



The applicability of nature-based interventions to support mothers' postnatal wellbeing: A conceptual review

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ABSTRACT

Nature-based interventions represent promising candidates for supporting mothers and infants in the postnatal period, which is a vulnerable time for mothers to experience mental health difficulties. Possible mechanisms by which nature-based interventions may support postnatal health include those of a biological/physiological nature (for example natural light optimising circadian rhythm, improving microbiome health, providing opportunities for physical activity), relational/social pathways, and cognitive and creative pathways. A conceptual understanding of these possible mechanisms will aid the design and evaluation of postnatal nature-based interventions.

1. Introduction

There is reason to suggest that nature-based interventions could be effective in supporting mothers experiencing a range of postnatal mental health difficulties. Despite the growing evidence base for nature-based interventions in other populations, such as people with depression outside the postnatal period (Rosa et al., 2021; Kotera et al., 2020), research exploring the role of nature in supporting postnatal mental health remains limited. Moreover, the potential theoretical underpinnings of nature as a source of support for postnatal mothers have not been studied. Furthering this understanding is important if nature-based interventions are to be developed and empirically tested for this group.

The new MRC—NIHR framework for developing and evaluating complex health interventions (Skivington et al., 2021) recommends following several stages. This process includes developing an understanding of possible mechanisms of action, enabling the creation of programme theories or logic models that can inform both intervention development and evaluation. In this article, we outline a conceptual rationale for why nature-based interventions represent promising research candidates for improving postnatal mental health. We situate

the discussion within current evidence about contributors to poor postnatal mental health, invoking understanding from multi-disciplinary fields.

Our conceptual discussion is organised into four main sections. We begin by outlining postnatal mental health difficulties using an evolutionary theory-informed framework, followed by a rationale for the use of nature-based interventions in other contexts. In the second and main section, we speculate on possible mechanisms by which nature-based interventions could support postnatal health. We explore the potential scalability of such interventions, and finish by presenting suggestions for future research.

1.1. Postnatal mental health difficulties

The birth of a baby can be a time of great joy, but for many families it is complicated by the onset or worsening of mental health problems. These can have detrimental implications for mothers, their infants, families and society (Howard and Khalifeh, 2020). The general population prevalence of postnatal depression is approximately 15–20 % (Shorey et al., 2018), and of postnatal anxiety around 10 % (Dennis et al., 2017; Fawcett et al., 2019). The aetiology of postnatal depression

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and postnatal anxiety are complex and not fully understood. In the medical literature, certain risk factors have consistently emerged as contributors to the risk of postnatal depression since early meta-analyses. These include a lack of social support, life stress, and a history of depression (Beck, 1996; O'Hara and Swain, 1996; van der Zee-van den Berg et al., 2021). Further documented risk factors include severe life events, notably adverse childhood experiences, obstetric complications, a family history of affective disorders, and a low sense of maternal self-efficacy (van der Zee-van den Berg et al., 2021; Yim et al., 2015; Nidey et al., 2020; Racine et al., 2020). A recent meta-analysis found premenstrual syndrome, violent experiences, and unintended pregnancy as the most indeed risk factors for some (Gastaldon et al., 2022). For postnatal anxiety, risk factors include a history of depression, low partner support, low maternal perceived self-efficacy, negative experience of delivery, and 'excessive' infant crying (van der Zee-van den Berg et al., 2021).

Despite evidence for the efficacy of psychological and pharmacological interventions for postnatal depression (Howard and Khalifeh, 2020), very few mothers receive treatment due to underdiagnosis, long waiting lists for therapies, and childcare commitments, as well as fear of medication side effects (Cox et al., 2016; Owais et al., 2018). Furthermore, there is scepticism and concern amongst some cultures about the application of Western medical constructs such as 'postnatal depression' to the experience of human distress, requiring 'treatment' in a medical setting (Oates et al., 2004; Husain et al., 2022). Postnatal distress may instead be understood as a response to an insufficiently socially or economically supportive environment (Taylor et al., 2022; Chung et al., 2004), or as a challenging period of adjustment to a mother's new role and responsibilities (Rallis et al., 2014), without significant recognition through rites and rituals in many Western countries. Moreover, many current treatment modalities neglect the importance of the dyadic relationship between mother and infant (Forman et al., 2007). There is a need to investigate the potential for innovative, scalable and sustainable interventions to support postnatal mental health, which involve both the mother and infant, and may hold appeal for people from diverse cultural and social backgrounds.

