moreover, the unavailability of mental health services and the limited health provider resources were found to impede access to care (54). Mobile interventions can operate asynchronously without the direct communication with health care providers (106), and can deliver care in a self-directed nature without the need for time-sensitive resources (120). These features allow for an equitable access to and uptake of mental health care among pregnant and postpartum women.

We have also hypothesized in chapter 1.3 that certain characteristics and social identities position pregnant and postpartum women in a social disadvantage that further worsens their mental health outcomes. Ethnicity and race is one characteristic that influenced women's mental health outcomes (79). Mobile interventions provide the opportunity to be attuned to the ethnicity, race, and culture of different patient groups (121), thus allowing pregnant and postpartum women to better benefit from and accept them. Age is another characteristic that played a role in impacting pregnant women's mental health (66). Mobile phones technologies are acceptable among younger age groups (122), giving them an advantage over traditional mental health care in appealing to this demographic. Moreover, being of low socio-economic status and not being able to afford mental health care is a third unjust barrier to care (66,72) that could be mitigated using cost-effective mobile interventions (108). Social capital (67) and the experience of intimate partner violence (83) are socially significant factors that influence how this population perceives and benefits from mental health care. Supported care mobile interventions (described in chapter 1.4) provide pregnant and postpartum women with a safe and private environment to connect with other peers, share their experiences, and benefit from social support (123).

In the context of COVID-19, the global public health restrictions preventing physical and social interactions have limited pregnant and postpartum women's social capital (38), impacted their access to traditional face-to-face mental health care (39), and worsened the severity of mental health symptoms (41). Mobile interventions are on the rise globally (98,124), and carry the potential to provide pregnant and postpartum women with the

means to access mental health care during and after the COVID-19 pandemic without jeopardizing their health or the health of their newborn.

By juxtaposing the access barriers and social characteristics that influence the mental health outcomes of pregnant and postpartum women with the features and designs of mobile interventions, we can recognize the potential this novel approach of mental health care carries to mitigate such barriers and remedy any social injustice.

1.6 Rationale and Framework of this Work

We have, thus far, explored the burden of pregnancy stress and common mental disorders (CMDs) on the wellbeing of pregnant and postpartum women. We have also addressed the limited access and uptake of traditional mental health care among this population and the health inequities they face due to their characteristics and social identities. And finally, we have shed light on mobile technology assisted interventions or "mobile interventions" and postulated how they could mitigate the access and uptake barriers of mental health care among pregnant and postpartum women, providing an alternative to a rather fragmented mental health care during pregnancy and postpartum. However, the limited knowledge of the clinical effectiveness associated with mobile interventions prevents us from conclusively framing this approach of mental health care as an effective solution among this population. A more comprehensive knowledge base is, therefore, needed to inform researchers, providers of care, patients, decision makers, as well as other stakeholders on what works in the field of technology- assisted mental health care. Moreover, it is unidimensional and narrow in scope to assume that the clinical effectiveness of these interventions is homogeneous across different subgroups of pregnant and postpartum women. This precludes any future development and implementation initiatives of mobile interventions. Analyzing the effectiveness of these interventions using an equity lens (93,94) is needed before conclusively framing mobile interventions as an equitable solution among pregnant and postpartum women.

The logic model provided in Figure 1 represents a clinical pathway of pathology, diagnosis, prevention and management of common mental disorders among pregnant and

postpartum women. The pathway starts with psychological stress that increases women's risk of developing common mental disorders, before moving into the identification and subsequent prevention or management of these disorders using traditional or technology-assisted interventions, such as mobile interventions. The pathway ends with the impact of these interventions on patient-important mental health outcomes (explained in chapter 2). As illustrated by figure 1, the health equity of pregnant and postpartum women could be impacted at one of four stages along this pathway:

1. The level of psychological stress and the impact this stress has on the development of common mental disorders is heterogeneous across pregnant and postpartum women's PROGRESS+ characteristics and social identities. (*Equity 1*)

2. The identification and diagnosis of common mental disorders, as well as the acceptability and feasibility of this identification and diagnosis, differs between subgroups of pregnant and postpartum women based on their PROGRESS+ characteristics and social identities. (*Equity 2*)

3. Access to and uptake of traditional and technology-assisted interventions, such as mobile interventions, that target the prevention and management of common mental disorders is variable across pregnant and postpartum women's PROGRESS+ characteristics and social identities. (*Equity 3*)

4. The effectiveness of traditional and technology-assisted interventions, such as mobile interventions, that target the prevention and management of common mental disorders (CMDs) is different across pregnant and postpartum women's PROGRESS+ characteristics and social identities. (*Equity 4*)

To complete this project in a timely manner, we elected to focus on one stage of this clinical pathway in which health equity is impacted. We envision that providing our knowledge users with a comprehensive understanding of the gradients in effectiveness of mobile interventions (Equity 4) across different subpopulation will incentivize future research that examines other areas where equity may be impacted (e.g., level of stress,

identification of CMDs, and access to care), and will facilitate the promotion of awareness and knowledge on whether mobile interventions serve the purpose of preventing or managing common mental disorders.

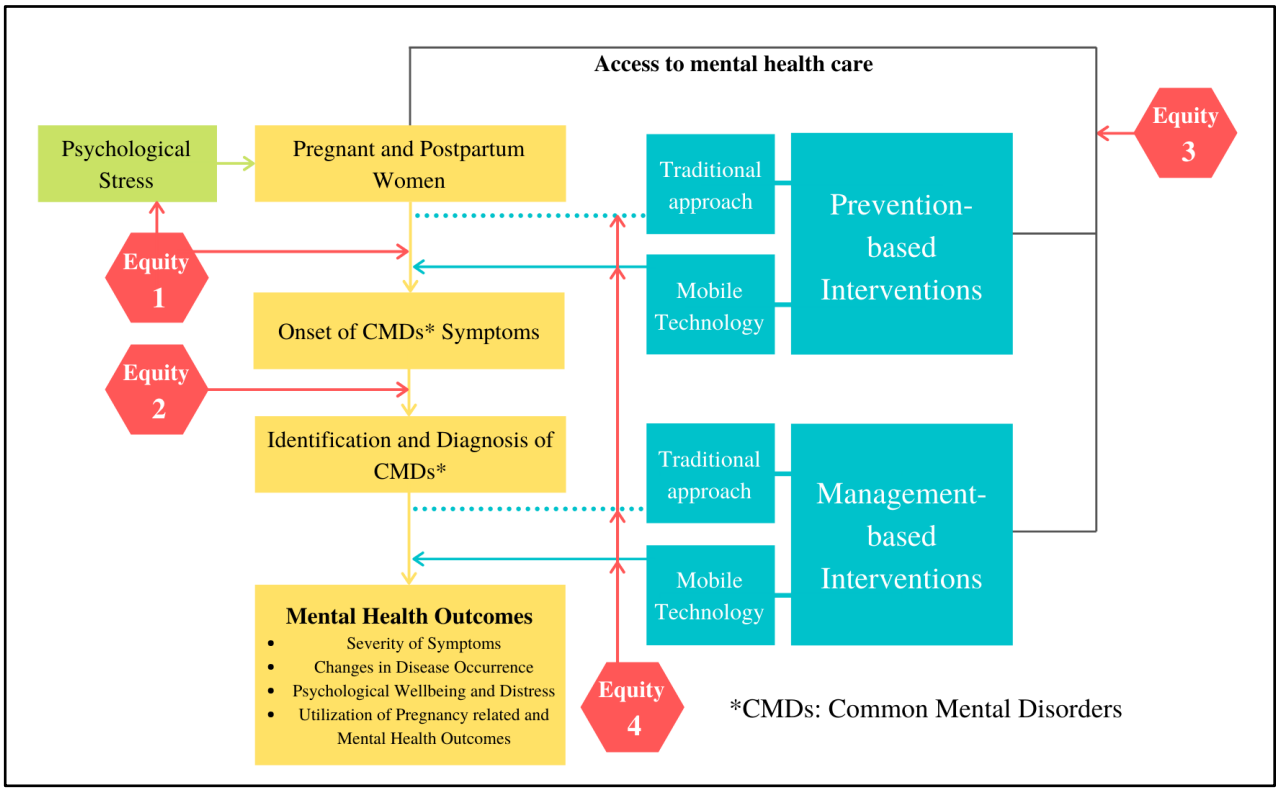

Figure 1. Logic Model of the Clinical Pathway of Common Mental Disorders.

Systematic reviews of interventions provide a reliable and timely knowledge base of existing evidence (91). Yet, findings of systematic reviews usually lack equity considerations, which limits their influence on policy and practice (125,126). Equity-focused systematic reviews not only examine evidence of average effectiveness, but also apply an equity lens to the definition of the population, methods of selection and analysis, and applicability of evidence to different cohorts of the population and in different settings (91,93). This thesis will use an equity-focused systematic review approach described by Welch and colleagues (94), to synthesize knowledge on the effectiveness and equity impact of mobile technology assisted interventions targeting the prevention and management of common mental disorders (CMDs) and stress among pregnant and postpartum women.

1.7 Objectives

The objective of this thesis is to synthesize a knowledge base on the effectiveness and equity impact of mobile technology-assisted interventions targeting the prevention and management of common mental disorders and stress among pregnant and postpartum women. To achieve this objective, we will conduct an equity-focused systematic review (94), the methods of which are described in Chapter 2.

CHAPTER 2
Mobile Technology-Assisted Interventions Targeting Common Mental Disorders Among Pregnant and Postpartum Women: An Equity Focused Systematic Review

Authors
Ammar Saad [1,2], Tim Aubry PhD [3], Olivia Magwood MPH [2,4], Qasem Alkhateeb MD [5], Syeda Shanza Hashmi BA [6], Julie Hakim MD [7], Azaad Kassam MD [8,9,10], Peter Tugwell MD [1,11,12], Kevin Pottie MD [1,2,13]

Authors affiliations

1. School of Epidemiology and Public Health, University of Ottawa, Ottawa, ON
2. C.T. Lamont Primary Healthcare Centre, Bruyère Research Institute, Ottawa, ON
3. Department of Psychology, University of Ottawa, Ottawa, ON
4. Interdisciplinary School of Health Sciences, University of Ottawa, Ottawa, ON
5. Department of Internal Medicine, Schulich School of Medicine, London, ON
6. School of Medicine, University of Ottawa, Ottawa, ON
7. Texas Children's Hospital, Baylor College of Medicine, Texas, US
8. Department of Psychiatry, University of Ottawa, Ottawa, ON
9. Pinecrest Queensway Community Health Centre, Ottawa, ON
10. Ottawa Newcomer Health Centre, Ottawa, ON
11. Ottawa Hospital Research Institute, Ottawa, ON
12. Centre of Global Health, University of Ottawa, Ottawa, ON
13. Department of Family Medicine, University of Ottawa, Ottawa, ON

Corresponding author
Ammar Saad

Acknowledgements
We would like to extend our appreciation to Amanda Hodgson, our librarian at the Health Science Library/ Bibliothèque des sciences de la santé, University of Ottawa for her assistance with developing, reviewing and adapting our search strategies.

Funding
Ammar Saad is the recipient of the Bruyère Research Institute Graduate Studentship Award (2020). The research activities described herein were made possible through this funding.

PREFACE TO CHAPTER 2

This equity-focused systematic review will be submitted for publication. To comply with the submission requirements of the journal, we shortened the submitted manuscript, but we elected to expand on several sections in this chapter to provide readers with a more detailed and clear description of our methods and results. To ensure that our work adheres to the highest standards of reporting, we prepared this systematic review in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) (127), and its equity extension (PRISMA-E) (91). Both checklists are presented in Supplementary Materials I and II.

All authors contributed to this work to merit their authorship status using the recommendations put forward by the International Committee of Medical Journal Editors (ICMJE). AS led the project and coordinated all research activities. AS and OM developed the search strategy and reviewed it with the health sciences librarian. AS, QA, and SH screened records, extracted data from included studies, critically appraised the methodological rigour of included studies, and assessed the certainty of results using the GRADE methodology. AS coordinated and performed data analysis, and all authors contributed to data analysis. AS drafted the first version of the manuscript. All authors contributed to editing the manuscript and approved the final version. KP supervised this work.

This review has been registered with PROSPERO (ID. CRD42020200828). The protocol has been published on the Cochrane Equity Methods Group Website (63) (Found here). Our research included only secondary analysis of data and thus, we did not seek ethical approval for our activities.

No conflicts of interests declared.

2.1 Summary

Background: Pregnant and postpartum women are at higher risk of developing common mental disorders, such as depression and anxiety. Mobile interventions present a novel approach to the prevention and management of such conditions. This equity-focused systematic review aimed to examine the effectiveness and equity impact of mobile interventions among pregnant and postpartum women.

Methods: We systematically searched MEDLINE, EMBASE, and 4 other databases, from inception until Jan 2021, for experimental studies on mobile interventions. We used pooled and narrative synthesis methods and performed equity-specific analyses. We critically appraised the methodological rigour of all studies and assessed the certainty of findings using the GRADE approach. Pregnant and postpartum women were engaged in this work.

Findings: Our search identified 6476 records, of which 14 randomized and 4 non-randomized controlled trials were included for analysis. Mobile interventions showed a statistically significant and clinically meaningful decrease in depression diagnosis (OR=0.51; 95% CI 0.41, 0.64; RR=0.56; 95% CI 0.46, 0.68; absolute risk reduction RD: 7.14%; 95% CI 4.92, 9.36; one study; GRADE certainty: low) and reduced symptom severity to a statistically significant and probably clinically meaningful level (MD=-3.07; 95% CI -4.68, -1.46; two studies; GRADE certainty: very low). Mobile cognitive behavioural therapy (CBT) was statistically and clinically effective in managing postpartum depression (MD=-6.87; 95% CI -7.92, -5.82; one study; GRADE certainty: very low), but other interventions had no added benefit. Findings on psychological wellbeing showed potential, whereas anxiety and utilization outcomes were understudied. Finally, mobile interventions showed improvements across ethnicities and age groups, but being of a Taiwanese ethnicity increased the magnitude of effect, whereas being of young age decreased the effect.

Interpretation: As the COVID-19 pandemic expands virtual mental health care, novel mobile interventions show promise in preventing and managing common mental

disorders among pregnant and postpartum women. More rigorous research that actively involves patients in the co-creation and evaluation of mobile interventions and focuses on the intersectionality of their characteristics is needed.

2.2 Background

Pregnancy is an important life experience that brings about significant physical and psychological changes to the childbearing mother (5,18). Although the majority of these changes are transient in nature, two systematic reviews describe long-term psychological sequelae (13,14). Indeed, the sacred act of carrying a human being into life rarely comes without emotional and psychological stressors which, if left unaddressed, could affect the mother for years to come (17).

Common mental disorders (CMDs) comprise a plethora of non-psychotic conditions defined by the presence of two symptom dimensions; depression and anxiety (26,27). Evidence shows that depression and anxiety are the most common mental health conditions during pregnancy and postpartum (31,32). Recent evidence also suggests that the social isolation and stress surrounding COVID-19 increase the severity and occurrence of depression and anxiety among pregnant and postpartum women (40,41). Yet, this population suffers from limited access and uptake of mental health care to address their needs (45,47,51). This healthcare inequity is heterogeneous across pregnant women's characteristics and social identities (21,91,128), magnifying vulnerability and worsening pregnancy and postpartum outcomes (129). Equity research has identified several patient characteristics which influence pregnant women's mental health outcomes (63).

Mobile technology-assisted interventions, hereafter referred to as "*mobile interventions*", are on the rise globally (98,124), providing a convenient and easily accessible approach to mental healthcare delivery (108). These interventions are acceptable among pregnant women (117), as well as their mental health care providers (118). They utilize self-paced (119) and asynchronous (106) features to mitigate a plethora of access barriers to traditional mental health care among pregnant and postpartum women (54). Such

intervention characteristics position mobile interventions as an equitable solution to bridge the gap of a rather fragmented mental health care, especially during times of limited access, such as the COVID-19 pandemic (130).

Multifold mobile interventions exist and provide pregnant and postpartum women with the means to prevent and manage common mental disorders (131,132); using features, such as peer support (133), self-management (134), health promotion and behavioural change (112), and symptom tracking (135). Yet little is known about their effectiveness and impact on inequities for pregnant and postpartum women.

2.3 Research Questions

The objective of this equity-focused systematic review is to comprehensively search and synthesize quantitative evidence to answer the following research questions:

1. What is the effectiveness of prevention-based mobile interventions targeting pregnant and postpartum women's mental health outcomes?

2. What is the effectiveness of management-based mobile interventions targeting pregnant and postpartum women's mental health outcomes?

3. What health equity impact (i.e., differences or gradients of effect estimates) do mobile interventions targeting mental health have across pregnant and postpartum women's PROGRESS+ characteristics (62)?

2.4 Methods

The methods described herein have been conceptualized "a priori" and reported in a published protocol (63). This equity-focused systematic review (94) was prepared in accordance with the Preferred Reporting Items for Systematic Reviews (PRISMA) (127), and its equity extension (PRISMA-E) (91). Reporting elements from these guidelines have been detailed in Supplementary Materials I and II.

2.4.1 Search Strategy and Literature Sources

2.4.1.1 Primary Search

We developed a comprehensive search strategy in consultation with a health sciences librarian (AH) who has expertise in systematic searches of databases. The strategy was developed iteratively and peer reviewed by the health sciences librarian, as well as members of our research team with expertise in searching databases. It included an extensive list of free text keywords, content and indexed terms, as well as subject and MeSH headings that were tailored to each bibliographic database search host. Please see Appendix I for our primary search strategy.

Using this strategy, we systematically searched the following electronic bibliographic databases: Medline, Embase, PsychINFO, Cochrane CENTRAL, CINAHL, PTSDPubs, as well as citation lists from Web of Science. Table 1 describes each database we have searched, the host engine or "platform" used to search this database, year of database inception and date of our search. We conducted all searches from the date of database inception until June 26, 2020, and then updated our search on Monday January 4th, 2021. Of note, we did not apply any date, language, or setting restrictions to our search to ensure inclusivity of effectiveness and equity evidence.

Table 1. Electronic Bibliographic Databases

Database	Engine host	Year of database inception	Date of search	Date of updated search
Medline	Ovid	1946	June 26, 2020	Jan 4, 2021
Embase	Ovid	1947	June 26, 2020	Jan 4, 2021
PsychINFO	Ovid	1806	June 26, 2020	Jan 4, 2021
CINAHL	EBSCO	1981	June 26, 2020	Jan 4, 2021

Cochrane CENTRAL	Ovid	1996	June 26, 2020	Jan 4, 2021
PTSDpubs (PILOTS)	ProQuest	1871	June 26, 2020	Jan 4, 2021
Web of science	Clarivate web	1900	June 26, 2020	Jan 4, 2021

2.4.1.2 Secondary Search

To supplement our search and ensure a comprehensive inclusion of all relevant records, we followed the following secondary search approaches:

1. We hand-inspected the reference lists of systematic reviews captured by our primary search for additional relevant records.

2. We hand-inspected the reference lists of included randomized and non-randomized controlled trials for additional relevant records.

3. We searched listings of Clinical Trial Registries (136) for relevant trials.

4. We forward-traced relevant study protocols and trial registrations by contacting their corresponding authors and inquiring about potential publications or reports of their findings.

5. We consulted experts in the fields of psychiatry, psychology, and primary health care for any additional relevant records.

2.4.1.3 Grey Literature Search

We developed a focused grey literature search strategy to capture reports of experiments that meet our eligibility criteria but are not published or indexed in any of the primary search sources proposed in the review protocol.

We first started by searching "*OpenGrey"* for grey literature originating from Europe, using a combination of truncated keywords presented in Table 1 of Appendix I. We then used a custom google search engine (developed by the National University of Singapore Library) to search the websites of over 1500 non-governmental organizations (NGOs) and over 400 intergovernmental organizations (IGOs). To ensure feasibility of this grey literature search, we set a search limit sensitive to the relevance of search outputs using the following approach: We explored publications from websites of NGOs and IGOs in the order that was yielded by the search, but tested the sensitivity of these results (i.e., how relevant the organizations and publications were to our review scope) beyond the 20-website level. If relevant websites with publications existed beyond the 20-website limit, we continued the search process for another 5 websites and performed the sensitivity testing again and until search results were deemed completely irrelevant. Search results are presented in tables 2 and 3 of Appendix I.

Finally, we searched for pregnancy-specific organizations and associations that provided care, services, or representation to pregnant or postpartum women at the national and international level using a focused Google search strategy and excluding ad-forwarded websites. We used a similar search limit sensitive to whether these organizations (and any publications found on their websites) were relevant to our review scope at the 20-website level. If relevant websites with publications existed beyond the 20-website limit, we continued the search process for another 5 websites and performed the sensitivity testing again and until search results were deemed completely irrelevant. Search results are presented in table 4 of Appendix I.

2.4.2 Eligibility Criteria

Table 2 summarizes our eligibility criteria described, with detail, in sections 2.4.2.1 and 2.4.2.2.

Table 2. Eligibility Criteria Summary

Study characteristic	**Description of the inclusion criteria**
Population	Pregnant and postpartum women
Intervention	Mobile technology-assisted interventions “mobile interventions”
Comparison	Usual or standard care Controlled intervention Placebo intervention No intervention Waitlisting
Outcomes	Severity of common mental health symptoms Psychological wellbeing and distress Changes in the occurrence of common mental health disorders Utilization of pregnancy related and mental healthcare services
Study design	Randomized and quasi-randomized controlled trials (RCTs; qRCTs) Non-randomized controlled trials (nRTs) Controlled before and after studies (CBA) Controlled interrupted time series (CITs) and repeated measures studies.

2.4.2.1 Population, Intervention, Comparison, Outcomes

Population of Interest: We included studies that were conducted among pregnant and postpartum women, at any period of the pregnancy experience (antenatal, perinatal, or postpartum), and regardless of the pregnancy outcome (e.g., full birth, miscarriage, medically-induced abortion).

We consulted our maternal health experts in defining the following pregnancy stages:

- ***Antenatal*** refers to the period between conception and until the 4-week window of expected delivery (usually 0 to 36 weeks of pregnancy).
- ***Perinatal*** refers to the 4-week window immediately preceding delivery (usually 36 weeks to delivery).
- ***Postpartum*** (or ***postnatal***) refers to the period of 12 months following the delivery, and regardless of the delivery outcome.

Interventions of Interest: We included studies that delivered mobile technology-assisted intervention targeting the prevention and/or management of common mental disorders and stress. We defined these interventions as meeting all of the following criteria:

- Deliver care or support to pregnant or postpartum women using features supported by mobile technology (e.g., smartphone applications, text messaging programs, a combination of both, other features of mobile technology).

- Designed and implemented with the intention or purpose of preventing or managing common mental disorders by reducing psychological stress, improving the severity of mental health symptoms, or enhancing access to and uptake of pregnancy-related and mental health care and services.

- Operate asynchronously and/or independent of direct, face-to-face contact with a provider of mental health care (e.g., psychiatrist, psychotherapist, or physician).

- Deliver care using any of the following care designs: self-management of symptoms; self-management with supported care (peer support); improving cognition and thinking; improving skills and behaviours; providing psychoeducation or psychotherapy; self-monitoring and tracking of symptoms.

Comparisons of Interest: We included studies that used a controlled design, allowing a comparison between the intervention of interest and receiving either no intervention, a placebo or controlled intervention, usual or standard care appropriate to the stage of pregnancy, or being waitlisted for the same intervention.

Outcomes of Interest: We aimed to choose outcome domains and measures that were of critical importance to end users of this review (137). We mapped the literature for mental health outcomes that were most commonly used and reported in scientific literature of mental health interventions among pregnant and postpartum women (63). We then deliberated these outcomes with our team of physicians, psychologists,

psychiatrists, health equity experts, maternal and reproductive health professionals, and health services evaluation scientists. We hypothesized that by examining these outcomes, meaningful effectiveness and equity differences would be detected. Table 3 describes, with detail, our outcomes of interest, potential approaches of measurement, and the nature of this measurement. Of note, we did not exclude any studies on the account of using an author-developed or non-validated tool to measure the outcome, but when that occurred, we have increased our concerns for result-level risk of bias coming from that measurement.

Table 3: Outcome Domains, Measurements, and Categorizations

Outcome category	**Outcome measurement**	**Categorization**
Severity of common mental disorder symptoms	Severity of depression symptoms	Continuous
	Severity of anxiety-spectrum disorder symptoms (e.g., Generalized anxiety, PTSD, etc.)	Continuous
	Percentage of patients with severe depression symptoms	Categorical (dichotomous)
	Percentage of patients with severe anxiety-spectrum disorder symptoms (e.g., Generalized anxiety, PTSD, etc.)	Categorical (dichotomous)
	Percentage of episodes of severe depression symptoms	Categorical (dichotomous)
	Percentage of episodes of severe anxiety-spectrum disorder symptoms (e.g., Generalized anxiety, PTSD, etc.)	Categorical (dichotomous)
Psychological wellbeing and distress	Changes in levels of psychological wellbeing	Continuous
	Changes in levels of psychological distress	Continuous
	Percentage of patients who reported changes in their psychological wellbeing levels	Categorical (dichotomous)
	Percentage of patients who reported changes in their psychological distress levels	Categorical (dichotomous)

Change in common mental disorder occurrence	Percentage of patients who meet/ no longer meet standardized diagnosis criteria for depression	Categorical (dichotomous)
	Percentage of patients who meet/ no longer meet standardized diagnosis criteria for anxiety-spectrum disorders (e.g., Generalized anxiety, PTSD, etc.)	Categorical (dichotomous)
	Percentage of patients who experience/ no longer experience mental health symptoms relating to depression	Categorical (dichotomous)
	Percentage of patients who experience/ no longer experience mental health symptoms relating to anxiety-spectrum disorders (e.g., Generalized anxiety, PTSD, etc.)	Categorical (dichotomous)
Utilization of pregnancy related services and mental health care	Percentage of patients compliant with their pharmacological treatment regimen	Categorical (dichotomous)
	Percentage of patients compliant with their non-pharmacological treatment regimen	Categorical (dichotomous)
	Percentage of patients who accessed pregnancy-related or mental care services	Categorical (dichotomous)
	Mean number of contacts or visits that patients made with mental, primary, or pregnancy-related healthcare providers	Continuous

2.4.2.2 Study Design

To ensure that our effectiveness and equity findings are based on rigorous evidence, we included study designs as recommended by the Cochrane Effective Practice and Organization of Care (EPOC) group (138):

1. Randomized (and quasi randomized) controlled trials (RCTs; qRCTs)
2. Non-randomized controlled trials (nRTs)
3. Controlled before and after studies (CBA)
4. Interrupted time series or repeated measures studies (ITS)

2.4.3 Record Screening

All records captured by our primary and secondary searches were uploaded to a systematic review management system "Covidence" (139), and screened against our eligibility criteria. We followed a two-phased screening approach whereby we first screened all records using their titles and abstracts, and then screened eligible records using their full-text publications. Two reviewers screened all records against our eligibility criteria, in duplicate and while blinded to the decision of the other reviewer. Reviewers provided an independent decision on whether to include or exclude each record. Any discrepancies in screening decisions were resolved using a consensus process or the help of a third reviewer with expertise in the subject matter of discrepancy.

To ensure the reliability of our screening process, we selected reviewers with expertise in record screening and provided them with comprehensive information about our review scope and eligibility criteria. As well, we pilot-tested the screening process with a random sample of n=100 records and estimated the inter-rater reliability using Kappa coefficient (140). We used the categorization proposed by Landis and Koch to determine whether agreement between reviewers was above the substantial level (0.81 and higher) (141).

2.4.4 Data Extraction

We developed a standardized data extraction form to collect data from each included primary study pertaining to its design, characteristics, and results. Appendix II describes the standardized forms that were developed in consultation with experts in the fields of health equity, systematic review methodology, and mental health. Further, because this is an equity-focused systematic review, we applied an equity lens to the standardized data extraction form to capture information regarding whether any stratification or adjustment of participant selection or data analysis were undertaken using the PROGRESS+ framework (62), which stands for place of residence; race, ethnicity, culture, and language; occupation; gender and sex; religion; education; socioeconomic status; social capital; as well as personal characteristics associated with discrimination (62).

Two reviewers used the full-text publications of each included study to extract data, in duplicate and independently. Any discrepancies in data extractions were resolved by reaching a consensus between reviewers after the unblinding of results, or through the consultation of a third member of the research team with expertise on the subject matter of discrepancy.

2.4.5 Critical Appraisal

We critically appraised the methodological rigour of included randomized trials using the revised Cochrane Risk of Bias 2.0 tool (aka. ROB 2.0) (142,143). For non-randomized trials, we used the Cochrane Risk of Bias in Non-Randomized Studies of Interventions (aka. ROBINS-I) tool (144,145). The ROB 2.0 tool allowed us to make judgements about concerns for risk of bias in the following five domains: a) the randomization process, including random sequence generation and allocation concealment, b) deviations from the intended interventions while examining the effect of assignment to the intervention, c) missing outcome data, d) measurement of outcomes, and e) selection of the reported results (143). The ROBINS-I tool has allowed us to make judgements about concerns for risk of bias in the following seven domains: a) selection of participants, b) confounding, c) classification of the intervention, d) deviation from the intended intervention, e) missing data, f) measurement of outcomes, and g) selection of reported results (144).

Two independent reviewers provided, in duplicate, a decision on the level of risk of bias concerns for each included result, of each included outcome, of each included randomized (low, high, some concerns) and non-randomized controlled trials (low, moderate, serious, or critical). Any discrepancies in judgement were resolved by reaching a consensus, or through the help of a third reviewer with expertise in critical appraisal. We used the decision trees of the tools to confirm our risk of bias assessments. Finally, visual representations of risk of bias for each outcome domain and each study level result were created using the ROBVIS platform (146).

2.4.6 Certainty of Evidence Assessment

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology was used to assess the certainty of evidence (147). Certainty was rated down by making a judgement on the level of concerns (not serious, serious, very serious) in regard to risk of bias, inconsistency, indirectness, imprecision, and publication bias. Certainty was rated up when (and if) we detected presence of a large magnitude of effect estimate, a dose-response gradient, or if we judged that all residual confounding that would decrease this magnitude of effect was addressed (147). Judgements and effect estimates are presented in GRADE Evidence Profiles (148), alongside a final assessment of evidence certainty using one of the following domains: Very low; low; moderate; and high (149). Please see Table 4 for a description of each level of evidence certainty rating.

