

Research paper

Mobile app-based intervention for paternal perinatal depression, anxiety, and stress: A randomised controlled trial

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ABSTRACT

Background: Paternal perinatal mental health significantly impacts family outcomes, yet fathers are often overlooked and underserved in mental health services. This study evaluates the efficacy of a mindfulness-based cognitive behaviour therapy intervention delivered via mobile app to address paternal perinatal depression, anxiety, and stress symptoms.

Method: A randomised controlled trial was conducted with perinatal fathers experiencing moderate depression, anxiety, or stress symptoms. Participants were assigned to either the Rover app mindfulness-based CBT intervention ($n = 81$) or an active control app, moodmonitor ($n = 75$). Primary outcomes were depression (EPDS), anxiety, and stress (DASS21); secondary outcomes included social support, parenting self-efficacy, and couple relationship quality. Post-test analysis occurred at four weeks, with an additional eight-week follow-up for the intervention group.

Results: Contrary to hypotheses, no differences were found between groups for depression, anxiety, and stress symptoms. Both groups showed significant reductions in anxiety (intervention $d = -1.7$, control $d = -1.94$) and stress (intervention $d = -2.9$, control $d = -2.8$) and improved couple relationship quality. Rover users maintained improvements at 8-week follow-up. Fathers with severe baseline depression experienced greater reductions in depression using the Rover app ($b = 5.36$, $p < 0.01$).

Limitations: Low adherence to the intervention and moderate attrition over the study duration.

Conclusions: Although the intervention was acceptable to fathers, treatment adherence was low, highlighting the need for more engaging content. App-based interventions show potential benefits for paternal mental health, but user engagement must be improved. This study contributes to the growing literature on digital interventions for fathers' mental health and emphasizes the importance of including fathers in perinatal mental health research.

Trial registration: Australian and New Zealand Clinical Trials Registry: ACTRN12621000275864.

1. Introduction

Perinatal mental health problems, such as depression, anxiety, and stress, represent major public health challenges for mothers and fathers alike (Howard and Khalifeh, 2020), yet these problems are commonly overlooked in men during the perinatal period (Fisher et al., 2021; Philpott et al., 2017; Volling et al., 2019). The perinatal years are a critical risk period for men's mental health, with downstream outcomes

observable in their partners and children. Approximately 10 % of fathers experience depression during pregnancy and into the first year postpartum, 20 % experience anxiety, and 5 % report suicidal thoughts; the latter being double the rate for men in the general population (Giallo et al., 2023; Rao et al., 2020). Fathers experiencing perinatal depression, anxiety, and stress also commonly report anger, substance misuse, and antisocial or aggressive tendencies (Rice et al., 2015), which can impact the mental health and safety of their partner and children (Gutierrez-

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Galve et al., 2019; Scarlett et al., 2023; Seedat, 2020). Men also frequently experience changing expectations in the transition to fatherhood, with contemporary views of fatherhood associated with greater responsibility in providing emotional care and responsiveness to infants than in previous generations (Fitzgerald et al., 2021). Paternal depression, anxiety and stress have a unique impact on children's behaviour and emotional problems beyond maternal factors, with offspring effects observed from early postpartum to adolescence (Challacombe et al., 2023; Gutierrez-Galve et al., 2019). Combined, the perinatal period represents an opportune time to target for paternal mental health interventions at the establishment family life.

To date, most countries do not routinely screen fathers for perinatal depression or anxiety, resulting in many men being overlooked by healthcare providers who may potentially benefit from support (Walsh et al., 2020). Men also experience substantial barriers to help-seeking in the perinatal period, including stigma, and more limited awareness of, and access to, mental health and other support services. This often results in men only seeking support if/when a crisis point is reached (Schuppan et al., 2019; Seidler et al., 2016). Likewise, many fathers never seek and/or are never offered help, reducing opportunities for preventative or early intervention.

The aforementioned issues are further compounded by the lack of evidence-based interventions focussed on mental health among fathers during the perinatal period. Three systematic reviews identified 10–14 articles on perinatal mental health interventions for fathers, with most interventions reporting no change in paternal mental health post-intervention; just six effective interventions were identified for depression (42.9 % of all paternal depression interventions) and anxiety (50 % of all paternal anxiety interventions) respectively (Fisher et al., 2022; Goldstein et al., 2020). Notably, few interventions were identified that used established psychotherapies for depression, anxiety, and stress, such as cognitive behaviour, mindfulness, or acceptance-based therapies; rather, most interventions used psychoeducation or practical skills training, such as information provision on maternal and newborn care (e.g., breastfeeding and bathing). Substantial limitations in the intervention literature were noted across these reviews, including a lack of interventions focused specifically on paternal mental health symptoms as a primary outcome, few randomised controlled trial designs or studies with active controls, and a lack of interventions focused on treatment rather than prevention of mental health symptoms (Fisher et al., 2022; Goldstein et al., 2020; Rominov et al., 2016). This highlights a major gap in the availability of effective interventions for fathers that use evidence-based treatments for depression, anxiety and stress, tailored to the perinatal period.

Research on fathers also highlights a preference during the perinatal period for informal, digital modalities of support (Teague and Shatte, 2021, 2018); yet currently few such tools exist for men (Fisher et al., 2022; Goldstein et al., 2020). Mobile apps are promising as they are accessible tools for delivering psychotherapies for mental health (Linardon et al., 2024), with emerging evidence indicating that mobile apps are a highly feasible and acceptable option for targeting more difficult-to-reach populations, such as fathers (Hamil et al., 2021; Liverpool et al., 2023; Teague et al., 2022). Commercial perinatal mobile apps are plentiful, but few are evidence-based and none to our knowledge focus on paternal mental health (Trahan et al., 2021). Only one app-based intervention in fathers has been evaluated perinatally by employing a randomised controlled trial; the 'Home But Not Alone' app, which focuses on psychoeducation about newborn and maternal care, was trialled in Singapore with couples post-birth, finding no improvements in maternal or paternal depression, although improvements were reported in social support and both parenting self-efficacy and satisfaction (Shorey et al., 2017). Research is thus warranted to investigate the digital delivery of other therapeutic approaches, particularly evidence-based psychotherapies for mental health symptoms in men during the transition to parenthood.

To address these gaps, this study aimed to evaluate the efficacy of a

mindfulness-based cognitive behaviour therapy mobile app intervention targeting depression, anxiety, and stress, compared to an active control condition (mood monitoring only). It was hypothesised that participants randomised to the app-based intervention would report significantly greater reductions at follow-up in depression, anxiety, and stress symptoms, as well as greater improvements in perceived social support, parenting self-efficacy, and couple relationship quality, compared to those in the active control condition. Further, it was hypothesised that these improvements would be maintained at 8-week follow-up.