1.1.1. An evolutionary perspective on the role of nature in the postnatal period

As a species, humans have spent millennia living an intimate existence with nature, and the human brain has evolved to be optimally attuned to cues within the natural environment (Richardson and McEwan, 2018). The human genome, adapted mostly for hunter-gatherer lifestyles, has not substantially changed in the last 200,000 years, but the rapid transition from traditional to post-industrial society has led to radical lifestyle changes. Many individuals, including mothers of young children, lead lifestyles that diverge significantly from those believed to have been typical throughout evolutionary history: for example now involving isolation from kin support networks, lower levels of physical activity and sun exposure (Hahn-Holbrook and Haselton, 2014; Tsai et al., 2009; Tsai et al., 2012), and with more time in built environments and less time in natural spaces. In addition, changing social pressures for women include opportunities for and challenges of professional and financial independence, often balanced with persisting unequal domestic labour expectations.

For many of the reasons outlined, postnatal depression has been conceptualised as 'a disease of modern civilisation' (Hahn-Holbrook and Haselton, 2014; Crouch, 1999). Modern living and urbanisation have been associated with pressing public health and environmental challenges (Moore et al., 2003; World Health Organization 2015; Sundquist et al., 2004). One example is reduced time spent outdoors and in proximity to biodiverse ecosystems, which has various consequences for humans, ranging from disturbed circadian rhythms to sub-optimal microbiomes (Haahntela et al., 2013; Bumgarner and Nelson, 2021). For some, this 'evolutionary mismatch' provides a unifying theory explaining the high prevalence of psychological distress in modern

society (Hidaka, 2012). Engagement with nature, in addition to addressing entrenched societal inequalities, is becoming increasingly recognised as a means of alleviating some of these challenges (Shanahan et al., 2019).

Indeed, there is a body of evidence suggesting that contact with nature has the potential to reduce health inequalities for under-served populations (Mitchell and Popham, 2008; Ganzleben and Kazmierczak, 2020; de Vries et al., 2003; Rigolon et al., 2021; Frumkin et al., 2017). The key role of the natural environment in maintaining and improving mental and physical health has been well-established in the expanding literature, across age ranges, cultures, and social class (Frumkin et al., 2017; Bratman et al., 2019; Capaldi et al., 2015; Pritchard et al., 2019). Though not a panacea for issues such as poor housing conditions and living in poverty, a close relationship with nature is considered by some to be a basic psychological need and a pre-requisite to wellbeing (Pritchard et al., 2019; Baxter and Pelletier, 2019; Hurley and Walker, 2019). Certainly, the restorative effects of stepping outside for a walk with a new baby are well-known anecdotally amongst new parents. Several commonly cited theories explain why this may be the case. The Biophilia Hypothesis posits that humans possess an innate preference for natural surroundings given our evolutionary history, with attraction to nature being evidenced across diverse cultures and from very young ages (Capaldi et al., 2015; Wilson, 1984). According to Kaplan's Attention Restoration Theory (Kaplan, 1995), the effortless attention and pleasurable fascination elicited by natural environments allow the brain to recover from the mental fatigue caused by the cognitive tasks of modern society, in which prolonged directed attention is required. Another model, Ulrich's Stress Reduction Theory (Ulrich et al., 1991), describes how humans respond to immersion in unthreatening natural settings, in which survival possibilities abound, inducing positive emotions and soothing autonomic arousal. This theory is supported by several decades of research suggesting that contact with nature improves stress-related physiological parameters such as reducing heart rate, blood pressure and cortisol levels, increasing heart rate variability, and improving immune functioning (Capaldi et al., 2015; Farrow and Washburn, 2019; Tsunetsugu et al., 2010; Bowler et al., 2010). More recently, Richardson's emotion regulation theory (Richardson, 2019) describes neurophysiological pathways for how the aesthetic qualities of natural scenes facilitate affect regulation.