Table 4. Description of GRADE certainty ratings (147)

Certainty rating	**GRADE description**
High	Further research is very unlikely to change our confidence in the effect estimate
Moderate	Further research is likely to have an important impact on our confidence in the effect estimate and may also change the estimate
Low	Further research is very likely to have an important impact on our confidence in the effect estimate and is also likely to change the estimate
Very Low	Any estimate of the effect is very uncertain

2.4.7 Data Synthesis and Analysis

2.4.7.1 Statistical Analysis

Continuous outcome measures were synthesized and reported as **a)** between-group mean differences in the change from baseline; and/or **b)** between-group mean differences at follow-up. Categorical or dichotomous outcome measures were synthesized and reported as **a)** relative risk estimates, such as risk ratios (RR) and odds ratios (OR); and/or **b)** absolute risk estimates, such as risk difference (RD). We prioritized the use of risk ratios

over odds ratios because the latter tends to overestimate the magnitude of effect compared to the former (150). All continuous and categorical effect estimates were accompanied by estimates of statistical significance, such as 95% confidence intervals and/or p values at the 0.05 level of significance.

If study investigators had adjusted or controlled for a certain covariate, we prioritized the adjusted or "corrected" effect estimates, as they represent a more internally valid result among the sample of the study. Of note, when investigators had only reported regression analysis coefficients without means to calculate effect estimates described above, we reported their results as have been provided.

2.4.7.2 Time Frame of Analysis

We categorized the time points of outcome measurement into three narrow intervals as follows:

a) **Short term**: Measuring the outcome immediately post-intervention and until the 3-month time point.

b) **Medium term**: Measuring the outcome after the 3-month time point and until the 6-month time point.

c) **Long term**: Measuring the outcome after the 6-month time point.

We have selected these time intervals to be narrow in width to reflect the short-term nature of delivering mobile interventions among pregnant and postpartum women. A similar approach was found in other systematic reviews of technology-assisted interventions for the same population of interest (114,115).

2.4.7.3 Primary Data Analysis of Interest

Answering our research questions requires examining the effectiveness of mobile interventions delivered in pragmatic conditions, such as clinical practice or the community. These pragmatic conditions are assumed to suffer from a certain degree of non-compliance, attrition to treatment, and missingness in outcomes (151). We, therefore, have focused on intention to treat (ITT) analysis methods to examine the effect of assignment to the intervention (152), using the number of individuals allocated into the study (including individuals with missing data) as the denominator, and assuming that the event did not occur among missing individuals.

2.4.7.4 Clinical Homogeneity Assessment

We recognized that investigators used variable terminology to describe their population, intervention, comparison, and measurement of outcomes. Therefore, we followed the PICO standardization approach proposed by Cochrane (153), and coded the description of populations, interventions, comparisons, outcomes, and timepoints of outcome measurements as detailed in table 5.

Table 5: Categories of the PICO Standardization Process

<table>
<tr><th>PICO</th><th colspan="2">PICO standardization categories</th></tr>
<tr><td rowspan="3">Population</td><td rowspan="2">Pregnant women</td><td>Antenatal [0-36 weeks of pregnancy]</td></tr>
<tr><td>Perinatal [36 weeks and until delivery]</td></tr>
<tr><td colspan="2">Postpartum women [12 months following delivery]</td></tr>
<tr><td rowspan="3">Intervention</td><td rowspan="3">Target the management of CMDs and/or stress</td><td>Smartphone application</td></tr>
<tr><td>Text messaging program</td></tr>
<tr><td>Other features</td></tr>
</table>

	Target the prevention of CMDs and/or stress	Smartphone application
		Text messaging program
		Other features
Comparison	Standard/ usual care	
	No intervention	
	Placebo/ controlled intervention	
	Waitlisting	
Outcome	Severity of CMD symptoms	
	Psychological wellbeing	
	Psychological stress	
	Changes in occurrence of CMDs	
	Utilization of pregnancy-related and mental health care	
Time frame	Short term: [0-3] months	
	Medium term:]3-6] months	
	Long term: >6 months	

Using the described PICO coding we assessed for clinical homogeneity between studies that measured the outcome using the same measurement tool (e.g., measured depression severity using the Edinburgh Postnatal Depression Scale), by searching for any clinically important differences in study populations, characteristic of interventions, nature of comparator groups, outcome measurements, and time points of measurement.

2.4.7.5 Pooling Data and Assessing Statistical Heterogeneity

Pooling of results was undertaken by meta-analyzing effect estimates from studies that were deemed clinically homogeneous. Due to the inherent degree of unreported heterogeneity in the delivery of the intervention and history of the population of interest, we used a random effects model in our analyses (154), but compared pooled results to those yielded by a fixed effects model and reported any differences. Pooled effect estimates were synthesized and reported as relative risks and mean differences for categorical and continuous outcome measurements, respectively. Meta-analyses were presented as forest plots created using RevMan 5.3 software (155). We planned to assess for publication bias in all meta-analyses of 10 or more studies (156), but our small number of pooled studies prevented this activity. Further, we assessed the statistical heterogeneity of pooled results by calculating the I^2 and Chi Square statistics (156). Following Cochrane recommendations, we set a cut-off for statistical heterogeneity as follows: **a)** I^2 estimate of 75% or higher; or **b)** Chi Square estimate with a p value of 0.1 or lower (156). When clinical heterogeneity prevented meta-analyzing results, we followed a narrative approach to synthesize results (157). When (and if) statistical heterogeneity was detected, we proposed to conduct sensitivity analyses and examine the impact of this statistical heterogeneity on the pooled effect estimate.

2.4.7.6 Equity Analysis

We mapped all "equity evidence", defined: Between-group or inter-group gradients in effect estimates reported or analyzed by stratifying participants at the selection process or adjusting effect estimates at the data analysis process, using any of the PROGRESS+ characteristics: place of residence; race, ethnicity, culture, and language; occupation; gender and sex; religion; education; socioeconomic status; social capital; as well as personal characteristics associated with discrimination such as age and disability; features of relationships; and time-dependent relationships where a person may be temporarily at a disadvantage (62). Evidence was aggregated into a "PROGRESS+ equity framework" that compartmentalized gradients in effect estimates by PROGRESS+ characteristics and outcome domains.

Our primary equity analyses focused on pregnant and postpartum women's race and ethnicity, age, socioeconomic status, intimate partner violence, and social support (Please see section 1.3). Exploratory equity-focused analyses reported any meaningful subgroup analyses stratifying for other PROGRESS+ characteristics.

2.4.7.7 Handling Missing and Overlapping Data

Whenever effect estimates were not reported, we attempted to calculate them using the formulae performed via RevMan 5.3 software (155). When available data prevented calculating effect estimates, we reported the findings narratively as have been provided by investigators in the study.

Moreover, whenever a study reported a certain outcome using more than one outcome measurement tool, we avoided the double counting of data from that sample by selecting one measurement that is most common among other studies and carries more clinical importance. This was assumed to increase the likelihood of pooling effect estimates and allowed for reporting results as a narrative whole. The remaining measurements were dropped from all analyses. Further, if an outcome was measured at different time points, we analyzed and reported effect estimates at the earliest time point post-intervention for the short-term effectiveness, closer to the six months post-intervention time-point for the medium-term effectiveness, and the longest follow-up period for the long-term effectiveness. Finally, if a study measured the outcomes at more than one time interval, we reported these results explicitly, and highlighted the temporal relationship between them.

2.5 Results

2.5.1 Search Results and Characteristics of Included Studies

Our search yielded a total of n=6476 records, of which n=4210 records were screened independently after the removal of duplicates, and n=4162 were excluded after screening

their title and abstract (Please see figure 1). The inter-rater reliability assessed with a random sample of n=100 records was determined to be high (Cohen's kappa coefficient= 0.9). We screened n=48 studies using their full text publications and excluded 30 for reasons described in Figure 2. A complete list of excluded studies at the full-text screening stage with reasons for exclusion is presented in Supplementary Material III. No additional studies met our eligibility criteria from the search update. A total of n=18 studies were included in our quantitative analysis with a cumulative sample size of n=7,200 pregnant or postpartum women.

We included thirteen randomized controlled trials, four non-randomized controlled trials, and one quasi-randomized controlled trial. The geographical location of the studies was diverse and included countries such as the United States (n=5), Singapore (n=2), China (n=2), Taiwan (n=2), Australia (n=1), Canada (n=1), Iran (n=1), Italy (n=1), South Korea (n=1), South Africa (n=1), and Thailand (n=1). Two studies required translation from Chinese and Korean.

Nine studies received funding from governmental sources, one study received partial funding from the World Health Organization, one study received no funding from external sources, whereas seven studies did not report their funding sources.

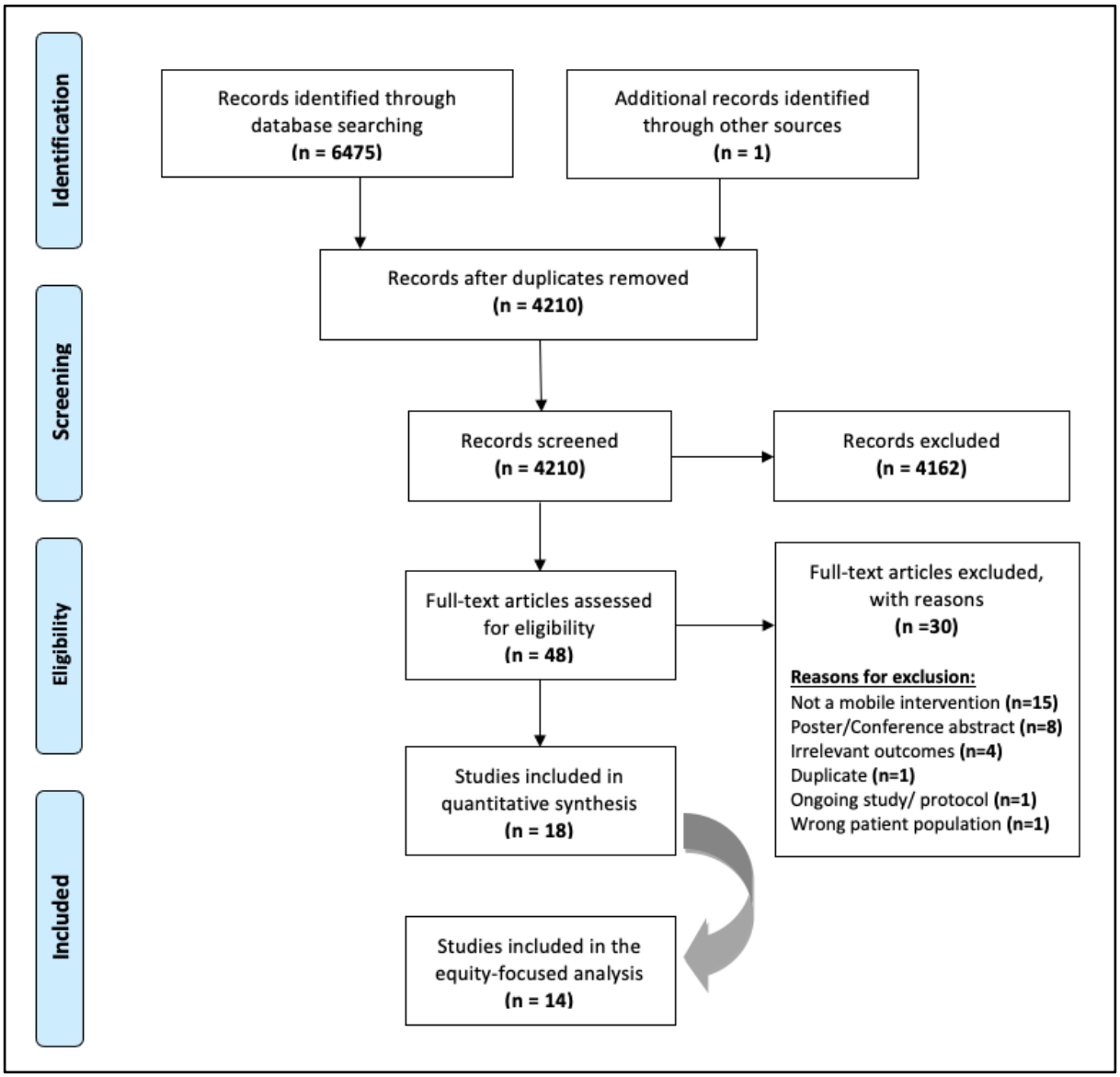

Figure 2: PRISMA Flow Diagram of Study Screening and Selection

The characteristics of included studies are presented in Table 6. Ten studies examined the effectiveness of prevention-based mobile interventions (158–167), and employed different features to achieve that purpose, such as the provision of peer social support (159,160,166), or health promotion and behavioural changes (158,161–165,167). Eight studies examined management-based interventions (168–175), using a combination of features such as peer support (168,175), guided meditation (169), psychotherapy (171,173,174), education about adverse events (170), and mood tracking (172).

Table 6. Characteristics of Included Studies

Study ID	Study design	Setting	Participants	Intervention	Comparison	Outcome measurements
Mobile interventions targeting the *prevention* of mental health disorders						
Chan et al. 2019 (158)	Randomized controlled trial	Kwong Wah Hospital (KWH) Hong Kong, China	First-time pregnant Chinese women Pregnancy stage: Antenatal	iParent app: Smartphone application providing pregnancy-related health promotion. The app provided a platform to allow asking pregnancy-related questions. Purpose: Preventing postpartum depression.	Standard antenatal care including a 4-session nurse-led antenatal course	Severity of depression: Chinese version of the Edinburgh Postnatal Depression Scale (EPDS) Psychological stress: The Depression, Anxiety, Stress Scale (DASS)
Cheng et al. 2016 (159)	Randomized controlled trial	Hospital affiliated obstetric clinic Kaohsiung City, Taiwan	Expecting Taiwanese pregnant women Pregnancy stage: Perinatal	Smartphone application providing women with the means to connect and talk with peers (postpartum women). Purpose: Preventing postpartum depression and stress.	Standard perinatal care	Severity of depression: Chinese version of the Edinburgh Postnatal Depression Scale (EPDS) Severity of stress: Chinese version of the Perceived Stress Scale
Chyzzy et al. 2019 (160)	Randomized controlled trial	Community-based young parents agencies Toronto, Canada	Expecting pregnant adolescents 16-24 years Pregnancy stage: Perinatal	Smartphone application providing women with the means to talk (via voice and messages) with peer mentors (postpartum women) Purpose: Preventing postpartum depression	Standard community support and care services	Severity of depression: Edinburgh Postnatal Depression Scale (EPDS) Severity of anxiety: State-Trait Anxiety Inventory (STAI) Utilization of care: Health services utilization using a questionnaire
Gong et al. 2020 (161)	Non-randomized controlled trial	Three public hospitals. Jiangmen City, Guangdong	Chinese pregnant women Pregnancy	Text messaging program consists of one-way messages promoting health and behavioural changes,	Standard antenatal care	Severity of depression: Chinese version of the Edinburgh Postnatal

		Province, China	stage: Antenatal	as well as reminding participants of their routine appointments Purpose: Preventing depression during pregnancy		Depression Scale (EPDS) Occurrence of depression: EPDS>9
Jareethum et al. 2008 (162)	Randomized controlled trial	The antenatal care unit of the Siriraj Hospital Bangkok, Thailand	Thai Pregnant women planning to deliver at the hospital Pregnancy stage: Antenatal	Text messaging program providing antenatal support and education about pregnancy symptoms Purpose: Increasing satisfaction with care and preventing anxiety	Standard antenatal care from the hospital	Severity of antenatal anxiety: Investigator-build questionnaire Severity of perinatal anxiety: Investigator-build questionnaire
Lee et al. 2017 (163)	Non-randomized controlled trial	Four maternal hospitals Daegu, South Korea	First-time South Korean Postpartum mothers Pregnancy stage: Postpartum	Smartphone application with an interactive platform and newsfeed feature providing postpartum women with postpartum-related health management education and emergency contacts. Purpose: Preventing postpartum depression and increasing confidence	Standard postpartum discharge care from the hospital	Severity of depression: Korean version of the Edinburgh Postnatal Depression Scale (EPDS)
Mauriello et al. 2016 (164)	Randomized controlled trial	Three federally-funded health centre organizations Connecticut, Rhode Island, and New York, United States	English and Spanish speaking pregnant women Pregnancy stage: Antenatal	Healthy Pregnancy Step By Step: iPad-delivered application providing women with risk stage-matched and tailored guidance on theoretically and empirically determined behavioural change strategies. Purpose: Preventing postpartum stress and promoting stress management	Standard antenatal care from community organizations and behavioural change brochures	Utilization of care: Number of minutes of stress management practice using a questionnaire
Shorey et al.	Randomized	Postnatal ward	Postpartum	Mobile-based	Standard	Severity of

2019 (166)	controlled trial	of a local tertiary hospital National University Hospital region, Singapore	mothers at risk of depression Pregnancy stage: Postpartum	program providing mothers with the means to communicate with a trained peer volunteer using text-messages, phone calls, or applications depending on the mother's preference Purpose: Preventing postpartum depression and buffering the negative effects of childbirth	postnatal care from the hospital	depression: Edinburgh Postnatal Depression Scale (EPDS) Severity of anxiety: State-Trait Anxiety Inventory (STAI)
Shorey et al. 2017 (165)	Randomized controlled trial	Maternity ward of a local tertiary hospital National University Hospital region, Singapore	Postpartum mothers and their partners Pregnancy stage: Postpartum	Home But Not Alone: Mobile application providing mothers and their partners with psychoeducation and health promotion and reminding them of their appointments Purpose: Decreasing the risk of postpartum depression and improving parenting self-efficacy	Standard postnatal care provided by the hospital	Severity of depression: Edinburgh Postnatal Depression Scale (EPDS)
Tsai et al. 2018 (167)	Non-randomized controlled trial	Obstetrics outpatient clinic at a medical center Tainan, Taiwan	Taiwanese pregnant women with low-risk pregnancy Pregnancy stage: Antenatal	Smartphone application where pregnant women can upload and access their antenatal care records. The application provided women with health promotion and journals for the self-management of symptoms. Access was available through the internet as well as the smartphone. Purpose: Improving self-efficacy and preventing psychological stress	Standard antenatal support and education	Psychological stress: 36-item Chinese Pregnancy Stress Rating Scale (PSRS-36)

Mobile interventions targeting the *management* of mental health disorders						
Baumel et al. 2018 (168)	Non-randomized controlled trial	The Adult Outpatient Department in the Zucker Hillside Hospital New York, United States	New mothers with postpartum depression Pregnancy stage: Postpartum	7Cups: Smartphone application providing women with the means to contact community peers or "past survivors", a personalized progress map, and psychotherapy, such as gratitude exercises, mindfulness, psychoeducation, exercises drawn from principles of acceptance and commitment therapy. Purpose: Managing postpartum depression and supporting women with mood disorders	Standard care or "treatment as usual"	Severity of depression: Edinburgh Postnatal Depression Scale (EPDS)
Carissoli et al. 2017 (169)	Randomized controlled trial	At childbirth classes organized at the obstetrics wards of Saronno, Gallarate and Busto Arsizio Hospitals Province of Varese, Italy	First-time Italian pregnant women approaching birth Pregnancy stage: Perinatal	BenEssere Mama: Smartphone application providing mothers with daily relaxation and guided imagery exercises alongside mood journaling. Purpose: Helping mothers manage their affective state and improve their psychological wellbeing	Standard perinatal care	Psychological wellbeing: Italian version of the Psychological Wellbeing Scale (PWB)
Constant et al. 2014 (170)	Randomized controlled trial	Two non-governmental organizations (NGOs) and two public sector primary care clinics Cape Town, South Africa	Pregnant women undergoing medical abortion Pregnancy stage: Post-abortion	Uniform text messaging program with health information about managing symptoms and side effects, alongside routine abortion care. Purpose: Managing anxiety and emotional discomfort	Routine abortion care (including the provision of 200-mg mifepristone on site and self-administration of 800-mcg misoprostol at home) was provided to women in both	Severity of anxiety symptoms: Hospital Anxiety and Depression Scale (HADS) Subjective stress (both intrusion and avoidance): Impact of Event Scale- Revised (IES-R)

					study arms	
Dennis-Tiwary et al. 2017 (171)	Randomized controlled trial	Large urban hospital New York, United States	Pregnant women Pregnancy stage: Antenatal	Personal Zen: smartphone application that utilizes an attention bias modification training (ABMT) protocol with video game-like features such as animated characters and sound effects. Purpose: Managing anxiety and stress	Controlled application providing placebo training (PT)	Severity of depression: Depression, Anxiety, Stress Scale (DASS-21) Severity of anxiety: Depression, Anxiety, Stress Scale (DASS-21) Severity of stress: Depression, Anxiety, Stress Scale (DASS-21) Biological stress: Lab cortisol ug/dl
Hantsoo et al. 2018 (172)	Randomized controlled trial	Urban ambulatory prenatal clinic within an academic medical center Pennsylvania, United States	Pregnant women from racial-ethnic minority groups with low incomes who were experiencing depressive symptoms. Pregnancy stage: Antenatal	GINGER.IO Mood tracking and alert app: Smartphone application that monitors participants' mood through daily surveys and physical activity trends and alerts providers of care of worsened mood Purpose: Enhancing management of mood symptoms by improving mental health care delivery	Participants in both study arms received standard of care that includes a controlled smartphone application that allows access to the patient portal (PP)	Utilization of care: Number of obstetrician telephone encounters with mention of mental health Utilization of care: Percentage of patients referred to mental health specialized Utilization of care: Percentage of patients who attended mental health specialist visits
Jannati et al. 2020 (173)	Randomized controlled trial	Three health care centers affiliated with Kerman University of Medical Sciences Kerman, Iran	New mothers with postpartum depression Pregnancy stage: Postpartum	Happy Mom: Smartphone application providing women with cognitive behavioural therapy in the form of 8 lessons that read like a story Purpose: Managing postpartum depression symptoms	Standard postpartum care as needed by mothers	Severity of depression: Persian version of the Edinburgh Postnatal Depression Scale (EPDS)
Prasad et al.	Quasi-	Local	New mothers	VeedaMom:	Standard	Severity of

2018 (174)	randomized controlled trial	physician clinics Texas, United States	with postpartum depression Pregnancy stage: Postpartum	Smartphone application providing mothers with mindfulness and meditation exercises, videos that provide psychoeducation based on acceptance and commitment therapy (ACT) and dialectical behavioural therapy (DBT), as well as social support, in-app journalling, and mood tracking. Purpose: Managing symptoms of depression after delivery and improving psychological wellbeing	postnatal care	depression: Edinburgh Postnatal Depression Scale (EPDS) Psychological wellbeing: The World Health Organization Quality of Life BREF Scale (WHOQOL-BREF)
Sawyer et al. 2019 (175)	Randomized controlled trial	Child and Family Health Service (CaFHS) community clinics Adelaide and South, Australia	New mothers with depression and parenting problems Pregnancy stage: Postpartum	eMums Plus: Smartphone application that provides mothers with means to chat with mothers and post questions about their experience. A time-sensitive guidance and health reminders, as well as resources and contacts. All chats were monitored by a nurse Purpose: Managing depression symptoms and improving parenting skills	Standard postnatal care	Severity of depression: Edinburgh Postnatal Depression Scale (EPDS) Utilization of care: Percentage of mothers who visited their family physician using a questionnaire Utilization of care: Percentage of mothers who visited the emergency department using a questionnaire Utilization of care: Percentage of mothers who used online pregnancy resources using a questionnaire

2.5.2 Risk of Bias of Included Studies

The majority of included studies were judged to have high risk of bias (figures 3 and 4). Among non-randomized controlled studies, concerns of serious risk of bias arose due to the methods by which confounding was addressed and outcomes measured. Lack of information about whether deviations from assignments to the intended interventions was detected across non-randomized studies. Among randomized controlled trials, biases mainly arose due to deviations from assignment to the intended interventions and measurement of outcomes, and to a lesser degree from the methods by which missing outcome data were handled. Some concerns of risk of bias arose due to the unclarity of reporting the randomization process. Risk of bias results were included in the GRADE certainty of results assessment and therefore, not presented alongside findings in text to prevent duplication of reporting. Visual representations of critical appraisal assessments are presented for each outcome domain in appendix III.

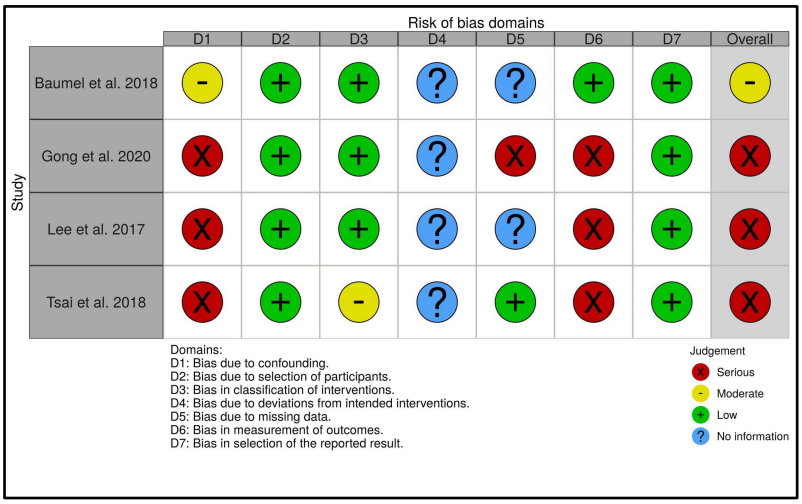

Figure 3. Visual Representation of ROBINS-I Results - Across Outcomes

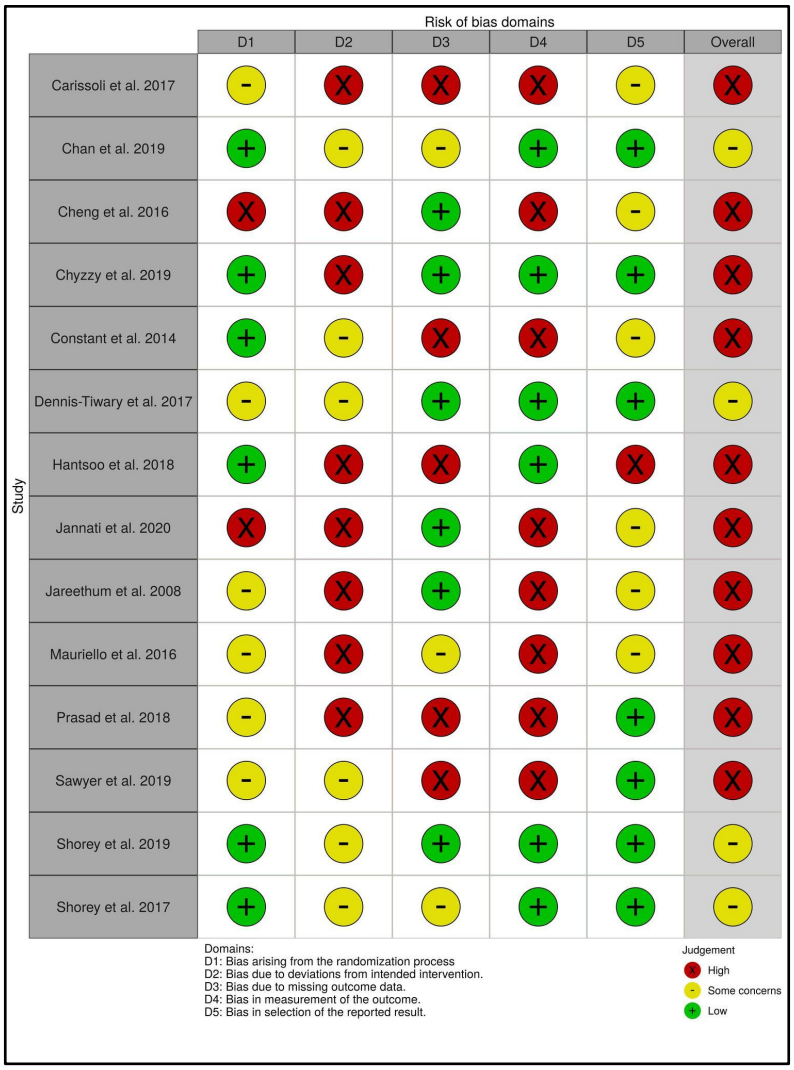

Figure 4: Visual Representation of ROB 2.0 Results - Across Outcomes

2.5.3 Certainty of Evidence

GRADE Evidence Profiles for each outcome are presented in appendix IV and provided alongside effectiveness findings in text. In summary, effectiveness findings of mobile interventions targeting the prevention of mental health disorders were judged to be of higher certainty relative to interventions that target the management of mental health disorders. Certainty assessments ranged from high to very low (Please see appendix IV) and were downgraded due to serious risk of bias concerns, and limitations regarding imprecision that could be attributed to not reaching an optimal information size (OIS) (i.e., sample size < 300 participants).

2.5.4 Effectiveness of Prevention-based Mobile Interventions

Findings on antenatal prevention-based mobile interventions showed their added benefit of preventing the occurrence and maintaining the severity of depression. One non-randomized controlled trial provided a text messaging psychoeducation intervention and found a statistically significant and clinically meaningful decrease in depression diagnosis (OR=0.51; 95% CI 0.41, 0.64; RR=0.56; 95% CI 0.46, 0.68; absolute risk reduction RD: 7.14%; 95% CI 4.92, 9.36; p<.001; GRADE certainty: low) among the intervention group compared to the usual care group, short term (161). Another randomized controlled trial of a similar mobile application found a statistically significant but not clinically meaningful improvement in the severity of depression symptoms measured using the Edinburgh Postnatal Depression Scale (EPDS) after adjusting for baseline scores at 4-weeks follow-up (MD=-0.65; 95%CI -1.29,0.00; p=.049; GRADE certainty: high) (158). Evidence on anxiety was limited; one randomized controlled trial provided antenatal women with a supportive text messaging program and found statistically significant but not clinically meaningful lower levels of antenatal anxiety, measured using an investigator-built questionnaire, associated with the intervention compared to usual care (MD=-2.15; 95% CI 3.42,-0.88; p=.002; GRADE certainty: very low) (162), but this effect was not statistically significant for perinatal anxiety (162). Another randomized trial of a psychoeducation mobile application reported decreased postpartum anxiety, which did not reach statistical or clinical significance (158).

Evidence on psychological stress is mixed. One randomized controlled trial of a psychoeducation mobile application found no statistical or clinical added benefit of receiving the intervention on women's psychological stress at 4-weeks follow-up (158), whereas a non-randomized trial of a similar intervention measured stress using the Pregnancy Stress Rating Scale 36 (PSRS-36) and found a statistically significant and clinically meaningful improvement associated with the intervention relative to usual care at 12 weeks follow-up (MD=-11.12; 95% CI -17.19,-5.05; p<.001; GRADE certainty: very low) (167).