2. Method

2.1. Design

A two-armed randomised controlled trial (RCT) was conducted to evaluate the mobile app-based intervention against a waitlist active control condition. Assessments took place at baseline and 4-week post-intervention, with the intervention group completing an additional 8-week post-intervention follow-up. The trial was pre-registered in the Australian and New Zealand Clinical Trials Registry (ACTRN12621000275864), and ethics approval was obtained from the Deakin University Human Research Ethics Committee (DUHREC 2020-151).

2.2. Study population and recruitment

Participants were recruited during the COVID-19 pandemic (March to November 2021) via paid social media advertisements on Facebook, Twitter and Reddit platforms. Participants were eligible if they: (1) were aged over 18 years; (2) owned a smartphone or tablet; (3) identified as a father; (4) had a pregnant partner or an infant aged under 12 months; (5) were living in Australia, New Zealand, the United States, the United Kingdom, or Canada; and, (6) scored at least in the moderate range for either depression, anxiety, or stress symptoms at baseline. Participants were offered a \$50 Amazon voucher after completing the final assessment. Given the study's focus on paternal perinatal mental health, the term "father" was used to specifically target individuals who identify as male parents, regardless of biological parenthood. This includes fathers in same-sex relationships, while excluding non-birthing parents who do not identify as fathers. We acknowledge that other non-birthing parents may also experience perinatal distress and highlight this as an area for future research.

2.3. Randomisation

Participants were randomly allocated to the intervention or active control condition following completion of the baseline survey. The Qualtrics platform automatically generated a random number sequence concealed from both the research team and participants, allocating participants at a ratio of 1:1 and a block size of 2. A total of 156 participants were randomly allocated to the intervention or active control conditions (see Fig. 1). Given the online nature of the study, screening was performed to assess data quality for careless responding (Ward and Meade, 2023). The completion times for the baseline survey were recorded, ranging from 9 min to 17 h and 7 min, with a median of 25 min ($SD = 2$ h 38 min). Qualtrics' Expert Review system reported that 99 % of responses passed their quality checks, including for potential bots, ambiguous text, unanswered questions, straightlining, overly fast responses, and good completion rates. The data was thus considered to be low risk for careless responding.

2.4. Study conditions

2.4.1. Intervention condition

The mobile-app intervention, *Rover* (see Fig. 2), was developed by forking from *schema*, an open-source mHealth platform (Shatte and

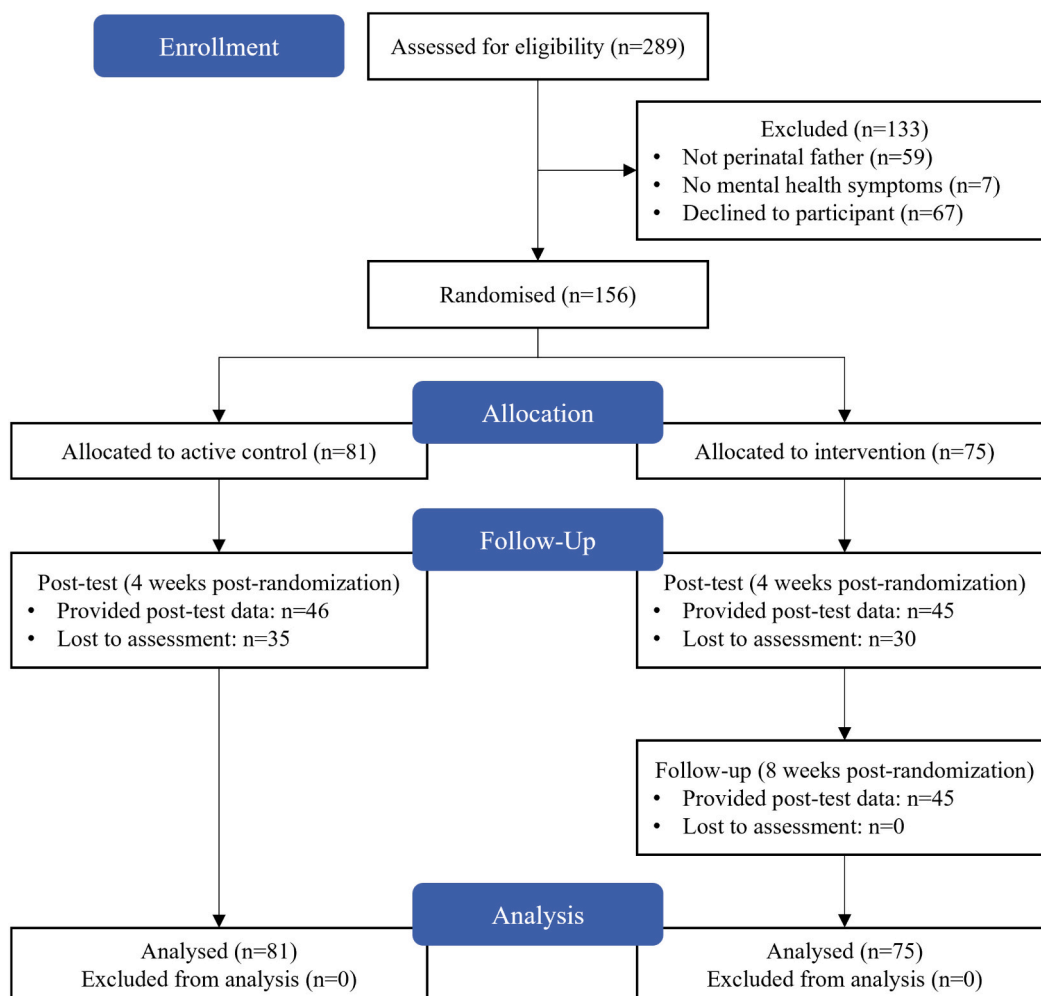


Fig. 1. Flow of participants throughout the study.

Teague, 2020). User-centred design principles were followed to develop the intervention, including a user evaluation with fathers and clinicians. For further details on the development and design of *Rover*, see (Teague et al., 2022).