In summary, human brains have evolved to perceive and respond to the natural environment with the optimal level of vigilance. We are not adapted to the rapidly expanding built environment, which is very recent in human evolutionary terms. The higher level of vigilance required of humans in a built environment, to which they are not optimally adapted, can increase the risk of stress-related disorders such as depression and anxiety. New motherhood is a time of heightened vigilance, which serves the purpose of protecting offspring. Notwithstanding specific safety concerns that women might experience in some natural settings, the general reduction in anxious arousal and the restorative effects of nature may be highly relevant in supporting parents coping with the stresses and sustained goal-directed attention required when providing 24-hour care to infants.

1.2. Nature-based interventions

Greater understanding of the synergistic link between nature and health could be of benefit to humans and the natural environment alike. In the UK, this notion has informed investment in Green Social Prescribing (HM Government 2021; Department of Health and Social Care 2023). Green Social Prescribing aims to link people with various health needs to specifically designed, structured, and facilitated nature-based interventions delivered in the community. Programmes include, but are not limited to, horticulture and gardening, conservation activities, and *shinrin-yoku* (forest bathing, defined as mindful immersion in a natural environment) (Fullam et al., 2021). It is noteworthy that, in the general population, or for people experiencing mental health difficulties

outside the perinatal period, nature-based interventions are gaining a relevant evidence base for alleviating many of the processes which are modifiable in the development of postnatal mental health difficulties: improving emotional regulation (Richardson and McEwan, 2018), improving stress (Yao et al., 2021), improving immune function (Li et al., 2008; Li, 2019), as well as improving sleep (Astell-Burt et al., 2013; Grigsby-Toussaint et al., 2015; Morita et al., 2011; Shin et al., 2020), social connectedness (Dadvand et al., 2016) and depressive symptoms themselves (Rosa et al., 2021; Nguyen et al., 2023).

Nature-based interventions are considered ‘complex interventions’ (Harper et al., 2021), owing to the number of components involved, the range of behaviours targeted, the expertise and skills required by those delivering and receiving the intervention, and the variety of groups and settings targeted, as well as the level of flexibility often permitted of the intervention components (Skivington et al., 2021). Moreover, a single intervention can affect people in numerous ways and potentially improve wellbeing across a multitude of domains (Shanahan et al., 2019). Although this creates complexity in the process of rigorous academic evaluation, it is likely to have real-world advantages. With regards to postnatal care, there have been calls for a shift from a ‘one-size fits all’ approach to more personalised approaches (Ayers et al., 2021). This is in keeping with the UK NHS Long Term Plan, which is committed to delivering personalised care (NHS 2019), and is especially important given the diversity of possible perinatal mental health difficulties and women’s individual and social circumstances (Ayers et al., 2021). To this end, nature-based interventions may be important candidates for further research, as they can be tailored to local communities and be flexible according to participants’ needs.

2. How might nature-based activities support postnatal mental health?

Evidence-based pathways in non-perinatal populations have been mapped by researchers at the European Centre for Environment and Human Health (University of Exeter), between nature-based activities, mechanisms of action, and mental health-related outcomes (Fullam et al., 2021). The following section offers an early exploration of the relevance of some of these pathways for postnatal mothers. As complex interventions, any mental health benefits are likely to arise from a combination of these pathways.

2.1. Biological/physiological pathways

2.1.1. Being outside: escaping the built environment and natural light

Being outside has been described as a valid stand-alone mechanism underlying the mental health benefits of nature-based interventions (Fullam et al., 2021), not least because it allows people to escape from the stresses of the built environment. This may be particularly important for mothers or other primary caregivers, who are often balancing caring for children with other household tasks or work commitments.

Another benefit of being outside is exposure to sufficient natural light - a powerful environmental stimulus required for the running of a healthy circadian rhythm and maintenance of healthy sleep (Walker et al., 2021). Altered circadian rhythms during pregnancy and the postpartum period are strongly correlated with depression (Gallaher et al., 2018). Studies have found that postnatal mothers and infants spend around 70 % and 80 % respectively of daytime hours in dim light, with infants spending as little as ~2 % in bright light (Tsai et al., 2009; Tsai et al., 2012). Supporting more time outdoors as part of a nature-based intervention could have important benefits to circadian rhythm entrainment for newborns (who are born without established circadian rhythms) (Thomas et al., 2014), which may in turn support sleep for postnatal mothers (Hall et al., 2022).