Furthermore, antenatal mobile interventions had a trivial effect on the utilization of care services. One randomized controlled trial of a behavioural change mobile application found small improvements in the mean number of minutes of stress management at 1 month and 4 months postpartum, which did not reach statistical significance (164).

Mobile interventions targeting pregnant women during the perinatal period showed similar trends of improvement. A meta-analysis of two randomized controlled trials providing women with peer support mobile applications (Figure 5) highlighted a statistically significant and probably clinically meaningful benefits in the severity of depression symptoms (EPDS) compared to usual care (MD=-3.07; 95% CI -4.68,-1.46; p<.001; GRADE certainty: very low) (159,160). Pooled results were judged to be statistically homogeneous (I^2=30%; Chi^2 p=0.23), and the small number of studies required no assessment of publication bias (156). On the contrary, the severity of anxiety symptoms from one study did not reach statistical or clinical significance relative to usual care (160).

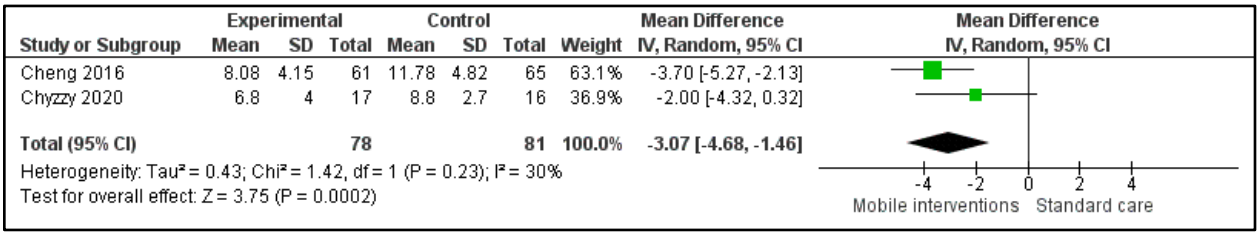

Figure 5: forest plot of comparison: peer support mobile applications vs standard of care, outcome: severity of depression symptoms measured using the Edinburgh Postnatal Depression Scale (EPDS)-short term

Only one randomized controlled trial providing perinatal women with a peer-support mobile application examined the severity of psychological stress using the Chinese Perceived Stress Scale and found statistically significant, but not clinically meaningful, lower levels of stress among participants in the intervention group compared to the control group at 4-weeks follow-up (MD=-3.52; 95% CI -4.95,-2.09; p<.001; GRADE certainty: very low) (159).

Results on utilization of care services among perinatal women were limited as only one randomized controlled trial providing a peer-support mobile application during the perinatal period examined this outcome and reported no statistically significant difference in the mean number of healthcare visits (Family physician, obstetrician, psychologist, psychiatrist) relative to usual care immediately post-intervention (160).

Mixed evidence on postpartum prevention-based mobile interventions showed the potential they carry on preventing severe depression symptoms. One randomized controlled trial provided postpartum mothers with a mobile-based peer-support program and found improvements in the severity of depression symptoms (EPDS) that reached only statistical significance at 3 months post-intervention compared to usual care (MD=-2.11; 95% CI -4.0,-0.3; p=.03; GRADE certainty: moderate) (166). Another non-randomized trial providing postpartum women with a health promotion-based mobile application found statistically significant, but not clinically important, lower severity of depression symptoms (EPDS) at 6-weeks follow-up among the intervention group compared to the usual care group (MD=-2.68; 95% CI -4.86,-0.5; p=.02; GRADE certainty: very low) (163). Conversely, one randomized controlled trial of a similar educational application delivered to both parents found no statistically significant or clinically meaningful added benefits in postpartum mothers' depression severity compared to usual care at 4 weeks follow-up (165).

Evidence on preventing anxiety postpartum was limited as only one randomized controlled trial of a mobile-based peer support program measured the severity of anxiety symptoms and showed no statistically or clinically significant improvements among women receiving the intervention compared to usual care at 4 weeks follow-up (166).

2.5.5 Effectiveness of Management-based Mobile Interventions

Evidence on management-based mobile interventions during the antenatal period was limited and showed trivial benefits to the mental health outcomes of pregnant women. One randomized controlled trial used a mobile application to deliver attention modification bias with the aim of reducing anxiety and stress among antenatal women

and found no statistically or clinically significant difference in the severity of depression, anxiety symptoms, or subjective psychological stress assessed using the Depression, Anxiety, and Stress Scale (DASS) post-intervention (171). However, improvements in biological stress measured using lab cortisol levels were found to be statistically significant but not clinically meaningful among the intervention group relative to the control group post-intervention ($F_{1,22}=4.96$; $p=.03$; GRADE certainty: low) (171). Another randomized controlled trial provided antenatal women with a mood tracking mobile application and found that, even though there was an intervention effect that statistically increased the number of telephone encounters with providers addressing mental health (ANCOVA $p=.02$; GRADE certainty: very low) (172), no statistical or clinical improvements were found in referral or attendance rates to mental health care specialists over time (172).

Evidence on the impact of perinatal management interventions on the mental health outcomes of pregnant women was limited as well. Only one randomized controlled trial provided perinatal women with a meditation-focused mobile application to manage their affective state and found that receiving the intervention was associated with a statistically significant increase in the sense of autonomy (MD from baseline=0.21; ANOVA $F=5.727$; Group x time $p<.05$; GRADE certainty: very low), but not other constructs of the Psychological Wellbeing Questionnaire (PWB) (169).

The effectiveness of postpartum management interventions depended on its feature and design. One randomized controlled trial of a mobile application delivering cognitive behavioural therapy (CBT) to postpartum women with depression showed statistically significant and clinically meaningful improvement in the severity of depression symptoms (EPDS) at 2-month follow-up (MD=-6.87; 95% CI -7.92,-5.82; $p<.001$; GRADE certainty: very low) (173). However, a meta-analysis (Figure 6) showed that interventions delivering support-based psychotherapy to manage depression symptoms did not statistically or clinically improve symptom severity (EPDS) compared to standard care, short-term (MD=-0.93; 95% CI -2.08,0.21; $p=.11$; GRADE certainty: very low) (174,175). Pooled results were judged to be statistically homogeneous ($I^2=0\%$; Chi^2

p=0.92), and the small number of included studies required no assessment of publication bias (156).

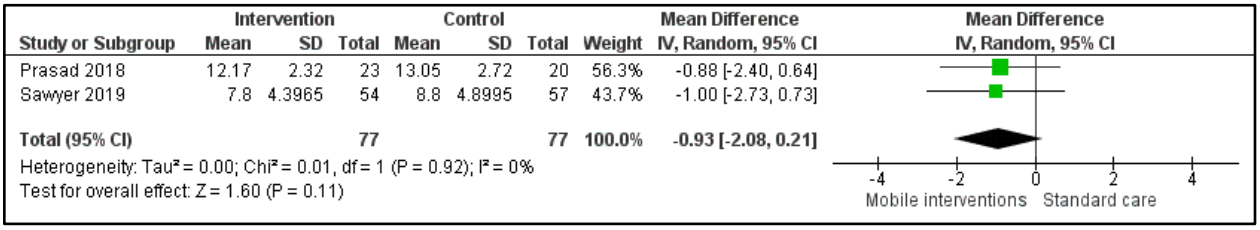

Figure 6. forest plot of comparison: support-based psychotherapy applications vs standard of care, outcome: severity of depression symptoms measured using the Edinburgh Postnatal Depression Scale (EPDS)-short term

This pooled result was supported by evidence from another non-randomized controlled study of a peer support intervention that found no statistical or clinical added benefit of receiving the intervention on the severity of depression relative to treatment as usual at 2-month follow-up (GRADE certainty: low) (168).

Among women who underwent medically-induced abortion, one randomized controlled trial of a text messaging intervention targeting symptom management reported a statistically significant but not clinically meaningful decrease in levels of anxiety measured using the Hospital Anxiety and Depression Scale (HADS) relative to usual discharge care at 2-3 weeks after abortion (MD=-1.30; 95% CI -2.33,-0.27; p=.01; GRADE certainty: very low) (170).

Findings on psychological wellbeing and distress showed some potential that postpartum management-based mobile interventions carry. One randomized controlled trial of a peer support mobile application showed a statistically significant, but not clinically meaningful, improvement in psychological wellbeing measured using the World Health Organization Quality of Life (WHOQOL-BREF) instrument among the intervention group compared to the usual care group (MD=0.23; F=4.56; ANOVA group x time p=.039; GRADE certainty: very low) (174). Another randomized controlled trial of a text messaging intervention following abortion measured avoidance and intrusive-based subjective stress using the Revised Impact of Event Scale (IES-R) and found that when adjusting for baseline anxiety, women receiving the intervention reported statistically

significant, but not clinically meaningful, lower avoidance-based stress (β=-1.8; 95% CI-3.2,-0.4; p=0.015; GRADE certainty: very low), but difference in intrusive-based stress did not reach the statistical significance threshold (170).

Finally, limited evidence reported on utilization of care services; one randomized controlled trial of a peer support mobile application found that women receiving the intervention were more likely to visit their family physician, though not statistically significant, (77.8% vs 63.2% for the intervention and control groups, respectively; p=.09; GRADE certainty: very low), more likely to visit the emergency department (15% vs 4% for the intervention and control groups, respectively; p=.04; GRADE certainty: very low), and more likely to seek pregnancy-related online resources when needed (41% vs 21% for the intervention and control groups, respectively; p=.03; GRADE certainty: very low) (175).

2.5.6 The health Equity Impact of Mobile Interventions

2.5.6.1 Mapping Equity Evidence

Table 7 represents a heat map of the sixty-two results that adjusted for patient characteristics at the selection of participants, stratification of data, or analysis of results using the PROGRESS+ framework (62). Overall, women's ethnicity was the most examined characteristic, followed by age, and being primiparous (first-time mother) when receiving the intervention. We found scarce evidence on women's socioeconomic status, occupation, social capital, and education.

Table 7. Heat Map of Equity Evidence

Equity findings	**Severity of symptoms**	**Psychological wellbeing and distress**	**Occurrence of psychiatric illnesses**	**Utilization of pregnancy and psychiatric care**
Place of residence	1	0	0	0
Race, ethnicity, culture	9	9	1	3
Occupation	1	0	1	0
Gender, sex	0	0	0	0
Religion	0	0	0	0
Education	4	0	1	0
Socioeconomic status	1	0	1	3
Social capital	3	0	1	0
+ Age	8	0	1	5
+ Disability	0	0	0	0
+ Time-dependent: Primiparous	3	7	0	0
+ Time-dependent: IPV	0	0	0	0
+ Discrimination	1	0	0	0

Different hues of the colour red were used to describe the quantity of results per characteristic.

2.5.6.2 Synthesizing Equity Impact

Gradients in effect estimates are compartmentalized into a "*PROGRESS+ equity framework*" of patients' characteristics by outcome domains. The framework is presented in appendix V.

I. Primary Equity Results

Ethnicity and race: Overall, mobile interventions showed improvements in the severity of mental health symptoms across East and South East Asian ethnicities, such as Chinese (158,161), Taiwanese (159,167), South Korean (163), and Thai (162), as well as West Asian

ethnicities, such as Persian (173). Evidence on other ethnicities such as Italian (169), and women from racial minorities, mainly African American and Latino (172) is limited.

Our results highlighted several inter-ethnicity gradients in effect estimates. A sensitivity analysis of our pooled result on the effectiveness of prevention-based peer-support smartphone applications showed a larger and more clinically meaningful effect estimate in the decrease of depression severity (EPDS) among Taiwanese women (MD=-3.70; 95% CI -5.27,-2.13; p<.001; GRADE certainty: very low) (159), compared to our meta-analysis result that included data from pregnant women regardless of ethnicity (MD=-3.07; 95% CI -4.68,-1.46; p<.001; GRADE certainty: very low) (Figure 5). Moreover, mobile interventions consistently prevented psychological stress among Taiwanese women in the antenatal and perinatal periods (159,167), whereas their management impact was not significant among Chinese women (158). Even though antenatal interventions consistently improved Chinese women's depression symptoms, whether by using a smartphone application (158), or a text messaging program (161), little impact was found on the severity of anxiety symptoms among women from this ethnicity (158).

Age: An age-specific sensitivity analysis of our pooled result on the effectiveness of prevention-based peer-support smartphone applications showed that the between- group difference in depression severity among pregnant adolescents was pulled away from the statistical significance and clinical importance threshold and closer towards the null (MD=-2.0; 95% CI -4.32,0.32; p=.11; GRADE certainty: low) (160), as opposed to the more statistically significant and clinically meaningful meta-analysis result that did not adjust for age (MD=-3.07; 95% CI -4.68,-1.46; p<.001; GRADE certainty: very low) (Figure 5). Controlling for the age of mothers, among other variables, yielded mixed results; in one randomized trial, this adjustment pushed the results towards the statistical significance threshold (175), whereas in other studies with different intervention features, adjusting for age did not have an impact on their depression or anxiety symptoms (165,166,173).

Socioeconomic status: Socioeconomic status impact was limited. In one non-randomized controlled trial, adjusting for monthly income, among other variable such as

marital status, education level, and work intensity, further decreased the odds of depression diagnosis among Chinese women receiving an antenatal prevention-based text messaging program by 2% (unadjusted OR=0.51, adjusted OR=0.49; GRADE certainty: low) (161). In another randomized trial, the effectiveness of a CBT-based mobile application was not associated with women's income (173).

Social capital: Evidence on the impact of social capital was limited. Only one randomized trial of a prevention-based mobile intervention adjusted for marital status among other variables, which seemed to increase the statistically significant difference in depression severity at 3 months , but had no impact on anxiety symptoms (166).

Time-dependent relationships characterized by intimate partner violence: No studies examined the effectiveness of mobile technology assisted interventions targeting pregnant women experiencing intimate partner violence.

II. Exploratory Equity Results

Occupation: Evidence on employment impact was limited. Adjusting for employment status in one randomized controlled trial of a health promotion intervention to prevent depression did not impact the symptom severity between groups (165).

Education: Evidence on the impact of education was mixed. In one randomized trial of pregnancy support mobile application, adjusting for women's level of education, among other variables such as age and housing status, pushed the between-group difference in depression severity into the statistical significance threshold (175). Moreover, in one randomized trial of a text messaging program following medically-induced abortion, investigators reported higher magnitude of effectiveness among women who did not reach high school compared to those with high school education (170). Conversely, women's education did not impact effectiveness results in two other randomized trials (165,173).

Time-dependent relationships characterized by being primiparous (First-time mothers): Smartphone applications were effective in preventing depression among primiparous pregnant women in two studies (158,163). These interventions, however, did not seem to have a statistically significant or clinically meaningful impact on women's anxiety or stress levels (158), and only increased primiparous women's sense of autonomy, but not other psychological wellbeing constructs of the Psychological Wellbeing Questionnaire (169).

2.6 Interpretation

COVID-19 and its public health restrictions have shifted the approach by which mental health care is accessed and delivered. Exploring mental health interventions that utilize mobile technology requires a comprehensive understanding of their benefits and harms, as well as their equity impact among different populations. Our equity-focused systematic review aimed to examine the effectiveness and equity impact of mobile interventions targeting the prevention and management of common mental disorders among pregnant and postpartum women.

Our results highlight the clinical impact prevention-based mobile interventions had on lowering the severity and occurrence of depression throughout pregnancy (158–161), as well as the potential they carried on maintaining symptom levels postpartum (163,166). One study reported that mobile interventions may prevent anxiety when delivered early in the pregnancy experience, but that effect was attenuated as the pregnancy progressed (162). Evidence on management-based mobile interventions was limited during pregnancy and only showed potential postpartum. A smartphone application delivering cognitive behavioral therapy was effective in managing the severity of postpartum depression (173), whereas interventions delivering other models of support-based psychotherapy to moderate existing symptoms did not show an added benefit compared to standard care (168,174,175).

Inter-ethnicity and age gradients in effect estimates highlighted the role these two patient characteristics played in moderating the effectiveness of mobile interventions among

pregnant and postpartum women. Mental health outcomes were found to consistently improve among Taiwanese pregnant women (159,167), and to a lesser degree among women from other ethnicities such as Chinese (158) and Italian (169). As well, evidence suggested that pregnant adolescents aged 16 to 24 years showed lessened improvements when receiving peer support mobile interventions to prevent or manage their mental health symptoms (160). The latter finding is preliminary in nature and thus, more research is needed before conclusively interpreting effectiveness results among this demographic. As well, more comprehensive research that examines qualitative evidence (176,177) and the mutually constructed equity impact of patients' characteristics and social identities using an intersectionality lens (178) may shed light on the reasons behind these gradients in effectiveness.

Our results identified two intervention characteristics that may mutually influence effectiveness; timing of intervention delivery relative to pregnancy stage and the psychotherapy features delivered through mobile phones. For example health education and promotion may benefit pregnant women antenatally, but fail to do so as delivery time approaches (162). Similarly, peer support interventions may significantly prevent depression (159,160), but fall short of managing existing symptoms (168,175). Of note, effectiveness findings alone usually fall short of comprehensively determining which components of the intervention were effective and why. This requires an in-depth evaluation research that utilizes a realist lens when examining an intervention of interest (179).

Our review is unique in that it utilized an equity lens to examine the effectiveness of novel interventions that can mitigate unfair and unjust barriers to mental health care among pregnant and postpartum women. We used rigorous methods to comprehensively search for, critically appraise, and synthesize our evidence. This work, however, is not without limitations; the majority of evidence originated from studies that were judged to have high risk of bias and low sample size which, in turn, impacted the certainty of our results. Future researchers should aim to adequately power their studies and apply more rigorous methods to its execution. Furthermore, the majority of equity evidence adjusted for many variables and characteristics but did not report the independent effect of each of these

variables. We did report this adjustment under the appropriate PROGRESS+ characteristic, but explicitly mentioned its indirect nature. Finally, evidence on the utilization of care was scarce across intervention categories, measured heterogeneously, and reported selectively. We, therefore, were unable to synthesize evidence or reach a conclusion on this outcome. Future researchers should further explore how mobile interventions impact this outcome. Similarly, we identified a gap of knowledge on mobile interventions that target anxiety as a stand-alone condition, which requires more research in the future.

As the COVID-19 pandemic transitions mental health care delivery into a virtual reality, a knowledge base is needed to inform key stakeholders on what mobile interventions work among pregnant and postpartum women. Our review highlights the impact these interventions have on preventing depression throughout pregnancy and managing its symptoms postpartum using cognitive behavioural therapy. Ethnicity and age impacted the level of effectiveness, which requires further investigation and thorough consideration when implementing mobile interventions among pregnant and postpartum women in the future.

CHAPTER 3
Comprehensive Discussion

This work aimed to "*set the stage*" for a new era of equitable mental health care, one that employs agile technologies, such as mobile phones, to better care for pregnant and postpartum women. We examined the effectiveness of mobile technology assisted interventions or "mobile interventions" that target the prevention and management of common mental disorders among this vulnerable population and used an equity lens to explore gradients in effect estimates by patients' characteristics and social identities. In this chapter, we highlight the need to address gaps in knowledge around anxiety and utilization of care and the importance of exploring the mutually constructed influence of patients characteristics and social identities using an intersectionality lens (178), to inform future development, adaptation, and implementation of mobile interventions in different contexts and settings.

3.1 Interpretation of Effectiveness Results

In the field of preventative mental health care, mobile interventions often showed superiority relative to standard care in regard to the severity of depression symptoms. Earlier in the antenatal stages of pregnancy, evidence showed that mobile interventions not only maintained lower symptom levels (158,161), but also decreased the odds of being clinically diagnosed with depression (161). As well, approaching delivery can be a stressful period for the childbearing mother, leaving her with long lasting psychological stress and trauma (180). Our results showed a statistically significant and probably clinically meaningful impact of peer-support mobile interventions on preventing depression during the perinatal period (159,160), and maintaining lower levels of depression severity 3 months postpartum (166). Mobile interventions that utilized health education and behavioural change had an impact of a lesser magnitude postpartum, as they only showed an added benefit among South Korean postpartum women (163), but failed to reach statistical significance in another randomized trial of an ethnically diverse cohort (165).

These results have allowed us to postulate that two characteristics of mobile interventions may contribute to their effectiveness; timing of intervention delivery and features of the delivered psychotherapy. For example, our evidence suggested that delivering prevention-based mobile interventions that utilize health education or behavioural change may be more beneficial to pregnant women earlier in the pregnancy experience relative to after delivery. These results align with global policies that promote the pivotal role of early health promotion and education in preventing mental disorders (181), and highlight the need to tailor mobile interventions to the needs, context, and time of patients by following a "*just-in-time adaptive design*" when developing future mobile interventions among pregnant and postpartum women (182,183).

Anxiety results showed some potential earlier in the antenatal pregnancy stages (162), which attenuated throughout pregnancy and failed to reach a statistical significance threshold after delivery (162). Even interventions that had an impact on depression did not seem to impact anxiety symptoms (158). This circulates back to our postulation on the influence of psychotherapy features delivered through mobile interventions and brings about the need to explore not only "*what*" works in the field of mobile mental health, but also "*how*" it works. This requires using a realist lens to explore the sensemaking of the mental health care delivery process through mobile interventions (179).

Our results on psychological stress and wellbeing were mixed, with two studies showing added benefits of mobile interventions on preventing stress (159,167), whereas another failed to reach this statistical or clinical significance threshold (158). It is worth noting that the psychotherapy feature was not as influential on this outcome as it was on mental health symptoms. For example, mobile interventions that utilized health education and promotion showed significant improvements in stress levels among pregnant women in one study (167), but this improvement was not statistically significant in another (158). The limited evidence on this outcome and heterogeneity in population characteristics and outcome measurements may have contributed to this inconclusive finding.

In the field of mental disorder management, results were more limited and of lower certainty compared to results from studies on prevention-based mobile interventions (Please see Appendix IV). Using mobile interventions early in the antenatal period showed no statistically or clinically significant added benefit in subjective outcomes of depression, anxiety, or stress, and only showed potential for improvements in biological stress (i.e., saliva cortisol) (171). Similar trends were found perinatally, as only one study examined mobile interventions provided to women closer to their delivery and found improvements in their sense of autonomy but no other constructs of psychological wellbeing (169). This highlights a gap in knowledge around the effectiveness of mobile interventions that manage common mental disorders during pregnancy, which potentially echoes a reluctance among health care providers to screen and manage these conditions during pregnancy (51,184), a problem that mobile interventions might represent a solution to (185).

It is during the postpartum period, however, when management-based interventions showed more potential to impact mental health outcomes. An impact that may, very well, be influenced by the psychotherapy feature of these interventions. For example, managing depression symptoms using mobile Cognitive Behavioural Therapy (CBT) was found to significantly improve the severity of depression symptoms (173), whereas a meta-analysis showed that any improvements of depression symptoms among women receiving support-based psychotherapy interventions relative to standard care were non-significant (174,175). This raises the question of "*why*" did peer support interventions show potential in the prevention but not management of depression? We hypothesize two arguments in response to this question. The first postulates that once postpartum women reach a certain threshold of depression severity, usually diagnostic of postpartum depression, they experience a psychological "broken compensation" phase in which interventions that provide non-intensive and support-based psychotherapy techniques, such as peer support, may fail to elicit improvements compared to validated and intensive psychotherapy, such as Cognitive Behavioural Therapy (CBT). The second argument speaks to depressed women's varied perceptions of depression and peer support and highlights the internal barriers that may prevent postpartum women from having a conversation about their depression symptoms once they develop, even with peers who

share similar lived experiences (50). Peer support mobile interventions may, therefore, be perceived differently when they are delivered to prevent depression compared to when they intend to manage its existing symptoms. Exploring both hypotheses requires using a qualitative lens to understand the experiences and perceptions of pregnant and postpartum women around peer support mobile interventions with or without a diagnosis of depression (176,177).

Moreover, it is noteworthy to highlight the gap in evidence on mobile interventions that target the management of anxiety or post-traumatic stress disorder as stand-alone conditions. Only one study targeted anxiety primarily among pregnant women who were undergoing medically-induced abortion and found a statistically significant decrease in the severity of anxiety symptoms (170). This limited research, both in the prevention and management of common mental disorders, raises the concern that anxiety might be perceived as a byproduct of depression among pregnant and postpartum women and is often overlooked when designing and implementing mobile interventions.

Finally, our results have highlighted the scarcity and heterogeneity of evidence that examined the effectiveness of both prevention- and management-based mobile interventions on the utilization of pregnancy-related and mental health outcomes. Across studies that attempted to examine this outcome, investigators tended to use descriptive statistics to measure encounters with providers of care (e.g., family physicians, psychologists, psychiatrists, obstetricians, etc.) (160,172,175). These studies were usually underpowered to detect a meaningful difference in these outcomes or reported them secondarily to other outcomes. We postulate two reasons for such results; the first highlights a common perception that utilization of health services is not a direct outcome of using mobile interventions that target mental health. The second highlights the scarcity of mobile interventions that aim to enhance utilization of care as their primary purpose. Both reasons stem from the same concern that mental health may be perceived as an independent sector of providing care to pregnant and postpartum women, as opposed to being on the same continuum of their health care. Mitigating these perceptions requires actively engaging different stakeholder groups in the design, implementation, and

evaluation of mobile interventions to ensure that their purposes and outcomes of interest are attuned to their needs and expectations (186,187).

3.1 Exploring Solutions to Health Inequity

We have called attention to the health inequities facing pregnant and postpartum women who, despite their heightened levels of needs, find themselves struggling with major internalized and externalized barriers to accessing and uptaking traditional mental health care. This equity-focused systematic review has highlighted the potential mobile interventions carry on improving health equity and reducing social injustice among different cohorts of pregnant and postpartum women.

While our introductory work has highlighted worsened mental health outcomes among pregnant women of different ethnicities relative to their Caucasian counterparts (63), our results reported on evidence of improvements in symptom severity associated with receiving mobile interventions across ethnicities, such as Taiwanese (159,167), Chinese (158,161), Thai (162), South Korean (163), and Persian (173). This suggests that mobile interventions could serve the purpose of delivering equitable mental health among different ethnicities. However, evidence on non-Asian ethnicities was limited and, therefore, more research is needed before generalizing our results to diverse cohorts of pregnant and postpartum women, such as African Americans and Latinas. Moreover, our results have highlighted a trend of inter-ethnicity differences in effect estimates. For example, Taiwanese women showed better improvements in depression symptoms (159), compared to our ethnically-diverse pooled results (Please see Figure 5). Similarly, improvements in psychological stress among Taiwanese women were statistically significant (159) and clinically meaningful (167), whereas they failed to reach this threshold among Chinese women (158). More research that implements a homogeneous intervention design to compare outcomes across both ethnicities is needed to better explore and confirm this phenomenon. This also suggests the need to adapt mobile interventions to different ethnicities and attune their contents to the cultural context of pregnant and postpartum women.

Conversely, our equity results have suggested a trend of lessened impact associated with prevention-based mobile interventions on the symptom severity of pregnant adolescents relative to their adult counterparts (160). This result is of low certainty and, thus, requires caution in interpreting. We postulate three reasons for this trend with suggested means to further explore them. Firstly, we highlight pregnancy at a young age as an experience that brings about increased stress and heightened levels of mental health needs (188,189), which require more intensive preventative measures than those usually delivered through mobile phones. Future research needs to examine a dose-response relationship between intervention intensity and symptom levels. Secondly, we point to the abundance of literature that emphasize suboptimal adherence to mobile interventions among youth populations (190–192). This low fidelity to utilization could signify that mobile interventions fall short of reaching the same therapeutic dose among pregnant and postpartum adolescents compared to adults. Development and implementation scientists should qualitatively explore and try to remedy the reasons behind this suboptimal adherence. Thirdly, we hypothesize that the content and materials delivered using mobile interventions may not appeal to pregnant adolescents (Please see section 3.3). We, similarly, suggest actively engaging pregnant youth in the co-creation of mobile interventions to enhance their relatability and appeal among this vulnerable subgroup of pregnant and postpartum women (186,193).

Finally, while our exploratory equity results highlighted the potential of mobile interventions among primiparous pregnant women, evidence on other PROGRESS+ characteristics was limited and non-conclusive. This points to a gap in knowledge on these characteristics, which we still assume to impact the health equity of pregnant and postpartum women. For example, although mobile interventions may provide a cost-friendly alternative to traditional mental health care, examining their impact among women in low- and middle-income countries may further emphasize socioeconomic status as a barrier for obtaining compatible mobile phones, accessing proper internet, and paying for electricity charges. This requires future efficacy studies to put more emphasis on exploring the equity impact of these characteristics and social identities, and use an intersectionality lens to examine their mutually constructed inequities (178).

3.3 The Global State of Development, Adaptation, and Implementation

Mobile interventions represent one part of the "virtual" health care paradigm that has long been recognized globally as a solution to increased population needs. Further, the COVID-19 pandemic has, and continues to, position virtual care as an "alternative" rather than a "complement" to traditional health care delivery. Indeed, the increased motivation under COVID-19 to overcome many barriers that have held virtual care back for years is one silver lining of this pandemic (194).

In Canada, a collaboration between the Canadian Medical Association (CMA), the Royal College of Physicians and Surgeons of Canada, and the College of Family Physicians of Canada (CFPC) established a Virtual Care Task Force (VCTF) to scale up virtual health care delivery (195);

"*We all recognize the potential of new technologies to transform the way we deliver and receive care; it's time we were able to take more advantage of them*"
-Dr. Gigi Osler, Virtual Care Task Force Co-chair (195).

Several guidance initiatives have been brought forward to facilitate the dissemination and utilization of mobile health interventions. For example, the Canadian Medical Association has published a guidance document to advise physicians on how to appraise and recommend the most suitable mobile intervention to their patients (196). Similarly, the American Psychiatric Association (APA) has recognized the exponentially increasing utilization of mobile interventions in mental health practice and thus, developed an initiative called "APP Advisor" to assist psychiatrists and other mental health professionals in navigating this new field of health care delivery and choosing the most suitable treatment option for their patients (197). Other lead states in virtual mental health care have established initiatives and recommendations to better provide virtual mental health care to their nations, such as Australia (198), the UK (199), and Norway (200).