The *Rover* app consisted of five components. First, a chatbot guide named ‘Rover the dog’ acted as a guide to accessing the app’s features. This included onboarding users when they first opened the app, conducting daily mood assessments, and weekly goal setting/tracking activities. The chatbot could also suggest exercises to participants based on their mood assessment score for the day and engage in open dialogue by asking participants to reflect on what factors may have been involved in their reported daily mood score. The daily mood assessment was completed using the Immediate Mood Scaler-12 (Nahum et al., 2017), a validated daily measure of depression and anxiety symptoms across 12-items, which were scored and presented to the user using as a feedback graph of the previous 7 days scores. Second, the app contained four self-guided modules of mindfulness-based cognitive behaviour therapy audio content with embedded exercises (see Table 1 for full details). The chatbot suggested that users complete each module over a week (totalling 4 weeks), though users could access and complete the modules at their own pace and in any order. Third, a resources page was included with 21 articles addressing common challenges faced by new fathers, including providing care to your baby, partner, and self. Finally, the settings page allowed users to personalise the app, including the nickname Rover called them in chatbot dialogue and the notification schedule, as well as information for contacting the study team and crisis mental health services.

2.4.2. Active control condition

The active control was an app-based mood tracking intervention called *moodmonitor*, built directly in the *schema* platform (Shatte and Teague, 2020; see Fig. 3). The mood tracking mirrored the activity in the chatbot *Rover* in the intervention condition using the Immediate Mood Scaler-12 (Nahum et al., 2017), though the activity was completed without guidance from the chatbot. Participants were prompted by the *moodmonitor* app each day to report their mood via a notification. Missed days could not be retrospectively reported. Daily mood scores for depression and anxiety were displayed on a line graph across the four-week period, along with a count of how many daily assessments had been completed as a consecutive streak and their longest streak record. After completing four weeks of mood tracking and the post-test assessment, participants were given access to download the full intervention.

2.5. Measures

2.5.1. Participant characteristics

Demographic data on participant age, gender, ethnicity, education level, current treatment status, and diagnosis of depression or anxiety (current/past) were collected at baseline.

2.5.2. Primary outcomes

Primary outcomes were depression, anxiety, and stress symptomatology. Depression symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS), a 10-item self-report screening tool assessing past week symptomatology (Cox et al., 1987). The EPDS is the

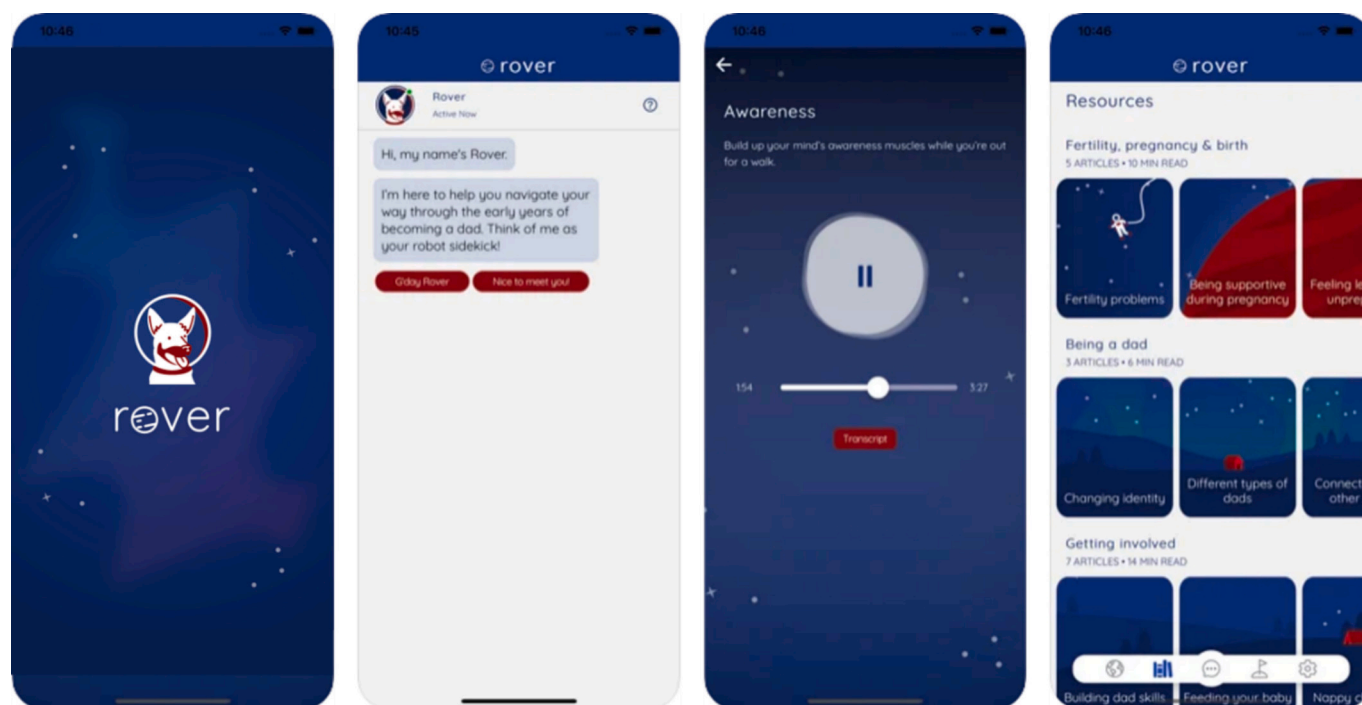


Fig. 2. Rover app of mindfulness-based CBT for the intervention condition, from left: (1) splash screen; (2) chatbot interaction with Rover the dog; (3) mindfulness exercise; (4) psychoeducation resource page.

gold standard measure for depression symptoms in the perinatal period for women and men, with excellent validity and reliability (Cox et al., 1987; McBride et al., 2014). Internal consistency in the current sample was $\alpha = 0.84$. Scores >9 are indicative of major depressive disorder in men (range 0–30) (Edmondson et al., 2010).

Anxiety and stress symptoms were assessed using the anxiety and stress subscales of the Depression, Anxiety and Stress Scales – 21 (DASS21) (Lovibond and Lovibond, 1996). The DASS21-Anxiety scale assesses symptoms of autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect experienced over the past week (Lovibond and Lovibond, 1996). In contrast, the DASS21-Stress scale assesses chronic non-specific arousal, including difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive and impatient over the past week (Lovibond and Lovibond, 1996). Both scales are 7-item self-report screening tools with excellent validity and reliability (Antony et al., 1998; Lovibond and Lovibond, 1996). Internal consistency in the current sample was $\alpha = 0.89$ for the Anxiety subscale and $\alpha = 0.88$ for the Stress subscale. Scores of >9 and >18 are indicative of moderate anxiety and stress symptoms, respectively (range 0–42) (Lovibond and Lovibond, 1996).

2.5.3. Secondary outcomes

Secondary outcomes were social support, parenting self-efficacy, and couple relationship quality. The pre-registered trial also included an additional secondary outcome of paternal-foetal/infant bonding, however given some fathers experienced the birth of their child between assessments and thus could not be used consistently for pre-post evaluations, this outcome was removed from the analysis.