2.1.2. Physical activity

The perinatal period is a time of significant mental and bodily change

for women. Physical activity has the potential to reconnect women with their bodies, whilst reducing mental duress and conferring a range of health benefits (Lesser et al., 2023). In addition, regular physical activity around this time reduces the risk of developing postnatal depression (Kotomanska-Bogucka and Mazur-Bialy, 2019; Haßdenteufel et al., 2020; Baran et al., 2022). However, mothers face several challenges in meeting minimum requirements for physical activity (Dipietro et al., 2019), such as a lack of confidence in their bodies or their capacity to engage in exercise after the birth of a child (Lesser et al., 2023). In a small single arm study, mothers engaging in a socially supportive outdoor group-based exercise programme were able to overcome some of these challenges, increasing their motivation to exercise and qualitatively reporting subsequent wellbeing benefits (Lesser et al., 2023; Hatfield et al., 2022). Exercise and movement are common features of nature-based interventions, in which the type of activity can be flexibly adapted to suit the target population.

Encouraging gentle physical activity as part of a postnatal nature-based intervention may be particularly promising for several reasons. A systematic review tentatively found self-reported mental wellbeing to be enhanced after exercise in outdoor and natural settings compared to exercise indoors, although poor methodological quality of available studies and heterogeneity of outcome measures makes findings difficult to interpret (Thompson Coon et al., 2011). Exercising in nature may result in greater distraction, lower perceived effort, and more positive psychological states compared to indoor activity (Lahart et al., 2019). This may be highly relevant to postnatal mothers, in whom fatigue can reduce motivation to exercise (Saligheh et al., 2016; Ryan et al., 2022). Furthermore, mothers engaging in nature-based interventions alongside their infant helps to overcome the barrier of sourcing alternative childcare, and an infant’s contentment outdoors may further enhance women’s capacity to engage in physical activity.

2.2. Relational and social pathways

2.2.1. Supporting the mother-infant relationship

It has been argued that treatment for postnatal depression should take into account the mother-infant relationship, which also has profound effects on an infant’s long-term health and wellbeing (Forman et al., 2007; Myers and Johns, 2018). Time in nature may theoretically support this relationship in a variety of ways.

2.2.2. Shared joy, fun and awe

Sharing fun and enjoyable experiences with others helps to build physical, intellectual, social and psychological resources throughout our lifespans (Puura et al., 2019). The capacity for shared pleasure and mutual positive affect is an important component of the mother-infant dyadic relationship (Puura et al., 2019). An environment allowing the infant to be an active partner within the dyadic interaction, for example engaged in mutual enjoyment, fosters positive parent-child interactions (Puura et al., 2019). These concepts are related to the wellbeing benefits from experiencing awe in nature, and to the documented increased collective concern for others expressed by humans after experiencing awe (Piff et al., 2015).

It should be acknowledged that, for those with depression, the capacity to feel pleasure may be complicated by the symptom of anhedonia: the inability to find pleasure in normally pleasurable activities. This phenomenon is captured by the writer, Lucy Jones, who described her experiences after she was diagnosed with postnatal depression:

‘Until my symptoms started to improve, I lost any interest, joy or delight in nature. I had very little response to trees, clouds or the colours of the leaves or birds. I felt nothing in wild places that used to fill me with joy. I continued to go to the wellspring, walking in a daze with my baby in the pram, and hoping that it would be restored, but it was chilling to lose that connection for a while. One winter morning, sleep-deprived, anxious and emotionally strung out, I walked out into the garden, baby bundled up

warm in a suit and hat, and into the path of a deep, heady, orangey, sugary perfume. I couldn't believe there could be a smell so strong at this time of year. I followed the molecules in the air with my nose and noticed a bush with compact pink flowers. I pulled one off to smell it up close. It was a bright, clean, Cleopatra-strong scent. I put it to my daughter's tiny acorn nose and I'm sure her eyes widened slightly [...] Each time I smelled the flowers, I felt hopeful, reassured, connected' (Jones, 2021).