Among pregnant and postpartum women, specifically, a plethora of new mobile interventions are on the rise across lead nations, as well as in low- and middle-income countries (LMICs). Yet, the efficacy of these interventions has not been tested relative to a control group. "*Mind the Bump*" and "*MindMum*" are Australian smartphone applications designed to improve pregnant women's psychological wellbeing and lift their mood (201,202). "*Baby Buddy*" is a similar smartphone application based in the UK and aims to guide perinatal and postpartum mothers through their pregnancy journeys and improve their wellbeing (203). "*Mamma Mia*" is a supportive program, recently adapted to a smartphone application, which has been developed in collaboration between the United States and Norway with the purpose of improving the wellbeing of pregnant and postpartum women with depression (204). "*Hope*" is a digital platform that provides Canadian pregnant women in Alberta with mental health screening, management, and referral during pregnancy and postpartum (205). Similarly, "*iMumz*" is a smartphone application used in India and aims to improve pregnant women's wellbeing and reduce their stress (206). Even though, and to the best of our knowledge, the efficacy of these specific programs has not been evaluated relative to a control group, our equity-focused systematic review provides comprehensive evidence on the effectiveness, or lack thereof, of mobile interventions that used similar design, psychotherapy features, and purpose, and that were implemented among diverse cohorts of pregnant and postpartum women.

Our "PROGRESS+ equity framework" has highlighted that mobile interventions work differently across different age groups and ethnicities of pregnant and postpartum women. We, thus, hypothesize that adapting these interventions to the level of need and characteristics of each age group and ethnicity is a prerequisite to providing equitable mental health care among these vulnerable populations. We note preliminary initiatives that may serve as a stepping stone for future adaptations of mobile interventions to cater to different cohorts of pregnant and postpartum women. In regard to age, our preliminary results showed that pregnant youth may benefit to a lesser degree from mobile interventions compared to their adult counterparts. A qualitative study explored this phenomenon by interviewing pregnant teenagers and health care professionals after providing them with the "*Positively Pregnant*" mobile application (207). Investigators examined patient and provider feedback and suggestions on how to tailor the intervention

to address the specific challenges that pregnant teenagers experience during pregnancy (207). Thematically mapping this feedback allowed the investigators to highlight several areas in which adaptation is required, such as: simplifying language, adding more pictures and humor, and using more interactive features (207). Furthermore, our results have highlighted inter-ethnicity differences in effectiveness that favoured Taiwanese women over other ethnicities, including Chinese. A platform analysis evaluated the quality of mobile interventions that target postpartum depression across three Chinese application platforms (208). By applying the US Preventive Services Task Force Recommendation Statement on preventing perinatal depression to critically appraise the content of each intervention, investigators concluded that, regardless of their increased popularity and availability, Chinese interventions usually suffer from lack of adherence to evidence-based guidelines and recommendations (208). These two initiatives shed some light on potential reasons behind our equity findings. We note, however, that more research is needed among these specific populations, and others, before any large-scale adaptation of mobile interventions is undertaken (Please see section 3.5).

Moreover, although virtual mental health care may provide a cost-friendly alternative to traditional mental health from the patient's perspective (108), we hypothesize that implementing virtual care programs, such as mobile interventions, in healthcare systems and practices is a rather costly process that requires intra- and inter-governmental financial support. Fortunately, the increased need for a suitable and easily accessible approach to mental health care has yielded distinguished funds to support the implementation and evaluation of such novel interventions. For example, the Canadian federal government has announced a $240.5 Million fund to invest in the development and implementation of virtual mental health programs among Canadians (209). Similarly, The National Institute of Mental Health (NIMH) has funded 404 grants in the United States with a total of $445 Million to support the evaluation and implementation of technology-enhanced mental health care between the years 2009 and 2015 (108). Similar governmental and non-governmental funds exist and provide program developers, policy makers, and researchers with the means to re-envision mental health care now and in the post COVID-19 era and move the findings of our equity-focused systematic review into reality.

3.4 Strengths and Limitations of this Work

Our work is unique in that it provides readers with a comprehensive and time-sensitive understanding of the psychological problem surrounding the experience of pregnancy. We have highlighted some of the major health inequities that continue to jeopardize a fair and just provision of mental health care to pregnant and postpartum women. By doing so, we portray to readers an image of how health equity may be impacted throughout the clinical pathway of etiology, diagnosis, prevention, and management of common mental disorders among this vulnerable population. We used a broad intervention definition that includes smartphone applications, as well as other features of mobile technologies (e.g., text messages, pushed notifications, etc.) to assist in the delivery of mental health care. The scope of our work focused on interventions that are designed to not only manage common mental disorders (CMDs) and psychological stress, but also prevent them from developing in the first place. As well, we included studies of pregnant and postpartum women throughout the pregnancy experience and regardless of its outcome. Our findings, therefore, highlight what works in both fields of prevention and management, and for every stage of pregnancy and the postpartum period. This allows knowledge users, such as researchers, providers of care, and patients to make informed and evidence-based health decisions when addressing the mental health state of this vulnerable population.

Furthermore, we utilized rigorous methodology to ensure that our work is trustworthy and relevant to our knowledge users; a) our primary and secondary search strategies were comprehensive and inclusive of multifold sources of evidence, including bibliographic databases, reference listings, trial registries, communication with investigators, as well as grey literature; b) we did not apply any date, setting, or language restrictions to our search to prevent reporting bias by the time, place, or language of publications, and we updated our search in 2021 to guarantee the timeliness of our work; c) our knowledge base is established using evidence from controlled studies of different designs (138). We elected to include different study designs to capture effectiveness and equity evidence which may not be captured by randomized controlled trials of interventions; d) we utilized an equity-focused systematic review approach (93,94) to examine the effectiveness and equity impact of mobile interventions among pregnant and postpartum women. To the best of

our knowledge, no other knowledge synthesis has used an equity lens to explore this topic, creating a gap of knowledge which we have attempted to address; and e) we have used rigorous methods to critically appraise the methodological rigour of included studies, such as the Cochrane Risk of Bias (ROB 2.0) and Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) tools (143,144). The certainty of results was, also, assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) methodology (147,149), and reported alongside effect estimates. This positions our results to serve as a timely, relevant, and transparent source of knowledge on the subject matter.

Our work, however, is not without limitations; we focused on the quantitative effectiveness and equity impact of these interventions and did not examine qualitative evidence that may further enrich equity results, especially those revolving around the experiences of patients with mobile interventions. Moreover, our decision to include only studies that employed a controlled design ensured that our results depicted the effectiveness and equity impact of mobile interventions relative to situations in which pregnant and postpartum women did not access these novel technologies (e.g., usual care, no intervention, placebo, waitlisting). This has allowed us to put forward comparative findings that are based on high-quality evidence but has limited us from including single-arm studies that are usually longitudinal in timing and may add additional information to our current understanding.

Furthermore, there exist several limitations to the results themselves that are noteworthy. Firstly, the certainty of results ranged from “high” to “very low”. Many studies were downgraded for their low sample size (imprecision concerns) and/or limited methodological rigour (risk of bias concerns). Knowledge users of this work should interpret results of “low” and “very low” certainty with caution as future research is likely to impact such effect estimates (147). Secondly, we noted a lack of research on the efficacy of mobile interventions on the utilization of pregnancy-related and mental health care. This outcome domain was commonly reported in the scientific literature of mental health interventions among pregnant and postpartum women, and was prioritized by our project partners (Please see Chapter 4) (63). Investigators of mobile interventions, however,

seemed to examine such outcomes using exploratory and descriptive statistics, which has prevented us from synthesizing conclusive knowledge on utilization of care. Thirdly, our equity results were based on evidence from studies that either selected participants with a certain PROGRESS+ characteristic (158–160), or by analyzing their data while adjusting or controlling for such characteristics (165,170,175). Choosing the former approach usually signifies that investigators have powered their studies to detect a meaningful difference in our outcomes of interest, whereas analyzing data from a subset of participants using the latter approach is usually underpowered and exploratory in nature. Fourthly, many studies adjusted or "controlled" for certain PROGRESS+ characteristics of interest among other variables, but only reported their results before and after adjustment for all combined variables. This has prevented us from detecting the independent impact of certain characteristics. To ensure reporting transparency, we have compartmentalized such results under the appropriate PROGRESS+ characteristics in our framework but have reported their indirect nature.

Despite these limitations, knowledge users of this research may benefit from our knowledge base to inform their health decision making process. They should, however, utilize their judgement, as well as our certainty assessments, when determining the degree of validity of our results, and how applicable and transferable they are to their context, setting, and population of interest.

3.5 Implications for Future Research and Practice

Although our results may inform future implementation of mobile interventions that target the prevention and management of common mental disorders among pregnant and postpartum women, many of our interpretations are of hypothetical nature which requires more research prior to successfully implementing these interventions in practice. Future research studies should apply more rigorous methodology in the allocation of participants to study arms, protection against deviation from the assigned intervention, handling missing data, measuring outcomes, addressing confounding, and reporting results. This would increase the internal validity of their effect estimates and allow for the creation of more trustworthy results. As well, we highlight several gaps in knowledge that

require further research, especially in the field of managing common mental disorders early in pregnancy, as well as preventing and managing anxiety as a stand-alone condition. Investigators may also use this work to perceive mobile interventions not as a final destination for the prevention and management of common mental disorders, but rather as a means to further improve utilization of other health care services, both traditional and virtual. This holistic perception to health care would increase investigators' motivation to examine the impact such interventions have on the utilization of pregnancy-related and mental health care, an outcome lacking in evidence as we stand. Further, this project has shed light on the significance and unignorable role of health equity along the clinical pathway of common mental disorders among pregnant and postpartum women. We suggest that health equity should be explored more rigorously and reported more clearly in future studies of interventions, by examining and reporting the independent impact of individual patient characteristics on intervention effectiveness and powering the sample size to allow for the detection of meaningful differences in effect estimates between different subgroups. Health equity should also be explored along the clinical pathway of common mental disorders (Please see figure 1), especially in regard to women's response to psychological stress, acceptability of diagnosis and screening interventions, and access to both traditional and technology-assisted mental health care.

Future knowledge syntheses such as systematic and realist reviews should complement our work by examining other constructs of the decision making process using criteria from the GRADE evidence-to-decision (EtD) framework (210). For example, we recognize that mobile interventions provide a cost-friendly alternative from the patients' perspective, but future systematic review should examine the cost-effectiveness of these interventions from societal and healthcare system perspectives. Similarly, future systematic review should focus on the feasibility and utilization of mobile interventions by examining access-specific outcomes such as adherence to treatment and useability of programs. Complementing this work also requires understanding the experiences of patients and providers of care around mobile interventions, as well as their satisfaction with the care they receive or provide. We suggest that a systematic review of qualitative evidence is needed to complement our quantitative results. Finally, although our updated search early in 2021 did not capture emerging evidence under the COVID-19 era, more

research is projected to be published on interventions that are tailored to the context of this pandemic. We, therefore, highlight the need to update our search within a 12-month time frame, and plan to do so should resources and time allow.

In regard to future implementation, we have highlighted the importance of adapting mobile interventions to cater to different levels of needs and characteristics of patients. We have also recognized that our findings may not be equally transferable across different contexts and, therefore, suggest that researchers and decision makers use our findings as a blueprint for future implementation, and address any variability in the setting, characteristics of patient cohorts, nature of health care system, and funding opportunities before applying our findings to implement mobile interventions within their respective contexts. Moreover, we have highlighted multiple financial support opportunities that focus on evaluating and implementing virtual mental health programs, such as mobile interventions, among the general populations in Canada and globally, but funding to support tailoring such interventions to the levels of need of pregnant and postpartum women is limited. We suggest using our findings that highlight the potential of these interventions to collaboratively advocate for future funding that supports evidence-based research, guideline development, equity adaptation, and intervention co-creation. Finally, re-envisioning mental health care requires perceiving mobile technologies as a stepping stone to using more advanced and agile technologies, such as artificial intelligence which shows promise in its ability to personalize standardized mental health interventions to cater for the individual characteristics and levels of need of each pregnant and postpartum woman (211).

CHAPTER 4
Knowledge Translation and Exchange in the Context of COVID-19

4.1 Overview of our Knowledge Translation Plan

The heightened levels of mental health needs among pregnant and postpartum women, especially during the COVID-19 era, has posed an "ethical urgency" to move our knowledge from the folds of this work and into the real world (212). Knowledge translation serves as the medium by which this is possible (212). The Canadian Institute of Health Research defines knowledge translation as "*a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system*." (213). We have adopted CIHR's definition as well as the views put forward by Straus, Tetroe, and Graham (212) in designing our "collaborative" research project (214) that comprised elements from both integrated and end-of-project knowledge translation approaches (213). We note, however, that our project coincided with the World Health Organization declaring COVID-19 as a global pandemic in March 2020 (215), which initiated several public health restrictions against in-person gatherings and hindered our capacity to engage partners and knowledge users in our early work.

Evidence suggests that no single knowledge translation plan or strategy can yield effective results across different research projects (216). The knowledge translation plan described herein was conceptualized and iteratively adapted to the nature of our research, characteristics of our knowledge users, and the context of COVID-19. Across different phases of the project, we have collaborated with multiple stakeholder groups, hereby referred to as "project partners". Working alongside our partners has shaped our project's scope, methods, outcomes, and findings, and iteratively informed our knowledge translation plan and strategies. Figure 7 represents our knowledge translation framework, which is explained, with detail, in this chapter.

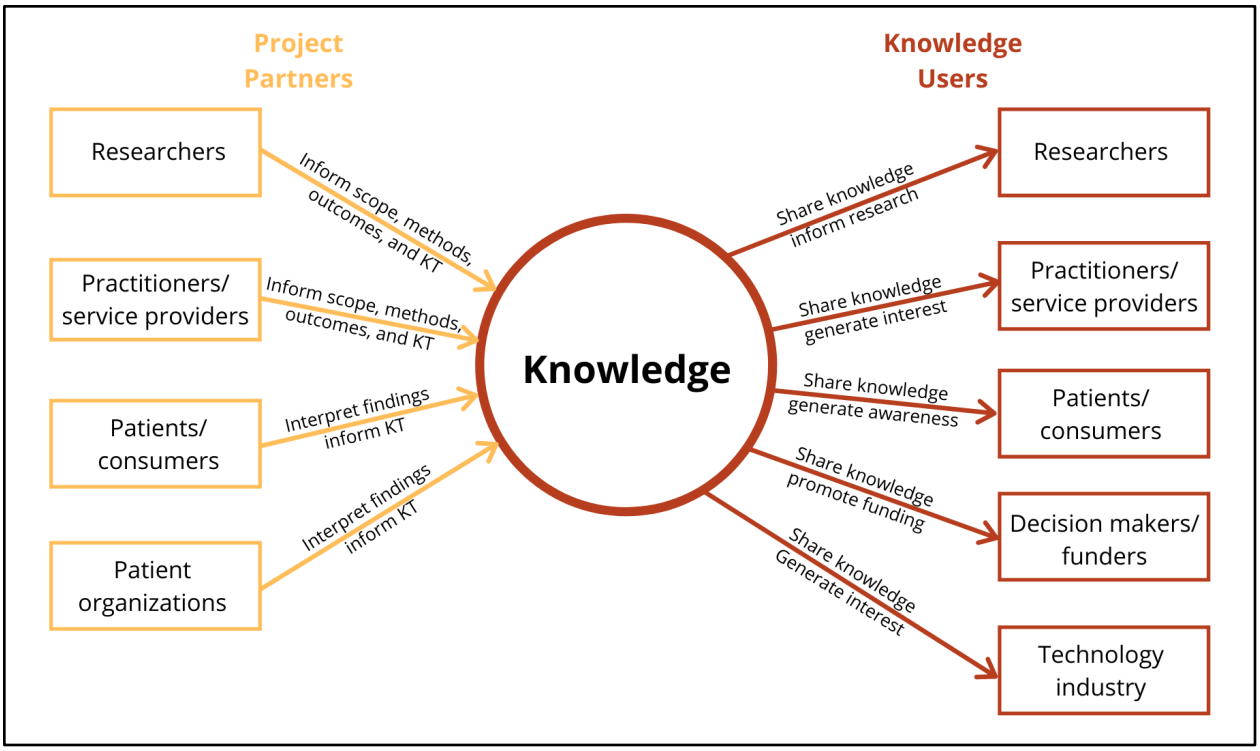

Figure 7. Knowledge Translation Framework

4.2 Time Frame of Knowledge Translation

We denote four time frames in which we have sought, or continue to seek, engagement with project partners for the purpose of translating our knowledge. Engagement with partners was heterogeneous across these time frames and depended on our capacity, the feasibility of activities under the COVID-19 public health restrictions, and the need for engagement:

Time Frame 1 "T1" (March 2020- April 2020) represents the project planning phase before the formulation of project scope and research questions. It involved assessing the needs of the population and reviewing the literature for gaps in knowledge. T1 ended at the formulation of the project scope and research questions.

Time Frame 2 "T2" (April 2020- June 2020) represents the project planning phase after the formulation of project scope and research questions. It included the conceptualization of methods and selection of outcomes. T2 ended at the submission of

the project proposal to the office of graduate studies at the University of Ottawa, School of Epidemiology and Public Health.

Time Frame 3 "T3" (June 2020- February 2021) represents the project execution phase. It included performing all research activities that have been proposed in the protocol and the writing of this work. T3 ended at the submission of this work to the office of graduate studies at the University of Ottawa, School of Epidemiology and Public Health.

Time Frame 4 "T4" (February 2021- January 2022) represents the end-of-project phase and thereafter. It includes all end-of-project KT activities and their evaluation. T4 is a long-term period that may extend for two or more years. It ends by evaluating our knowledge translation impact at 12 months following the publication of this work in a peer reviewed journal (Please see section 4.6), or by linking this project to future initiatives that enhance research, policy, and practice.

4.3 A Collaborative Research Approach

We have recognized that establishing meaningful relationships with our project partners would ensure that our project scope addressed a relevant knowledge gap (217), our methods and activities properly addressed the research questions (187), our outcomes and findings were attuned to the needs of our populations (186), and our knowledge messages that we have translated along the process of this project and the activities by which they have been translated were feasible and effective within our capacity, time frame, and in the context of the COVID-19 pandemic (212). Project partners were invited through our networks and have ensured their commitment to meaningfully support our work, now and in the post COVID-19 era. They have been engaged heterogeneously across the four time frames described above, and have been categorized into four major groups: researchers; practitioners and service providers; patients and consumers of care; and patient organizations. Table 8 represents our collaborative research matrix which has been developed using the stakeholder engagement guidance put forward by Concannon and colleagues (186). The matrix describes project partner groups and qualifies their

roles, contributions, and level of engagement, as well as the time frame and mode of such engagement.

Table 8. Collaborative Research Matrix

Stage/ Time Frame	**Research activity**	**Project partner groups**					
		Researchers		Practitioners/ providers		Patients/ consumers	Patient organizations
		Health services and equity methods researchers	Research organizations	Psychiatrists	Psychologists	Pregnant and postpartum women	Patient advocacy group
"T1"	Building research capacity	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Advisors **M**: emails	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	N
	Training to work with stakeholders	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	N	N
	Prioritizing evidence gaps	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Advisors **M**: emails	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	N
	Choosing research topics	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R:** Feedback **M**: emails	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	N
	Defining scope and research questions	**R**: Decision maker **M**: virtual meetings,	**R**: Feedback **M**: emails	**R**: Decision maker **M**: virtual meetings,	**R**: Decision maker **M**: emails, Google	N	N

		emails, phone calls		emails, phone calls	documents		
"T2"	Choosing relevant outcomes	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	**R**: Decision maker **M**: virtual meetings, emails, phone calls	**R**: Advisor **M**: virtual meetings, emails, phone calls	N	N
	Designing research protocol	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	**R**: Decision maker **M**: virtual meetings, emails, phone calls	N	N	N
"T3"	Performing research activities (as described in methods)	**R**: Decision maker **M**: virtual meetings, emails, Google documents	N	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	N	N
	Identifying findings	**R**: Decision maker **M**: virtual meetings, emails, Google documents	N	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Advisor **M**: virtual meetings, phone calls, emails and messages	**R**: Decision makers **M**: virtual meetings, phone calls, emails and messages
	Interpreting findings	**R**: Decision maker **M**: virtual meetings, emails, Google documents	N	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision makers **M**: virtual meetings, phone calls, emails and messages	**R**: Decision makers **M**: virtual meetings, phone calls, emails and messages
	Identifying implications for future research	**R**: Decision maker **M**: virtual meetings, emails, Google documents	N	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision makers **M**: virtual meetings, phone calls, emails and messages	**R**: Decision maker **M**: virtual meetings, emails, Google documents

"T4"	Designing End-of-Project KT	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R:** Advisor **M:** emails and phone calls	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents
	Disseminating findings	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents
	Evaluating KT	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Advisors **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Advisors **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents
	Evaluating engagement	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents	**R**: Decision maker **M**: virtual meetings, emails, Google documents

Moreover, we have consulted with multiple experts in the field of knowledge translation to inform the design and execution of our KT plan. Our team included a scientist representative (Olivia Magwood), as well as communication experts from our partner organizations with working experience in KT. Our experts have, and continue to, consult us on the conceptualization of the knowledge translation plan, design of knowledge diffusion and dissemination interventions, and evaluation of our knowledge translation impact. We have also reached an agreement with the Bruyère Research Institute to disseminate our knowledge through their communication networks (e.g., mailbag, Life Changing Day, research grand rounds), and highlight our publications through their social media channels.

Researchers: Collaborating with scientists with expertise in health service and policy (Peter Tugwell) and equity methods (Kevin Pottie, Olivia Magwood) has informed our decision to apply an equity lens to our work and guided the process to properly do so. The Bruyère Research Institute, a research-focused organization, has supported this project, both financially and logistically, and provided the means to communicate our early findings to different stakeholders through utilizing their internal communication network, or by supporting our external endeavours to engage key stakeholders groups. Further, the University of Ottawa, Faculty of Medicine has provided the venue to present our methods (i.e., protocol) and early equity findings (Please see chapter 1.3) to a group of scientists and peer investigators, who provided feedback on our work and refined the process by which we report our results.

Practitioners and service providers: Choosing mobile interventions to prevent and manage common mental disorders among pregnant and postpartum women is a shared health decision that requires buy-in from not only patients, but also practitioners and providers of care. We have, therefore, engaged multiple representatives of practitioners and care providers, such as psychiatrists (Azaad Kassam), psychologists (Tim Aubry), Maternal psychotherapists (Leanne Ford), maternal health providers (Julie Hakim), as well as graduate and undergraduate medical students (Qasem Alkhateeb, Syeda Shanza Hashmi). Our partners have guided the process of conceptualizing methods, selecting clinically meaningful outcomes, and interpreting findings in the context of practice and care delivery. As well, they have collaborated on the design of our end-of-project KT plan.

Patients: We have partnered with "patient representatives", defined as pregnant and postpartum women with lived experience of stress and common mental disorders, and have worked with them to attune our work to their needs and values. Our patient representatives chose to remain anonymous for privacy concerns. To facilitate this engagement, we have created a "patient summary" (Supplementary Materials IV), which explained our rationale and methods in plain and jargon-free language, and then worked with our patient representatives to interpret our data, identify gaps in knowledge, and plan for end-of-project knowledge translation. Our experience collaborating with patient representatives has highlighted the value of moving towards an active and early

involvement of patients in the co-creation of future research and development of mobile interventions (193).

Patient organizations: "FemTech" or "Female Technology" represents an emerging sector that focuses on using technology-based care to improve the health and wellbeing of women (218). We have partnered with "FemTech Focus", a patient-oriented organization well-rooted among women opinion and community leaders with a global reach to thousands of women. We have consulted experts from "FemTech Focus" to help us interpret our data, tailor our findings to the context of pregnant and postpartum women, and move towards an effective end-of-project knowledge translation. Our deliberations have highlighted the need to advocate for the democratization of women's health and call for supporting women to take control of their own mental health during and after pregnancy.

4.4 End-of-Project Knowledge Translation

4.4.1 Main Knowledge Messages

Our work has allowed us to put forward five main knowledge messages that we continue to collaborate with our project partners to translate effectively with the purpose of sharing knowledge, informing research, promoting funding, and generating awareness and interest:

Message 1: Mobile interventions are positioned to serve as a just-in-time solution to prevent depression throughout pregnancy and postpartum.

Message 2: The timing and features of mobile interventions influenced their effectiveness to manage postpartum depression.

Message 3: Mobile interventions carry the potential to improve the health equity of pregnant and postpartum women, especially now and in the post COVID-19 era.

Message 4: More research and funding are needed to address gaps in knowledge on anxiety and utilization of care, especially among pregnant youths.

Message 5: Collaborating with patients and other project partners has highlighted the value of moving towards actively engaging patients and consumers in the co-creation of future research and development of mobile interventions.

4.4.2 End-of-Project Knowledge Translation Plan

In planning our end-of-project knowledge translation, we have selected knowledge users (KUs) who are most "responsible for or affected by" the health issues addressed by the knowledge of this project (219). Our knowledge users can be categorized into five groups: researchers, practitioners and service providers, patients, decision makers and funders, and the technology industry. Our knowledge translation plan aims to share knowledge, generate interest and awareness, inform research, and promote funding. We recognize that our knowledge is limited to the effectiveness and equity impact of mobile interventions, and cannot solely inform guideline development without the consideration of other Evidence-to-decision constructs (210). We have, therefore, decided to exclude knowledge translation goals that target practice change until more research that addresses this guideline implementation gap has been conducted (220). Table 9 links each knowledge user group to the knowledge translation goals we intend to achieve, as well as the strategies (interventions) by which we aim to achieve these goals. In summary, we propose a combination of knowledge diffusion strategies, such as peer and non-peer reviewed publications, conference presentations, and virtual tutorials, as well as more patient-tailored knowledge dissemination strategies, such as patient-oriented plain language summaries and targeted stakeholder engagement. For example, collaborating with "FemTech Focus", we propose a patient-oriented workshop in which we train women champions and opinion leaders to actively generate awareness on mobile interventions by supporting a "snowball" and targeted approach to knowledge dissemination through their social networks. Finally, building on other projects in the field of technology-assisted mental health care, we plan to call for a stakeholder meeting with representatives from

different knowledge user groups, for the purpose of sharing knowledge, and planning future partnerships, funding, and research.

Table 9. End-of-Project Knowledge Translation Goals and Plan

Knowledge users	**Knowledge translation goals**	**Knowledge translation messages**	**End of project KT strategies**
Researchers	Share knowledge Inform research	1, 2, 3, 4, 5	Peer reviewed publication
		1, 2, 3, 4	Conference poster
		1, 2, 3, 4	Conference workshop
		1, 2, 3, 4	Bruyère monthly mailbag
		1, 2, 3, 4, 5	Stakeholder meeting
Practitioners and service providers	Share knowledge Generate interest	1, 2, 3, 4, 5	Peer reviewed publication
		3, 5	Opinion publication in a medical journal
		1, 2, 3, 4, 5	Stakeholder meeting
Patients/ consumers of care	Share knowledge Generate awareness	1, 2, 3	Plain language summary
		1, 2, 3	Social media campaign
		1, 2, 3	Tutorial video
		1, 2, 3, 5	Patient-produced pamphlets
		1, 2, 3, 4, 5	Patient-oriented workshop
		1, 2, 3, 5	FemTech Focus mailbag
		1, 2, 3, 4, 5	Stakeholder meeting
Decision	Share knowledge	1, 2, 3, 4, 5	Peer reviewed publication

makers/ funders	Facilitate funding	1, 2, 4	Policy brief
		1, 2, 3	Evidence synthesis brief
		1, 2, 3, 4, 5	Stakeholder meeting
		4	Advocacy editorial
Private sector/ health technology industry	Share knowledge Generate interest	1, 2, 3, 5	Evidence synthesis brief
		1, 2, 3, 4, 5	Stakeholder meeting

4.4.3 Evaluating End-of-Project KT Strategies

Properly evaluating the reach, use, collaboration level, and usefulness of our end-of-project knowledge translation strategies will help us assess the project impact, detect any unaddressed gaps in knowledge translation, and iteratively improve our KT strategies. Table 10 describes our evaluation indicators and the strategies they assess. The indicators will be examined at 6 and 12 months following the end-of-project timepoint and will be compared to existing network projects to determine their effectiveness.

Table 10. End-of-project Knowledge Translation Evaluation Plan

KT evaluation domain	KT evaluation
Reach indicators	Number of publication views
	Conference workshop attendance
	Stakeholder meeting attendance
	Patient training attendance
	Number of contacts (Network size) to which plain language summaries were sent
	Social media reach and impact metrics
	Tutorial video views

	Number of policy/ funding and industry contacts to which policy and evidence briefs were sent
	Size of opinion leaders' social network
Usefulness indicators	Before and after survey measuring gained knowledge and changed views on mobile interventions
	Sentiment analysis of comments left on social media posts and video tutorials
	Reports of opinion leaders on gained knowledge and changed views following their outreach to pregnant and postpartum women in their networks
Use indicators	Citation monitoring to detect the number of citations of the peer reviewed publications that led to enhanced research.
	Number of provincial and federal funding, or calls for funding, generated using our policy brief.
	Number of future technology development, or call for development, generated using our evidence synthesis brief.
Partnership and collaboration indicators	Number of partnerships established on this topic during or after our presentations, workshops, and stakeholder meetings.
	Number of KT products co-created with knowledge users
	Number of opinion leaders recruited for training and outreach
	Number of KT products disseminated through our network of project partners and knowledge users

CONCLUSION

Mobile technology assisted interventions represent a promising step in the direction of improving mental health equity among pregnant and postpartum women. Such agile technologies can mitigate access and uptake barriers that prevent traditional mental health care from addressing the heightened needs of pregnant and postpartum women. The COVID-19 pandemic has widened the discontinuity of mental health care, worsened common mental disorder symptoms, and threatened access to care among soon to be mothers. Our collaborative research examined mobile interventions that target the prevention and management of common mental disorders such as depression and anxiety, as well psychological stress as the root risk factor for these conditions among pregnant and postpartum women. Mobile interventions were found to prevent and manage depression throughout and after pregnancy and showed potential to prevent and reduce psychological stress. Their impact spanned across different ethnicities, which position mobile interventions as a solution to health inequity. The global recognition and interest in mobile interventions, especially during the COVID-19 era, requires a timely and collaborative movement from stakeholders involved in the decision-making process, and using our work as a "blueprint" to better examine some critical gaps of knowledge, especially among pregnant youth. Addressing these gaps starts with actively involving stakeholders and consumers of care in the co-creation and evaluation of mobile interventions.