Social support was assessed using the Multidimensional Scale of Perceived Social Support (MSPSS), a 12-item self-report measure evaluating participants' perception of support from family, friends, and their significant other over the past 4 weeks (Zimet et al., 1988). Subscales for each type of social support person (family, friends, and significant other), as well as a total score capturing overall perceived social support, with higher scores indicating greater perceived social support (range 12 to 84). The MSPSS has good validity and reliability (Hardan-Khalil and Mayo, 2015; Zimet et al., 1990), with an internal consistency $\alpha = 0.93$

for the total score in the current sample.

Parenting self-efficacy was assessed using the Parenting Sense of Competence scale (PSOC), a 16-item self-report scale assessing how capable a caregiver feels as a parent, and how satisfied they are with being a parent (Johnston and Mash, 1989). The PSCS has demonstrated good validity and internal validity (Gilmore and Cuskelly, 2009; Rogers and Matthews, 2004). Internal consistency was $\alpha = 0.77$ in the current sample. Total scores range from 16 to 96, with higher scores indicating greater parenting self-efficacy.

Couple relationship quality was assessed using the Revised Dyadic Adjustment Scale (RDAS), a 14-item scale assessing relationship satisfaction on the domains of consensus, satisfaction, and cohesion (Busby et al., 1995). The RDAS demonstrates excellent validity and reliability (Anderson et al., 2014; Busby et al., 1995). Internal consistency was $\alpha = 0.87$ for the total scale in the current sample. Total scores range from 0 to 69 with higher scores indicating greater relationship satisfaction. A cut-off score of 47 or less indicate marital or relationship distress (Anderson et al., 2014).

2.6. Sample size calculation

Based on previous app RCTs, a priori power analyses indicated that $n = 53$ participants per condition was required to detect statistically meaningful differences (calculated using $g = 0.55$, power = 0.8, two-tailed $\alpha = 0.05$) (Cuijpers et al., 2020; Fogarty et al., 2017). With 20% attrition, a target sample of 64 participants per condition was required.

2.7. Statistical analyses

The study used Stata version 16. Outcome analyses were conducted using the intention-to-treat principle, with participant data included as per initial group allocation. Linear mixed models were used for all outcome measures, and repeated measures clustered within individuals. Comparisons between the intervention and active control groups were possible for baseline vs. post-intervention time-points only as participants in the active control condition were given access to the Rover

Table 1
Description of the modules in the *Rover* app.

Topics covered	Exercises
Module 1: plan (values)	
1. Finding out what's really important to you	• 'Living up to your values' self-rating exercise across work/education, relationships, personal growth and health, leisure.
2. Identifying your key strengths and values	• 'What are your top strengths?' self-rating exercise across 24 character strengths (Ruch et al., 2014)
3. Turning values and strengths into actions	• Goal setting according to your values self-complete exercise
Module 2: focus (mindfulness)	
1. What is mindfulness	• Mindfulness self-rating exercise (Osman et al., 2016)
2. Building focus by slowing down your attention process, improving awareness, and accepting your present state.	• Mindfulness walking for awareness audio exercise
3. Acceptance without judgement and reducing stress	• Diffusing negative thoughts using the power of the breath
	• Mindful photography exercise
	• Alleviating stress and refocusing your attention using the breath
	• Fighting distractions audio exercise
	• Observing negative thoughts and feelings without judgement mindfulness exercise
	• Body Scan breathing and observing exercise
Module 3: recharge (wellbeing)	
1. Finding satisfaction by focusing on where you are now and what you've got.	• Gratitude self-rating exercise (McCullough et al., 2002)
2. What is happiness, explaining the PERMA model of wellbeing	• Guided meditation for visualising happiness
3. Building self-worth by noticing and reframing your thoughts	• Savouring guided meditation
	• Gratitude diary of three things per day that you are grateful for
	• Guided meditation of noticing but not reacting to negative self-evaluations
	• Self-esteem diary documenting three things per day of positive traits you demonstrated
Module 4: action (behavioural activation)	
1. Motivation and action – improving your mood by getting yourself moving	• Behavioural activation self-rating exercise (Manos et al., 2011)
2. Tracking your activity to improve awareness	• Activity Scorecard exercise tracking how much of your day is spent doing enjoyable things
	• Mindfulness exercise to improve mood by focusing on positive experiences
	• My "To-Do" List exercise of adding more pleasurable activities to your day

intervention at post-test. Models are reported in adjusted form using the following covariates selected a priori due to their established role as social determinants of paternal mental health: age, financial hardship, and COVID diagnosis. Effect sizes are reported as standardised mean differences, with values of $0.50 \geq 0.20$ considered small, $0.50 < 0.80$ moderate, and ≥ 0.80 large (Cohen, 1992).

Multiple imputations were used to handle missing data with 50 imputations. Sensitivity analyses were conducted to assess the robustness of the results against potential non-ignorable missing data patterns (not missing at random, NMAR). The sensitivity analyses were carried out using pattern mixture models implemented via the *mimix* package (Cro et al., 2016). Several NMAR scenarios were evaluated with *mimix*, including: (1) last mean carried forward (LMCF) which imputes the previous time-point's group mean; (2) jump to reference (J2R), which imputes missing data with the control group's mean at that time-point; and (3) copy increments in reference (CIR), which imputes missing data

with the mean increment from the previous time-point for the control group, irrespective of group assignment. Each model underwent 50 imputations.

Finally, subgroup analyses were conducted to examine whether the severity of baseline depression, anxiety, and stress symptoms or baseline prepartum or postpartum status influenced intervention effectiveness and treatment adherence. Baseline depression, anxiety, and stress scores were grouped by symptom severity using established cut-offs for each measure; baseline EPDS-Depression was coded as Severe or Low-Moderate using a cutoff of 13 (Cox et al., 1987), baseline DASS21-Anxiety was coded as Severe-Extreme or None-Moderate using a cutoff of 15, and DASS21-Stress was coded as Severe-Extreme or None-Moderate using a cutoff of 26 (Lovibond and Lovibond, 1996). A mixed-effects regression analysis was performed for each baseline symptom severity group and for prepartum or postpartum status. The analysis utilized 50 imputations. Subgroup treatment adherence calculations were performed using the same baseline mental health symptom severity and pregnancy status categories.

3. Results

3.1. Baseline characteristics

Sample characteristics at baseline are presented in Table 2. Most participants were multiparous Australian fathers living with their partner in the early postpartum period. The mean depression score was in the moderate range, with 62.8 % of fathers scoring above the cut off for major depressive disorder. Anxiety and stress scores were in the severe to very severe range in both conditions. No differences were observed between the active control and intervention conditions, suggesting that randomisation was effective.