It may be that the pleasure experienced by the infant, when their attention is drawn to nature, kindles a pleasure in the mother who is struggling with depression. There is, as yet, little understanding of how mothers and infants may experience awe together, but another author speculates that the natural world provides a containing space in which a mother and baby's love and joint amazement at nature can reverberate and reinforce the feelings of the other (Nicholsen, 2002). Natural environments which offer space, sensory stimulation, interest and opportunities for mutual gaze and awe are thereby potentially highly conducive to shared enjoyment between parent and infant. Such opportunities to enhance synchronicity within the early mother-infant relationships are precious, both to support maternal wellbeing and infant development (Leclère et al., 2014).

2.2.3. Enhanced communication

There is a paucity of research exploring communication between caregivers and young infants when in nature. Our recent qualitative work indicates that mothers from diverse backgrounds conceptualise nature as a special space which facilitates communication with their baby and other people (Hall et al., 2023). This was attributed to the relaxing effects of being outdoors, and the expansive yet psychologically containing properties of natural environments. Given the propensity for mothers and infants to mirror one another's emotions, the calming effect of nature on the dyadic pair may facilitate enjoyable connection, bonding, and communication.

Many of the proposed mechanisms that follow also bear relevance to mother-infant attachment, highlighting the interconnected nature of these processes.

2.2.4. Relationship with nature and 'nature connectedness'

Nature connectedness is a multidimensional psychological construct related to a person's subjective beliefs about their relationship with the natural world (Mayer and Frantz, 2004). Greater nature connectedness is associated with better mental and physical wellbeing (Pritchard et al., 2019; Dopko et al., 2019), pro-environmental and pro-conservation behaviours (Richardson et al., 2020), and enhanced emotional regulation (Richardson and McEwan, 2018). The capacity of nature to facilitate emotional regulation (Richardson and McEwan, 2018) may be particularly welcome during the postnatal period, in which mood instability may be linked to a variety of mental health difficulties (Li et al., 2020). The positive affect experienced when noticing nature's beauty, alongside its calming effects, may mediate this emotional regulation, and enable people to build resources and grow psychologically (McEwan et al., 2020).

Researchers at the University of Derby have developed the Five Pathways to Nature Connection (Lumber et al., 2017), using survey methods and then operationalising the findings into a walking intervention study (Lumber et al., 2017). These pathways are 'Contact' through the senses, 'Beauty' (appreciating nature's aesthetic qualities), 'Meaning' (for example using natural metaphors to represent ideas), 'Emotion' (which may include happiness and wonder), and 'Compassion' for nature (Lumber et al., 2017). Many of these pathways may be relevant to the mother-infant dyad. We take here the example of sensory contact with the natural world, which has been cited as an important mediator of the wellbeing benefits achieved through nature-based interventions (Fullam et al., 2021). Such rich, diverse sensory stimulation is important for mothers in and of itself (Hall et al., 2023), but there is also evidence that adequate sensory stimulation reduces infant cry-fuss

problems (Douglas and Hill, 2013). Infant cry-fuss problems correlate with higher scores on maternal depression and anxiety scales (Douglas and Hill, 2013), highlighting the fact that postnatal mental health difficulties cannot be viewed in isolation to the experiences of the infant. Diverse sensory stimulation, when combined with cue-based care, is associated with more settled infant behaviour, as well as optimising infant neurodevelopment (Douglas and Hill, 2013; Whittingham and Douglas, 2014; Douglas and Hill, 2011).

Postnatal nature-based interventions could therefore fall under the category of treatment approaches prioritising neuroprotective developmental care; these emphasise supporting parents to engage with rich biosocial cues in the daytime (including activity, social interaction and exercise – examined in Section 2.1.2.), whilst in close proximity to their infant (Whittingham and Douglas, 2014). Such notions are in keeping with preclinical neuroscientific research suggesting beneficial neurogenesis from 'environmental enrichment', key aspects of which are thought to include environmental novelty and complexity (Nithianantharajah and Hannan, 2006). How enrichment from natural environments affects the maternal brain, which is increasingly recognised to undergo profound structural and functional neuroplasticity perinatally (Orchard et al., 2023), is an under-explored but potentially rich area of study.