References

1. Balin J. The sacred dimensions of pregnancy and birth. Qual Sociol. 1988;11(4):275–301.

2. Daulter A. Sacred Pregnancy: A Loving Guide and Journal for Expectant Moms. North Atlantic Books; 2012.

3. Hytten FE, Leitch I. The physiology of human pregnancy. Physiol Hum Pregnancy. 1964;

4. Talbot L, Maclennan K. Physiology of pregnancy. Anaesth Intensive Care Med. 2016;17(7):341–5.

5. Soma-Pillay P, Catherine N-P, Tolppanen H, Mebazaa A, Tolppanen H, Mebazaa A. Physiological changes in pregnancy. Cardiovasc J Afr. 2016;27(2):89.

6. Abbas AE, Lester SJ, Connolly H. Pregnancy and the cardiovascular system. Int J Cardiol. 2005;98(2):179–89.

7. Smith GN, Louis JM, Saade GR. Pregnancy and the postpartum period as an opportunity for cardiovascular risk identification and management. Obstet Gynecol. 2019;134(4):851–62.

8. Lapinsky SE. Management of acute respiratory failure in pregnancy. In Thieme Medical Publishers; 2017. p. 201–7.

9. Whitty JE, Dombrowski MP. Respiratory disease in pregnancy. Gabbes Obstet Essent Norm Probl Pregnancies E-Book. 2018;282.

10. Cheung KL, Lafayette RA. Renal physiology of pregnancy. Adv Chronic Kidney Dis. 2013;20(3):209–14.

11. Belzile M, Pouliot A, Cumyn A, Côté AM. Renal physiology and fluid and electrolyte disorders in pregnancy. Best Pract Res Clin Obstet Gynaecol. 2019;57:1–14.

12. Dunkel Schetter C. Psychological science on pregnancy: stress processes, biopsychosocial models, and emerging research issues. Annu Rev Psychol. 2011;62:531–58.

13. Slomian J, Honvo G, Emonts P, Reginster J-Y, Bruyère O. Consequences of maternal postpartum depression: A systematic review of maternal and infant outcomes. Womens Health. 2019;15:1745506519844044.

14. Shorey S, Chee CYI, Ng ED, Chan YH, San Tam WW, Chong YS. Prevalence and incidence of postpartum depression among healthy mothers: a systematic review and meta-analysis. J Psychiatr Res. 2018;104:235–48.

15. Lake J, Turner MS. Urgent need for improved mental health care and a more collaborative model of care. Perm J. 2017;21.

16. Herman J, Mock K, Blackwell D, Hulsey T. Use of a pregnancy support web site by low-income African American women. J Obstet Gynecol Neonatal Nurs. 2005;34(6):713–20.

17. Slade A, Cohen LJ, Sadler LS, Miller M. The psychology and psychopathology of pregnancy. Handb Infant Ment Health. 2009;3:22–39.

18. Staneva AA, Bogossian F, Wittkowski A. The experience of psychological distress, depression, and anxiety during pregnancy: A meta-synthesis of qualitative research. Midwifery. 2015;31(6):563–73.

19. Bennett HA, Boon HS, Romans SE, Grootendorst P. Becoming the best mom that I can: women's experiences of managing depression during pregnancy–a qualitative study. BMC Womens Health. 2007;7(1):13.

20. Braveman P, Gruskin S. Defining equity in health. J Epidemiol Community Health. 2003;57(4):254–8.

21. Whitehead M. The concepts and principles of equity and health. Health Promot Int. 1991;6(3):217–28.

22. Cardwell MS. Stress: pregnancy considerations. Obstet Gynecol Surv. 2013;68(2):119–29.

23. Thayer ZM, Gildner TE. COVID-19-related financial stress associated with higher likelihood of depression among pregnant women living in the United States. Am J Hum Biol. 2020;e23508.

24. Chang Y, Fine MA. Modeling parenting stress trajectories among low-income young mothers across the child's second and third years: Factors accounting for stability and change. J Fam Psychol. 2007;21(4):584.

25. Marmot M, Allen J, Bell R, Goldblatt P. Building of the global movement for health equity: from Santiago to Rio and beyond. The Lancet. 2012;379(9811):181–8.

26. Goldberg DP, Huxley P. Common mental disorders: a bio-social model. Tavistock/Routledge; 1992.

27. Goldberg D. A bio-social model for common mental disorders. Acta Psychiatr Scand. 1994;90:66–70.

28. Grayson D, Bridges K, Duncan-Jones P, Goldberg D. The relationship between symptoms and diagnoses of minor psychiatric disorder in general practice. Psychol Med. 1987;17(4):933–42.

29. Herbell K, Zauszniewski JA. Stress Experiences and Mental Health of Pregnant Women: The Mediating Role of Social Support. Issues Ment Health Nurs. 2019;40(7):613–20.

30. Söderquist J, Wijma B, Thorbert G, Wijma K. Risk factors in pregnancy for post-traumatic stress and depression after childbirth. BJOG Int J Obstet Gynaecol. 2009;116(5):672–80.

31. Jha S, Salve HR, Goswami K, Sagar R, Kant S. Burden of common mental disorders among pregnant women: A systematic review. Asian J Psychiatry. 2018;36:46–53.

32. Zivoder I, Martic-Biocina S, Veronek J, Ursulin-Trstenjak N, Sajko M, Paukovic M. Mental disorders/difficulties in the postpartum period. Psychiatr Danub. 2019;31(Suppl 3):338–44.

33. Gavin I, Gaynes N, Lohr N, Meltzer-Brody N, Gartlehner N, Swinson N. Perinatal Depression: A Systematic Review of Prevalence and Incidence. Obstet Gynecol. 2005;106(5, Part 1):1071–83.

34. Fawcett EJ, Fairbrother N, Cox ML, White IR, Fawcett JM. The prevalence of anxiety disorders during pregnancy and the postpartum period: a multivariate Bayesian meta-analysis. J Clin Psychiatry. 2019;80(4):0–0.

35. Yildiz PD, Ayers S, Phillips L. The prevalence of posttraumatic stress disorder in pregnancy and after birth: A systematic review and meta-analysis. J Affect Disord. 2017;208:634–45.

36. World Health Organization. Impact of COVID-19 on people's livelihoods, their health and our food systems. [cited 2021 Jan 21]; Available from: https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people's-livelihoods-their-health-and-our-food-systems

37. Pfefferbaum B, North CS. Mental health and the Covid-19 pandemic. N Engl J Med. 2020;

38. Jago CA, Singh SS, Moretti F. Coronavirus Disease 2019 (COVID-19) and Pregnancy: Combating Isolation to Improve Outcomes. Obstet Gynecol. 2020;136(1):33–6.

39. Ali NA, Feroz A. Maternal mental health amidst the COVID-19 pandemic. Asian J Psychiatry. 2020;

40. Davenport MH, Meyer S, Meah VL, Strynadka MC, Khurana R. Moms are not ok: COVID-19 and maternal mental health. Front Glob Womens Health. 2020;1:1.

41. Wu Y, Zhang C, Liu H, Duan C, Li C, Fan J, et al. Perinatal depressive and anxiety symptoms of pregnant women along with COVID-19 outbreak in China. Am J Obstet Gynecol. 2020;

42. Kilbourne AM, Beck K, Spaeth-Rublee B, Ramanuj P, O'Brien RW, Tomoyasu N, et al. Measuring and improving the quality of mental health care: a global perspective. World Psychiatry. 2018;17(1):30–8.

43. Smith K, Bhui K, Cipriani A. COVID-19, mental health and ethnic minorities. Evidence-Based Mental Health 2020;23:89-90

44. Marcus SM. Depression during pregnancy: rates, risks and consequences. J Popul Ther Clin Pharmacol. 2009;16(1).

45. Bales M, Pambrun E, Melchior M, Glangeaud-Freudenthal N-C, Charles M-A, Verdoux H, et al. Prenatal psychological distress and access to mental health care in the ELFE cohort. Eur Psychiatry. 2015;30(2):322–8.

46. Da Costa D, Zelkowitz P, Nguyen T-V, Deville-Stoetzel J-B. Mental health help-seeking patterns and perceived barriers for care among nulliparous pregnant women. Arch Womens Ment Health. 2018;21(6):757–64.

47. Byatt N, Xiao RS, Dinh KH, Waring ME. Mental health care use in relation to depressive symptoms among pregnant women in the USA. Arch Womens Ment Health. 2016;19(1):187–91.

48. Smith MV, Shao L, Howell H, Wang H, Poschman K, Yonkers KA. Success of mental health referral among pregnant and postpartum women with psychiatric distress. Gen Hosp Psychiatry. 2009;31(2):155–62.

49. Thapa SB, Mainali A, Schwank SE, Acharya G. Maternal mental health in the time of the COVID-19 pandemic. Acta Obstet Gynecol Scand. 2020;

50. Dennis C, Chung-Lee L. Postpartum depression help-seeking barriers and maternal treatment preferences: A qualitative systematic review. Birth. 2006;33(4):323–31.

51. Weinreb L, Byatt N, Simas TAM, Tenner K, Savageau JA. What happens to mental health treatment during pregnancy? Women's experience with prescribing providers. Psychiatr Q. 2014;85(3):349–55.

52. O'Mahen HA, Henshaw E, Jones JM, Flynn HA. Stigma and depression during pregnancy: does race matter? J Nerv Ment Dis. 2011;199(4):257–62.

53. Moore D, Ayers S, Drey N. A thematic analysis of stigma and disclosure for perinatal depression on an online forum. JMIR Ment Health. 2016;3(2):e18.

54. Sacks R, Greene J, Burke R, Owen E. Mental Health Care Among Low-Income Pregnant Women with Depressive Symptoms: Facilitators and Barriers to Care Access and the Effectiveness of Financial Incentives for Increasing Care. Adm Policy Ment Health Ment Health Serv Res. 2015;42(4):484–92.

55. Hermann A, Fitelson EM, Bergink V. Meeting maternal mental health Needs during the COVID-19 pandemic. JAMA Psychiatry. 2020;

56. Caparros-Gonzalez RA, Alderdice F. The COVID-19 pandemic and perinatal mental health. J Reprod Infant Psychol. 2020;38(3):223–5.

57. Hansotte E, Payne SI, Babich SM. Positive postpartum depression screening practices and subsequent mental health treatment for low-income women in Western countries: a systematic literature review. Public Health Rev. 2017;38(1):3.

58. Clarke K, King M, Prost A. Psychosocial interventions for perinatal common mental disorders delivered by providers who are not mental health specialists in low-and middle-income countries: a systematic review and meta-analysis. PLoS Med. 2013;10(10):e1001541.

59. Norris S, Norris ML, Sibbald E, Aubry T, Harrison ME, Lafontaine G, et al. Demographic characteristics associated with pregnant and postpartum youth referred for mental health services in a community outreach center. J Can Acad Child Adolesc Psychiatry. 2016;25(3):152.

60. Goldberg A. It matters how we define health care equity. Comment Wash DC Inst Med. 2012;

61. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. J Epidemiol Community Health. 2013;67(2):190–3.

62. O'Neill J, Tabish H, Welch V, Petticrew M, Pottie K, Clarke M, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. J Clin Epidemiol. 2014;67(1):56–64.

63. Saad A, Magwood O, Alkhateeb Q, Hashmi SS, Kassam A, Pottie K. Mobile technology assisted interventions targeting mental health among pregnant and post-partum women: A protocol for an equity focused systematic review. Cochrane Equity [Internet]. 2020 [cited 2021 Apr 1]; Available from: https://methods.cochrane.org/equity/projects/global-mental-health

64. Aitken Z, Hewitt B, Keogh L, LaMontagne AD, Bentley R, Kavanagh AM. Young maternal age at first birth and mental health later in life: Does the association vary by birth cohort? Soc Sci Med. 2016;157:9–17.

65. Joshi D, Shrestha S, Shrestha N. Understanding the antepartum depressive symptoms and its risk factors among the pregnant women visiting public health facilities of Nepal. PloS One. 2019;14(4):e0214992.

66. Roomruangwong C, Epperson CN. Perinatal depression in Asian women: prevalence, associated factors, and cultural aspects. Asian Biomed. 2011;5(2):179–93.

67. Schmied V, Johnson M, Naidoo N, Austin M-P, Matthey S, Kemp L, et al. Maternal mental health in Australia and New Zealand: a review of longitudinal studies. Women Birth. 2013;26(3):167–78.

68. Heaman MI, Martens PJ, Brownell MD, Chartier MJ, Thiessen KR, Derksen SA, et al. Inequities in utilization of prenatal care: a population-based study in the Canadian province of Manitoba. BMC Pregnancy Childbirth. 2018;18(1):430.

69. Huybrechts KF, Palmsten K, Mogun H, Kowal M, Avorn J, Setoguchi-Iwata S, et al. National trends in antidepressant medication treatment among publicly insured pregnant women. Gen Hosp Psychiatry. 2013;35(3):265–71.

70. Kornfield SL, Kang-Yi CD, Mandell DS, Epperson CN. Predictors and Patterns of Psychiatric Treatment Dropout During Pregnancy Among Low-Income Women. Matern Child Health J. 2018;22(2):226–36.

71. Alhusen JL, Ayres L, DePriest K. Effects of maternal mental health on engagement in favorable health practices during pregnancy. Journal of midwifery & women's health. 2016 Mar;61(2):210-6.

72. Nagandla K, Sivalingam N, Bhardwaj A, Loh K. Screening for Depression, Anxiety and Stress in Pregnancy–Ignorance is not Bliss: A Study of the Prevalence and Associated Factors of Common Mental Disorders (CMD) in Pregnancy at Seremban, Malaysia: FC 9.12. J Obstet Gynaecol Res. 2015;41:52–3.

73. Yang S, Kestens Y, Dahhou M, Daniel M, Kramer MS. Neighborhood deprivation and maternal psychological distress during pregnancy: a multilevel analysis. Matern Child Health J. 2015;19(5):1142–51.

74. Molenaar NM, Lambregtse-van den Berg MP, Bonsel GJ. Dispensing patterns of selective serotonin reuptake inhibitors before, during and after pregnancy: a 16-year population-based cohort study from the Netherlands. Arch Womens Ment Health. 2020;23(1):71–9.

75. Barker LC, Kurdyak P, Fung K, Matheson FI, Vigod S. Postpartum psychiatric emergency visits: a nested case-control study. Arch Womens Ment Health. 2016;19(6):1019–27.

76. Kimura LJ, McGee A, Baird S, Viloria J, Nagatsuka M. Healthy Mothers Healthy Babies: awareness and perceptions of existing breastfeeding and postpartum

depression support among parents and perinatal health care providers in Hawai'i. Hawaii J Med Public Health. 2015;74(3).

77. Liu CH, Tronick E. Do patient characteristics, prenatal care setting, and method of payment matter when it comes to provider-patient conversations on perinatal mood? Matern Child Health J. 2012;16(5):1102–12.

78. O'Mahony JM. Immigrant and refugee women's voices: exploring postpartum depression help seeking experiences and access to mental health care. 2011;

79. Edge D, Baker D, Rogers A. Perinatal depression among black Caribbean women. Health Soc Care Community. 2004;12(5):430–8.

80. Preis H, Mahaffey B, Heiselman C, Lobel M. Vulnerability and resilience to pandemic-related stress among US women pregnant at the start of the COVID-19 pandemic. Soc Sci Med. 2020;266:113348.

81. de Jesus Silva MM, Peres Rocha Carvalho Leite E, Alves Nogueira D, Clapis MJ. Depression in pregnancy. Prevalence and associated factors. Investig Educ En Enferm. 2016;34(2):342–50.

82. Kaiyo-Utete M, Dambi J, Chingono A, Mazhandu F, Madziro-Ruwizhu T, Henderson C, et al. Antenatal depression: an examination of prevalence and its associated factors among pregnant women attending Harare polyclinics. BMC Pregnancy Childbirth. 2020;20:1–8.

83. Barse K. Intimate Partner Violence and Depression Experienced by African American Women in Primary Care: Rates and Relationships during the Perinatal Period. Wheaton College; 2018.

84. Roth AM. Intimate Partner Violence and Depression in the Latino Community: Rates and Patterns During Pregnancy and the Postpartum Periods. Wheaton College; 2015.

85. Woolhouse H, Gartland D, Papadopoullos S, Mensah F, Hegarty K, Giallo R, et al. Psychotropic medication use and intimate partner violence at 4 years postpartum: Results from an Australian pregnancy cohort study. J Affect Disord. 2019;251:71–7.

86. Kim H, Mandell M, Crandall C, Kuskowski M, Dieperink B, Buchberger R. Antenatal psychiatric illness and adequacy of prenatal care in an ethnically diverse inner-city obstetric population. Arch Womens Ment Health. 2006;9(2):103–7.

87. Adler PS, Kwon S-W. Social capital: Prospects for a new concept. Acad Manage Rev. 2002;27(1):17–40.

88. Friedman LE, Gelaye B, Sanchez SE, Williams MA. Association of social support and antepartum depression among pregnant women. J Affect Disord. 2020;264:201–5.

89. Kroll-Desrosiers AR, Crawford SL, Simas TAM, Clark MA, Bastian LA, Mattocks KM. Rates and correlates of depression symptoms in a sample of pregnant veterans receiving Veterans Health Administration care. Womens Health Issues. 2019;29(4):333–40.

90. Gan Y, Xiong R, Song J, Xiong X, Yu F, Gao W, et al. The effect of perceived social support during early pregnancy on depressive symptoms at 6 weeks postpartum: a prospective study. BMC Psychiatry. 2019;19(1):232.

91. Welch V, Petticrew M, Tugwell P, Moher D, O'Neill J, Waters E, et al. PRISMA-Equity 2012 extension: reporting guidelines for systematic reviews with a focus on health equity. PLoS Med. 2012;9(10).

92. WHO Commission on Social Determinants of Health, World Health Organization. Closing the gap in a generation: health equity through action on the social determinants of health: Commission on Social Determinants of Health final report. World Health Organization; 2008.

93. Tugwell P, Petticrew M, Kristjansson E, Welch V, Ueffing E, Waters E, et al. Assessing equity in systematic reviews: realising the recommendations of the Commission on Social Determinants of Health. Bmj. 2010;341:c4739.

94. Welch VA, Petkovic J, Jull J, Hartling L, Klassen T, Kristjansson E, et al. Equity and specific populations. Cochrane Handb Syst Rev Interv. 2019;433–49.

95. Eyre HA, Ellsworth W, Fu E, Manji HK, Berk M. Responsible innovation in technology for mental health care. Lancet Psychiatry. 2020;7(9):728–30.

96. Nacinovich M. Defining mHealth. 2011; Taylor & Francis

97. Malvey D, Slovensky DJ. mHealth: transforming healthcare. Springer; 2014.

98. Ye J. The role of health technology and informatics in a global public health emergency: practices and implications from the COVID-19 pandemic. JMIR Med Inform. 2020;8(7):e19866.

99. Martínez-Pérez B, De La Torre-Díez I, López-Coronado M, Herreros-González J. Mobile apps in cardiology. JMIR MHealth UHealth. 2013;1(2):e15.

100. Olson CM. Behavioral nutrition interventions using e-and m-health communication technologies: a narrative review. Annu Rev Nutr. 2016;36:647–64.

101. Klonoff DC. The current status of mHealth for diabetes: will it be the next big thing? J Diabetes Sci Technol. 2013;7(3):749–58.

102. Aljaber T, Gordon N. A guidance and evaluation approach for mHealth education applications. In Springer; 2017. p. 330–40.

103. Marzano L, Bardill A, Fields B, Herd K, Veale D, Grey N, et al. The application of mHealth to mental health: opportunities and challenges. Lancet Psychiatry. 2015;2(10):942–8.

104. Adans-Dester CP, Bamberg S, Bertacchi FP, Caulfield B, Chappie K, Demarchi D, et al. Can mHealth technology help mitigate the effects of the COVID-19 pandemic? IEEE Open J Eng Med Biol. 2020;1:243–8.

105. Sossai P, Uguccioni S, Casagrande S. Telemedicine and the 2019 coronavirus (SARS-CoV-2). Int J Clin Pract. 2020;74(10):e13592.

106. Chan S, Li L, Torous J, Gratzer D, Yellowlees PM. Review of use of asynchronous technologies incorporated in mental health care. Curr Psychiatry Rep. 2018;20(10):85.

107. Donker T, Petrie K, Proudfoot J, Clarke J, Birch M-R, Christensen H. Smartphones for smarter delivery of mental health programs: a systematic review. J Med Internet Res. 2013;15(11):e247.

108. NIMH » Technology and the Future of Mental Health Treatment [Internet]. [cited 2020 Jun 12]. Available from: https://www.nimh.nih.gov/health/topics/technology-and-the-future-of-mental-health-treatment/index.shtml

109. Fortuna KL, Venegas M, Umucu E, Mois G, Walker R, Brooks JM. The Future of Peer Support in Digital Psychiatry: Promise, Progress, and Opportunities. Curr Treat Options Psychiatry. 2019;6(3):221–31.

110. Wang K, Varma DS, Prosperi M. A systematic review of the effectiveness of mobile apps for monitoring and management of mental health symptoms or disorders. J Psychiatr Res. 2018;107:73–8.

111. Lui JH, Marcus DK, Barry CT. Evidence-based apps? A review of mental health mobile applications in a psychotherapy context. Prof Psychol Res Pract. 2017;48(3):199.

112. Mani M, Kavanagh DJ, Hides L, Stoyanov SR. Review and evaluation of mindfulness-based iPhone apps. JMIR MHealth UHealth. 2015;3(3):e82.

113. Zhao J, Freeman B, Li M. Can mobile phone apps influence people's health behavior change? An evidence review. J Med Internet Res. 2016;18(11):e287.

114. Zhou C, Hu H, Wang C, Zhu Z, Feng G, Xue J, et al. The effectiveness of mHealth interventions on postpartum depression: A systematic review and meta-analysis. J Telemed Telecare. 2020;1357633X20917816.

115. Dol J, Richardson B, Murphy GT, Aston M, McMillan D, Campbell-Yeo M. Impact of mobile health interventions during the perinatal period on maternal psychosocial outcomes: a systematic review. JBI Evid Synth. 2020;18(1):30–55.

116. Price M, Yuen EK, Goetter EM, Herbert JD, Forman EM, Acierno R, et al. mHealth: a mechanism to deliver more accessible, more effective mental health care. Clin Psychol Psychother. 2014;21(5):427–36.

117. Hantsoo L, Podcasy J, Sammel M, Epperson CN, Kim DR. Pregnancy and the acceptability of computer-based versus traditional mental health treatments. J Womens Health. 2017;26(10):1106–13.

118. Sprenger M, Mettler T, Osma J. Health professionals' perspective on the promotion of e-mental health apps in the context of maternal depression. Plos One. 2017 Jul 12;12(7):e0180867.

119. Miller E, Polson D. Apps, avatars, and robots: the future of mental healthcare. Issues Ment Health Nurs. 2019;40(3):208–14.

120. Marley J, Farooq S. Mobile telephone apps in mental health practice: uses, opportunities and challenges. BJPsych Bull. 2015;39(6):288–90.

121. Burchert S, Alkneme MS, Bird M, Carswell K, Cuijpers P, Hansen P, et al. User-centered app adaptation of a low-intensity e-mental health intervention for Syrian refugees. Front Psychiatry. 2019;9:663.

122. Grist R, Porter J, Stallard P. Mental health mobile apps for preadolescents and adolescents: a systematic review. J Med Internet Res. 2017;19(5):e176.

123. Hussain-Shamsy N, Shah A, Vigod SN, Zaheer J, Seto E. Mobile Health for Perinatal Depression and Anxiety: Scoping Review. J Med Internet Res. 2020;22(4):e17011.

124. Mehta N, Vats M. Mobile Healthcare: A Transformation and Improvement. CSVTU Int J Biotechnol Bioinforma Biomed. 2020;5(2):34–9.

125. Petticrew M, Whitehead M, Macintyre SJ, Graham H, Egan M. Evidence for public health policy on inequalities: 1: the reality according to policymakers. J Epidemiol Community Health. 2004;58(10):811–6.

126. Vogel JP, Oxman AD, Glenton C, Rosenbaum S, Lewin S, Gülmezoglu AM, et al. Policymakers' and other stakeholders' perceptions of key considerations for health system decisions and the presentation of evidence to inform those considerations: an international survey. Health Res Policy Syst. 2013;11(1):19.

127. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.

128. Séguin L, Potvin L, Denis MS-, Loiselle J. Chronic stressors, social support, and depression during pregnancy. Obstet Gynecol. 1995;85(4):583–9.

129. Byatt N, Xu W, Levin LL, Moore Simas TA. Perinatal depression care pathway for obstetric settings. Int Rev Psychiatry. 2019;31(3):210–28.

130. Torous J, Myrick KJ, Rauseo-Ricupero N, Firth J. Digital mental health and COVID-19: Using technology today to accelerate the curve on access and quality tomorrow. JMIR Ment Health. 2020;7(3):e18848.

131. Berrouiguet S, Baca-García E, Brandt S, Walter M, Courtet P. Fundamentals for future mobile-health (mHealth): a systematic review of mobile phone and web-based text messaging in mental health. J Med Internet Res. 2016;18(6):e135.

132. Osma J, Barrera AZ, Ramphos E. Are Pregnant and Postpartum Women Interested in Health-Related Apps? Implications for the Prevention of Perinatal Depression. Cyberpsychology Behav Soc Netw. 2016 Jun;19(6):412–5.

133. McColl LD, Rideout PE, Parmar TN, Abba-Aji A. Peer support intervention through mobile application: An integrative literature review and future directions. Can Psychol Can. 2014;55(4):250.

134. Karasouli E, Adams A. Assessing the evidence for e-resources for mental health self-management: a systematic literature review. JMIR Ment Health. 2014;1(1):e3.

135. Hind J, Sibbald SL. Smartphone applications for mental health—a rapid review. West Undergrad Res J Health Nat Sci. 2014;5(1).

136. US Department of Health and Human Services. Listing of Clinical Trial Registries. 2015 [cited 2021 Apr 1]; Available from: https://www.hhs.gov/ohrp/international/clinical-trial-registries/index.html

137. Lasserson T, Thomas J, Higgins JP. Chapter 1: Starting a review. In: Cochrane Handbook for Systematic Reviews of Interventions. 2019.

138. Cochrane Effective Practice and Organization of Care (EPOC). What study designs should be included in an EPOC review and what should they be called? [cited 2021 Apr 1]; Available from: https://epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/EPOC%20Study%20Designs%20About.pdf

139. Covidence. Covidence Systematic Review Software [Computer Software]. 2017

140. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas. 1960;20(1):37–46.

141. Landis JR, Koch GG. The measurement of observer agreement for categorical data. biometrics. 1977;159–74.

142. Higgins J, Savović J, Page M, Sterne J. Revised Cochrane risk of bias tool for randomized trials (RoB 2.0). Bristol Univ Bristol. 2016;

143. Sterne JA, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. bmj. 2019;366.

144. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. bmj. 2016;355.

145. Jüni P, Loke Y, Pigott T, Ramsay C, Regidor D, Rothstein H, et al. Risk of bias in non-randomized studies of interventions (ROBINS-I): detailed guidance. 2016;

146. McGuinness LA, Higgins JP. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res Synth Methods. 2020;

147. Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. J Clin Epidemiol. 2011;64(4):383–94.

148. Guyatt GH, Thorlund K, Oxman AD, Walter SD, Patrick D, Furukawa TA, et al. GRADE guidelines: 13. Preparing summary of findings tables and evidence profiles—continuous outcomes. J Clin Epidemiol. 2013;66(2):173–83.

149. Balshem H, Helfand M, Schünemann HJ, Oxman AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. J Clin Epidemiol. 2011;64(4):401–6.

150. Knol MJ, Le Cessie S, Algra A, Vandenbroucke JP, Groenwold RH. Overestimation of risk ratios by odds ratios in trials and cohort studies: alternatives to logistic regression. Cmaj. 2012;184(8):895–9.

151. Higgins JP, Tianjing L, Deeks J. Chapter 6: Choosing effect measures and computing estimates of effect. In: Cochrane Handbook for Systematic Reviews of Interventions. 2019.

152. Ten Have TR, Normand SLT, Marcus SM, Brown CH, Lavori P, Duan N. Intent-to-treat vs. non-intent-to-treat analyses under treatment non-adherence in mental health randomized trials. Psychiatr Ann. 2008;38(12).

153. McKenzie J, Brennan S, Ryan R, Thomson H, Johnston R, Thomas J. Chapter 3: Defining the criteria for including studies and how they will be grouped for the synthesis. In: Cochrane Handbook for Systematic Reviews of Interventions. 2019.

154. Borenstein M, Hedges L, Rothstein H. Meta-analysis: Fixed effect vs. random effects. Meta-Anal Com. 2007;

155. Cochrane Collaboration. Review manager (version 5.3)[computer software]. Cph Den Nord Cochrane Cent Cochrane Collab. 2014;

156. Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. Cochrane handbook for systematic reviews of interventions. John Wiley & Sons; 2019.

157. Popay J, Roberts H, Sowden A, Petticrew M, Arai L, Rodgers M, et al. Guidance on the conduct of narrative synthesis in systematic reviews. Prod ESRC Methods Programme Version. 2006;1:b92.

158. Chan KL, Leung WC, Tiwari A, Or KL, Ip P. Using Smartphone-Based Psychoeducation to Reduce Postnatal Depression Among First-Time Mothers: Randomized Controlled Trial. Jmir Mhealth Uhealth. 2019 May 14;7(5):e12794.

159. Cheng H-Y, Huang T-Y, Chien L-Y, Cheng Y-F, Chen F-J. The effects of a mobile application social support program on postpartum perceived stress and depression. Hu Li Za Zhi. 2016;63(6):52.

160. Chyzzy B. Mobile Phone-Based Peer Support In The Prevention of Postpartum Depression Among Adolescent Mothers: A Pilot Randomized Controlled Trial. J Adolesc Health. 2019;64(2):S8-S.

161. Gong M, Zhang S, Xi C, Luo M, Wang T, Wang Y, et al. Comprehensive intervention during pregnancy based on short message service to prevent or alleviate depression in pregnant women: A quasi-experimental study. Early Interv Psychiatry. 2020;

162. Jareethum R, Titapant V, Tienthai C, Viboonchart S, Chuenwattana P, Chatchainoppakhun J. Satisfaction of healthy pregnant women receiving short message service via mobile phone for prenatal support: A randomized controlled trial. Med J Med Assoc Thail. 2008;91(4):458.

163. Lee JY, Kim HY. Development and validation of a postpartum care mobile application for first-time mothers. Korean J Women Health Nurs. 2017;23(3):210–20.