3.2. Study attrition

4-Week post-intervention assessments were completed by 91 participants, with no differences observed in drop-out rates between groups (active control $n = 46$ (56.8 %), intervention $n = 45$ (60 %); $\chi^2 = 0.008$, $p = 0.9$, $\phi = 0.01$). Those who dropped out were more likely to be younger Australian fathers ($d = -0.51$, $p = 0.001$; $\phi = 0.53$, $p < 0.001$, respectively), earlier in the perinatal period ($d = -0.77$, $p < 0.001$), with infant's sex not yet known ($\phi = 0.23$, $p = 0.04$). Further, fathers experiencing financial hardship ($\phi = 0.23$, $p = 0.04$) or COVID symptoms/diagnosis ($\phi = 0.37$, $p < 0.001$) were more likely to drop out. However, being a first-time father ($\phi = -0.09$, $p = 0.58$), and experiencing family impacts due to COVID-19 restrictions ($\phi = -0.08$, $p = 0.29$), was not associated with completion status.

3.3. Active control and intervention usage

Overall, 67.9 % ($n = 53$) of participants allocated to the intervention condition installed and completed onboarding into the *Rover* intervention app, while 65.1 % ($n = 56$) of participants allocated to the control condition installed and completed onboarding into the *moodmonitor* active control app. Table 3 below presents the number and proportion of participants that engaged with each module of the *Rover* app after installation. Daily mood assessments were completed at least once by 94.34 % ($n = 50$) of the *Rover* participants, and 98.21 % ($n = 55$) of the *moodmonitor* participants, while at least half of all daily mood assessments were completed by 33.96 % ($n = 18$) of *Rover*, and 69.64 % ($n = 39$) of *moodmonitor* participants. All daily mood assessments were completed by 9.43 % ($n = 5$) of *Rover*, and 39.28 % ($n = 22$) of *moodmonitor* participants. Between groups, daily mood assessments were completed more frequently by those in the active control condition, than those in the intervention (*Rover*: $M = 11.23$, $SD = 12.87$; *moodmonitor*: $M = 21.36$, $SD = 11.52$; $t_{(107)} = 4.34$, $p < 0.001$).

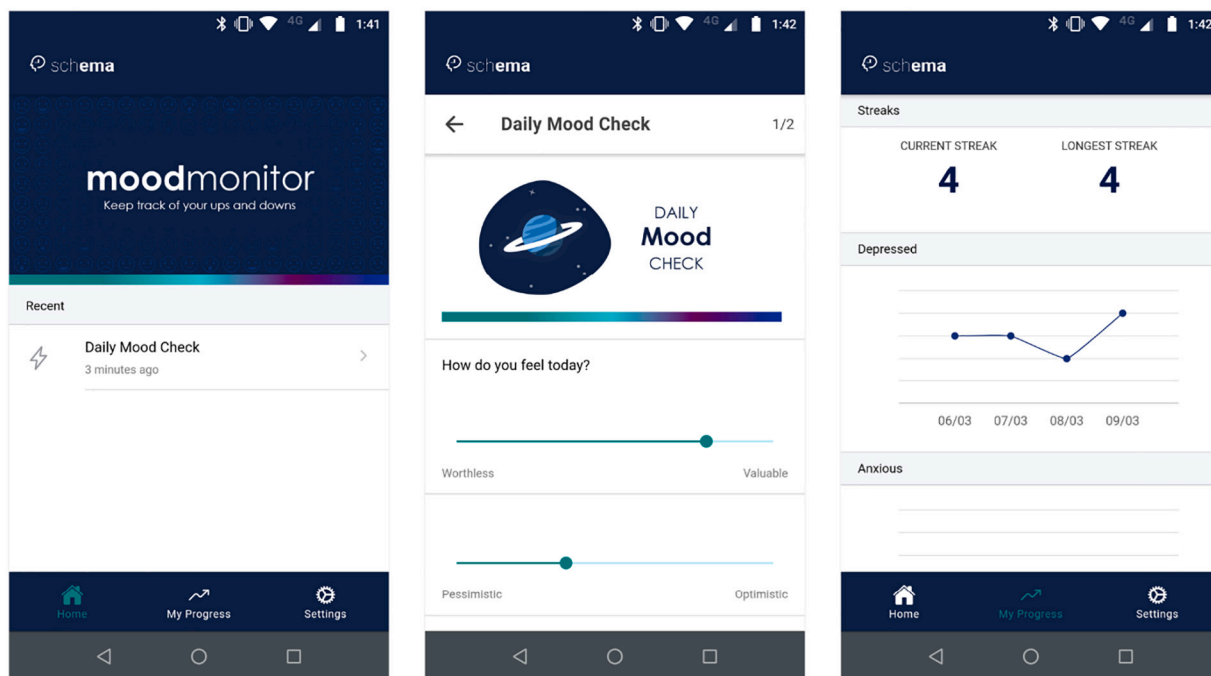


Fig. 3. moodmonitor app-based mood tracking for the active control condition, with daily prompts (left), self-report depression and anxiety using the Immediate Mood Scale-12 (centre), and feedback graph (right).

3.4. 4-Week post-test efficacy

3.4.1. Primary outcomes

Table 4 presents the results from the intention-to-treat analyses. No differences were observed between the active control and intervention conditions on the primary outcomes of depression, anxiety or stress symptoms. However, both groups experienced substantial improvements in anxiety and stress symptoms post-treatment.

3.4.2. Secondary outcomes

Between groups, no differences were found on the secondary outcomes of parenting competence or couple relationship quality, and a small effect was observed for greater improvements in social support for the active control condition. Both groups experienced a moderate-to-large improvement in couple relationship quality post-treatment.

3.4.3. Sensitivity analyses

Sensitivity analyses were conducted to evaluate post-test outcomes using different methods to handle data that were potentially not missing at random (NMAR: LMCF; J2R; CIR; see Supplementary Table 1). Results remained largely unchanged, except for the between-group difference in social support becoming non-significant in all of the NMAR models.

3.5. 8-Week follow-up

Follow-up results were available for $n = 79$ intervention participants which indicated reduced anxiety and stress symptoms were maintained in the intervention group at 8-weeks post-intervention (anxiety: $SMD = -0.32$, $p = 0.16$; stress: $SMD = 0.18$, $p = 0.43$), including improved couple relationship quality ($SMD = -0.02$, $p = 0.99$). No changes were observed from the 4-week to the 8-week post-intervention follow up for the remaining primary (depression: $SMD = -0.04$, $p = 0.83$) and secondary outcomes (social support: $SMD = 0.27$, $p = 0.24$; parenting sense of competence: $SMD = -0.13$, $p = 0.58$).