2.2.5. The group mechanism

Nature-based interventions tend to be group-based, building on the capacity of group settings to reduce loneliness, build confidence, experience belonging, create meaning, and reduce worrying, rumination, despair and hopelessness (Fullam et al., 2021). Formation of positive and meaningful psychological connections between group members may enhance the content of health interventions. The group experience may be highly pertinent to postnatal mothers, for whom postnatal mental health difficulties may either result from or compound feelings of loneliness and social isolation (Wittkowski et al., 2017).

2.3. Cognitive and creative pathways

2.3.1. Creativity

Giving birth can be thought of as a core animal process, sometimes medicalised by humans 'into a disembodied story that is fundamentally disconnected from nature's rage and glory' (Dr A. Kellas, 2022. Personal Communication. 26th September 2022). Creative processes, reconnecting to our place in nature, and its 'terrible, wonderful cycles and transformations', may represent an important therapeutic endeavour (*ibid*). Craft activities, making things and acts of creation are common features of nature-based interventions (Fullam et al., 2021). In other populations, being creative has been linked to wellbeing through empowerment, developing coping mechanisms, experiencing enjoyment and meaning, and reaffirmation of identity (Fullam et al., 2021). This may bear important relevance to new motherhood; the identity shift that occurs during acquisition of the maternal role has been documented as a trigger for postnatal distress and suicidal thoughts (Fonseca et al., 2018). Art-based programmes in parenthood have found that creative expression can provide a safe environment to explore challenging emotions, improve attachment between infant and parent (Bruce and Hackett, 2021), decrease parenting stress, improve social support, and reduce the distress associated with postnatal mental health difficulties (Crane et al., 2021). Studies have found that using art materials in group settings has allowed mothers to experience enhanced self-expression and access exploration of deep and complex emotional issues such as traumatic birth, loss, isolation, and shame (Crane et al., 2021).

Nature provides rich opportunities for creative expression with natural materials, allowing sharing of responses with other group members, which we speculate may support self-awareness and enhance wellbeing. Creative approaches in nature may also help participants to capture and articulate their sensory experiences of the natural world, which may otherwise be 'fleeting or difficult to express' (Fullam et al.,

2021). As well as facilitating creative exploration of identity shifts and difficult emotions, and of attachments new and old, invocation of rich metaphors within nature may be harnessed as powerful cognitive tools for mothers to find meaning in their situations.

2.3.2. Personal growth: mindfulness, shinrin-yoku and embodiment

Although likely to be a feature of many types of nature-based intervention, personal growth as a distinct mechanism applies well to interventions incorporating evidence-based therapeutic approaches (Fullam et al., 2021). An established feature of several nature-based interventions is mindfulness, with some evidence of enhanced effects in natural surroundings (Choe et al., 2020). Mindfulness aims to strengthen awareness of processes of thinking, feeling and perceiving, by practising directed attention (Fullam et al., 2021). Although its evidence-base for treating perinatal mental health difficulties remains preliminary, mindfulness-based Cognitive Behavioural Therapy (CBT) for the treatment and prevention of depression has a robust evidence base (Goldberg, 2008; McCartney et al., 2021).

The practice of shinrin-yoku involves mindful immersion in nature. It was established by Tomohide Akiyama in Japan's Ministry of Agriculture, Forestry, and Fisheries in 1982 as a response to high rates of suicide and work-based death in the business sector. Akiyama was influenced by traditions of nature-based meditation in Japanese Buddhism, as well as research into the effects of phytoncides on the immune system. Japanese research into forest bathing is as much concerned with physiological benefits as those of a psychological nature; this is similar in South Korea, where 'forest therapy' receives state funding. Shinrin-yoku is now receiving increasing attention internationally for its wellbeing benefits (Antonelli et al., 2022). As a gentle and intuitive approach, encouraging outward rather than inward attentional focus, shinrin-yoku may overcome the wellbeing risks posed by entering meditative states in vulnerable groups (Clarke et al., 2021). The practice emphasises an 'embodied' exploration of nature, using the senses, aiming to deepen an embodied sense of awareness. We speculate that is relevant to mothers and infants, given that body-body relational exchanges between mother and infant facilitate optimal attunement (Montirosso and McGlone, 2020). There is accumulating evidence that, during the first year of life, synchrony between the infant's bodily activities and those of the mother (as evidenced by variation in electroencephalogram activity, heart rhythm and neuroendocrine responses) is important for stress regulation within the dyad (Montirosso and McGlone, 2020). Deepening mothers' own sensory and bodily awareness by engaging with nature and with their infant may then promote greater synchrony and attunement within the dyadic pair.