164. Mauriello LM, Van Marter DF, Umanzor CD, Castle PH, de Aguiar EL. Using mHealth to deliver behavior change interventions within prenatal care at community health centers. Am J Health Promot. 2016;30(7):554–62.

165. Shorey S, Lau Y, Dennis C, Chan YS, Tam WW, Chan YH. A randomized-controlled trial to examine the effectiveness of the 'Home-but not Alone'mobile-health application educational programme on parental outcomes. J Adv Nurs. 2017;73(9):2103–17.

166. Shorey S, Ng YPM, Ng ED, Siew AL, Morelius E, Yoong J, et al. Effectiveness of a Technology-Based Supportive Educational Parenting Program on Parental

Outcomes (Part 1): Randomized Controlled Trial. J Med Internet Res. 2019 Feb 13;21(2):e10816.

167. Tsai Y, Hsu Y, Hou T, Chang C. Effects of a Web-Based Antenatal Care System on Maternal Stress and Self-Efficacy During Pregnancy: A Study in Taiwan. J Midwifery Womens Health. 2018;63(2):205–13.

168. Baumel A, Tinkelman A, Mathur N, Kane JM. Digital Peer-Support Platform (7Cups) as an Adjunct Treatment for Women With Postpartum Depression: Feasibility, Acceptability, and Preliminary Efficacy Study. JMIR MHealth UHealth. 2018;6(2):e38-.

169. Carissoli C, Villani D, Gasparri D, Riva G. Enhancing psychological wellbeing of women approaching the childbirth: a controlled study with a mobile application. Annu Rev Cybertherapy Telemed. 2017 SUM;15:45–50.

170. Constant D, de Tolly K, Harries J, Myer L. Mobile phone messages to provide support to women during the home phase of medical abortion in South Africa: a randomised controlled trial. Contraception. 2014 Sep;90(3):226–33.

171. Dennis-Tiwary TA, Denefrio S, Gelber S. Salutary effects of an attention bias modification mobile application on biobehavioral measures of stress and anxiety during pregnancy. Biol Psychol. 2017;127:148–56.

172. Hantsoo L, Criniti S, Khan A, Moseley M, Kincler N, Faherty LJ, et al. A mobile application for monitoring and management of depressed mood in a vulnerable pregnant population. Psychiatr Serv. 2018;69(1):104–7.

173. Jannati N, Mazhari S, Ahmadian L, Mirzaee M. Effectiveness of an app-based cognitive behavioral therapy program for postpartum depression in primary care: a randomized controlled trial. Int J Med Inf. 2020;104145.

174. Prasad V. Efficacy of an electronic application to moderate symptoms of postpartum depression and improve postpartum well-being: a pilot study. 2018; https://tamucc-ir.tdl.org/handle/1969.6/87012

175. Sawyer A, Kaim A, Le H-N, McDonald D, Mittinty M, Lynch J, et al. The effectiveness of an app-based nurse-moderated program for new mothers with depression and parenting problems (eMums Plus): pragmatic randomized controlled trial. J Med Internet Res. 2019;21(6):e13689.

176. Atkinson P, Coffey A, Delamont S. A debate about our canon. Qual Res. 2001;1(1):5–21.

177. Malagon-Maldonado G. Qualitative research in health design. HERD Health Environ Res Des J. 2014;7(4):120–34.

178. Misra J, Curington CV, Green VM. Methods of intersectional research. Sociol Spectr. 2020;1–20.

179. Pawson R. Realistic evaluation. London ; Sage; 1997.

180. Riecher-Rössler A, Steiner M. Perinatal stress, mood and anxiety disorders: from bench to bedside. Vol. 173. Karger Medical and Scientific Publishers; 2005.

181. World Health Organization. Prevention of mental disorders: Effective interventions and policy options: Summary report. World Health Organization; 2004.

182. Nahum-Shani I, Smith SN, Spring BJ, Collins LM, Witkiewitz K, Tewari A, et al. Just-in-time adaptive interventions (JITAIs) in mobile health: key components and design principles for ongoing health behavior support. Ann Behav Med. 2018;52(6):446–62.

183. Smyth JM, Heron KE. Is providing mobile interventions" just-in-time" helpful? An experimental proof of concept study of just-in-time intervention for stress management. In IEEE; 2016. p. 1–7.

184. Byatt N, Biebel K, Debordes-Jackson G, Lundquist RS, Simas TAM, Weinreb L, et al. Community mental health provider reluctance to provide pharmacotherapy may be a barrier to addressing perinatal depression: a preliminary study. Psychiatr Q. 2013;84(2):169–74.

185. Doherty K, Marcano-Belisario J, Cohn M, Mastellos N, Morrison C, Car J, et al. Engagement with mental health screening on mobile devices: Results from an antenatal feasibility study. In 2019. p. 1–15.

186. Concannon TW, Grant S, Welch V, Petkovic J, Selby J, Crowe S, et al. Practical guidance for involving stakeholders in health research. J Gen Intern Med. 2019;34(3):458–63.

187. Forsythe LP, Ellis LE, Edmundson L, Sabharwal R, Rein A, Konopka K, et al. Patient and stakeholder engagement in the PCORI pilot projects: description and lessons learned. J Gen Intern Med. 2016;31(1):13–21.

188. Siegel RS, Brandon AR. Adolescents, pregnancy, and mental health. J Pediatr Adolesc Gynecol. 2014;27(3):138–50.

189. Corcoran J. Teenage pregnancy and mental health. Societies. 2016;6(3):21.

190. Earle AM, LaBrie JW, Boyle SC, Smith D. In pursuit of a self-sustaining college alcohol intervention: Deploying gamified PNF in the real world. Addict Behav. 2018;80:71–81.

191. Flett JA, Conner TS, Riordan BC, Patterson T, Hayne H. App-based mindfulness meditation for psychological distress and adjustment to college in incoming

university students: a pragmatic, randomised, waitlist-controlled trial. Psychol Health. 2020;1–26.

192. Hammonds T, Rickert K, Goldstein C, Gathright E, Gilmore S, Derflinger B, et al. Adherence to antidepressant medications: a randomized controlled trial of medication reminding in college students. J Am Coll Health. 2015;63(3):204–8.

193. Voorberg WH, Bekkers VJ, Tummers LG. A systematic review of co-creation and co-production: Embarking on the social innovation journey. Public Manag Rev. 2015;17(9):1333–57.

194. Webster P. Virtual health care in the era of COVID-19. The Lancet. 2020; 395 (10231):1180–1.

195. The Canadian Medical Association. New report: a roadmap to improve virtual care in Canada. 2020 [cited 2021 Jan 4]; Available from: https://www.cma.ca/new-report-roadmap-improve-virtual-care-canada

196. Canadian Medical Association. Guiding principles for physicians recommending mobile health applications to patients. 2015 [cited 2021 Jan 4]; Available from: https://policybase.cma.ca/en/permalink/policy11521#_ga=2.31949246.1204815991.1609437631-298172416.1609437631

197. American Psychiatric Association. App Advisor. [cited 2021 Jan 4]; Available from: https://www.psychiatry.org/psychiatrists/practice/mental-health-apps

198. Byambasuren O, Beller E, Hoffmann T, Glasziou P. mHealth App Prescription in Australian General Practice: Pre-Post Study. JMIR MHealth UHealth. 2020;8(6):e16497.

199. National Health Service. Mental Health Apps. [cited 2021 Jan 4]; Available from: https://www.nhs.uk/apps-library/category/mental-health/

200. Norwegian Centre for E-health Research. Digital Services for my Mental Health. 2016 [cited 2021 Jan 4]; Available from: https://ehealthresearch.no/en/fact-sheets/digital-services-for-my-mental-health

201. Smiling Mind. Mind the Bump. [cited 2021 Jan 4]; Available from: https://www.mindthebump.org.au/

202. Mum Space. MindMum. [cited 2021 Jan 4]; Available from: https://www.mumspace.com.au/when-you-need-extra-help/

203. Best Beginnings. Baby Buddy. [cited 2021 Jan 4]; Available from: https://web.bestbeginnings.org.uk/web/lets-get-started

204. VCU Health. Mamma Mia: Pregnant women and depression: New app may help. 2020 [cited 2021 Jan 4]; Available from:

https://www.vcuhealth.org/news/pregnant-women-and-depression-new-app-may-help

205. WCHRI. Mental Health App Offers Hope For Pregnant Women In Alberta. [cited 2021 Jan 4]; Available from: https://www.wchri.org/Spring2019Newsletter-Hope

206. Gowthaman N. iMumz: this mobile app is helping pregnant women with health advice during the coronavirus lockdown. 2020 [cited 2021 Jan 4]; Available from: https://yourstory.com/herstory/2020/03/mobile-app-pregnant-women-health-coronavirus-lockdown

207. Bealing J. Teen pregnancy: Tailoring a pregnancy app to the needs of pregnant adolescents. 2019; The University of Waikato, Hamilton, New Zealand. Retrieved from https://hdl.handle.net/10289/12932

208. Li Y, Zhao Q, Cross WM, Chen J, Qin C, Sun M. Assessing the quality of mobile applications targeting postpartum depression in China. Int J Ment Health Nurs. 2020;

209. Healthcare Technology. Canada invests in virtual care, mental health tools. 2020 [cited 2021 Jan 4]; Available from: https://www.canhealth.com/2020/05/06/canada-invests-in-virtual-care-mental-health-tools/

210. Alonso-Coello P, Schünemann HJ, Moberg J, Brignardello-Petersen R, Akl EA, Davoli M, et al. GRADE Evidence to Decision (EtD) frameworks: a systematic and transparent approach to making well informed healthcare choices. 1: Introduction. bmj. 2016;353:i2016.

211. Graham S, Depp C, Lee EE, Nebeker C, Tu X, Kim H-C, et al. Artificial intelligence for mental health and mental illnesses: an overview. Curr Psychiatry Rep. 2019;21(11):116.

212. Straus S, Tetroe J, Graham ID. Knowledge translation in health care: moving from evidence to practice. John Wiley & Sons; 2013.

213. Canadian Institute of Health Research. Guide to Knowledge Translation Planning at CIHR: Integrated and End-of-Grant Approaches. [cited 2021 Jan 21]; Available from: https://cihr-irsc.gc.ca/e/45321.html

214. Nguyen T, Graham ID, Mrklas KJ, Bowen S, Cargo M, Estabrooks CA, et al. How does integrated knowledge translation (IKT) compare to other collaborative research approaches to generating and translating knowledge? Learning from experts in the field. Health Res Policy Syst. 2020;18:1–20.

215. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. [cited 2021 Jan 21]; Available from:

https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

216. LaRocca R, Yost J, Dobbins M, Ciliska D, Butt M. The effectiveness of knowledge translation strategies used in public health: a systematic review. BMC Public Health. 2012;12(1):1–15.

217. Viswanathan M, Ammerman A, Eng E, Garlehner G, Lohr KN, Griffith D, et al. Community-based participatory research: Assessing the evidence: Summary. AHRQ Evid Rep Summ. 2004;

218. Bjørn P, Menendez-Blanco M. FemTech: Broadening Participation to Digital Technology Development. In 2019. p. 510–1.

219. Concannon TW, Meissner P, Grunbaum JA, McElwee N, Guise J-M, Santa J, et al. A new taxonomy for stakeholder engagement in patient-centered outcomes research. J Gen Intern Med. 2012;27(8):985–91.

220. Shiffman RN, Michel G, Essaihi A, Thornquist E. Bridging the guideline implementation gap: a systematic, document-centered approach to guideline implementation. J Am Med Inform Assoc. 2004;11(5):418–26.

Appendices

Appendix I. Search Strategies and Grey Literature Search Results

MEDLINE via OVID
exp pregnancy/ or pregnant women/
exp prenatal care/ or exp perinatal care/ or exp postnatal care/ or exp postpartum period/
(pregnan* or prenatal or pre-natal or perinatal or peri-natal or postnatal or post-natal or postpartum or post-partum or ((perinatal or prenatal or postpartum or postnatal) adj2 care*) or ((peri-natal or pre-natal or post-partum or post-natal) adj2 care*)).ti,ab,kf.
1 or 2 or 3
mental health/ or exp mental disorders/ or depression/ or anxiety/ or stress disorder, post-traumatic/ or stress, psychological/ or psychological distress/
(mental health* or wellbeing or well-being or (mental adj2 health*) or psychology or psychiatry or psych* or stress* or depress* or anxiet* or anxi* or anxious* or posttrauma* or post-trauma* or trauma or PTSD).ti,ab,kf.
5 or 6
smartphone/ or exp cell phones/ or exp computers, handheld/ or mobile application/ or wireless technology/ or text messaging/
(mhealth* or m-health*).ti,ab,kf.
(((mobile or cell* or portable) adj2 phone*) or cellphone* or cell-phone* or smartphone* or smart-phone*).ti,ab,kf.
((mobile adj2 application*) or (phone adj2 application*) or app or apps).ti,ab,kf.
((mobile adj2 health) or (mobile adj2 tech*)).ti,ab,kf.
(text* or sms or (text* adj2 messag*) or (sms adj2 messag*)).ti,ab,kf.
8 or 9 or 10 or 11 or 12 or 13
4 and 7 and 14

Grey literature search outputs

Table 1: Search strategy for OpenGrey

Terms used	Records captured	Records screened
pregnan* AND psych*	232	232
post-partum AND psych*	70	70
postpartum AND psych*	41	41
postnatal AND psych*	87	87

pregnan* AND mobile	4	4
post-partum AND mobile	4	4
postpartum AND mobile	0	0
postnatal AND mobile	0	0
pregnan* AND mental	22	22
post-partum AND mental	2	2
postpartum AND mental	1	1
postnatal AND mental	15	15
pregnan* AND digital	6	6
postpartum AND digital	0	0
post-partum AND digital	0	0
postnatal AND digital	0	0
TOTAL	484	484

Table 2: Non-governmental websites search results

Website	**Publications relevant to our review scope?**
WHO Maternal Health https://www.who.int/data/maternal-newborn-child-adolescent-ageing	No
International Atomic Energy Agency https://www.iaea.org/resources/rpop/health-professionals/radiology/pregnant-women	No
Publication: The Importance of a Life Course Approach to Health: Chronic Disease Risk from Preconception through Adolescence and Adulthood https://www.who.int/life-course/publications/life-course-approach-to-health.pdf	No
mHealth New horizons for health through mobile technologies https://www.who.int/goe/publications/goe_mhealth_web.pdf	No
Evidence of accessing antenatal care information via social media platforms supports mental wellbeing in COVID-19 epidemic https://www.who.int/bulletin/online_first/20-255489.pdf	No
United Nations: Crimes against humanity https://www.un.org/en/genocideprevention/crimes-against-humanity.shtml	No
Africa Wired: Portable ultrasound device to tackle child mortality https://www.un.org/africarenewal/magazine/december-2016-march-2017/africa-wired-portable-ultrasound-device-tackle-child-mortality	No

Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations https://www.who.int/bulletin/volumes/88/12/09-071852/en/	No
United Nations: War crimes https://www.un.org/en/genocideprevention/war-crimes.shtml	No
WHO: Urban green spaces and health https://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1	No
One stillbirth occurs every 16 seconds, according to first ever joint UN estimates https://www.who.int/news/item/08-10-2020-one-stillbirth-occurs-every-16-seconds-according-to-first-ever-joint-un-estimates	No
WHO: Telemedicine: Opportunities and developments in member states https://www.who.int/goe/publications/goe_telemedicine_2010.pdf	No
United Nations: Policy Brief: The Impact of COVID-19 on Women https://www.un.org/sexualviolenceinconflict/wp-content/uploads/2020/06/report/policy-brief-the-impact-of-covid-19-on-women/policy-brief-the-impact-of-covid-19-on-women-en-1.pdf	No
UNESCO: Digital inclusion for low-skilled and low-literate people: a landscape review https://unesdoc.unesco.org/ark:/48223/pf0000261791	No
UNESCO: Mapping of online articles on Covid-19 and Gender https://en.unesco.org/news/mapping-online-articles-covid-19-and-gender	No
WHO: Mental health promotion and mental health care in refugees and migrants Technical guidance https://www.euro.who.int/__data/assets/pdf_file/0004/386563/mental-health-eng.pdf?ua=1	No
United Nations: Realizing the Sustainable Development Goals by, for and with persons with disabilities https://www.un.org/development/desa/disabilities/wp-content/uploads/sites/15/2019/07/disability-report-chapter2.pdf	No
UNESCO strategy on education for health and well-being: contributing to the Sustainable Development Goals https://unesdoc.unesco.org/ark:/48223/pf0000246453	No
WHO: Child marriages: 39 000 every day https://www.who.int/mediacentre/news/releases/2013/child_marriage_20130307/en/	No
UNHCR: Human Rights Standards and Practice for the Police https://www.ohchr.org/documents/publications/training5add3en.pdf	No
Results were deemed irrelevant for the scope of our review at the 20-website level. Search terminated.	

Table 3: Intergovernmental organizations websites search results

Website	Publications relevant to our review scope?
mHealth Alliance: mHealth and MNCH: State of the Evidence https://www.gfmer.ch/mhealth/coursefiles2013/mhealthmnch-evidence-final.pdf	No
Geneva Foundation for Medical Education and Research: Sexual and Reproductive mHealth Better Access to Health Care through Mobile phones https://www.gfmer.ch/mhealth/pdf/Sexual-Reproductive-mHealth-Nurmi-2013.pdf	No
OCHA: Adolescent Girls Fact Sheet https://m.reliefweb.int/report/1294976/world/adolescent-girls-fact-sheet?lang=ru	No
World Bank: Gender Dimensions of the COVID-19 Pandemic https://openknowledge.worldbank.org/bitstream/handle/10986/33622/Gender-Dimensions-of-the-COVID-19-Pandemic.pdf	No
United Nations: Policy Brief: The Impact of COVID-19 on Women https://reliefweb.int/sites/reliefweb.int/files/resources/policy-brief-the-impact-of-covid-19-on-women-en.pdf	No
USAID: Delivering sexual and reproductive health services to young people https://www.msichoices.org/media/2117/delivering-sexual-and-reproductive-health-services-to-young-people.pdf	No
OCHA: South Asia: Reproductive health care being restored in Tsunami-hit areas https://reliefweb.int/report/indonesia/south-asia-reproductive-health-care-being-restored-tsunami-hit-areas	No
The PATH Organization: Life Planning Skills: A curriculum for young people in africa Uganda version https://path.azureedge.net/media/documents/HIV-TB_aya_lps_facilitator_ugan_sec3.pdf	No
Kenya Human Rights Commission: Teenage Pregnancy and Unsafe Abortion The Case of Korogocho Slums https://www.khrc.or.ke/mobile-publications/equality-and-anti-discrimination/69-teenage-pregnancy-and-abortion-case-study/file.html	No
IPPF Western Hemisphere region: Guidelines on Sexual and Reproductive Healthcare for Youth https://www.ippfwhr.org/wp-content/uploads/2018/08/Youth_Meeting_-_English_-_NOV__1_.pdf	No
World Bank: Disease Control Priorities, Third Edition (Volume 4) https://openknowledge.worldbank.org/bitstream/handle/10986/23832/9781464804267.pdf;sequence=3	No
Food Research and Action Centre: Making WIC Work Better: Strategies to Reach More Women and Children and Strengthen Benefits Use https://frac.org/wp-content/uploads/Making-WIC-Work-Better-Full-Report.pdf	No
Population council: Unintended Pregnancy and Abortion in India: Country Profile Report	No

https://www.popcouncil.org/uploads/pdfs/2014STEPUP_IndiaCountryProfile.pdf	
Human Rights Watch: Barriers to HIV Services and Treatment for Persons with Disabilities in Zambia https://www.hrw.org/reports/zambia0714_ForUpload_1.pdf	No
Evidence Consortium on Women's Group: The Impact of COVID-19 on Opportunities for Adolescent Girls and the Role of Girls' Groups https://www.popcouncil.org/uploads/pdfs/2020PGY_ECWG-AdolescentGirlsCOVID.pdf	No
IDRC: Feminist advocacy, family lawand violence against women https://www.idrc.ca/sites/default/files/sp/Images/IDRC%20Books/idl-57272.pdf	No
Food Research and Action Centre: Addressing Food Insecurity: A Toolkit for Pediatricians https://frac.org/wp-content/uploads/frac-aap-toolkit.pdf	No
OCHA: South Asia: Tsunami & Health Situation Report # 34 https://m.reliefweb.int/report/411552?lang=ru	No
The 10th International Congress on Adolescent Health: Theme: Bridging clinical and public health perspectives to promote adolescent health https://iaah.org/wp-content/uploads/2019/05/Posters-Presentations-Symposiums-2013-World-Congress.pdf	No
The 31st Conference of the International Society for Environmental Epidemiology: Program and abstracts https://www.iseepi.org/common/Uploaded%20files/PROGRAM-ISEE-A4_FINAL.pdf	No
Results were deemed irrelevant for the scope of our review at the 20-website level. Search terminated.	

Table 4: National and international pregnancy-specific organizations and associations

Website	**Publications relevant to our review scope?**
Pregnancy Care Canada www.pregnancycarecanada.ca	No
American Pregnancy Association www.americanpregnancy.org	No
Pregnancy Centres Network UK https://pregnancycentresnetwork.org.uk/	No
The MoTHERS Program www.themothersprogram.ca	No
Pregnancy Info www.pregnancyinfo.ca	No

Women's Health: Pregnancy www.womenshealth.gov/pregnancy	No
Mother to Baby www.mothertobaby.org	No
Postpartum Support International www.postpartum.net	No
Birth Companions https://www.birthcompanions.org.uk/	No
Beginnings Family Services www.beginnings.ca/	No
Pregnancy help www.pregnancyhelp.ca	No
St. Stephen Community House www.sschto.ca/adults/pregnant-women	No
Guttmacher Institute: United States Pregnancy https://www.guttmacher.org/united-states/pregnancy	No
Ontario Settlement: Pregnancy and Health https://settlement.org/ontario/health/sexual-and-reproductive-health/pregnancy-and-birth/i-am-pregnant-where-can-i-find-services/	No
The British Columbia Association of Pregnancy Outreach Programs https://www.bcapop.ca/	No
Perinatal Services of British Columbia http://www.perinatalservicesbc.ca/	No
Crisis Pregnancy Centre of New York https://www.cpcny.org/	No
Anxiety Canada: Moms to Be https://www.anxietycanada.com/general/moms-to-be/	No
Pacific Postpartum Support Society http://postpartum.org/	No
Maternity Action UK https://maternityaction.org.uk/what-we-do/our-research/	No
Results were deemed irrelevant for the scope of our review at the 20-website level. Search terminated.	

Appendix II. Standardized Data Extraction Form

Study ID	Study citation		
Study design	Specific study design structure		
Background, rationale, and context (Any epidemiological, statistical, contextual, or equity-related information used by investigators to introduce the topic) (**E)**			Study objectives and aims as described by the investigators
Study location (city, country)	Study setting (in which participants were recruited or the intervention delivered)		
Target population as described by investigators	Pregnancy period (antenatal, perinatal, postpartum)	Pregnancy age (in weeks or trimesters)	Is the population being selected based on a PROGRESS+ criteria? (**E)**
Eligibility criteria	Recruitment procedures	Recruitment period	Sample size at allocation (Total and per study arm)
Name of the intervention	Focus/ purpose of the intervention	Is the intervention using mobile technology as the primary method of delivery? (Yes/ No)	
Nature of the intervention (Smartphone application, text messaging program, combination, other)		Design of the intervention (information, knowledge, therapy technique, or support provided)	Delivery of the intervention (length, dosage, and by whom)

Description of the comparison/ control treatment		
Time of data collection	Nature of baseline data collection	Nature of follow-up data collection (Face-to-face interviews, online questionnaires, etc.)
Demographic data analysis procedures		Outcome measurement data analysis procedures
Were the results analyzed/stratified based on a PROGRESS+ criteria? (**E)**		
Significance level set by investigators		Analysis principle (Intent-to-treat, per-protocol, unidentified)
Sample size at follow up (Total and per study arm)	Baseline demographics as described by investigators	Equity-related (PROGRESS+) baseline demographics (**E)**
Outcome domain #1	Outcome measurement tool #1	Summary of result #1
Outcome domain #2	Outcome measurement tool #2	Summary of result #2
Outcome domain #3	Outcome measurement tool #3	Summary of result #3

Outcome domain #4	Outcome measurement tool #4	Summary of result #4	
Equity-related findings as described by investigators **(E)**			
Study conclusions	Study limitations	Funding	Conflicts of interest

(E) Equity was considered when extracting data at this level

Appendix III. Visual Representation of Critical Appraisal Assessments - By Outcome (146)

1. Visual representations of critically appraising results on the severity of depression symptoms

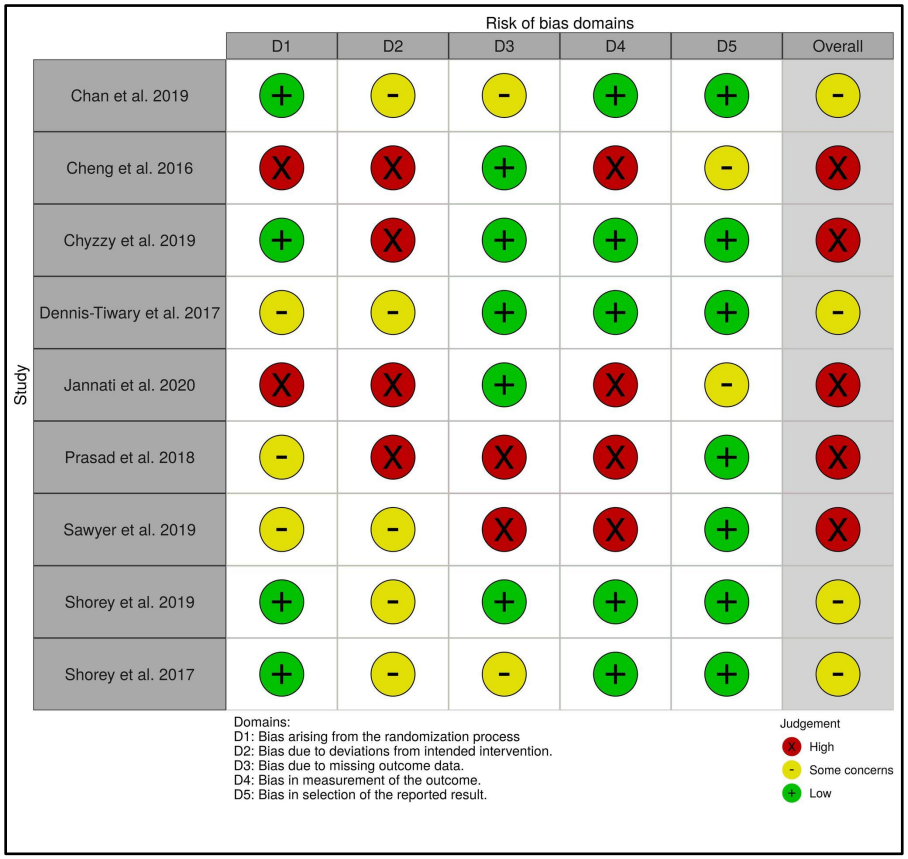

Figure 1: Risk of bias assessments on the severity of depression symptoms from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - study level

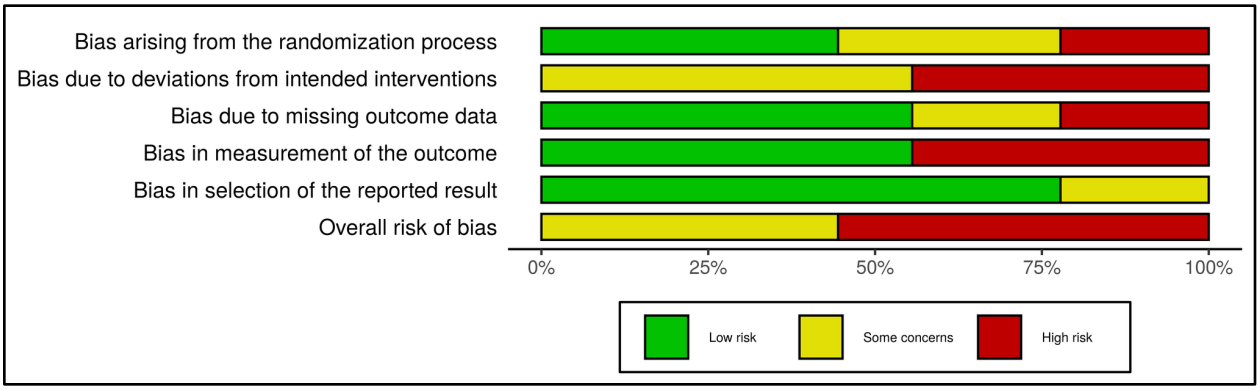

Figure 2: Risk of bias assessments on the severity of depression symptoms from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - across studies

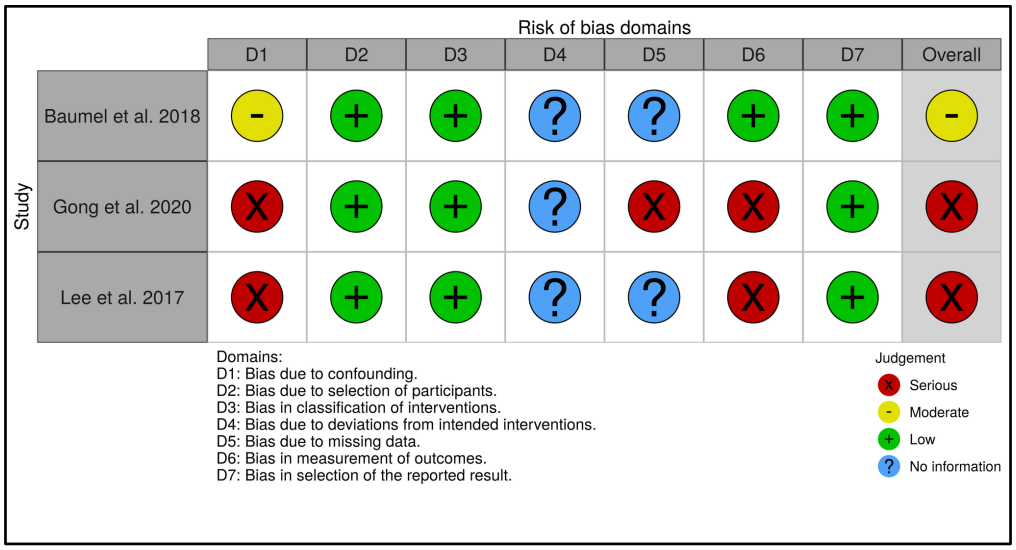

Figure 3: Risk of bias assessments on the severity of depression symptoms from non-randomised controlled studies using the Cochrane *Risk of Bias In Non-randomised Studies of Interventions* Tool (ROBINS-I) - study level