3.6. Subgroup analyses

3.6.1. Baseline mental health symptom severity

Subgroup analyses were conducted to examine whether the severity of baseline depression, anxiety or stress symptoms influenced intervention effectiveness. Participants with severe baseline depression were found to experience a greater decline in depression symptoms over time in the intervention group compared to the active control group ($F_{(6, 2547.5)} = 7.64$, $p < 0.01$, group \times time interaction: $b = 5.36$, $p = 0.008$), however no group \times time interaction effects were found for low-to-moderate baseline depression symptoms ($F_{(6, 27,075.3)} = 1.15$, $p = 0.329$). Similarly, no group \times time interaction effects were found for anxiety (Severe: $F_{(4, 588.6)} = 12.64$, $p < 0.001$; group \times time interaction: $b = 2.62$, $p = 0.53$; Normal-Moderate: $F_{(4, 4405.3)} = 19.34$, $p < 0.001$, group \times time interaction: $b = 0.88$, $p = 0.27$), or stress baseline symptoms (Severe: $F_{(4, 4145.5)} = 58.82$, $p < 0.001$, group \times time interaction: $b = 1.53$, $p = 0.546$; None-Moderate: $F_{(4, 1605.5)} = 59.94$, $p < 0.001$, group \times time interaction: $b = -0.47$, $p = 0.627$).

Table 5 presents differences in treatment adherence across the intervention by the severity of participants' baseline depression, anxiety, or stress symptoms. Participants without severe depression were more likely to complete at least one activity over the duration of the intervention, with a moderate effect and marginally non-significant p -value ($t_{(28,73)} = 1.95$, $p = 0.06$, $d = 0.62$ (95 % CI [0.03–1.2])). In contrast, no differences were observed in whether participants completed at least one exercise across the intervention duration by the severity of baseline anxiety ($t_{(6,40)} = 0.33$, $p = 0.753$, $d = 0.16$ (95 % CI [-0.69–1.01])) or baseline stress ($t_{(19,07)} = -0.78$, $p = 0.443$, $d = -0.25$ (95 % CI [-0.91, 0.42])). No differences were observed for completing the full intervention between baseline symptom severity groups (depression: $t_{(26,32)} = -1.193$, $p = 0.24$; anxiety: $t_{(6,32)} = -0.21$, $p = 0.84$; stress: $t_{(12,76)} = -1.18$, $p = 0.26$).

3.6.2. Baseline pregnancy status

Subgroup analyses examined whether intervention effectiveness differed between prepartum and postpartum fathers. No group \times time interaction effects were found for depression symptoms in either

Table 2
Baseline characteristics of the total sample.

Variable	Active control (n = 81)	Intervention (n = 75)	Test statistic	ES
Age	30.23 (4.90)	30.77 (4.48)	-0.72	-0.01
Living with partner (n (%))			0.94	-0.08
Yes	79 (98.7 %)	75 (100 %)		
No	1 (1.1 %)	0 (0.0 %)		
In paid employment (n (%))			0.01	0.01
Yes	77 (95.1 %)	71 (94.7 %)		
No	4 (4.9 %)	4 (5.3 %)		
Education attainment (n (%))				
Did not complete high school	3 (3.7 %)	2 (2.7 %)	0.12	-0.03
All high school completed	78 (96.3 %)	72 (97.3 %)		
First-time father			0.05	-0.02
Yes	50 (61.7 %)	45 (60.0 %)		
No	31 (38.3 %)	30 (40.0 %)		
Country			1.37	0.09
Australia	34 (42.0 %)	29 (38.7 %)		
New Zealand	1 (1.2 %)	0 (0.0 %)		
USA	20 (24.7 %)	19 (25.3 %)		
UK	19 (23.5 %)	21 (28.0 %)		
Canada	7 (8.6 %)	6 (8.0 %)		
Infant age (months)	0.28 (0.46)	0.23 (0.06)	0.63	0.1
Pregnancy status (n (%))			0.69	-0.07
Prepartum	18 (22.2 %)	21 (28.0 %)		
Postpartum	63 (77.8 %)	54 (72.0 %)		
Infant sex (n (%))			3.01	0.14
Male	37 (45.7 %)	42 (56.0 %)		
Female	35 (43.2 %)	25 (33.3 %)		
Don't know	9 (11.1 %)	8 (10.7 %)		
Depression diagnosis	8 (10.7 %)	10 (13.9 %)	0.35	0.05
Anxiety diagnosis	9 (12.0 %)	6 (8.3 %)	0.54	-0.06
EPDS	11.64 (5.58)	12.01 (5.39)	-0.48	-0.08
DASS21 - Anxiety	10.62 (8.41)	9.17 (7.58)	1.13	0.18
DASS21 - Stress	17.48 (8.43)	17.81 (8.50)	-0.24	-0.04
MSPSS - Total	61.99 (14.82)	63.59 (11.91)	-0.74	-0.13
PSOC - Total	61.85 (9.78)	59.57 (9.07)	1.51	0.24
RDAS - Total	46.43 (9.40)	47.57 (8.29)	-0.81	-0.12

Notes: Test statistic for continuous variables is t-statistic from two-sample t-test with unequal variances, categorical variables are χ^2 tests; Effect size for continuous variables is Cohen's *d*, categorical variables are phi or Cramer's V coefficient; **p* < 0.05.

Table 3
Number and proportion (n (%)) of participants that engaged with each Rover intervention module and the full intervention (all four modules combined).

Adherence (exercises engaged with)	Module 1 - plan	Module 2 - focus	Module 3 - recharge	Module 4 - action	Full intervention
≥1 exercise	32 (60.38 %)	26 (49.06 %)	10 (18.87 %)	11 (20.75 %)	39 (73.58 %)
≥50 % exercises	28 (52.83 %)	14 (26.42 %)	7 (13.21 %)	6 (11.32 %)	9 (16.98 %)
100 % exercises	21 (39.62 %)	9 (16.98 %)	7 (13.21 %)	6 (11.32 %)	7 (13.21 %)

Note: Proportion is relative to those that downloaded the app.