2.3.3. Parental self-efficacy

Parental self-efficacy has its roots within Social Cognitive Theory (Bandura, 1977), and is a type of self-reflective thought that affects how a parent thinks, feels and acts (Bandura, 1977; Bandura, 1997). It is also a major determinant of human motivation (Koul, 1999) and can be 'domain-general' (applying to parenting broadly) or 'domain-specific' (applying to a specific context). In this sense, parents make judgements about their ability to perform parenting tasks and activities successfully (Bandura, 1997). Reviews (Coleman and Karraker, 1997; Jones and Prinz, 2005; Fang et al., 2021) indicate that parents who feel more efficacious display more sensitive behaviour towards their baby, choose to do activities that are more challenging, and persevere when confronting obstacles or adverse situations (Leerkes and Crockenberg, 2002). Evidence also suggests that parents who feel more competent in their role are less likely to experience parental depression (Porter and Hsu, 2003; Jover et al., 2014) and stress (Dunning and Giallo, 2021; Gordo et al., 2018), and cope better with difficult life demands (Cooklin et al., 2012). Recent research investigating nature-related parental self-efficacy has found that parents who felt more efficacious when doing things in nature with their children visited a greater range of natural places, and more frequently (Barnes et al., 2021). Furthermore,

parents who felt more efficacious also reported a greater connectedness to the natural world and had significantly higher wellbeing scores. Therefore, nature-based interventions that enhance a parent's self-efficacy may in turn have a positive impact on the psychological wellbeing and development of the parents and their families.

3. Scalability

As well as taking an important toll on the lives of women and their families, perinatal mental health difficulties pose a huge economic burden to society, mostly from health and social care. In the UK, an estimated £75,728 and £34,840 is spent for perinatal depression and anxiety respectively per woman lifetime, with an aggregate cost for the country of £6.6 billion (Howard and Khalifeh, 2020; Bauer et al., 2016). Around 75% of this cost burden is associated with subsequent childhood morbidity. There is growing concern that traditional health service models and interventions are unlikely to meet increasing mental health demands more generally, and that whole-system, salutogenic or asset-based approaches to improving population health are needed (Coventry et al., 2021).

Innovative strategies are particularly required in resource-scarce contexts in which families face socioeconomic disadvantage (Stein et al., 2014). Not only are high-quality green spaces highly salutogenic, but they can also reduce health inequalities, given that contact with nature may disproportionately benefit disadvantaged populations (Mitchell and Popham, 2008; Ganzleben and Kazmierczak, 2020; de Vries et al., 2003; Rigolon et al., 2021; Frumkin et al., 2017). This is because, although natural spaces may be more accessible to the affluent, people from disadvantaged backgrounds may stand to gain more from accessing them. Relevant to mothers, a qualitative (unpublished dissertation) study identified developmental, physical and mental benefits from nature contact in low-income, single mothers in the U.S, with the theme of 'nature as a survival strategy for low-income single mothers', to combat 'the violence of poverty' (Frost, 2019). Clearly, wider societal and economic changes are required across the globe to improve the lives of under-served populations, and contact with nature cannot alone mitigate structural inequality. However, with further research, nature-based interventions may potentially offer an inclusive, non-stigmatising, low-cost and scalable option for tackling important public health problems (136).