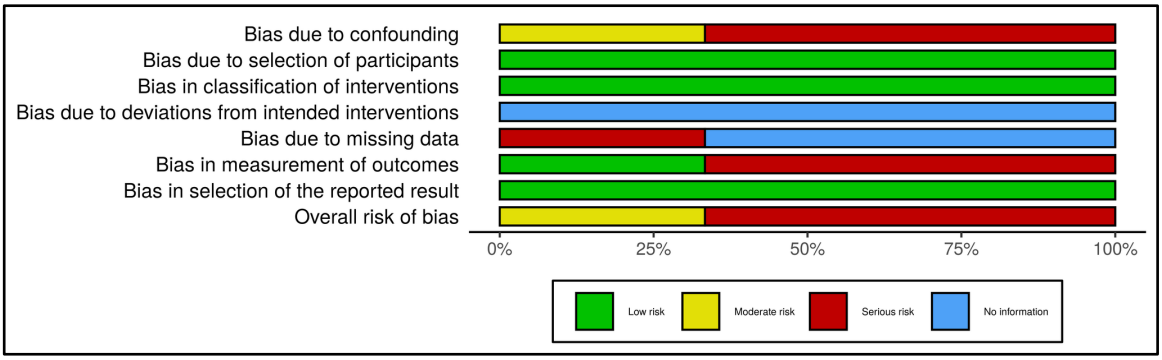

Figure 4: Risk of bias assessments on the severity of depression symptoms from non-randomised controlled studies using the Cochrane *Risk of Bias In Non-randomised Studies of Interventions* Tool (ROBINS-I) - across studies

2. Visual representations of critically appraising results on the severity of anxiety symptoms

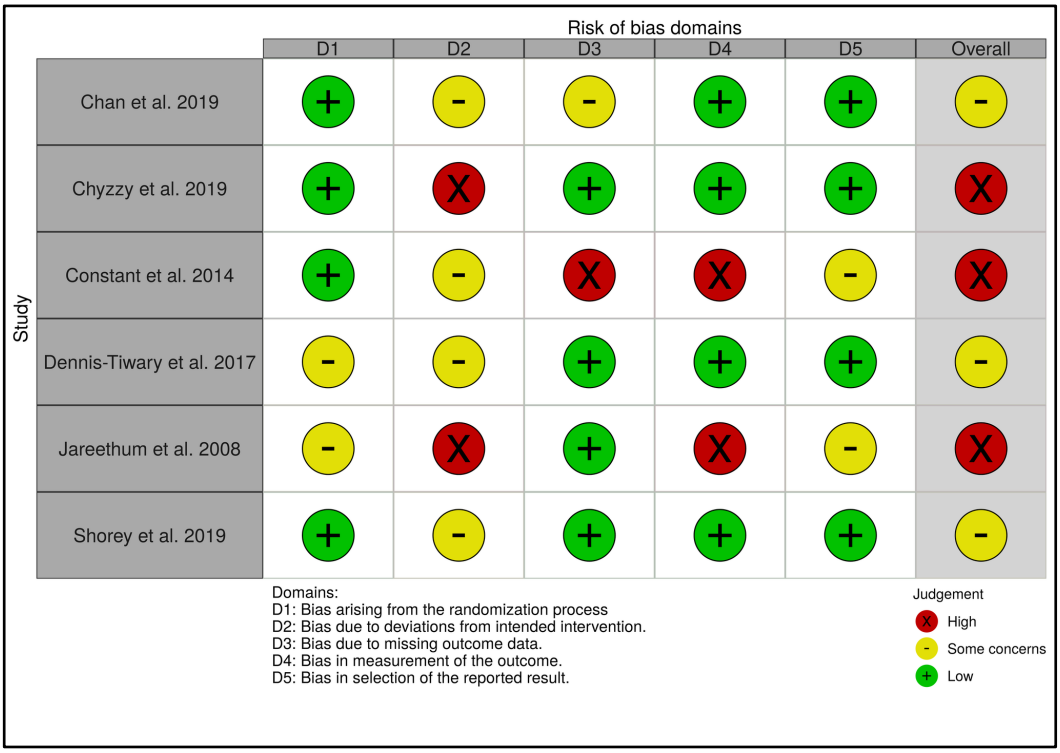

Figure 5: Risk of bias assessments on the severity of anxiety symptoms from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - study level

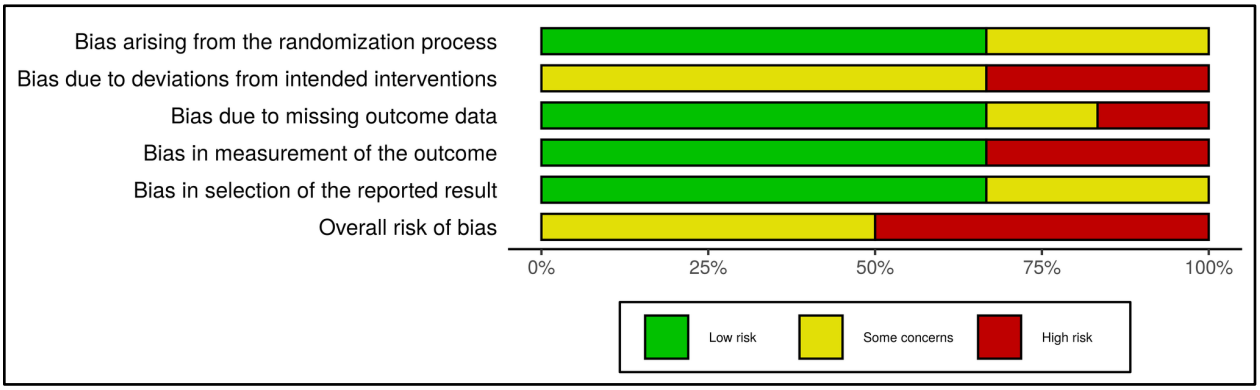

Figure 6: Risk of bias assessments on the severity of anxiety symptoms from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - across studies

Note: No results from non-randomised controlled studies were found on the severity of anxiety symptoms

3. Visual representations of critically appraising results on the psychological wellbeing and distress

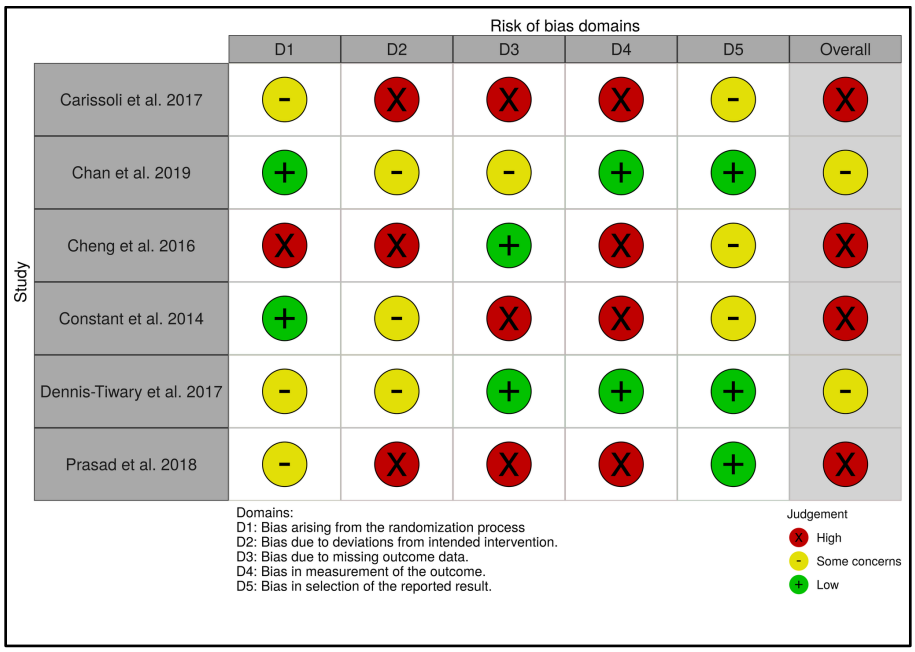

Figure 7: Risk of bias assessments on psychological stress from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - study level

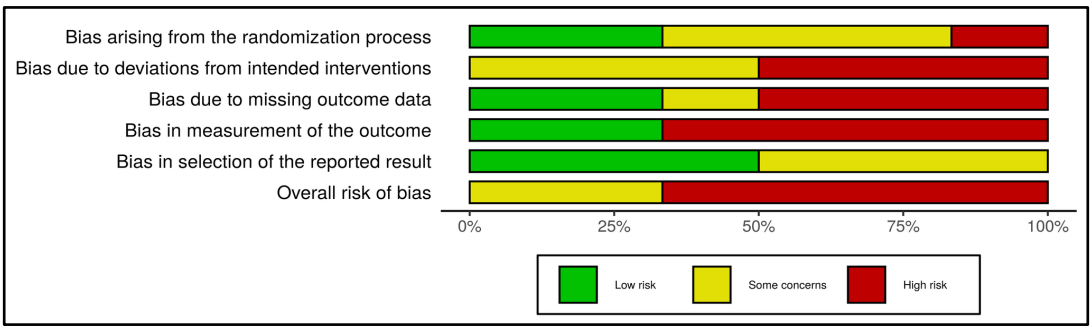

Figure 8: Risk of bias assessments on psychological stress from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - across studies

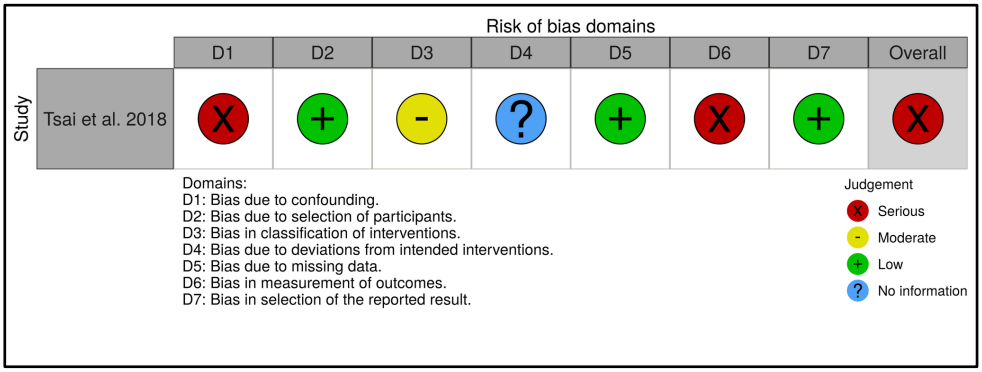

Figure 9: Risk of bias assessments on psychological stress from non-randomised controlled studies using the Cochrane *Risk of Bias In Non-randomised Studies of Interventions* Tool (ROBINS-I) - study level

4. Visual representations of critically appraising results on the utilization of pregnancy-related and mental health care and services

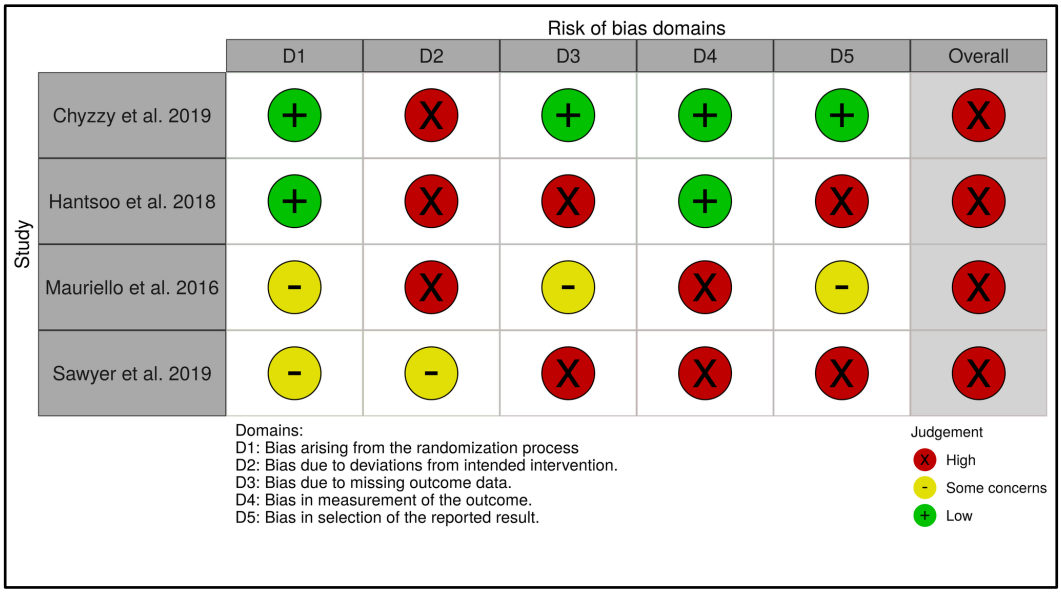

Figure 10: Risk of bias assessments on utilization of pregnancy-related and mental health care and services from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - study level

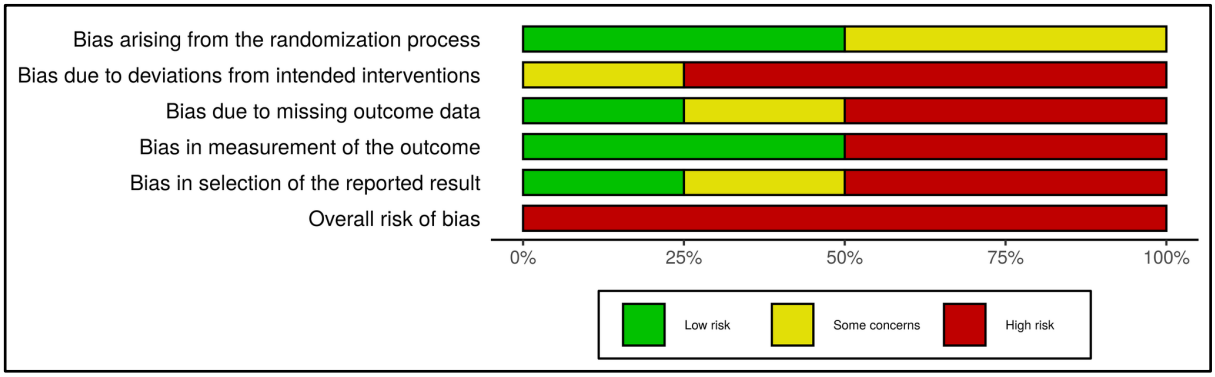

Figure 11: Risk of bias assessments on utilization of pregnancy-related and mental health care and services from randomized controlled trials of interventions using the Cochrane *Risk of Bias 2.0* tool (ROB 2.0) - across studies

Appendix IV. GRADE Evidence Profiles

Table I. GRADE Evidence profiles: Outcomes of mobile interventions targeting the *prevention* of common mental disorders (147)

Certainty assessment							№ of patients		Effect		Certainty	Importance
No.	**Study design**	**ROB**	**Inc.**	**Ind.**	**Imp.**	**Oth.**	**E**	**C**	**Relative (95% CI)**	**Absolute (95% CI)**		
Outcome: Severity of mental health symptoms												
Severity of depression symptoms-short term (Study IDs: Cheng 2016+Chyzzy 2019; Chan 2019; Gong 2020; Lee 2017; Shorey 2019; Shorey 2017) (159+160; 158; 161; 163; 166; 165) [assessed with: Edinburgh Postnatal Depression Scale (EPDS)]												
2	randomised trials	very serious [a,b]	not serious	not serious	serious [c]	none	78	81	-	MD **3.07 lower** (4.68 lower to 1.46 lower)	⊕◯◯◯ VERY LOW	CRITICAL
1	randomised trials	not serious	not serious	not serious	not serious	none	330	330	-	MD **0.65 lower** (1.29 lower to 0)	⊕⊕⊕⊕ HIGH	CRITICAL
1	Non-randomised trials	very serious [d]	not serious	not serious	not serious	none	1481	1855	-	MD **1.3 lower** (1.58 lower to 1.02 lower)	⊕⊕◯◯ LOW	CRITICAL
1	Non-randomised trials	very serious [e]	not serious	not serious	serious [c]	none	26	26	-	MD **2.68 lower** (4.86 lower to 0.5 lower)	⊕◯◯◯ VERY LOW	CRITICAL
1	randomised trials	not serious	not serious	not serious	serious [c]	none	54	57	-	MD **2.11 lower** (4 lower to 0.3 lower)	⊕⊕⊕◯ MODERATE	CRITICAL
1	randomised trials	not serious	not serious	not serious	serious [c]	none	63	62	-	MD **0.69 lower** (1.66 lower to 0.29 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Severity of anxiety symptoms-short term (Study ID: Chan 2019) (158) [assessed with: The Depression, Anxiety, and Stress Scale (DASS)]												
1	randomised trials	not serious	not serious	not serious	serious [f]	none	330	330	-	MD **0.01 higher** (0.3 lower to 0.32 higher)	⊕⊕⊕◯ MODERATE	CRITICAL

Severity of anxiety symptoms-short term (Study ID: Chyzzy 2019; Shorey 2019) (160; 166) [assessed with: The State-Trait Anxiety Inventory (STAI)]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	17	15	-	MD **2 lower** (7.71 lower to 3.71 higher)	⊕⊕◯◯ LOW	CRITICAL
1	randomised trials	not serious	not serious	not serious	serious [c]	none	52	53	-	MD **2.45 lower** (9.9 lower to 5 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Severity of prenatal anxiety-short term (Study ID: Jareethum 2008) (162) [assessed with: Questionnaire]												
1	randomised trials	very serious [g]	not serious	not serious	serious [c]	none	32	29	-	MD **2.15 lower** (3.42 lower to 0.88 lower)	⊕◯◯◯ VERY LOW	CRITICAL
Severity of perinatal anxiety-short term (Study ID: Jareethum 2008) (162) [assessed with: Questionnaire]												
1	randomised trials	very serious [g]	not serious	not serious	serious [c]	none	32	29	-	MD **1.01 lower** (2.28 lower to 0.26 higher)	⊕◯◯◯ VERY LOW	CRITICAL
Outcome: Psychological wellbeing and distress												
Psychological stress-short term (Study ID: Chan 2019) (158) [assessed with: The Depression, Anxiety, and Stress Scale (DASS)]												
1	randomised trials	not serious	not serious	not serious	serious [f]	none	330	330	-	MD **0.07 higher** (0.35 lower to 0.5 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Psychological stress-short term (Study ID: Cheng 2016) (159) [assessed with: The Perceived Stress Scale]												
1	randomised trials	very serious [b]	not serious	not serious	serious [c]	none	61	65	-	MD **3.52 lower** (4.95 lower to 2.09 lower)	⊕◯◯◯ VERY LOW	CRITICAL
Psychological stress-short term (Study ID: Tsai 2018) (167) [assessed with: The 36-item Pregnancy Stress Rating Scale (PSRS-36)]												
1	Non-randomised trials	very serious [h]	not serious	not serious	serious [c]	none	68	67	-	MD **11.12 lower** (17.19 lower to 5.05 lower)	⊕◯◯◯ VERY LOW	CRITICAL
Outcome: Changes in occurrence of mental health disorders												
Odds of depression diagnosis post-intervention-short term (Study ID: Gong 2020) (161) [assessed with: Edinburgh Postnatal Depression Scale (EPDS)>9]												

1	Non-randomised trials	very serious [d]	not serious	not serious	not serious	none	133/1481 (9.0%)	299/1855 (16.1%)	**OR 0.51** (0.41 to 0.64)	**72 fewer per 1,000** (from 88 fewer to 52 fewer)	⊕⊕◯◯ LOW	CRITICAL
Outcome: Utilization of pregnancy-related and mental health care												
Mean number of healthcare visits-short term (Study ID: Chyzzy 2019) (160) [assessed with: Health Services Utilization Questionnaire]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	17	16	-	MD **5.3 higher** (6.97 lower to 17.57 higher)	⊕⊕◯◯ LOW	CRITICAL
Percentage of patients who visited their family physician-short term (Study ID: Chyzzy 2019) (160) [assessed with: Health Service Utilization Questionnaire]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	15/17 (88.2%)	14/16 (87.5%)	**RR 1.01** (0.78 to 1.29)	**9 more per 1,000** (from 192 fewer to 254 more)	⊕⊕◯◯ LOW	CRITICAL
Percentage of patients who visited their obstetrician-short term (Study ID: Chyzzy 2019) (160) [assessed with: Health Service Utilization Questionnaire]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	3/17 (17.6%)	5/16 (31.3%)	**RR 0.56** (0.16 to 1.99)	**137 fewer per 1,000** (from 263 fewer to 309 more)	⊕⊕◯◯ LOW	CRITICAL
Percentage of patients who visited their psychologist-short term (Study ID: Chyzzy 2019) (160) [assessed with: Health Service Utilization Questionnaire]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	0/17 (0.0%)	2/16 (12.5%)	**RR 0.19** (0.01 to 3.66)	**101 fewer per 1,000** (from 124 fewer to 333 more)	⊕⊕◯◯ LOW	CRITICAL
Percentage of patients who visited their psychiatrist-short term (Study ID: Chyzzy 2019) (160) [assessed with: Health Service Utilization Questionnaire]												
1	randomised trials	serious [a]	not serious	not serious	serious [c]	none	1/17 (5.9%)	2/16 (12.5%)	**RR 0.47** (0.05 to 4.70)	**66 fewer per 1,000** (from 119 fewer to 463 more)	⊕⊕◯◯ LOW	CRITICAL
Number of minutes practicing stress management-short term (Study ID: Mauriello 2016) (164) [assessed with: Questionnaire]												
1	randomised trials	very serious [i]	not serious	not serious	serious [c]	none	The mean difference in number of minutes was not significant between groups when adjusting for minutes of stress management at baseline (Intervention N=52 M=45.77 SD 50, Control N=55 M=30.0 SD 29.4; adjusted p=.288)				⊕◯◯◯ VERY LOW	CRITICAL

Number of minutes practicing stress management-medium term (Study ID: Mauriello 2016) (164) [assessed with: Questionnaire]									
1	randomised trials	very serious [i]	not serious	not serious	serious [c]	none	The mean difference in number of minutes was not significant between groups when adjusting for minutes of stress management at baseline (Intervention N=47 M=61.06 SD 54.1, Control N=49 M=52.86 SD 37.3; adjusted p=.559)	⊕◯◯◯ VERY LOW	CRITICAL

ROB: Risk of Bias**; Inc:** Inconsistency**; Ind:** Indirectness**; Imp:** Imprecision**; Oth:** Other considerations
E: Experimental**; C:** Control**; CI:** Confidence interval**; MD:** Mean difference**; OR:** Odds ratio**; RR:** Risk ratio

Explanations
a. High risk of bias due to concerns of deviations from assignment to the intervention (Chyzzy 2019) (160)
b. High risk of bias due to concerns with randomisation, deviation from assignment to the intended intervention, and measurement of outcomes. Some concerns with selective outcome reporting (Cheng 2016) (159)
c. Optimal Information Size (OIS) not reached: Sample < 300
d. Serious concerns regarding confounding, missing outcome data and measurement of outcomes (Gong 2020) (161)
e. Serious concerns due to confounding and bias in measurements of outcomes (Lee 2017) (163)
f. Confidence interval crosses the null value and excludes meaningful values
g. High risk of bias due to concerns with deviation from assignment to the intervention and measurement of outcomes. Some concerns with randomisation and selective outcome reporting (Jareethum 2008) (162)
h. Serious concerns due to confounding and bias in measurement of outcomes, moderate risk due to the classification of interventions (Tsai 2018) (167)
i. High risk of bias due to concerns with deviation from assignment to intended interventions and measurement of outcomes. Some concerns with randomisation, missing outcome data, and selective outcome reporting (Mauriello 2016) (164)

Table II. GRADE Evidence profiles: Outcomes of mobile interventions targeting the *management* of common mental disorders (147)

Certainty assessment							№ of patients		Effect		Certainty	Importance
No.	**Study design**	**ROB**	**Inc.**	**Ind.**	**Imp.**	**Oth.**	**E**	**C**	**Relative (95% CI)**	**Absolute (95% CI)**		
Outcome 1: Severity of mental health symptoms												
Severity of depression symptoms-short term (Study ID: Baumel 2018; Jannati 2020; Prasad 2018+ Sawyer 2019) (168; 173; 174+175) [assessed with: Edinburgh Postnatal Depression Scale (EPDS)]												
1	Non-randomised trials	serious [a]	not serious	not serious	serious [b]	none	17	17	-	MD 2.82 higher (0.49 lower to 6.13 higher)	⊕⊕◯◯ LOW	CRITICAL

1	randomised trials	very serious [c]	not serious	not serious	serious [b]	none	38	37	-	MD 6.87 lower (7.92 lower to 5.82 lower)	⊕◯◯◯ VERY LOW	CRITICAL
2	randomised trials	very serious [d,e]	not serious	not serious	serious [b]	none	77	77	-	MD 0.93 lower (2.08 lower to 0.21 higher)	⊕◯◯◯ VERY LOW	CRITICAL
Severity of depression symptoms-long term (Study ID: Sawyer 2019) (175) [assessed with: Edinburgh Postnatal Depression Scale (EPDS)]												
1	randomised trials	very serious [d]	not serious	not serious	serious [b]	none	Linear regression results showed small significant improvements associated with the intervention compared to the control group (Intervention N=54 M=8.4 95% CI 7.2 to 9.6, control N=57 M=7.2 95% CI 5.9 to 8.3; Group x time p=.001)				⊕◯◯◯ VERY LOW	CRITICAL
Severity of depression symptoms-short term (Study ID: Dennis-Tiwary 2017) (171) [assessed with: The Depression, Anxiety, and Stress Scale (DASS)]												
1	randomised trials	not serious	not serious	not serious	serious [b]	none	15	14	-	MD 0.22 lower (2.36 lower to 1.92 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Severity of anxiety symptoms-short term (Study ID: Constant 2014) (170) [assessed with: The Hospital Anxiety and Depression Scale (HADS)]												
1	randomised trials	very serious [f]	not serious	not serious	serious [b]	none	197	184	-	MD 1.3 lower (2.33 lower to 0.27 lower)	⊕◯◯◯ VERY LOW	CRITICAL
Severity of anxiety symptoms-short term (Study ID: Dennis-Tiwary 2017) (171) [assessed with: The Depression, Anxiety, and Stress Scale (DASS)]												
1	randomised trials	not serious	not serious	not serious	serious [b]	none	15	14	-	MD 1.13 higher (1.29 lower to 3.55 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Outcome: Psychological wellbeing and distress												
Psychological wellbeing-short term (Study ID: Carissoli 2017) (169)[assessed with: The Italian Psychological Wellbeing Questionnaire (PWB)]												
1	randomised trials	very serious [g]	not serious	not serious	serious [b]	none	ANOVA analysis showed significant improvement in autonomy associated with the intervention over time (Intervention N=35 M=4.33, control N=43 M=4.42; F=5.725; p<.05), whereas changes in other constructs were not significant, such as environmental mastery				⊕◯◯◯ VERY LOW	CRITICAL

							(p=.97), personal growth(p=.34), positive relations (p=.73), purpose in life (p=.13), and self-acceptance (p=.19).					
Subjective stress: Intrusive and avoidance-short term (Study ID: Constant 2014) (170) [assessed with: The Revised Impact of Event Scale (IES-R)]												
1	randomised trials	very serious [f]	not serious	not serious	serious [b]	none	When adjusting for baseline anxiety, avoidance-based stress was significantly reduced in the intervention group (N=197 M=13.1 SD=7.3) compared to the control group (N=184 M=14.4 SD=7.4); linear regression coefficient B=-1.8; 95% CI -3.2 to -0.4; p=.015. However, changes in intrusive-based stress remained non-significant (B=-1.4; 95% CI -2.9, 0.2; p=.08).	⊕◯◯◯ VERY LOW	CRITICAL
Subjective stress-short term (Study ID: Dennis-Tiwary 2017) (171) [assessed with: The Depression, Anxiety, and Stress Scale (DASS)]												
1	randomised trials	not serious	not serious	not serious	serious [b]	none	15	14	-	MD 1.64 higher (0.98 lower to 4.26 higher)	⊕⊕⊕◯ MODERATE	CRITICAL
Biological stress-short term (Study ID: Dennis-Tiwary 2017) (171) [assessed with: Lab cortisol ug/dl]												
1	randomised trials	serious [h]	not serious	not serious	serious [b]	none	ANOVA analysis showed a significant reduction in post-intervention lab cortisol levels associated with receiving the intervention (Intervention N=15, M=-0.05 SD 0.09, control N=14 M=0.01 SD 0.09; F(1,22)=4.96; p=.037)				⊕⊕◯◯ LOW	CRITICAL
Psychological wellbeing-short term (Study ID: Prasad 2018) (174) [assessed with: The WHOQOL-BREF scale]												
1	randomised trials	very serious [e]	not serious	not serious	serious [b]	none	ANOVA results showed significant improvement in psychological wellbeing associated with the intervention across time (Intervention N=23 M=18.13 SD 1.75, control N=20 M=17.90 SD 1.71; F=4.568; p=.039)				⊕◯◯◯ VERY LOW	CRITICAL
Outcome: Utilization of pregnancy-related and mental health care												
Percentage of patients who had an obstetrician visit that addressed mental health-short term (Study ID: Hantsoo 2018) (172) [assessed with: Electronic Health Records]												
1	randomised trials	very serious [i]	not serious	not serious	serious [b]	none	Compared to the control group, women receiving the intervention had more telephone encounters with their providers than addressed mental health (Intervention N=41 M=0.98 SD 1.3, control N=23 M=0.1 SD 4.7; F=6.0, p=.02)				⊕◯◯◯ VERY LOW	CRITICAL
Percentage of patients who were referred to a mental health specialist-short term (Study ID: Hantsoo 2018) (172) [assessed with: Electronic Health Records]												