subgroup (Prepartum: $F_{(6, 3500.6)} = 1.69, p = 0.12$; group \times time interaction: $b = -2.15, p = 0.49$; Postpartum: $F_{(6, 16,463.7)} = 3.58, p = 0.001$; group \times time interaction: $b = -0.25, p = 0.79$). Similarly, no group \times time interaction effects were observed for anxiety symptoms (Prepartum: $F_{(4, 1533.1)} = 2.53, p = 0.04$; group \times time interaction: $b = -0.07, p = 0.97$; Postpartum: $F_{(4, 3103.7)} = 11.41, p < 0.001$, group \times

time interaction: $b = 1.01, p = 0.44$), or stress symptoms (Prepartum: $F_{(4, 2003.0)} = 1.57, p = 0.18$, group \times time interaction: $b = -1.13, p = 0.73$; Postpartum: $F_{(4, 10,253.4)} = 18.15, p < 0.001$, group \times time interaction: $b = 0.37, p = 0.81$). Treatment adherence rates by prepartum and postpartum status are presented in Table 5. No differences were found between subgroups for completing at least one activity ($t_{(51)} = 1.03, p = 0.31, d = 0.3$ (95 % CI [-0.30–0.96])), completing >50 % of activities ($t_{(51)} = 0.66, p = 0.51, d = 0.21$ (95 % CI [-0.42–0.84])), or completing the full intervention ($t_{(51)} = -0.67, p = 0.51, d = -0.21$ (95 % CI [-84–0.41])). Overall, these findings indicate no evidence that intervention effects or treatment adherence differed based on prepartum or postpartum status.

4. Discussion

This study aimed to evaluate the efficacy of a mindfulness-based CBT app called *Rover* for paternal perinatal depression, anxiety, and stress symptoms via RCT. In contrast to our hypotheses, we found no meaningful differences between *Rover* and an active control condition of mood monitoring after four weeks of treatment. However, improvements in anxiety, stress, and couple relationship quality were observed across both conditions and were maintained in *Rover* users at 8-week follow-up. Further, fathers with severe depression experienced greater declines in symptoms in the *Rover* condition than active control. While fathers rated the intervention as acceptable (see Teague et al., 2022), treatment adherence was relatively low other than for mood tracking, indicating some elements are engaging to the father population but further work is needed to meet users' needs of engaging and accessible treatment materials. In so doing, this study contributes to an emerging literature on digital interventions for fathers' mental health in the perinatal period.

First, results showed no change in the primary outcome of depression, for either the intervention or active control condition. Subgroup analyses indicated fathers with severe depression at baseline experienced greater declines in depression symptoms with the *Rover* intervention than active control, however no differences between conditions were found for severe baseline anxiety or stress. Mindfulness-based CBT is a well-established treatment program for depression (Goldberg et al., 2019), however translating this to a self-complete mobile app intervention for fathers during the perinatal period may pose additional challenges (Bubolz et al., 2020). Meta-analytic evidence indicates that app-based interventions typically only have small effects for depression symptom improvement, though those that include CBT content and chatbot delivery, such as in the *Rover* app, tend to report stronger effects (Linardon et al., 2024). While the uptake of the *Rover* app was moderate (68 % of participants), only 17 % of participants completed at least half of the intervention, with intervention adherence declining across the four modules, suggesting that insufficient exposure to the app's psychotherapeutic content may be a key reason for the null effect. A self-guided, non-prescriptive design was chosen for presenting the mindfulness-based CBT content in the *Rover* app (Teague et al., 2022), in line with evidence that men prefer collaborative "power-sharing" models of treatment (Habib, 2012; Mahalik et al., 2012; Seidler et al., 2018). However, such a design may lack sufficient encouragement for participants experiencing symptoms of low energy and fatigue, difficulty concentrating and making decisions, and loss of interest or pleasure in activities that are common symptoms of depression. Future work is needed to investigate how to best design self-directed digital interventions for populations such as fathers experiencing depression symptoms.

Second, both the intervention and active control conditions reported improvements in the primary outcomes of anxiety and stress symptoms, and the secondary outcome of couple relationship quality. Common to both conditions was the same daily mood monitoring activity, the Immediate Mood Scaler-12 (Nahum et al., 2017), with gamification features of a streak-count and past 7-day scores presented back to

Table 4
Means, standard deviations, and change scores on all outcome variables.

Outcome	Baseline		Post-test			Change score difference		
	M (SD)	n	M (SD)	n	ES _{within}	M change (95 % CI)	ES _{between}	p
EPDS - Depression								
Active Control	11.64 (5.57)	81	8.58 (5.17)	46	-0.14	-0.27 (-2.48, 1.93)	-0.05	0.800
Intervention	12.06 (5.39)	75	9.53 (5.75)	45	-0.36			
DASS21 - Anxiety						2.12 (-0.17, 4.41)	0.26	0.069
Active Control	10.61 (8.41)	81	2.45 (2.81)	46	-1.94*			
Intervention	9.17 (7.57)	75	2.97 (3.58)	45	-1.7*			
DASS21 - Stress						0.16 (-2.21, 2.55)	0.01	0.89
Active Control	17.48 (8.43)	81	6.56 (4.04)	46	-2.8*			
Intervention	17.81 (8.5)	75	7.28 (4.26)	45	-2.9*			
MSPSS - Total						-3.68 (-6.89, -0.479)	-0.27	0.024
Active Control	61.98 (14.82)	81	67.19 (15.09)	46	0.4			
Intervention	63.58 (11.9)	75	63.77 (11.08)	45	-0.33			
PSOC - Total						-1.32 (-4.67, 2.03)	-0.13	0.439
Active Control	61.85 (9.78)	81	67.65 (12.52)	46	0.36			
Intervention	59.57 (9.07)	75	62.06 (13.37)	45	0.13			
RDAS - Total						0.16 (-1.25, 1.58)	0.01	0.82
Active Control	46.43 (9.4)	81	50.73 (7.14)	46	0.71*			
Intervention	47.57 (8.28)	75	50.35 (5.72)	45	0.99*			

Notes: Baseline and post-test mean and SD values are calculated on non-imputed data; mean change and effect estimates are calculated from ITT analysis; ES, standardised mean difference effect size.

* p < 0.001.

Table 5
Number and proportion (n (%)) of participants that engaged with any Rover exercises across the full intervention by subgroups.