Moreover, nature-based interventions are being found not only to improve human health, but planetary health through their sustainability (Frumkin et al., 2017; Bratman et al., 2019), which is itself one of the most important factors in reducing human health inequalities globally (Ganzleben and Kazmierczak, 2020). Feelings of nature connectedness, with the associated pro-environmental and pro-conservation behaviours, may be passed down intergenerationally, by parents providing exposure to nature and modelling pro-environmental behaviours to the child (Dadvand et al., 2016; Richardson et al., 2020; Passmore et al., 2020). These interventions also have the potential to encourage the protection of green spaces for future generations (Frumkin et al., 2017; Bratman et al., 2019).

4. Developing and evaluating postnatal nature-based interventions

To our knowledge, the only published intervention aiming to increase time spent in green space by postpartum women is a four-week intervention called 'Nurtured in Nature', that includes a 'Nature Coach', digital nudges, and personalised goal feedback. In a pilot randomised controlled trial with 36 postpartum mothers from low-income, predominantly Black neighbourhoods in the U.S., time spent in nature increased post-intervention, though the study was not powered to detect changes in depression scores, from low baseline scores (South et al., 2021). A quasi-experimental study in family shelters in the Netherlands found that parents of children (age range 0–16)

experienced nature as helping to satisfy their basic psychological needs when interacting with their children in the context of sheltering after becoming homeless or escaping violence (Peters et al., 2020). To date, the small body of research in this area suggests that nature-based interventions have the potential to be highly inclusive, as they can be adapted based on the needs of participants (Fullam et al., 2021). However, relatively little is yet known about the effectiveness of such interventions.

At each phase of the aforementioned MRC—NIHR framework for developing and evaluating complex health interventions, core elements should be considered, including those related to the intervention's context, underpinning programme theory, and incorporation of diverse stakeholder perspectives (Skivington et al., 2021). Approaches grounded in the lived experience of mothers, using co-design and person-based approaches, are promising avenues for improving psychological morbidity in women and their children (Howard and Khalifeh, 2020; Yardley et al., 2015). Such approaches maximise the chances of developing acceptable, effective and engaging interventions, with better translation of findings into practice (Price et al., 2018). Moreover, the qualitative research encouraged as part of these approaches may answer pressing questions about the cross-cultural validity of nature-based interventions for mothers and infants from diverse backgrounds, as well as the barriers faced by mothers to accessing nature. Furthermore, future research must pay careful attention to possible adverse consequences specific to mothers and their infants, as well as unintended harmful effects towards the natural environment. Given the complexity of such interventions, control groups, adequate sample size and statistical power for any randomised controlled trials will also require careful consideration (Harper et al., 2021; Owens and Bunce, 2022).

5. Conclusion

Treating postnatal mental health difficulties presents a critical opportunity to reduce short- and long-term adverse effects on mothers, infants, and families, and to support maternal-infant attachment and infant development. It is noteworthy that many of the pathways conferring benefits of nature-based interventions are highly relevant contributors to postnatal wellbeing. In this conceptual review, we have explored several possible processes by which nature-based interventions may potentially support postnatal mental health. These include spending time outside (allowing escape from indoor stressors and optimising circadian rhythm), physical activity, increasing nature connectedness, facilitating mother-infant attachment through opportunities for positive shared experiences and enhanced communication, creativity, personal growth, enhanced self-efficacy and being part of a group. There is also a hope that interventions increasing nature connectedness in parents and their children could provide opportunities for synergistic and transgenerational improvements to both human health and the health of our planet. Building on our rationale, rigorous research, which prioritises the views of target users, is required to explore the acceptability and feasibility, and ultimately effectiveness and cost-effectiveness, of nature-based interventions to promote postnatal mental health.

Ethics statement

Ethical review was not required for this research.

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CRedit authorship contribution statement

Katherine Hall: Conceptualization, Writing – original draft. **Christopher Barnes:** Supervision, Writing – review & editing. **Lucy Duggan:** Writing – review & editing. **Samantha Walton:** Writing – review & editing. **Paul Moran:** Supervision, Writing – review & editing. **Katrina Turner:** Supervision, Writing – review & editing. **Jonathan Evans:** Supervision, Writing – review & editing.

Declaration of competing interest

LD co-founded 'The Human Nature Project', which offers free forest bathing sessions to people in Bristol to support wellbeing. It is Big Lottery funded with a Reaching Communities grant. All other authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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