1	randomised trials	very serious [i]	not serious	not serious	serious [b]	none	11/41 (26.8%)	5/23 (21.7%)	RR 1.23 (0.49 to 3.11)	50 more per 1,000 (from 111 fewer to 459 more)	⊕◯◯◯ VERY LOW	CRITICAL
Percentage of patients who attended a mental health specialist visit-short term (Study ID: Hantsoo 2018) (172) [assessed with: Electronic Health Records]												
1	randomised trials	very serious [i]	not serious	not serious	serious [b]	none	3/11 (27.3%)	1/5 (20.0%)	RR 1.36 (0.17 to 10.09)	72 more per 1,000 (from 166 fewer to 1,000 more)	⊕◯◯◯ VERY LOW	CRITICAL
Percentage of patients who visited their family physician 2 times or more in the past 6 months-long term (Study ID: Sawyer 2019) (175) [assessed with: Questionnaire]												
1	randomised trials	very serious [j]	not serious	not serious	serious [b]	none	42/54 (77.8%)	36/57 (63.2%)	RR 1.23 (0.96 to 1.57)	145 more per 1,000 (from 25 fewer to 360 more)	⊕◯◯◯ VERY LOW	CRITICAL
Percentage of patients who visited the emergency department 2 times of more in the past 6 months-long term (Study ID: Sawyer 2019) (175) [assessed with: Questionnaire]												
1	randomised trials	very serious [j]	not serious	not serious	serious [b]	none	Results show that receiving the intervention was associated with an increase in the percentage of women who visited the emergency department 2 times or more in the past 6 months (Intervention 8/54=15%, control 2/54=4%; RR=4.00, 95% CI 0.89, 17.98; adjusted p=.04)				⊕◯◯◯ VERY LOW	CRITICAL
Percentage of patients who used online pregnancy resources in the past 6 months-long term (Study ID: Sawyer 2019) (175) [assessed with: Questionnaire]												
1	randomised trials	very serious [j]	not serious	not serious	serious [b]	none	Results show that receiving the intervention was associated with an increase in the percentage of women who used pregnancy-related online resources (Intervention 22/54=41%, control 12/56=21%; RR=1.90, 95% CI 1.04, 3.44; p=.03)				⊕◯◯◯ VERY LOW	CRITICAL

ROB: Risk of Bias**; Inc:** Inconsistency**; Ind:** Indirectness**; Imp:** Imprecision**; Oth:** Other considerations
E: Experimental**; C:** Control**; CI:** Confidence interval**; MD:** Mean difference**; OR:** Odds ratio**; RR:** Risk ratio

Explanations

a. Concerns of moderate bias due to confounding. No information regarding missing outcome data and deviation from assignment to intended intervention (Baumel 2018) (168)
b. Optimal Information Size (OIS) not reached: Sample < 300
c. High concerns of bias due to randomisation, deviation from assignment to intended intervention, and measurement of outcomes. Some concerns with selective outcome reporting (Jannati 2020) (173)
d. High concerns of bias due to missing outcome data and measurement of outcomes. Some concerns regarding randomisation and deviation from assignment to intended intervention (Sawyer 2019) (175)

e. High concerns of risk of bias due to deviation from assignment to intended interventions, missing outcome data, and measurement of outcomes. Some concerns regarding randomisation (Prasad 2018) (174)
f. High concerns of risk of bias due to missing outcome data and measurement of outcomes. Some concerns regarding deviation from assignment to intended intervention and selective outcome reporting (Constant 2014) (170)
g. High concerns of risk of bias due to deviation from assignment to intended intervention, missing outcome data, and measurement of outcomes. Some concerns regarding randomisation and selective outcome reporting (Carissoli 2017) (169)
h. High concerns of selective outcome reporting, some concerns regarding randomisation and deviation from assignment to intended interventions (Dennis-Tiwary 2017b) (171)
i. High concerns of risk of bias due to deviation from assignment to intended intervention, missing outcome data, and selective outcome reporting (Hantsoo 2018) (172)
j. High concerns of risk of bias due to missing outcome data, measurement of outcomes, and selective outcome reporting. Some concerns regarding randomisation and deviation from assignment to intended interventions (Sawyer 2019) (175)

Appendix V. PROGRESS+ Equity Framework

PROGRESS+	Severity of mental health symptoms *	Psychological wellbeing and distress *	Changes in occurrence of mental health illnesses *	Utilization of pregnancy and mental health care *
Place of residence	N/A	N/A	N/A	N/A
Race, ethnicity, culture	**<u>Prevention interventions</u>** Receiving antenatal prevention interventions showed statistically significant reduction in depression severity among **Chinese** women (MD=−0.65; 95% CI −1.29 to 0.00; p=.049) (Chan et al. 2019) (158) Receiving antenatal SMS prevention interventions showed statistically significant reduction in depression among **Chinese** women (MD=-1.30; t=9.03; p<.001) (Gong et al. 2020) (161) Receiving antenatal prevention interventions did **not** show a statistically significant reduction in the severity of anxiety symptoms among **Chinese** women (p=.94) (Chan et al. 2019) (158) Receiving antenatal SMS prevention interventions showed a statistically significant reduction in prenatal anxiety among **Thai** women (MD=-1.01; 95% CI: -3.42, -0.88; p=.002) (Jareethum et al. 2008) (162) Receiving antenatal SMS prevention interventions did not show a statistically significant reduction in perinatal anxiety among **Thai** women (p=.12) (Jareethum et al. 2008) (162) Postpartum prevention interventions were associated	**<u>Prevention interventions</u>** Antenatal prevention interventions showed statistically significant and clinically meaningful improvement in psychological stress among **Taiwanese** women (MD=-11.12; 95% CI -17.19, -5.05; p<.001) (Tsai et al. 2018) (167) Perinatal preventative interventions showed statistically significant reduction in **Taiwanese** women's stress levels (MD=-3.52; 95% CI -4.95 to -2.09; p<.001) (Cheng et al. 2016) (159) Receiving antenatal prevention interventions did **not** show statistically significant reduction in stress levels among **Chinese** women (p=.74) (Chan et al. 2019) (158) **<u>Management interventions</u>** Perinatal management interventions showed a statistically significant improvement in **Italian** women's sense of autonomy as a construct of psychological wellbeing (MD=-0.09; ANOVA Group x time p<.05) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **Italian** women's environmental mastery as a construct of psychological wellbeing (p=.78) (Carissoli et al.	**<u>Prevention interventions</u>** Receiving antenatal SMS prevention interventions showed a statistically significant and clinically meaningful reduction in the odds of depression diagnosis among **Chinese** women (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	**<u>Management interventions</u>** Antenatal management interventions showed a statistically significant intervention effect of addressing mental health during routine phone call providers among pregnant women from **racial minorities** (African American and Latino) (F=6.0; p=.02) (Hantsoo et al. 2018) (172) Antenatal management interventions did not show a statistically significant increase the rate of referral to mental health specialists among pregnant women from **racial minorities** (African American and Latino) (p=.65) (Hantsoo et al. 2018) (172) Antenatal management interventions did not show a statistically significant increase the rate of visits to mental health specialists among pregnant women from **racial minorities** (African American and Latino) (p=.76) (Hantsoo et al. 2018) (172)

	with statistically significant decreased severity of depression among **South Korean** women (MD=-2.68; 95% CI: -4.86 to -0.5; p=.02) (Lee et al. 2017) (163) Compared to our pooled results, perinatal prevention interventions were more statistically and clinically effective in decreasing the severity of depression symptoms among **Taiwanese** women (MD=-3.70; 95% CI -5.27 to -2.13; p<.001) (Cheng et al. 2016) (159) **Indirect effect:** The difference in depression severity was not statistically significant before and after adjusting for **ethnicity,** <u>among other variables,</u> (p=.23 and p=.16, respectively) (Shorey et al. 2017) (165) **<u>Management interventions</u>** Postpartum CBT interventions showed a statistically significant and clinically meaningful reduction in depression severity among **Persian** women (MD=-6.87; 95% CI -7.92 to -5.82; p<.001) (Jannati et al. 2020) (173)	2017) (169) Perinatal management interventions did not show a statistically significant improvement in **Italian** women's personal growth as a construct of psychological wellbeing (p=.88) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **Italian** women's positive relations as a construct of psychological wellbeing (p=.60) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in e **Italian** women's purpose in life as a construct of psychological wellbeing (p=.59) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **Italian** women's self-acceptance as a construct of psychological wellbeing (p=.93) (Carissoli et al. 2017) (169)		
Occupation	**<u>Prevention interventions</u>** **Indirect effect:** The difference in depression severity was not statistically significant before and after adjusting for **employment status**, <u>among other variables,</u> (p=.23 and p=.16, respectively) (Shorey et al. 2017) (165)	N/A	**<u>Prevention interventions</u>** **Indirect effect:** When adjusting for **work intensit**y, <u>among other variables,</u> receiving antenatal SMS prevention interventions further reduced the odds of depression diagnosis among Chinese women than before adjusting (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	N/A

Gender, sex	N/A	N/A	N/A	N/A
Religion	N/A	N/A	N/A	N/A
Education	**<u>Prevention interventions</u>** **Indirect effect:** The difference in depression severity was not statistically significant before and after adjusting for **education**, <u>among other variables,</u> (p=.23 and p=.16, respectively) (Shorey et al. 2017) (165) **<u>Management interventions</u>** **Indirect effect:** The difference in depression severity was not statistically significant before adjusting for **education**, <u>among other variables,</u> and only showed small significant improvements after adjusting for it (MD=1.2; Group x time p=.001) (Sawyer et al. 2019) (175) The effectiveness of Postpartum CBT interventions was not associated with women's **education** (Post-intervention correlation p=.44 and p=.89 for the intervention and control groups, respectively) (Jannati et al. 2020) (173) Post-abortion SMS interventions were more effective among those who had less than a **high school education** compared to those who had high school education (p=0.047) No further details. (Constant et al. 2014) (170)	N/A	**<u>Prevention interventions</u>** **Indirect effect:** When adjusting for **education level**, <u>among other variables</u>, receiving antenatal SMS prevention interventions further reduced the odds of depression diagnosis among Chinese women than before adjusting (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	N/A
Socioeconomic status	**<u>Management interventions</u>** The effectiveness of postpartum CBT interventions was not associated with women's **income level** (Post-intervention correlation p=.55 and p=.79 for the intervention and control groups,	N/A	**<u>Prevention interventions</u>** **Indirect effect:** When adjusting for **monthly income**, <u>among other variables,</u> receiving antenatal SMS prevention	**<u>Management interventions</u>** Antenatal management interventions showed a statistically significant intervention effect of mentioning mental health during routine

	respectively) (Jannati et al. 2020) (173)		interventions further reduced the odds of depression diagnosis among Chinese women than before adjusting (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	Obstetrician visits among pregnant women with **low-income status** (F=6.0; p=.02) (Hantsoo et al. 2018) (172) Antenatal management interventions did not increase the rate of referral to mental health specialists among pregnant women with **low-income status** (p=.65) (Hantsoo et al. 2018) (172) Antenatal management interventions did not increase the rate of visits to mental health specialists among pregnant women with **low-income status** (p=.76) (Hantsoo et al. 2018) (172)
Social capital	**Prevention interventions** **Indirect effect:** The difference in depression severity was not statistically significant at 1 month follow-up before and after adjusting for **marital status**, among other variables (p=.25 and p=.23, respectively) (Shorey et al. 2019) (166) **Indirect effect:** The difference in depression severity was statistically significant at 3 months follow-up before and after adjusting for **marital status**, among other variables (Unadjusted MD=-1.77; 95% CI -3.5 to 0.0; p=.04; adjusted MD=-2.11; 95% CI -4.0 to -0.3; p=.03) (Shorey et al. 2019) (166) **Indirect effect:** The difference in the severity of anxiety was not statistically significant at 1 month follow-up before and after adjusting for **marital status**, among other	N/A	**Prevention interventions** **Indirect effect:** When adjusting for **marital status**, among other variables, receiving antenatal SMS prevention interventions further reduced the odds of depression diagnosis among Chinese women than before adjusting (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	N/A

	variables (p=.31 and p=.52, respectively) (Shorey et al. 2019) (166)			
+ Age	**Prevention interventions** **Indirect effect:** The difference in depression severity was not statistically significant before and after adjusting for **age**, among other variables, (p=.23 and p=.16, respectively) (Shorey et al. 2017) (165) **Indirect effect:** The difference in depression severity was not statistically significant at 1 month follow-up before and after adjusting for **age**, among other variables (p=.25 and p=.23, respectively) (Shorey et al. 2019) (166) **Indirect effect:** The difference in depression severity was statistically significant at 3 months follow-up before and after adjusting for **age**, among other variables (Unadjusted MD=-1.77; 95% CI -3.5 to 0.0; p=.04; adjusted MD=-2.11; 95% CI -4.0 to -0.3; p=.03) (Shorey et al. 2019) (166) **Indirect effect:** The difference in the severity of anxiety was not statistically significant at 1 month follow-up before and after adjusting for **age**, among other variables (p=.31 and p=.52, respectively) (Shorey et al. 2019) (166) Compared to the significant difference of our pooled result, receiving perinatal peer-support interventions showed less statistically significant and less clinically meaningful improvements in depression severity among pregnant **adolescents** (p=.11) (Chyzzy et	N/A	**Prevention interventions** **Indirect effect:** When adjusting for **age**, among other variables, receiving antenatal SMS prevention interventions further reduced the odds of depression diagnosis among Chinese women than before adjusting (Unadjusted OR=0.51, adjusted OR=0.49) (Gong et al. 2020) (161)	**Prevention interventions** Receiving perinatal peer-support interventions did not show a statistically significant improvement the mean number of healthcare visits among pregnant **adolescents** (p=.41) (Chyzzy et al. 2019) (159) Receiving perinatal peer-support interventions did not show a statistically significant impact on the percentage of pregnant **adolescents** visiting their family physician (p=.95) (Chyzzy et al. 2019) (159) Receiving perinatal peer-support interventions did not show a statistically significant impact on the percentage of pregnant **adolescents** visiting their obstetrician (p=.37) (Chyzzy et al. 2019) (159) Receiving perinatal peer-support interventions did not show a statistically significant impact on the percentage of pregnant **adolescents** visiting their psychologist (p=.26) (Chyzzy et al. 2019) (159) Receiving perinatal peer-support interventions did not show a statistically significant impact on the percentage of pregnant **adolescents** visiting their psychiatrist (p=.52) (Chyzzy et al. 2019) (159)

	al. 2019) (159) Receiving perinatal peer-support interventions did not show a statistically significant improvement in the severity of anxiety symptoms among pregnant **adolescents** (p=.60) (Chyzzy et al. 2019) (159) **<u>Management interventions</u>** **Indirect effect:** The difference in depression severity was not statistically significant before adjusting for **age** <u>among other variables</u>, and only showed small statistically significant improvements after adjusting for it (MD=1.2; Group x time p=.001) (Sawyer et al. 2019) (175) The effectiveness of postpartum CBT interventions was not associated with women's **age** (Post-intervention correlation p=.87 and p=.85 for the intervention and control groups, respectively) (Jannati et al. 2020) (173)			
+ Disability	N/A	N/A	N/A	N/A
+ Time-dependent: Being primiparous	**<u>Prevention interventions</u>** Postpartum prevention interventions were associated with a statistically significant decrease in the severity of depression among **primiparous** women (MD=-2.68; 95% CI: -4.86 to -0.5; p=.02) (Lee et al. 2017) (163) Receiving antenatal prevention interventions showed a statistically significant decrease in depression severity among **first-time** mothers (MD=−0.65; 95% CI −1.29 to	**<u>Prevention interventions</u>** Receiving antenatal prevention interventions did not show a statistically significant reduction in stress levels among **primiparous** mothers (p=.74) (Chan et al. 2019) (158) **<u>Management interventions</u>** Perinatal management interventions showed a statistically significant improvement in **primiparous** women's sense of autonomy as a construct of psychological wellbeing (MD=-0.09; ANOVA Group x time p<.05) (Carissoli et al. 2017) (169)	N/A	N/A

	0.00; p=.049) (Chan et al. 2019) (158) Receiving antenatal prevention interventions did not show a statistically significant reduction in the severity of anxiety symptoms among **first-time** mothers (p=.94) (Chan et al. 2019) (158)	Perinatal management interventions did not show a statistically significant improvement in **primiparous** women's environmental mastery as a construct of psychological wellbeing (p=.78) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **primiparous** women's personal growth as a construct of psychological wellbeing (p=.88) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **primiparous** women's positive relations as a construct of psychological wellbeing (p=.60) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **primiparous** women's purpose in life as a construct of psychological wellbeing (p=.59) (Carissoli et al. 2017) (169) Perinatal management interventions did not show a statistically significant improvement in **primiparous** women's self-acceptance as a construct of psychological wellbeing (p=.93) (Carissoli et al. 2017) (169)		
+ Time-dependent: IPV	N/A	N/A	N/A	N/A

** Results are assumed to have no clinically meaningful effect, unless mentioned otherwise.

Supplementary Material I: PRISMA Checklist (127)

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Pg. 27
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Pg. 29
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Pg. 31
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Pg. 31
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Pg. 31
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Pg. 34-38
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Pg. 32-34

Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix I Pg. 114
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Pg. 39
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Pg. 39-40
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Pg. 39
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Pg. 40
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Pg. 41
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Pg. 45

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Pg. 45
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Pg. 45
RESULTS			

Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Pg. 46-48
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Pg. 48-54
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Pg. 55-56
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	GRADE EP Appendix IV Pg. 128
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Pg. 57- 62
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Appendix III Pg. 123
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Pg. 63-66
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Pg. 66
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Pg. 67-68
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Pg. 68
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Pg. 27

Supplementary Material II: PRISMA-E Checklist (91)

Checklist of Items for Reporting Equity-Focused Systematic Reviews			
Section	**Item**	**Extension for Equity-Focused Reviews**	**Pg #**
Title			
Title	1	Identify equity as a focus of the review, if relevant, using the term equity	Pg. 27
Abstract			
Structured summary	2	State research question(s) related to health equity.	Pg. 29
	2A	Present results of health equity analyses (e.g. subgroup analyses or meta-regression).	Pg. 29
	2B	Describe extent and limits of applicability to disadvantaged populations of interest.	Pg. 29-30
Introduction			
Rationale	3	Describe assumptions about mechanism(s) by which the intervention is assumed to have an impact on health equity.	Pg. 30
	3A	Provide the logic model/analytical framework, if done, to show the pathways through which the intervention is assumed to affect health equity and how it was developed.	Pg. 25 (May publish as appendix)
Objectives	4	Describe how disadvantage was defined if used as criterion in the review (e.g. for selecting studies, conducting analyses or judging applicability).	Pg. 31
	4A	State the research questions being addressed with reference to health equity	Pg. 31

Methods			
Protocol and registration	5		See PRISMA table
Eligibility criteria	6	Describe the rationale for including particular study designs related to equity research questions.	Pg. 38
	6A	Describe the rationale for including the outcomes - e.g. how these are relevant to reducing inequity.	Pg. 36-38
Information sources	7	Describe information sources (e.g. health, non-health, and grey literature sources) that were searched that are of specific relevance to address the equity questions of the review.	Pg. 32-34
Search	8	Describe the broad search strategy and terms used to address equity questions of the review.	Pg. 32
Study selection	9		See PRISMA table
Data collection process	10		See PRISMA table
Data items	11	List and define data items related to equity,where such data were sought (e.g. using PROGRESS-Plus or other criteria, context).	Pg. 39
Risk of bias in individual studies	12		See PRISMA table
Summary measures	13		See PRISMA table

Synthesis of results	14	Describe methods of synthesizing findings on health inequities (e.g. presenting both relative and absolute differences between groups).	Pg. 41-42 + 45
Risk of bias across studies	15		See PRISMA table
Additional analyses	16	Describe methods of additional synthesis approaches related to equity questions, if done, indicating which were pre-specified	N/A
Results			
Study selection	17		See PRISMA table
Study characteristics	18	Present the population characteristics that relate to the equity questions across the relevant PROGRESS-Plus or other factors of interest.	Pg. 62- 63
Risk of bias within studies	19		See PRISMA table
Results of individual studies	20		See PRISMA table
Synthesis of results	21	Present the results of synthesizing findings on inequities (see 14).	Pg. 63-66+ Appendix V Pg. 136
Risk of bias across studies	22		See PRISMA table
Additional analysis	23	Give the results of additional synthesis approaches related to equity objectives, if done, (see 16).	N/A
Discussion			

Summary of evidence	24		See PRISMA table
Limitations	25		See PRISMA table
Conclusions	26	Present extent and limits of applicability to disadvantaged populations of interest and describe the evidence and logic underlying those judgments.	Pg. 67-68
	26A	Provide implications for research, practice or policy related to equity where relevant (e.g. types of research needed to address unanswered questions).	Pg. 68
Funding			
Funding	27		See PRISMA table

Supplementary Material III: List of Excluded Studies

Study citation	**Reason for exclusion**
Barrera AZ, Wickham RE, Muñoz RF. Online prevention of postpartum depression for Spanish-and English-speaking pregnant women: A pilot randomized controlled trial. Internet interventions. 2015 Sep 1;2(3):257-65.	Intervention not mobile based
Bhati SR. *The Effect of the Sleep Support for Moms Intervention on Postpartum Sleep and Depressive Symptoms: A Pilot Randomized Controlled Trial* (Doctoral dissertation, George Mason University).	Intervention not mobile based
Bragadóttir H. Computer-mediated support group intervention for parents. Journal of Nursing Scholarship. 2008 Mar;40(1):32-8.	Wrong population
Carissoli C, Villania D, Gasparria D, Rivaa G. Enhancing psychological wellbeing of women approaching the childbirth: a	Duplicate

controlled study with a mobile application. ANNUAL REVIEW OF CYBERTHERAPY AND TELEMEDICINE 2017. 2017 Jun 1:45.	
Chabrol H, Coroner N, Rusibane S, Séjourné N. A pilot study of prevention of postpartum blues. Gynecologie, obstetrique & fertilite. 2007 Dec;35(12):1242.	Intervention not mobile based
Chyzzy B, Dennis CL. 16. Mobile phone-based peer support in the prevention of postpartum depression among adolescent mothers: a pilot randomized controlled trial. Journal of Adolescent Health. 2019 Feb 1;64(2):S8-9.	Poster/ Conference abstract
Cooper PJ, Murray L, Wilson A, Romaniuk H. Controlled trial of the short-and long-term effect of psychological treatment of post-partum depression: I. Impact on maternal mood. The British Journal of Psychiatry. 2003 May;182(5):412-9.	Intervention not mobile based
Evans WD, Wallace JL, Snider J. Pilot evaluation of the text4baby mobile health program. BMC public health. 2012 Dec 1;12(1):1031.	Irrelevant outcomes
Fealy S, Jones D, Ebert L, Dowse E, Wynne O, Chan S. "Supporting new Mums"–Developing a postnatal psycho-educational smartphone application for first time mothers. Women and Birth. 2017 Oct 1;30:31.	Poster/ Conference abstract
Forsell E, Bendix M, Holländare F, von Schultz BS, Nasiell J, Blomdahl-Wetterholm M, Eriksson C, Kvarned S, van der Linden JL, Söderberg E, Jokinen J. Internet delivered cognitive behavior therapy for antenatal depression: A randomised controlled trial. Journal of Affective Disorders. 2017 Oct 15;221:56-64.	Intervention not mobile based
Garfield CF, Lee YS, Kim HN, Rutsohn J, Kahn JY, Mustanski B, Mohr DC. Supporting parents of premature infants transitioning from the NICU to home: a pilot randomized control trial of a smartphone application. Internet interventions. 2016 May 1;4:131-7.	Irrelevant outcomes
Himes KP, Donovan H, Wang S, Weaver C, Grove JR, Facco FL. Healthy beyond pregnancy, a web-based intervention to improve adherence to postpartum care: randomized controlled feasibility trial. JMIR human factors. 2017;4(4):e26.	Intervention not mobile based
Hoffenkamp HN, Tooten A, Hall RA, Braeken J, Eliëns MP, Vingerhoets AJ, van Bakel HJ. Effectiveness of hospital-based video interaction guidance on parental interactive behavior, bonding, and stress after preterm birth: A randomized controlled trial. Journal of Consulting and Clinical Psychology. 2015 Apr;83(2):416.	Intervention not mobile based
Husain N, Kiran T, Fatima B, Chaudhry IB, Saeed Q, Masood SN,	Poster/ Conference abstract

Husain M, Zafar SN, Gire N, Alvi MH, Khoja S. Development and assessment of a mobile phone-based intervention to reduce maternal depression and improve child health. European Psychiatry. 2016 Mar;33(S1):S608-9.	
Kennelly MA, Ainscough K, Lindsay KL, Cronin M, McAuliffe FM. 336: An antenatal lifestyle intervention in overweight and obese pregnancy improves sleep behaviour and maternal wellbeing. American Journal of Obstetrics & Gynecology. 2019 Jan 1;220(1):S234-5.	Poster/ Conference abstract
Kersting A, Dölemeyer R, Steinig J, Walter F, Kroker K, Baust K, Wagner B. Brief Internet-based intervention reduces posttraumatic stress and prolonged grief in parents after the loss of a child during pregnancy: a randomized controlled trial. Psychotherapy and Psychosomatics. 2013;82(6):372-81.	Intervention not mobile based
Kimmel MC, Platt RE, Steinberg DN, Cluxton-Keller F, Osborne LM, Carter T, Payne JL, Solomon BS. Integrating maternal mental health care in the pediatric medical home: treatment engagement and child outcomes. Clinical pediatrics. 2017 Oct;56(12):1148-56.	Intervention not mobile based
Lau YK, Cassidy T, Hacking D, Brittain K, Haricharan HJ, Heap M. Antenatal health promotion via short message service at a Midwife Obstetrics Unit in South Africa: a mixed methods study. BMC pregnancy and childbirth. 2014 Dec 1;14(1):284.	Irrelevant outcomes
Ledford CJ, Canzona MR, Cafferty LA, Hodge JA. Mobile application as a prenatal education and engagement tool: a randomized controlled pilot. Patient education and counseling. 2016 Apr 1;99(4):578-82.	Irrelevant outcomes
Lenz B, Eichler A, Schwenke E, Buchholz VN, Hartwig C, Moll GH, Reich K, Mühle C, Volz B, Titzmann A, Beckmann MW. Mindfulness-based stress reduction in pregnancy: an app-based programme to improve the health of mothers and children (MINDFUL/PMI Study). Geburtshilfe und Frauenheilkunde. 2018 Dec;78(12):1283.	Ongoing study/ protocol
Simmons A, Pehme P, Egan LJ, Rincon A, Altemus M, Gelber S, Denefrio S, Dennis TA. A Gamified Attention Bias Modification App Reduces Stress Reactivity During Pregnancy.	Poster/ Conference abstract
Lund S, Nielsen BB, Hemed M, Boas IM, Said A, Said K, Makungu MH, Rasch V. Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial. BMC pregnancy and childbirth. 2014 Dec 1;14(1):29.	Intervention not mobile based
Milgrom J, Gemmill A, Holt C, Olivia J. Perinatal e-mental health support: Evidence and challenges in translation to practice.	Poster/ Conference abstract

Archives of Women's Mental Health. 2019; 22(5):681-682	
Moridi A, Modarres M, Mogaddam ZB, Foroushani AR. Investigating the effect of anger management counseling and stress controlling on mental health of pregnant women. International Journal of Pharmaceutical Research & Allied Sciences. 2016 Jul 1;5(3).	Intervention not mobile based
Mundorf C, Shankar A, Moran T, Heller S, Hassan A, Harville E, Lichtveld M. Reducing the risk of postpartum depression in a low-income community through a community health worker intervention. Maternal and child health journal. 2018 Apr 1;22(4):520-8.	Intervention not mobile based
Nieminen K, Berg I, Frankenstein K, Viita L, Larsson K, Persson U, Spånberger L, Wretman A, Silfvernagel K, Andersson G, Wijma K. Internet-provided cognitive behaviour therapy of posttraumatic stress symptoms following childbirth—a randomized controlled trial. Cognitive behaviour therapy. 2016 Jul 3;45(4):287-306.	Intervention not mobile based
Rowe H, Fisher J. Online and mobile psychoeducation initiatives to prevent postnatal mental health problems: Research and evaluation. Archives of Women's Mental Health. 2019; 22(5):682	Poster/ Conference abstract
Scherer S, Alder J, Gaab J, Berger T, Ihde K, Urech C. Patient satisfaction and psychological well-being after internet-based cognitive behavioral stress management (IB-CBSM) for women with preterm labor: A randomized controlled trial. Journal of psychosomatic research. 2016 Jan 1;80:37-43.	Intervention not mobile based
Suharwardy S, Ramachandran M, Leonard SA, Gunaseelan A, Robinson A, Darcy A, Lyell DJ, Judy A. 116: Effect of an automated conversational agent on postpartum mental health: A randomized, controlled trial. American Journal of Obstetrics & Gynecology. 2020 Jan 1;222(1):S91.	Poster/ Conference abstract
Urech C, Scherer S, Emmenegger M, Gaab J, Tschudin S, Hoesli I, Berger T, Alder J. Efficacy of an internet-based cognitive behavioral stress management training in women with idiopathic preterm labor: A randomized controlled intervention study. Journal of psychosomatic research. 2017 Dec 1;103:140-6.	Intervention not mobile based

Supplementary Materials IV: Patient Summary

Can Mobile Phone Programs Improve the Mental Health of Pregnant and Postpartum Women?

Background

Pregnant and postpartum women face many stressors, which may cause depression and anxiety. Research shows that pregnant and postpartum women find a lot of difficulties when trying to visit their doctor or therapist, especially during the COVID-19 pandemic. Mobile phone programs can help, but we need to look at research that has explored whether these mobile phone programs work or not.

What kind of research are we doing?

We are doing an "*equity focused systematic review*". Let's introduce you to this research design:

- ★ ***Review*** means that we are looking at other research studies that have studied mobile programs on pregnant and postpartum women.
- ★ ***Systematic*** means using very strict research methods to "catch" all studies on this topic, judge the quality of these studies, and analyze their results.
- ★ ***Equity-focused*** means we are looking at whether mobile programs can help women from different backgrounds and with different qualities, such as women from different ethnicities, different age groups, etc.

What have we found?

- ➔ We have found 18 studies that looked at mobile phone programs among pregnant and postpartum women.
- ➔ Some studies explored smartphone applications, and some explored text messaging programs.
- ➔ Some studies focused on "preventing" depression, anxiety, or stress, and some studies focused on "treating or managing" these illnesses if they already exist.

What can I do to help?

- We want our research to become your research and want to invite you to become a team member. This doesn't mean that you will spend hours in our research lab! It just means that we want you to make decisions with us on what our results mean and how we can make these results easily digestible to other pregnant and postpartum women.
- Someone from our research team will set up a short phone call or Zoom meeting with you and share our results.