Subgroups	Adherence (exercises engaged with)		
	≥1 exercise	≥50 % exercises	100 % exercises
EPDS-Depression			
Severe	10 (55.5 %)	4 (22.2 %)	4 (22.2 %)
Low-Moderate	28 (82.3 %)	5 (14.7 %)	3 (8.8 %)
DASS21-Anxiety			
Severe - Extreme	4 (66.7 %)	1 (16.7 %)	1 (16.7 %)
Normal - Moderate	8 (17.4 %)	8 (17.4 %)	6 (13.0 %)
DASS21-Stress			
Severe - Extreme	9 (81.8 %)	3 (27.3 %)	3 (27.3 %)
Normal - Moderate	29 (70.7 %)	6 (14.6 %)	4 (9.7 %)
Prepartum	11 (85 %)	3 (23 %)	1 (8 %)
Postpartum	28 (70 %)	6 (15 %)	6 (15 %)

Note: Proportion is relative to those that downloaded the app.

participants as a line graph. Adherence was moderate to high in both conditions, with the mean number of daily mood assessments completed in the active control condition indicating that participants tracked their mood every day for an average of three out of four weeks. Mood monitoring alone can be an effective intervention for mood disorder symptoms through improvements in self-awareness and self-reflection about one’s emotions and behaviours (Caldeira et al., 2017; Dubad et al., 2018). Recent meta-analytic evidence suggests that anxiety symptoms particularly may benefit from mobile app-based mood monitoring program features, with meaningful change in depression symptoms harder to achieve (Linardon et al., 2024), a finding supported by the current study.

Men in both conditions likely experienced substantial reductions in anxiety and stress symptoms as a result of the graphic mapping of past week mood trends. In qualitative feedback sought from Rover users during the co-design of the intervention, fathers reported the mood tracking element as a favourite feature in the app design, commenting that this feature helped to improve their awareness of their mood and mental state (Teague et al., 2022). Mood tracking has been demonstrated to improve recognition of mood patterns over time, including early warning signs, triggers, and management strategies that are effective in managing anxiety and stress. This improved understanding may subsequently have helped participants develop their emotion regulation skills, by recognising when they are in a state of emotional

distress or when emotional distress is imminent, as well as insight into the implementation of coping strategies that help regulate their mood. Further, the act of labelling and tracking emotional states may have assisted men to communicate with their partners more effectively about their emotional experiences. Mood tracking may be especially helpful for men who also commonly experience higher rates of alexithymia, hypothesised to be due to traditional male gender expectations of restricted emotions (Levant et al., 2009). Effective communication with partners could explain the improved couple relationship quality observed in both conditions – though notably, perceived social support did not improve over the duration of the study. Future work could investigate expanding the mood monitoring activities presented in the current study as a short, simple, yet powerful intervention for paternal perinatal anxiety and stress. This could include expanding the range of moods that are tracked and more assistance in helping fathers to develop insights on their mood data, such as enhanced feedback graphs that enable greater reflection on management strategies and pattern recognition. Such an intervention could also include short micro-interventions paired to mood states, creating a more direct, yet accessible method of targeting mental health symptomatology.

The current study has several limitations that should be considered when interpreting the findings. First, attrition was 41.67 % across both conditions, reflecting the difficulty of engaging men in mental health-care, reported extensively in the literature (Borg et al., 2024). App-based interventions also commonly experience high attrition rates, ranging from 26.2 %–47.8 % (Linardon et al., 2024; Torous et al., 2020). While attrition was anticipated in an a priori power analysis given the target population and self-directed, app-based nature of the intervention, the final sample size at post-test was lower than the target required to achieve full statistical power. To mitigate the impact of missing data, we employed multiple imputation and conducted sensitivity analyses to test the robustness of our findings. However, the reduced sample size may still have limited the ability to detect smaller effect sizes. Future research could consider strategies for enhancing fathers’ engagement with mental health apps, such as using brief, daily mood exercises, which were found to have greater uptake among participants in both conditions.

Second, a control condition was not included in the study design. As participant eligibility included moderate depression, anxiety, or stress symptoms, an active control condition was used as a comparator for ethical reasons. While the results indicate substantial improvement in the primary outcomes of anxiety and stress symptoms across both

conditions, time cannot be ruled out as a factor influencing outcomes. Future work may consider treatment as usual or other comparator groups to better delineate the impact of time on paternal anxiety and stress symptoms, relative to intervention.

Third, the intervention was designed for, and predominantly evaluated among western, English-speaking fathers. Generalising findings to other cultures and contexts may thus be limited, especially given that role expectations and norms about fathers during the perinatal period are diverse (Seward and Stanley-Stevens, 2013; Valiquette-Tessier et al., 2019). This limitation also applies to non-birthing partners who do not identify as fathers, as the Rover intervention and recruitment materials were specifically designed for men in the perinatal period. The term ‘father’ carries both sexed and gendered meanings (Gribble et al., 2022), and prior research suggests that explicitly using terms like ‘father’ or ‘dad’—rather than more inclusive terms such as ‘parent’—is necessary for fathers to recognise themselves as the target population (Yaremych and Persky, 2023; Leach et al., 2019). Future research should explore how digital interventions can be adapted to better support a broader range of non-birthing parents while maintaining strong engagement with fathers.

Finally, the study relied on self-report measures of primary and secondary outcomes. While the EPDS and DASS-21 are valid and reliable screening measures of mental health symptoms (Cox et al., 1987; Lovibond and Lovibond, 1996), future work could investigate the efficacy of similar interventions using diagnostic assessments for a more comprehensive clinical evaluation.

In conclusion, this study aimed to investigate the efficacy of an app, *Rover*, to reduce depression, anxiety, and stress symptoms in fathers perinatally. While no significant between-condition effects were observed, fathers with severe depression showed greater symptom improvement in the *Rover* condition, suggesting that app-based interventions may hold particular promise for those experiencing more severe distress. These findings highlight the potential role of digital interventions in addressing paternal mental health needs; however, engagement with the app’s therapeutic content was limited, underscoring the need for further refinement to optimise user engagement and clinical outcomes. Future iterations of *Rover* may benefit from integration into a stepped-care model, allowing for personalised levels of intervention based on symptom severity and need. Incorporating interactive elements, real-time feedback, and clinician-supported components could enhance its effectiveness and accessibility. Additionally, integrating *Rover* with maternal mental health services may provide a more holistic, family-centred approach to perinatal mental health care, recognising the interdependence of parental well-being (Pilkington et al., 2015; Cluxton-Keller and Bruce, 2018). These enhancements could strengthen *Rover*’s role as a scalable, low-cost intervention for fathers while promoting broader family mental health outcomes. This study contributes to an emerging literature on paternal mental health interventions, offering the first trial of an app-based intervention specifically targeting fathers’ mental health for treatment. Future research should focus on refining and expanding digital interventions to better meet the needs of fathers in the perinatal period, with an emphasis on engagement, integration into healthcare systems, and holistic family support.

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CRediT authorship contribution statement

Samantha J. Teague: Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Adrian B.R. Shatte:** Writing – review & editing, Software, Formal analysis, Data curation, Conceptualization. **Matthew Fuller-Tyszkiewicz:** Writing – review & editing, Formal analysis. **Delyse M. Hutchinson:** Writing – review & editing, Supervision,

Conceptualization.

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Declaration of competing interest

No conflicts of interest are reported.

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